Ph.D. Program
in
Electrical and Computer Engineering

Proposed Start Date: Fall 2008

Department of Electrical and Computer Engineering
School of Engineering and Computer Science
Oakland University

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SUMMARY

This proposal aims to create a new Ph.D. degree program in Electrical and Computer Engineering (ECE). There are three major motivating factors behind it. First and foremost, the current Ph.D. degree in Systems Engineering, which is really an umbrella degree, no longer adequately reflects the maturity, focus and flavor of the research conducted by the faculty and students of Electrical and Computer Engineering. Secondly, contrary to a Ph.D. degree in Systems Engineering, a Ph.D. in either Electrical Engineering (EE) or ECE is well recognized as one of the most popular mainstream degrees in U.S.A., where doctorates in EE represented about 30% of the total engineering doctorate degrees awarded in 2006. Finally, a recently conducted survey indicates that 69% of our former, current, and prospective students support the idea of starting a Ph.D. program in ECE.

The proposed Ph.D. program in ECE is consistent with the role and mission of the university. It will provide excellent instruction in a focused discipline, and it is proposed in response to the needs and requests of local industries and other organizations. The proposed program is also expected to provide some public and community service to the region and the state of Michigan.

The proposed program is also unanimously supported by our well qualified faculty, who hold Ph.D. degrees in various areas of ECE and have supervised 95 out of a total 168 doctoral dissertations in Systems Engineering produced here till 2006. The ECE faculty are actively engaged in research in various areas of Electrical and Computer Engineering, and most of them have external research supports from either government funding agencies or local industries. ECE faculty also serve actively on the executive boards of many professional societies, and as session chairs, organizers as well as program committee members of many national and international conferences. The ECE department can also boast of a well known research center as well as a number of well equipped research and development laboratories, where state-of-the-art research in various areas of ECE are being pursued.

The ECE department currently offers a wide range of courses for doctoral students. These course offerings are continuously being updated by the department's graduate affairs committee to keep track with the advancements in technologies. In addition to these existing courses, only one new course, ECE 790 (Doctoral dissertation research credits), is introduced in this proposal.

The course work, qualifying examination, and graduation requirements for the proposed Ph.D. program in ECE are very similar to the existing Ph.D. program in Systems Engineering. Admission to the proposed program will be highly selective. Normally a master's degree from an accredited institution will be required for admission; however, students with outstanding undergraduate records may apply directly for admission to the doctoral programs. As soon as possible after admission, but prior to earning 16 credits of coursework, students must form an advisory committee, which will direct and guide the progress of their program. To earn a Ph.D. in Electrical and Computer Engineering, a student must fulfill the following requirements:

- Complete at least 56 credits of coursework beyond the bachelor's degree,

- Pass a Comprehensive Examination consisting of both a written component and an oral component,
- Present a Dissertation Proposal to the Advisory Committee and secure their approval,
- Earn at least 24 credits of Doctoral Research credits,
- Satisfy a Residency requirement,
- Write a Doctoral Dissertation and submit it to the Advisory Committee, and
- Satisfactorily defend the dissertation in a final oral examination administered by the Advisory Committee.

As this proposal primarily represents a restructuring of our existing doctoral program in Systems Engineering, minimal additional resources are being requested. Specifically, these additional resources include two additional part-time faculty appointments and six additional teaching assistantships for alleviating the grading loads of regular faculty and allowing them to devote more time on directing doctoral dissertation research. Based on a conservative budget estimate, the program is expected to become self-sufficient and generate significant income for the University from its third year. Even during the first two years, an anticipated increase in external funding is expected to compensate for the losses, if any.

Finally, the proposed Ph.D. program in ECE is a direct outgrowth of the following (recent) administrative changes in SECS:

- Change of the name of our department from Electrical and Systems Engineering (ESE) to Electrical and Computer Engineering (ECE), and
- The migration of the Bachelor of Science program in Computer Engineering from CSE department to ECE department.

Such a program was strongly recommended by a Strategic Planning Task Force established in the School of Engineering and Computer Science in April 2003. The Task Force recommended that a new Ph.D. program in ECE be established to provide an opportunity for our doctoral students to excel in multi-disciplinary Electrical and Computer Engineering research.

We are very hopeful that a Ph.D. in ECE will make our doctoral degree more visible in both U.S.A. and worldwide, attract more students to this as well as other doctoral programs in SECS, and generate additional revenue for the University without requiring any significant new resources.

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1. RATIONALE

1.1 Need for a Ph.D. Program in Electrical and Computer Engineering

For almost five decades now, Electrical and Computer Engineering (ECE) has been at the forefront of all engineering disciplines in technological innovation, resulting in one breakthrough after another. Automated control systems, computers, electronic devices and instruments, microprocessors, medical imaging, radar, radio, telephone, television, and wireless communication have transformed our lives, automated our factories, shrunk our world into a global village, and extended human reach to farthest corners of the universe. ECE represents one of the most challenging, dynamic, and rewarding engineering professions today.

In view of above, it is no wonder that ECE continues to be one of the most popular mainstream doctoral engineering degrees in both U.S.A and abroad. According to the latest available statistics published in 2006 by the National Science Foundation, the number of Ph.D. degrees awarded in disciplines related to Electrical Engineering (EE) was 2133 compared to a total of 7,191 awarded in all engineering disciplines combined [1]. In other words, the Ph.D. degrees awarded in disciplines related to EE constitute 30% of the total number of doctorate degrees awarded in all engineering disciplines.

An explosive growth of electrical and computer engineering technology worldwide, the establishment of the Oakland Technology Park in the neighborhood of Oakland University, and a burgeoning demand of ECE engineers in the automotive and ancillary industries have resulted in an increasing need for highly qualified electrical and computer engineers with master's and doctoral degrees in ECE. This strong regional and worldwide demand for electrical and computer engineers with doctoral degrees has led to the development of this proposal.

1.2 How the Program Will Help Promote the Role and Mission of the University

The role and mission of Oakland University (OU) identifies four essential ingredients: excellent and relevant instruction, high-quality basic and applied research and scholarship, responsive and effective public and community service and a comprehensive schedule of student development activities.

The proposed Ph.D. program in ECE is consistent with the role and mission of the university. It will provide excellent instruction in a focused discipline and will further develop basic engineering research and scholarship. It is proposed in response to the needs and requests of local industries (see Appendix C - Support Letters). To date, 16 supporting letters have been obtained with representation from the following corporations: Air Force Research Laboratory, Chrysler LLC, Continental Automotive Systems, Delphi, Denso, Fanuc Robotics, Ford Motor Company, General Motors, Harman/Becker Automotive Systems, Hitachi America Ltd., and U.S. Army RDECOM-TARDEC. Also, the ECE Department receives many requests every year inquiring about our plans to offer a Ph.D. program in Electrical Engineering at Oakland University.

The proposed program is also expected to provide some public and community service to the region and the state of Michigan. Some of the public and community service activities envisaged include:

- Establishing an ECE Research Experience for Undergraduates (REU) program and engaging Ph.D. students as their mentors;
- Encouraging Ph.D. students to participate in the Detroit Area Pre-College Engineering Program (DAPCEP);
- Organizing seminars/workshops/conferences in areas related to ECE;

- Encouraging Ph.D. students to provide mentorship to middle school and high school students for
    - Future city competition,
    - FIRST Robotics competition,
    - FIRST LEGO League competition, etc.

Nationally, a dedicated Ph.D. program in ECE will significantly improve our visibility. With the Electrical and Computer Engineering research conducted under the umbrella degree of Systems Engineering, we are currently absent from most (if not all) of the databases, and invisible to all search engines where students look for a Ph.D. program in either Electrical Engineering or Electrical and Computer Engineering. Attracting quality students is a key to our success. By offering a doctoral degree in ECE, we will be able to compete nationally as well as internationally and attract good, qualified students from the pool of eligible students.

1.3 Goals of the Program

The ECE department currently has 12.5 faculty members. Four of them currently serve as Assistant Professors, who are trying to develop their research careers. A focused Ph.D. program in ECE will significantly bolster their efforts by attracting better qualified students from local, national, as well as international sources. It will prepare these students for academic positions as well as careers in industrial and governmental research and development laboratories.

Overall, the goals of the program are:

(a) To sustain existing research and increase the overall research productivity level in the department,

(b) To attract qualified students to Oakland University and prepare them for research careers,

(c) To improve the funding base of the ECE department,

(d) To further enhance the excellence of our graduate course offerings,

(e) To stimulate additional interaction with local industries,

(f) To provide a competitive edge for our doctoral graduates in seeking jobs with research focus in the areas of Electrical and Computer Engineering, and

(g) To enhance our visibility nationally and globally.

These goals are consistent with many of the goals expressed in the university's vision and the report of the Strategic Planning Task Force (April 2003) outlining the goals of the School of Engineering and Computer Science, Oakland University. The Task Forces' report recommended that a new Ph.D. program in ECE be established to provide an opportunity for our doctoral students to excel in multi-disciplinary Electrical and Computer Engineering research.

This program contributes to our focusing resources on creating and strengthening areas of graduate study in a manner that is responsive to regional and national needs. Oakland University's goals pertaining to creating the future will be met by our focus on research, scholarship and creative activities that are the university's greatest strengths today. These will be strongly encouraged and supported along with the university's mission and views on community outreach as an integral component of our activities. A focused doctoral program with stronger emphasis on Electrical and Computer Engineering will provide us with expanded opportunities to serve our constituents and contribute to the economic growth of our community.

1.4 Comparison to Similar Programs in Michigan

Currently, five state-supported universities in Michigan offer Ph.D. programs in either Electrical Engineering (EE) or Electrical and Computer Engineering (ECE). These are:

1. The University of Michigan: Ph.D. in EE.
2. Michigan State University: Ph.D. in EE.

3. Wayne State University: Ph.D. in ECE.
4. Western Michigan University: Ph.D. in ECE.
5. Michigan Technological University: Ph.D. in ECE.

All five programs share the same goal of training top researchers who will play leading roles in the areas related to Electrical Engineering. The following notable differences characterize our program in comparison to the above programs. We believe that these distinctions will help us succeed in attracting quality students to Oakland.

- The research areas of our faculty encompass both theory and application, and many of our research constituents are located in the Oakland Technology Corridor. Our program thus fulfills the unique needs of these constituents and provides our prospective doctoral students with an opportunity to work on applied research in different areas of Electrical and Computer Engineering.
- From the standpoint of theoretical research, our faculty has nationally acclaimed expertise in the areas of communication, control, electromagnetics, microelectronics, and robotics. Some of these specialization areas are complementary to the expertise of faculty at other Michigan universities.

Furthermore, our program will be unique as we expect that a majority of our Ph.D. students will be employees of local industries and other organizations. Therefore, it is anticipated that there will be little or no conflict with the other five universities in terms of competition for students.

1.5 Source of Students

Under normal economic conditions in Michigan, there should not be any shortfall of students interested in pursuing a Ph.D. degree in ECE, because it continues to be one of the most popular

mainstream engineering degrees in both U.S.A and abroad. A quick glance at Tables 1 and 2 below, which summarize the number of Electrical Engineering degrees awarded compared to all other engineering disciplines combined [1],[2], reinforce this fact.

Table 1. Number of Doctorate degrees awarded in Electrical/Computer Engineering compared to other engineering disciplines

Discipline	**Number of doctorate degrees awarded in last three years**		
	2004	**2005**	**2006**
Electrical Engineering	1651 (28.6% of total)	1,851 (28.8% of total)	2,133 (29.7% of total)
Combined total of all (about 20) engineering disciplines	5,777	6,425	7,191

Table 2. Number of Bachelor's and Master's degrees awarded in Electrical/Computer Engineering compared to other engineering disciplines

Discipline	**Number of Bachelor's and Master's degrees awarded in last three years of available statistics**					
	2002		**2003**		**2004**	
	Bachelor's	Master's	Bachelor's	Master's	Bachelor's	Master's
Electrical Engineering	18,977 (31.3% of total)	8,279 (31.5% of total)	20,729 (32.5% of total)	10,075 (33.9% of total)	21,342 (33% of total)	12,173 (36% of total)
Combined total of all (about 20) engineering disciplines	60,639	26,266	63,773	29,704	64,675	33,872

There is a large pool of college graduates in the southeastern Michigan area. Many of these graduates are currently employed by the local automotive industry and its suppliers. The proposed doctoral degree program will attract these students and allow them to continue their

graduate studies locally. Currently we attract some of these students who opt to enroll in our Systems Engineering program and conduct research related to ECE under that umbrella. By offering a dedicated program, we will be much more visible to students nationwide.

As our current doctoral research in ECE falls under the auspices of Systems Engineering, our program is not listed in major databases of ECE doctoral degree granting institutions. Consequently, prospective students searching for potential ECE related doctoral institutions do not apply to our programs. The new program will enable us to reach a larger body of prospective students. With a larger pool of applicants, we will be able to screen the applications more rigorously. In this manner, we can enhance the quality of our students as well as increase the enrollment. With the proposed dedicated program, we will be more competitive for international students and scholars as well. Furthermore, our faculty will be intimately involved with this process and will recruit students on an individual basis.

Unquestionably, our department will attract students to an ECE program much more effectively in comparison to the attempts to recruit students for pursuing ECE research under the Systems Engineering umbrella. The results of a student survey summarized below attest further testimony to this fact.

1.5.1 Results of a Student Survey

In the Fall semester of 2006 a survey was sent to about 200 current and former graduate students of the ECE department, and 63 of them responded. The purpose of this survey was to determine their interest in a Ph.D. in ECE program. Some key findings from this survey are:

- 69% of the respondents feel that ECE department should offer a Ph.D. program in Electrical and Computer Engineering.

- 42% would be interested in enrolling in a Ph.D. program in Electrical and Computer Engineering at Oakland University, if offered.
- 37% would consider the Ph.D. in Systems Engineering program at Oakland University.
- 58% believe a Ph.D. in Electrical and Computer Engineering will provide students with a better chance of employment than a Ph.D. in Systems Engineering, while only 14% believe the Ph.D. in Systems Engineering will provide students with a better chance of employment.

Complete results from the survey are included in Appendix A - Student Surveys.

2. CURRENT STATUS

2.1 Relationship to Existing Ph.D. Program in Systems Engineering

The current Ph.D. degree program in Systems Engineering dates back to 1974. Since 1978, when our first batch of doctorates earned their degrees, the program has conferred the Ph.D. degree in Systems Engineering on approximately 168 graduates till 2006. The faculty of Electrical and Computer Engineering (ECE), formerly known as Electrical and Systems Engineering (ESE), has played a very important role in the success of this program. Among 168 doctoral dissertations in Systems Engineering produced till 2006, about 95 (i.e., 56.6%) were supervised by the ECE faculty. It goes without saying that all these 95 dissertations pertain to topics in the areas of EE or ECE.

As mentioned earlier, the current Ph.D. degree in Systems Engineering is really an umbrella degree that was designed originally to be a program different from the doctoral degrees offered by other Universities in Michigan in the 1970s. It no longer adequately reflects the maturity, focus and flavor of the research conducted by the faculty and students of Electrical and

Computer Engineering. That is why two of our other departments, Mechanical Engineering (ME) and Computer Science and Engineering (CSE), introduced their own Ph.D. programs recently.

Our proposal aims to continue this restructuring process. Our faculty believes that the degree awarded must reflect the training and expertise of our graduating doctoral students. Therefore, we propose to offer a doctoral degree in Electrical and Computer Engineering. However, a strong interest of some students in Systems Engineering will keep that program thriving as well. Having gained maturity and a better focus, the Systems Engineering program will be in a stronger position to address research challenges and problems in many multidisciplinary fields.

2.2 Goals of the Unit Served by the Program

A current goal of the Department of Electrical and Computer Engineering is to increase both the quality and quantity of scholarly activities within our department. The proposed program will support this goal by producing an influx of new graduate students, increased research activities in diverse areas, additional technical publications and development of new courses. Another goal is to increase research collaboration with local industries. The Ph.D. program will accomplish this by allowing engineers working in local industries to pursue their Ph.D.'s with enthusiastic support of their employers, and it is expected that many students will undertake research projects supported by local industries.

2.3 Faculty Qualifications and Departmental Strengths

The department’s faculty is actively engaged in research in various areas of Electrical and Computer Engineering, and most of them have external research supports from either government funding agencies or local industries. Some of the departmental strengths as demonstrated by the faculty research areas are highlighted below.

Hoda S. Abdel-Aty-Zohdy: Bio-Technology with Bio-Inspired Intelligent Signal Perception and Processing (ISPP); Electronic Nose and other bio-inspired systems including smart interface-systems and novel resonating polymer-sensors; Sub-micro-electronics, VLSI circuits of embedded neural networks and genetic algorithms for novel systems-on-a-chip; Analog, Digital and Mixed-Signal Integrated Circuits; Device/circuit modeling and simulation; 3-D Electronic Devices: low noise, low power.

Daniel N. Aloi, Ph.D: Electromagnetics; Antenna design; All aspects of Global Positioning Systems (GPS).

Ka C. Cheok: Control and estimation theory (internal model principle, optimal, adaptive, robust, fuzzy, neural, intelligent systems); Mechatronics (principles, modeling, simulation, computer tools, virtual and physical prototyping, systems engineering); Virtual realistic simulation (virtual vehicle system simulation, automobile driving simulator); Autonomous and intelligent systems (ground robotics, aerial robotics).

Manohar Das: Adaptive signal processing; System identification and adaptive control theory; Digital signal processing; Digital image processing; Data compression; Pattern recognition; Modeling and simulation; Monitoring and adaptive control of resistance spot welding process.

Pieter A. Frick: Real time computer systems; Optimization and optimal control; Parallel computing in systems and control; Power system modeling and control; Stochastic processes; System identification.

Edward Y. Gu: Kinematics, task-planning, dynamic modeling and control of robotic systems; Modeling, analysis, adaptive control and computer simulations of nonlinear

systems; Human biomechanical and biodynamic modeling and digital simulations; Learning and intelligent control of Human-Machine Interactive Systems.

Richard E. Haskell: Pattern Recognition; Soft computing; Embedded systems; Computer learning; Microprocessor applications.

Jia Li: Automatic segmentation of 3D Ultrasonography for Fetal Growth Analysis; Tumor dose quantification using I-131 SPECT; Quantitative assesment of Gestational Sac Shape; Channel Sounding for ultra-wideband intra-vehicle communications; Prototyping intra-vehicle wireless sensor networks.

Robert N.K. Loh: Control systems, estimation theory, systems identification; Robotics, intelligent systems, complex autonomous systems, unmanned ground vehicles, unmanned underwater vehicles, unmanned aerial vehicles; Automotive systems, advanced defense systems, digital signal and image processing, and time series analysis.

Hongwei Qu: Micro-electro-mechanical systems (MEMS); CMOS-MEMS technology; CMOS-MEMS inertial sensors; Physiological and security monitoring using CMOSMEMS devices; Nanotechnology and devices; MEMS/NEMS modeling.

Osamah A. Rawashdeh: Embedded Systems; Fault tolerance; Instrumentation; Ubiquitous computing.

Andrzej Rusek: Electromagnetic compatibility; Cell phone interference; Testing and modeling of automotive data busses.

Mohamed A. Zohdy: Advanced control and estimation; Intelligent pattern information processing; Neural, fuzzy, and evolutionary systems; Chaos control; Smart simulation and hybrid systems; Fuel Cell modeling and control for transportation; Micromotor

analysis with applications to biomedical engineering; Control of biological regulatory networks.

Since the inception of the Ph.D. program in Systems Engineering in 1972, the ECE faculty have supervised over 95 Ph.D. dissertations in various areas of ECE including advanced control engineering, automotive mechatronic systems, computer engineering, digital and wireless communication systems, digital signal and image processing, electromagnetics and antenna theory, electronics and microelectronics system design, embedded systems, and robotic control systems.

ECE faculty are very active in publishing academic articles in well known, refereed technical journals, and proceedings of various national and international conferences. A detailed of list of their technical publications can be found in the curriculum vitae included in Appendix B. Our faculty have also established solid reputations as applied researchers, and received funding from many government and industrial agencies including Air Force Office of Scientific Research, Chrysler Corporation, DARPA, DOE, Federal Aviation Administration, Ford Motor Company, Hitachi America, General Dynamics, General Motors, National Science Foundation, Nippon, OnStar, Pulse Engineering, SONY Electronics, SYSTRAN Federal Corporation, U.S. Army TACOM, and Yokowo.

ECE faculty also serve actively on the executive boards of many professional societies, and as session chairs, organizers as well as program committee members of many national and international conferences. They also serve on the editorial boards and reviewer panels of many international journals, including IEEE Transactions on Aerospace and Electronic Systems, IEEE Transactions on Antennas and Wave propagation, IEEE Transactions on Automatic Control, IEEE Transactions on Communication, IEEE Transactions on Image Processing, IEEE

Transactions on Instrumentation and Measurements, IEEE Transactions on Medical Imaging, IEEE Transactions on Signal Processing, International Journal of Advanced Robotics, International Journal of Automotive Technology, International Journal of Intelligent Automation and Soft Computing, International Journal of Intelligent Control, International Journal of Nonlinear Dynamics, International Journal of Robotics and Automation, and International Journal of Systems Science. Some faculty also serve regularly on various review panels of National Science Foundation.

2.4 Library Holdings

Currently Kresge Library provides electronic access to all the journals and magazines published by the Institute of Electrical and Electronics Engineers (IEEE). This has served our faculty and students quite well, because IEEE is the premier international institute that publishes state-of-the-art literature in many different areas of both ECE and Computer Science and Engineering (CSE). The access to these journals is very important to both CSE and ECE researchers.

What seems to be lacking at present is the access to the recent conference proceedings, especially the ones published by IEEE. In a dynamic field like Electrical and Computer Engineering, where inventions abound everyday, such an access is crucial for conducting state-of-the-art research in this field, but unfortunately, the cost of subscription to these conference proceedings has also become prohibitively high. Luckily for us, IEEE has come up with a reasonably cost-effective solution to this problem – in the form of a digital access to these conference proceedings. The annual cost of subscription to the IEEE digital library of recent conference proceedings is currently in the vicinity of $46,000. Because of its importance to the

Ph.D. program in ECE as well as the recently approved Ph.D. program in CSE, we propose that such a subscription be purchased by Kresge library.

2.5 Labs and Lab Equipment

The ECE department today can boast of a well known research center as well as a number of well equipped research and development laboratories, where state-of-the-art research in various areas of ECE are being pursued. These include:

- Applied Electromagnetics and Wireless Laboratory (AEWL)
- Automotive Mechatronics Laboratory (AML)
- Broadband Wireless Communication Laboratory (BWCL)
- Center for Robotics and Advanced Automation (CRAA)
- Chrysler Welding Laboratory (CWL)
- Chrysler Controls and Robotics Laboratory (CCRL)
- Embedded Engineering Research Laboratory (EERL)
- Intelligent Ground Vehicle Laboratory (IGVL)
- Microelectronics Systems Design Laboratory (MSDL)
- Micro-electromechanical System (MEMS) Laboratory

Brief descriptions of these labs are provided below.

Applied Electromagnetics and Wireless Laboratory (AEWL)

The Applied Electromagnetics and Wireless Laboratory (AEWL), supervised by Professor Aloi, combines its expertise in applied electromagnetics and wireless applications, along with its measurement and modeling capabilities to address issues relating to signal propagation modeling, channel characterization, EMC, antenna design, and antenna performance on complex structures. Antenna measurements at the component-level can be performed from 1.0 GHz up to 6.0 GHz in an anechoic chamber while vehicle-level antenna measurements can be made at the Automotive Antenna

Measurement Instrumentation (AAMI), which is a spherical near-field system. The AAMI was made possible with a $400K award from the NSF. Also, four workstations equipped with advanced hardware and three-dimensional electromagnetic field solver software are available to perform antenna modeling, antenna placement, EMC, and scattering analyses.

Automotive Mechatronics Laboratory (AML)

This laboratory, supervised by Professor Cheok, was established by a grant from Ford Motor Company. It emphasizes use of computer-aided software for designing virtual rapid prototyping of mechatronics components and systems. Saber and Simplorer are two such software packages. Students procure parts and build their mechatronic project based on the design. Numerous term projects built from this approach have timely and successfully been completed by students.

Broadband Wireless Communication Laboratory (BWCL)

The Broadband Wireless Communication Laboratory (BWCL), supervised by Professor Li, is equipped with state-of-the-art equipment to pursue advanced research in various areas of wireless communication. One of the current projects, funded by NSF and General Motors, involves development of an wireless ultra wideband (UWB) sensor network for automotive vehicles.

Center for Robotics and Advanced Automation (CRAA)

Since its establishment in the early 80s by Professor Loh, the Center for Robotics and Advanced Automation (CRAA) at Oakland University has been at the forefront of research and development in the areas of controls, robotics, automation and machine vision. Over the last two decades, CRAA has successfully completed numerous R&D projects sponsored and funded by the national research organizations and agencies, department of defense and military sectors, local automotive industries, and the State of Michigan. In addition to the funded projects, the faculty associated with CRAA has published numerous articles in various academic and

technical journals, industrial magazines and conference proceedings to report and disseminate their research findings.

Chrysler Welding Laboratory (CWL)

The Chrysler Welding Laboratory, supervised by Professor Das, was established in 2003 with a gift from Chrysler Corporation. It serves as an active research center for development of advanced techniques for weld monitoring and control. It is equipped with many AC and MFDC weld controllers, industry-standard weld guns, and facilities for conducting research in the area of advanced weld control techniques.

Chrysler Controls and Robotics Laboratory (CCRL)

The Chrysler Controls and Robotics Laboratory, jointly supervised by Professors Das and Gu, was established in 2006 by a gift from Chrysler Corporation. It serves as an active research center in various areas of controls and robotics. It is equipped with two state-of-the-art industrial-grade robots, advanced control equipment, and advanced communication hardware to pursue advanced research in simulation and testing of robotic control and communication schemes.

Embedded Engineering Research Laboratory (EERL)

The Embedded Engineering Research Laboratory, supervised by Professor Rawashdeh, is engaged in research on methodologies, design, verification, and implementation of embedded systems. The lab's current research focus is on online reconfiguration as means to fault-tolerance for real-time safety-critical distributed embedded systems targeting automotive applications. Other interests and extensive experiences are in the areas of rapid prototyping, product development, data acquisition and control in addition to novel technologies for low- and high-altitude autonomous aerial vehicle systems.

Intelligent Ground Vehicle Laboratory

The Intelligent Ground Vehicle Laboratory, supervised by Professor Cheok, emphasizes systems integration of technologies for mobile robots. The robot platforms include Airtrax omnidirectional vehicles, a Packbot, many student built teleoperated vehicles. Navigation technologies for the robots include computer vision, ultra-wideband ranging radios, GPS, LIDAR, IMU, etc. Embedded communication and control devices are essential for the system integration. The key technologies lie in the communication networks and artificial intelligence of the mobile robot.

Microelectronic Systems Design Laboratory (MSDL)

The Microelectronics System Design Lab, supervised by Professor Abdel-Aty-Zohdy, is a well recognized research center for design, testing and evaluation of prototype Very Large Scale Integrated Ciruits (VLSIC). The MSDL has the expertise, tools and facilities needed to build advanced microelectronic circuits and systems for the defense, biomedical, and industrial applications. These include Application Specific Integrated Circuits (ASICs), Integrated signal processing circuitry, Sensors and actuators integrated interfacing circuits, Neural Networks, Analog and Digital Implementation for smart ICs, Automotive Electronics Design, Evaluation, Implementation, and Testing.

Micro-electromechanical Systems (MEMS) Laboratory

The Micro-electromechanical Systems (MEMS) laboratory, supervised by Professor Qu, was established recently to pursue advanced research in MEMS and Nano-electromechanical Systems (NEMS). It has a fume hood and wet chemical etch setup for MEMS device fabrication preparation, and also houses workstations equipped with COMSOL, Mentor Graphics, and other software. Most fabrication processes are carried out at the Michigan Nanofabrication Facility. The lab is equipped with mechanical and optical characterization tools for MEMS devices,

including a precision rotary table, an electromagnetic shaker, a laser vibrometer and other instruments.

2.6 Impact on the Current Programs

The proposed doctoral program in ECE has been long overdue, and it represents a natural progression of the existing bachelor's and master's programs in our department. Our master's programs in both ECE and Systems Engineering will benefit from the emergence of new research avenues, new lab facilities, new course offerings, and increased name recognition that goes with a doctoral program. Our undergraduate programs in both electrical engineering and computer engineering will also benefit a great deal from the creation of new labs as well as research facilities, and opportunities of some undergraduate research experience that are often created as spin-offs of strong doctoral research programs.

It is anticipated that approximately one-half of our students in the Ph.D.-ECE program will be students who would have enrolled in the existing Ph.D. program in Systems Engineering if that were the only option available. This shift is deemed to be positive, because the new Ph.D. program in ECE will better suit the needs of these students. However, a strong interest of some students in multidisciplinary Systems Engineering will keep that program thriving as well. Having gained maturity and a better focus, the Systems Engineering program will be in a stronger position to address research challenges and problems in many multidisciplinary fields.

3. PROGRAM PLAN

This section provides a detailed description of the course work, qualifying examination, and graduation requirements for the proposed Ph.D. program in ECE. It is very similar to the existing Ph.D. program in Systems Engineering.

3.1 Admission Requirements

The Ph.D. program in ECE is designed for students with academic backgrounds in either electrical or computer engineering. Students with backgrounds in other engineering disciplines, computer science, mathematics or the physical sciences may also be admitted to the program, but they will be required to build up basic electrical and computer engineering knowledge through remedial coursework. Normally a master's degree from an accredited institution is required for admission; however, students with outstanding undergraduate records may apply directly for admission to the doctoral programs. Admission is highly selective; applicants should present transcripts of all previous academic work and recommendations from three faculty members of their most recent study program who can evaluate their scholarly achievement and potential. Applicants must submit scores from the Graduate Record Examination (GRE) if they graduated from an institution not accredited by a regional accrediting agency. The Test of English as a Foreign Language (TOEFL) must be submitted by applicants who are graduates of programs taught in a language other than English.

3.2 Advisory Committee

As soon as possible after admission, but prior to earning 16 credits of coursework, students must form an advisory committee, which will direct and guide the progress of their program. Such a committee is composed of four faculty members, specified as follows:

1. Three faculty members nominated by the student (one designated as chair and one selected from a department outside the School of Engineering and Computer Science).
2. One member appointed by the Dean of the School of Engineering and Computer Science.
3. Upon recommendation of the advisory committee, following successful completion of the Ph.D. comprehensive examination, one member from within or outside the university

community may either be added to the committee or replace a member for the dissertation proposal and review.

The entire committee must have the approval of the Dean of the School of Engineering and Computer Science and Graduate Study and Lifelong Learning.

3.3 Degree Requirements

To earn a Ph.D. in Electrical and Computer Engineering, a student must fulfill the following requirements.

3.3.1 Coursework

At least 56 credits must be earned for coursework beyond the bachelor's degree (exclusive of dissertation). The normal full-time load is 8 to 12 credits per semester. Students who have earned a master's degree may petition to have a maximum of 32 credits applied toward the 56. The advisory committee will evaluate the student's prior master's degree work and allow Ph.D. credits for courses relevant to the proposed Ph.D. course of study. All candidates must complete at least 24 credits of additional coursework exclusively at Oakland University. In the Ph.D. program, credit will not be awarded for courses in which a grade less than 3.0 is earned. All numerical grades earned are used in computing a student's grade point average.

Also, at least eight of these credits must be taken from one of the following Mathematics course groups:

Mathematics Group I (8 credits)

APM 541	Mathematical Analysis For Engineers I	4
APM 542	Mathematical Analysis For Engineers II	4
APM 565	Differential Geometry	4
MTH 551	Real Analysis	4
MTH 651	Functional Analysis	4

Mathematics Group II (8 credits)		
APM 563	Applied Mathematics: Discrete Methods I	4
APM 564	Applied Mathematics: Discrete Methods II	4
Or		
APM 581	Theory of Computation	4

The remaining coursework should be completed according to the Plan of Study, approved by the student's Advisory Committee.

3.3.2 Comprehensive Examination

Each student is required to take a comprehensive examination after the student has completed all of his/her coursework, but before completing no more than 8 credits of dissertation research. The examination is designed to assess the student's analytical reasoning, theoretical understanding, and preparedness to do independent research. The examination is composed of a written component and an oral component. The written examination includes at least two discipline-specific areas relevant to the student's coursework and research interest. The student's advisory committee, based on the student's preparation, selects the areas for the examination. The oral examination follows within a month of the written examination. The written examination is commonly split into no more than three parts to be taken over a reasonable period of time (usually not to exceed one month). A student may repeat the comprehensive examination once.

3.3.3 Dissertation Proposal Review

As soon as a candidate and the advisory committee chair agree on a specific research topic, the candidate must write a dissertation proposal. This document contains a formulation of the problem, the background work leading to the formulation and a plan for the subsequent research. Candidates must orally present the proposal to their advisory committees and any other

interested faculty, at which time the committee may question the preparedness of the student to carry out the research.

3.3.4 Research Credits

Students who have advisory committee approval of their dissertation proposals and are conducting research should register for ECE 790. At least 24 research credits are required of all doctoral candidates. However, merely amassing credits does not indicate satisfactory progress toward or completion of the dissertation. These judgments are made by the advisory committee. The dissertation is judged completed upon successful completion of the final examination and acceptance of the dissertation by Graduate Study and Lifelong Learning.

3.3.5 Dissertation

Each candidate will submit a dissertation to the advisory committee. The dissertation must be the candidate's own work and must constitute a contribution to knowledge in his/her field of endeavor. All dissertations must conform to university standards.

3.3.6 Residency Requirement

Writing a doctoral dissertation requires a full commitment to research. Such research cannot be effectively pursued in an environment, which places research in a secondary role. Doctoral students are required to be full-time students for at least one year of their active dissertation research. The doctoral student should arrange such a period of residency by (1) registering for at least 8 credits of doctoral dissertation research for two consecutive semesters, and (2) making a commitment, in a statement addressed to his/her advisory committee, to a program of full-time (at least 20 hours per week) research.

The above represents the normal residency requirement. However, if the present occupation of the candidate (e.g., industrial research or teaching) is conducive to the intended research, there

is an alternative method to fulfilling the residency requirement. To arrange for that kind of residency, the candidate must apply in writing to his/her advisory committee at the time of the dissertation proposal review. The committee must be furnished with a written statement by the candidate's employer confirming that the dissertation research constitutes a major portion of the job assignment. If the advisory committee grants permission to pursue this option, the student must enroll in doctoral dissertation research (8 credits maximum) for at least two consecutive semesters.

The work of Ph.D. students described in the above paragraph will be documented by term reports, reviewed and accepted by the chair of the advisory committee. A copy of every report will be kept in the student's file. The advisory committee will review these reports. If the progress is unsatisfactory or the student and the employer are unable to fulfill the terms of the residency agreement, the advisory committee can declare the residency requirements unfulfilled.

3.3.7 Final Examination

Each Ph.D. candidate must satisfactorily defend the dissertation in a final oral examination administered by the advisory committee. The examination is taken after the advisory committee certifies that the dissertation is ready for final review. At the committee's option, one re-examination may be permitted if a candidate fails to pass the final examination.

3.3.8 Time Limit

Students have a seven-year time limit to complete all requirements for the Ph.D., beginning with the first term of enrollment in the program. Credits earned prior to entry into the program will be evaluated by the Advisory Committee for their currency before completion of 24 credits of doctoral coursework at Oakland University by the student. Course work that is determined to be outdated will not be applicable toward the degree.

3.4 Recruitment Plan

Since the proposed program will be very closely tied to the department, we will be able to better focus on our recruitment efforts by creating a web-presence. We will also begin listing ourselves in the major databases of Electrical and Computer Engineering related programs that our prospective students consult while planning their doctoral education. Our faculty will also be able to easily recruit students at the individual level, since it is considerably easier to attract students to a mainstream Electrical and Computer Engineering degree than it is to attract them to a Systems Engineering degree.

During the first four years, we have set very realistic and achievable goals. After the first four years of starting this program, we expect to double our doctoral student enrollment and reach a level of granting about 10 degrees per year, using our existing degree granting rate of 5 to 6 per year as the basis. More importantly, we will attract higher caliber students and create synergy within our faculty to enable us to achieve national and international recognition, which will help recruit bright young researchers.

4. NEEDS AND COSTS OF THE PROGRAM

Under its new name, our doctoral program will become much more attractive to the prospective applicants both from our local area, as well as from other parts of USA and abroad. Our expected growth rate is projected to graduate 10 doctoral students per year by 2013 (compared to the current level of 5-6 students per year).

In addition, with the recruitment of high caliber students and scholars our faculty is expected to generate additional revenues through higher success in extramural funding. While this is hard to estimate, it would not be unrealistic to expect an increase in funding of approximately

$250,000-$350,000 based on a higher success rate attributed to a better quality of research proposals that become possible with the help of a high-caliber doctoral student body.

An estimate of the revenues and expenses associated with the proposed Ph.D. program in ECE is presented in Table 3 below. As this proposal primarily represents a restructuring of our existing doctoral program in Systems Engineering, minimal additional resources are being requested. Specifically, these resources include two additional part-time faculty appointments and a few additional teaching assistantships for alleviating the grading loads of regular faculty and allowing them to devote more time on directing doctoral dissertation research. The following assumptions were made in developing the Pro-forma shown in Table 3.

- Tuition Revenue: Based on a student survey and our current rate of recruitment, we assume that 15 new students will be recruited in the first year and at least 5 more per year thereafter. This will generate a steady-state revenue of more than $200,000 per year from the fourth year. All students are assumed to carry full course loads, i.e. enroll for 16 credits per year.
- Expenses – Salary
    a) Funds are being requested to support three new teaching assistants in the first year, four in the second, five in the third, and six from the 4^{th} year onward. Currently only four full-time doctoral teaching assistantships (TA) are available in our department. Since the number of applicants for these assistantships is usually 10-12, we are forced to select only 8 best candidates and offer just a half-time TA to each one of them. The availability of the additional full-time TA positions will help alleviate this problem.

b) Two part-time faculty positions may be needed from time to time to offset the teaching loads of full-time faculty to enable them to focus on directing research and developing external grant proposals.

- **Operating Expenses**

  The Kresge Library currently provides electronic access to all the journals and magazines published by the Institute of Electrical and Electronics Engineers (IEEE), which has served our faculty and students quite well. However, in order to support a good doctoral program in a dynamic engineering discipline like ECE, where inventions abound everyday, the need for access to the recent conference proceedings is a genuine and critical one. Funds for online access to all IEEE conference proceedings only is being requested. This will also be greatly beneficial for the newly approved doctoral program in Computer Science and Informatics (CSI), because many of these IEEE conferences cover topics that are common to both CSE and ECE.

Thus, from the tuition revenue alone, the proposed doctoral program in ECE is expected to generate additional net income for the university from the third year onward. It is also expected that the new program will generate additional revenue through extra-mural grants to the order of $200-$250K per year attributed to the stimulation of research activities.

Table 3. Pro-forma Income Statement

Program Title: Ph.D. in Electrical and Computer Engineering
Program Start Date: Fall 2008

		Year 1 (FY2009)	Year 2 (FY 2010)	Year 3 (FY 2011)	Year 4 (FY 2012)	Year 5 (FY 2013)
Headcount of self-supported students[1]		15	20	25	30	30
Credit Hours Per Student		16	16	16	16	16
Undergraduate		0	0	0	0	0
Graduate		0	0	0	0	0
Total Credit Hours (Doctoral)		240	320	400	480	480
Doctoral FYES		15	20	25	30	35
Total FYES		15	20	25	30	35
Tuition Rate Per Credit Hour						
Undergraduate						
Graduate		$472.50	$472.50	$472.50	$472.50	$472.50
Other Fees						
Revenue						
Tuition		$113,400.00	$151,200.00	$189,000.00	$226,800.00	$226,800.00
Other Fees						
Total Revenue		$113,400.00	$151,200.00	$189,000.00	$226,800.00	$226,800.00
Expenses	ACCT					
Salaries/Wages						
Faculty Salaries	6101					
Visiting Faculty	6101					
Administrative	6201					
Clerical	6211					
Administrative – IC	6221					
Faculty Inload (Replacement Costs)	6301					
Faculty Overload	6301					
Part-time Faculty (2)	6301	$8,000.00	$8,000.00	$8,000.00	$8,000.00	$8,000.00
Graduate Assistants (3 in yr. 1, increasing by 1/yr to 6 from year 4 onward)	6311	$42,000.00	$56,000.00	$70,000.00	$84,000.00	$84,000.00
Wages	6401					
Out of Classification	6401					
Overtime	6401					
Student	6501					
Total Salary Expenses		$50,000.00	$64,000.00	$78,000.00	$92,000.00	$92,000.00
Fringe Benefits	6701	$692.00	$692.00	$692.00	$692.00	$692.00
Total Salary and Fringe Benefits		$50,692.00	$64,692.00	$78,692.00	$92,692.00	$92,692.00
Supplies and Services	7101					
Graduate Assistant Tuition	7101	$22,680.00	$30,240.00	$37,800.00	$45,360.00	$45,360.00
Facility Charges	7101					
Travel	7201					
Telephone	7301					
Equipment	7501					
Library [2]	7401	$59,000.00	$59,000.00	$59,000.00	$59,000.00	$59,000.00
Total Operating Expenses		$81,680.00	$89,240.00	$96,800.00	$104,360.00	$104,360.00
Total Expenses		$132,372.00	$153,932.00	$175,492.00	$197,052.00	$197,052.00
Net Income/Loss		($18,972.00)	($2,732.00)	$13,508.00	$29,748.00	$29,748.00
Anticipated Increase in External Funding		$100,000.00	$150,000.00	$200,000.00	$250,000.00	$250,000.00

[1]Based on a conservative estimate;
[2]Cost of online access to all recent IEEE Conference Proceedings and funding to continue current ECE resources

An estimate of the revenues and expenses associated with the proposed Ph.D. program in ECE

5. COURSE DESCRIPTION

The ECE department currently offers a wide range of courses for doctoral students. These course offerings are continuously being updated by the department's graduate affairs committee to keep track with the advancements in technologies.

The catalog description of our graduate courses is provided below. It includes a proposed new course, ECE 790, for doctoral dissertation research credits.

ELECTRICAL AND COMPUTER ENGINEERING

ECE 515
Foundations of Electrical and Computer Engineering (4 credits)
A study of the foundations of Electrical and Computer Engineering. The use of vectors, matrices, Fourier transforms, and probability in Electrical and Computer Engineering. Computer-aided tools such as Matlab and C are used to solve problems in communications, digital logic, electronic circuit design, and applied electromagnetics.

ECE 520
Signal and Linear Systems Analysis (4 Credits)
Modeling and analysis of both continuous-time and discrete-time systems and signals. Time-domain and frequency-domain representation methods and transformations applied to electric circuits, mechanical systems and other dynamic systems. Fundamental theories of systems stability, controllability, observability and state-feedback control design. Computer simulation studies. Offered fall and summer. Credit cannot be received for both ECE 520 and SYS 520.

ECE 523
Robotic Systems and Control (4 credits)
Introduction to robotic systems and applications. Robotic forward and inverse kinematics. Task and path planning with motion controls. Jacobian matrix, differential motion and robotic statics. Redundant robots, mobile robots and multi-robot coordination. Robotic dynamics, position control and force control. Computer simulation and laboratory demonstration. Offered fall or winter.

ECE 525
Instrumentation and Measurements (4 Credits)
Errors in measurements, error corrections and minimization; transducers and their applications; signal conditioning and interfacing; electromagnetic compatibility and interference problems in instrumentation; measurement instrument and their characteristics. Measurement systems, signal analyzers and data acquisition systems; signal conversion; computer and microprocessor-based instrumentation. With project. (Previously EE 525.) Offered fall.

ECE 527
High-Frequency Electronics (4 Credits)
Transmission lines with sinusoidal and pulse excitation. Passive and active circuit components at high frequency. High frequency amplifiers, communication circuits, waveform generators and digital circuits. Introduction to high frequency measurements. (Previously EE 726, EE 626 and EE 527.)

ECE 533

Random Signals and Processes (4 Credits)

Provides the foundation needed to work with the random signals which are encountered in engineering. Concept of a stochastic process. Characterization of random waveforms using power spectral density and the correlation function. Random signals in linear systems. Applications to engineering systems. Offered fall.

ECE 534

Principles of Digital Communications (4 Credits)

Source coding, signal design, modulation and demodulation. The optimal receiver principle, synchronization, communications over narrow band channels, fading channels and error correction codes. Offered winter. Prerequisite: At least one course from the Core and Theory group of courses. Also, students must have completed a previous course in communications systems or have instructor permission.

ECE 537

Digital Signal Processing (4 Credits)

Analysis of discrete signals and systems. Introduction to digital filers including finite and infinite impulse response filter. Discrete and Fast Fourier Transformations. Application of digital signal processing. Offered Winter. Student must have a basic knowledge of linear systems at undergraduate level or permission of instructor.

ECE 545

Electromagnetic Engineering (4 Credits)

Electromagnetic theory with applications. Diffraction, radiation, propagation, guided waves, optical transmission and resonant cavities. Offered winter. Student must have a background in vector calculus and basic electromagnetic theory. Prerequisite: At least one course from the core and theory group of courses.

ECE 546

Introduction to Electromagnetic Compatability (4 Credits)

Review of EM basics related to ENMC applications. Analysis of EMI sources and receivers. Signal spectra, conducted and radiated emissions. Transmission line cross-talk. Introduction to shielding, filtering, and grounding. Electrostatic discharges (ESD). Circuit and system immunity. Signal spectra, conducted and radiated emissions. EMC requirements for component and system levels. US and European standards and their origin. Automotive EMC standards. EMC issues in vehicle multiplexing communication. With laboratory. Prerequisites: Undergraduate courses in electronic circuit design, electromagnetics, and communication systems

ECE 547

Antennas (4 credits)

Introduction to antenna performance parameters including field patterns, power patterns, beam area, directivity, gain, beam efficiency, radiation intensity, antenna apertures, impedance, polarization, and the radio communication link. Dyadic Green's Function, Radiation from current elements such as a dipole and a current loop, far-zone fields, arrays of point sources. Antenna modeling and measurement techniques will be introduced. Course will incorporate labs and/or laboratory demonstrations. Pre-Requisites: ECE 352 or equivalent electromagnetic class at undergraduate level. Also, at least one course from the Core and Theory group of courses.
Co-Requisites: APM 541 or ECE 515 or equivalent course at undergraduate level.

ECE 550

Satellite-Based Positioning Systems (4 Credits)

Introduction to the fundamentals of satellite-based positioning systems with an emphasis on the Global Positioning System (GPS). Understanding of the GPS satellite constellation, coordinate systems, timing standards and GPS signal structure. Determination of position from the range measurements for different modes of positioning. Introduction to various ranging error sources and mitigation techniques. Impact of ranging errors and satellite geometry on 3-dimensional position error. Offered Fall or Winter. Student must meet prerequisite (undergraduate course equivalent to ECE 335 or ECE 437).

ECE 557
Energy Conservation Systems (4 Credits)
Techniques for improving energy use in industrial and commercial applications. Topics include: energy accounting; energy auditing; energy conservation management; net energy analysis; second law methods of analysis; combined use energy systems; new technology for energy conservation; assessment of alternative technology. Credit can only be received for either ECE 557, or SYS 557, or ISE 557. Prerequisite: At least one course from the Core and Theory group of courses, or student must have permission of instructor.

ECE 567
Computer Networks (4 Credits)
Resource-sharing principles; communications and networks; packet switching; the ARPANET; network performance using principles of queuing theory; network design principles, capacity assignment; flow assignment; topological design. Other related topics. Prerequisite: At least one course from the Core and Theory group of courses, or student must have permission of instructor.

ECE 570
Microprocessor-based System Design (4 Credits)
Application of microprocessors and microcomputers to the solution of typical problems; interfacing microprocessors with external systems such as sensors, displays and keyboards; programming considerations, microcomputer system design. A laboratory design course, several short design projects and one large design project. This course integrates concepts learned in required courses and provides a design experience. The large design project includes cost/trade-off analysis, submitting a detailed written report and oral presentation of the project. Credit cannot be earned for more than one of CSE 470/570 and ECE 470/570. Offered fall and winter. Recommended prerequisite: (CSE 378 or EE 378) or CSE 508 or equivalent.

ECE 572
Microcomputer-based Control Systems (4 Credits)
Computer-aided engineering, analysis, design, evaluation of control systems. Microcomputer/microprocessor-based hardware and software development of digital controllers, estimators, filters. Data acquisition, signal conditioning and processing circuits, graphics displays. On-line system level and board-level microcomputer-based control experiments. Laboratory and projects emphasize realtime applications, programming and hardware integration. With laboratory. Offered winter.

ECE 575
Automotive Mechatronics I (4 Credits)
Overview of mechatronics; modeling, identification and simulation of electro-mechanical devices; introduction to computer-aided software; basic automotive sensors; basic actuators and power train devices; principles of automotive and industrial electronic circuits and control systems (analog and digital); principles of product design; mechatronics case studies. Offered fall. Credit cannot be received for both ECE 575 and SYS 575.

ECE 581
Integrated Circuits and Devices (4 Credits)
Fundamentals of semiconductor electronics. Theory and operation of PN junctions and junction devices. MOS devices. Integrated circuits functional blocks, fabrication techniques, processing steps

and equivalent circuits. Device modeling and simulation techniques. Offered Fall. Student must have permission of instructor.

ECE 585
VLSI Circuits and Systems Design of Digital Chips (4 Credits)
Design techniques for rapid implementation and evaluation of Very Large Scale Integrated Circuits (VLSIC), including behavioral, functional, logic, circuit, device, physical IC fabrication, and layout issues. CMOS and pseudo NMOS technology, inverters, logic and transmission gates switching characteristics and processing. Reliability, yield and performance estimation. The course is project oriented. Students start with concepts and finish with actual Application Specific Integrated Circuits (ASICs) using modern CAD tool suites. Offered winter. This course also has a lab component.

ECE 587
Integrated Electronics (4 Credits)
Modern microelectronics processes and fabrication of integrated circuits. Crystal growth and wafer preparation, photolithography, dielectric and polysilicon film deposition, epitaxial growth, oxidation, diffusion, ion implantation, etching, metallization and integrated circuits layout principles. Introduction to MOS-based and bipolar junction transistor-based microcircuits design and fabrication. Fabrication processing simulation using SUPREM, with projects. Offered winter, even years.

ECE 594
Independent Study (2 TO 4 Credits)
Independent study in a special area of electrical and computer engineering. Topic must be approved prior to registration.

ECE 595
Special Topics (2 TO 4 Credits)
Study of special topics in electrical and computer engineering. May be taken more than once.

ECE 620
Multi-dimensional Signal Theory (4 Credits)
Random vector analysis. Generalized harmonic analysis. Correlation and spectrum analysis of stochastic fields. Multidimensional linear systems. Transformations of random fields in multidimensional systems. Elements of generalized functions and Hilbert spaces. Applications to signal field processing, image processing and antenna and sensor array design. Student must meet prerequisites (SYS 520 and at least one course from the core and theory group of courses).

ECE 625
Applications of Analog Integrated Circuits (4 Credits)
Building blocks of analog integrated circuits and their limitations; characteristics, analysis and applications of analog integrated circuits; principles of circuit and system design with analog integrated circuits. Offered winter. . Student must meet the prerequisites (at least one course from the core and theory group of courses) and have permission of instructor.

ECE 632
Wireless Communications (4 Credits)
Introduction to wireless communication principles and systems. Wireless channel models, TDMA, FDMA, spread spectrum, CDMA, equalization, detection, estimation, coding, security, quality assessment of service and personal communications. The 2nd generation and 3rd generation wireless standards are also discussed. Offered fall, odd years. Student must meet prerequisites (ECE 534 and at least one course from the core and theory group of courses) or have permission of instructor.

ECE 633
Signal Detection and Estimation Theory (4 Credits)

Noise analysis concept review, binary decision theory, multiple decision, sequential decision theory, nonparametric decision theory, fundamentals of estimation, sequential estimation theory, detection of coded information and error control. Student must meet prerequisites (ECE 533 and at least one course from the core and theory group of courses) or have permission of the instructor.

ECE 634

Statistical Communication System Theory (4 Credits)

Harmonic analysis, sampling theory, stochastic process and correlation functions, linear systems response to random inputs, optimum linear systems (matched filters, Wiener filters) coherent and noncoherent filtering, nonlinear systems with random input (zero memory, square law, nth law devices), modulation theory, interference considerations. Student must meet prerequisites (ECE 533 or SYS 517).

ECE 635

Modulation and Coding (4 Credits)

Phase shift keying (PSK), quadrature amplitude modulation (QAM), continuous phase modulation (CPM), constant envelope modulation, power spectral density, bandwidth efficiency, block codes, convolutional codes and turbo codes. Offered winter, even years. Student must meet prerequisite (ECE 534).

ECE 638

Digital Image Processing (4 Credits)

Fundamentals of digital image processing; review of one-dimensional signal processing techniques; introduction to two-dimensional signals and systems; two-dimensional digital filtering; image enhancement techniques; statistical model based methods and algebraic techniques for image restoration; image data compression; image analysis and computer vision. Selected applications. Offered summer. Prerequisite: Student must have knowledge of linear systems, and probability and statistics. Also, at least one course from the Core and Theory group of courses.

ECE 639

Advanced Digital Signal Processing (4 Credits)

An overview of random signals and systems; signal modeling techniques, signal enhancement techniques and their applications; adaptive filtering and its applications; introduction to wavelet transforms and its applications. Student must meet prerequisite (ECE 537 or equivalent).

ECE 645

Intelligent Control Systems (4 Credits)

Definition and paradigm for intelligent control; self-learning and supervised learning; hierarchical decision architecture; fuzzy logic, neural network, heuristics, genetic algorithm, optimum strategy and related topics; examples of intelligent and autonomous systems; computer simulation and visualization of applications. Student must meet prerequisite (at least one course from the core and theory group of courses) and have permission of instructor.

ECE 675

Automotive Mechatronics II (4 Credits)

Extensive review of software and modeling fundamentals, sensors, actuators, power train characteristics, automotive and industrial control systems; selected topics include engine and exhaust gas sensors; sensor interfaces; injection electronic circuits, engine and transmission controllers, pneumatic servos and active suspension; electromagnetic compatibility and issues related to system design, compatibility requirements, filtering, shielding/grounding, testing; emerging technologies in automotive mechatronics systems. Student projects. Credit cannot be received for both ECE 675 and SYS 675. Student must meet prerequisites (ECE 575 and at least one course from the core and theory group of courses).

ECE 682

Field-Effect Devices (4 Credits)

Electronic structure of semiconductor surfaces. Concepts of surface states and surface change. Metal-Semi-conductor (MS) contacts: ohmic and rectifying. Conductivity modulation and the theory of JFET and MESFET transistors. Integrated device technology, including Silicon on Sapphire (SOS) and Silicon on Insulator (SOI) structures and their application. Student must meet prerequisite (ECE 581 and at least one course from the core and theory group of courses).

ECE 683

Advanced VSLIC Analog/Digital Systems Design (4 Credits)

Full-custom design and analysis techniques of ASICs. Metal- Oxide-Semiconductor (MOS) devices, circuits and future trends. MOS processing and design rules. Extensive circuit simulation. Analog VSLIC basic functions. Graphical model representation. Amplifiers. Current mirrors. Computer Aided Design (CAD) of analog integrated circuits. Layout and design for testability considerations. Implementing integrated system design from circuit topology to patterning geometry to wafer fabrication. The course is project oriented. Students start with concepts and finish with testing and evaluating ASIC prototypes. Student must meet prerequisite (at least one course from the core and theory group of courses) and have permission of instructor.

ECE 690

Graduate Engineering Project (2 TO 4 Credits)

Independent work on an advanced project in electrical engineering. Topic must be approved prior to registration.

ECE 691

Master's Thesis Research (2 TO 8 Credits)

Directed research leading to a master's thesis. Topic must be approved prior to registration. Prerequisite: At least one course from the core and theory group of courses.

ECE 725

Theory of Networks (4 Credits)

Network models of linear dynamic systems; network graphs and topological constraints, generalized equilibrium equations, time-frequency duality, energy and stability constraints, network passivity or activity, input-output representations, and state-transition matrices. Student must meet prerequisite (SYS 520 and at least one course from the core and theory group of courses).

ECE 741

Coherent Optics (4 Credits)

Current developments in coherent optics and holography; two-dimensional Fourier analysis, diffraction theory, Fourier transforming and imaging properties of lenses, holographic interferometry, optical data processing. With laboratory. Student must meet prerequisite (SYS 520 and at least one course from the core and theory group of courses).

ECE 790

Doctoral Dissertation Research (2 TO 12 Credits)

Directed research toward the doctoral dissertation.

ECE 794

Independent Study (2 TO 4 Credits)

Advanced independent study in a special area in electrical and computer engineering. Topic must be approved prior to registration.

ECE 795
Special Topics (2 TO 4 Credits)
Advanced study of special topics in electrical and computer engineering. May be taken more than once.

SYSTEMS ENGINEERING

SYS 510
Systems Optimization and Design (4 Credits)
Classical optimization techniques including Lagrange multipliers and Kuhn-Tucker conditions. Computer techniques for system optimization including linear programming, constrained and unconstrained nonlinear programming. Introduction to global optimization, genetic algorithm, and dynamic programming. The course emphasizes a design experience involving system modeling, simulation and optimal design. Offered summer.

SYS 517
Probability and Its Engineering Applications (4 Credits)
Techniques and topics from probability of use to engineers, particularly those interested in manufacturing. Includes topics from statistics, control charts, propagation of error and tolerancing, analysis of queuing systems using birth and death processes and Markov chains, reliability, decision trees, etc. Offered winter.

SYS 520
Signal and Linear Systems Analysis (4 Credits)
Modeling and analysis of both continuous-time and discrete-time systems and signals. Time-domain and frequency-domain representation methods and transformations applied to electric circuits, mechanical systems and other dynamic systems. Fundamental theories of systems stability, controllability, observability and state-feedback control design. Computer simulation studies. Offered fall and summer. Credit cannot be received for both SYS 520 and ECE 520.

SYS 557
Energy Conservation Systems (4 Credits)
Techniques for improving energy use in industrial and commercial applications. Topics include: energy accounting; energy auditing; energy conservation management; net energy analysis; second law methods of analysis; combined use energy systems; new technology for energy conservation; assessment of alternative technology. Credit can only be received for either ECE 557, or SYS 557, or ISE 557. Prerequisite: At least one course from the Core and Theory group of courses, or student must have permission of instructor.

SYS 558
Electrical Energy Systems (4 Credits)
Generation, transmission and distribution of electrical energy. Analysis and design of three-phase circuits, per unit normalization, system design evaluation and load-flow, symmetrical components and stability. Offered winter.

SYS 563
Foundation of Computer-Aided Design (4 Credits)
Computer-aided design as the cornerstone of computer integrated manufacturing. Presentation and exploration of "generic" CAD architecture. Mathematical representations of CAD primitives, surfaces and solids and manipulation. Comparison of wire-frame, surface, 2-1/2 D and solid models. IGES, STEP, CALS and DXF standards. Description of "feature based CAD" and the CAD manufacturing link.

SYS 569

Computer Simulation in Engineering (4 Credits)

Simulation as modeling tool for discrete-event and continuous systems; general principles of simulation; statistical models; input modeling; random variable generation; model building using a commercial simulation language; model verification and validation; determination of run length; output analysis; variance reduction techniques. Design and optimization of production service systems. Offered winter.

SYS 575

Automotive Mechatronics I (4 Credits)

Overview of mechatronics; modeling, identification and simulation of electro-mechanical devices; introduction to computer-aided software; basic automotive sensors; basic actuators and power train devices; principles of automotive and industrial electronic circuits and control systems (analog and digital); principles of product design; mechatronics case studies. Offered fall. Credit cannot be received for both SYS 575 and ECE 575.

SYS 577

Concurrent Engineering (4 Credits)

Principles of concurrent engineering including: manufacturing competitiveness, performance indicators, life-cycle management, strategic technology insertions, process re-engineering, cooperative work teams, supplier organization, information modeling and product realization taxonomy. Credit can only be received for one of the following: SYS 577, ISE 577 or ME 577.

SYS 583

Production Systems and Workflow Analysis (4 Credits)

Design issues to control the flow of material in manufacturing systems from forecast to finished product. Topics include characterization of production systems, aggregate planning and disaggregation to a master schedule, inventory control, MRP, JIT systems, scheduling and sequencing, project planning and resource balancing. Student must have completed a course in probability. Offered fall. Credit can not be received for both SYS 583 and ISE 583.

SYS 585

Statistical Quality Analysis (4 Credits)

Fundamentals of statistical quality control and their use in system design. Control charts for variables, control charts for attributes, cusum charts and other process quality monitoring topics. Sampling inspection plans. Fundamentals of design of experiments and their application to product/process design and improvement. Taguchi's approach to robust design and related topics. Credit can not be received for both SYS 585 and ISE 585. Offered winter. Students must have completed a course in probability.

SYS 587

Foundations of Systems Engineering (4 Credits)

Techniques for generation, analysis and verification of traceable product design requirements. System performance and structural modeling using object, behavioral and other models. Techniques for analysis of system for serviceability, reliability, maintainability and testability. System alternative trade-off study techniques. System life cycle and other tools for implementation of systems engineering techniques. Credit can not be received for both SYS 587 and ISE 587.

SYS 594

Independent Study (2 TO 4 Credits)

Independent study in a special area in systems engineering. Topic must be approved prior to registration.

SYS 595

Special Topics (2 TO 4 Credits)
Study of special topics in systems engineering. May be taken more than once.

SYS 623
Dynamics and Control of Robot Manipulators (4 Credits)
Cartesian and joint space representations and transformations. The Denavit-Hartenberg (D-H) convention and parameter tables. Robotic forward and inverse kinematics and task planning. Newton-Euler and Lagrangian dynamic models and formulations. Robotic joint servo control, position control, force control, compliant motion and many industrial application aspects. Computer numerical and graphical simulations. Offered winter. Student must meet prerequisite (SYS 520).

SYS 630
Optimal Control Theory (4 Credits)
Modern control theory applied to linear dynamical systems. Differential and difference equations; stability of optimal control systems; dynamic programming; calculus of variation and Pontryagin's minimum principle; optimally switched control systems, linear regulator problem; application of theory to practical control system design methodology; project involving the design of an optimal control system. Offered fall. Student must meet prerequisite (SYS 520).

SYS 631
Estimation and Control Theory (4 Credits)
Stochastic differential and difference equations; Luenberger observer theory; Kalman-Bucy filtering theory; design of stochastic optimal and microprocessor-based control systems; duality between optimal estimation and control problems; the separation principle; simulation and laboratory implementation of observers and filters in stochastic control system. Offered winter. Student must meet prerequisite (SYS 520).

SYS 632
Analysis of Nonlinear Control Systems (4 Credits)
Nonlinear systems modeling and analysis with various engineering applications. Special phenomena and nonlinear dynamics. Theory of nonlinear systems stability and stabilization. Controllability, observability, invertibility and linearizability of nonlinear control systems. Nonlinear feedback control, internal dynamics and nonlinear adaptive control. Advanced computer simulation studies. Offered fall. Student must meet prerequisite (SYS 520).

SYS 635
Adaptive Control Systems (4 Credits)
Classifications of self-tuning and adaptive systems; parameter estimation techniques, self-tuning regulators and state estimators, stability and convergence analysis; model reference adaptive systems using Lyapunov and hyperstability models; applications of adaptive control systems; computer simulation and laboratory experiments. Offered fall. Student must meet prerequisite (SYS 520).

SYS 645
Intelligent Control Systems (4 Credits)
Definition and paradigm for intelligent control; self-learning and supervised learning; hierarchical decision architecture; fuzzy logic, neural network, heuristics, genetic algorithm, optimum strategy and related topics; examples of intelligent and autonomous systems; computer simulation and visualization of applications. Student must have permission of instructor.

SYS 674
Digital Control Systems (4 Credits)
Theoretical foundation needed to implement the microprocessor in control applications. Effects of sampling, data conversion, quantization, finite word length and time delays on system response and stability are examined. Pole-placement and observer/estimator techniques. Actual construction of a

microcomputer-based controller culminates the course. Offered winter. Student must meet prerequisite (SYS 520).

SYS 675
Automotive Mechatronics II (4 Credits)
Extensive review of software and modeling fundamentals, sensors, actuators, power train characteristics, automotive and industrial control systems; selected topics include engine and exhaust gas sensors; sensor interfaces; injection electronic circuits, engine and transmission controllers, pneumatic servos and active suspension; electromagnetic compatibility and issues related to system design, compatibility requirements, filtering, shielding/grounding, testing; emerging technologies in automotive mechatronics systems. Student projects. Credit cannot be received for both SYS 675 and ECE 675. Student must meet prerequisite (SYS 575).

SYS 680
Engineering Decision in Analysis (4 Credits)
Consideration of risk and uncertainty in decision criteria for resource allocation. Mathematical programming in engineering applications for multi-attribute utility analysis. Offered fall.

SYS 690
Graduate Engineering Project (2 TO 4 Credits)
Independent work on an advanced project in systems engineering. Topic must be approved prior to registration.

SYS 691
Master's Thesis Research (2 TO 8 Credits)
Directed research leading to a master's thesis. Topic must be approved prior to registration.

SYS 721
Large-Scale Dynamic Systems (4 Credits)
Analysis using a systems methodology including state variable modeling and multilevel structure. Structural stability, dynamic reliability, aggregation and decomposition. Application to estimation and control of large systems. Student must meet prerequisite (SYS 520).

SYS 722
Linear Multivariable Systems (4 Credits)
Fundamental and state-of-the-art modeling, analysis and design of linear multivariable dynamic systems. The role of polynomial matrices and differential operators in the description and structural realization of multivariable systems. Concepts of multivariable poles, zeros, Nyquist arrays and generalized root loci. Algebraic design methods based on state feedback observers, and model-matching. Inverse Nyquist and characteristic locus techniques as extensions of classical control design. Student must meet prerequisite (SYS 520).

SYS 731
Stochastic Optimal Control and Estimation Theory (4 Credits)
Foundation of stochastic optimal control and estimation theory. Continuous-time and discrete-time stochastic linear and nonlinear systems; analysis and design of stochastic optimal control systems; nonlinear filtering smoothing and prediction theory; and adaptive control estimation. Offered fall, odd years. Student must meet prerequisite (SYS 630).

SYS 794
Independent Study (2 TO 4 Credits)
Advanced independent study in a special area in systems engineering. Topic must be approved prior to registration.

SYS 795
Special Topics (2 TO 4 Credits)

Advanced study of special topics in systems engineering. May be taken more than once.

6. PLANS FOR ASSESSMENT

An assessment plan consisting of statements related to the institutional purpose, intended outcomes and objectives of the program, and criteria and procedures for assessments is shown in Appendix D (Assessment Plan for Ph.D. Program in ECE).

7. REFERENCES

[1] National Science Foundation, Division of Science Resources Statistics. Science and Engineering Doctorate Awards: 2006, http://www.nsf.gov/statistics/doctorates.

[2] National Science Foundation, Division of Science Resources Statistics. Science and Engineering Degrees by Race/Ethnicity of Recipients: 2004, http://www.nsf.gov/statistics/degreerecipients/

[3] School of Engineering and Computer Science Strategic Planning Task Force Report, April 2003.

Appendix A – Student Survey

- **Student Survey Form**
- **Summary of Student Survey Results**

Student Survey Form

Your Rank: _____ Masters Student _____ Doctoral Student

Student Survey
Fall 2006

1. Currently, the department of Electrical and Computer Engineering (ECE) offers a Ph.D. in *Systems Engineering*. Do you think that the ECE department should offer a Ph.D. program in *Electrical and Computer Engineering* instead?

___ Yes ___ No ___ No Opinion

2. If you are interested in enrolling in a Ph.D. program, would you consider enrolling in a Ph.D. in *Systems Engineering* at Oakland University?

___ Yes ___ No ___ Maybe ___ Not Applicable

3. If you are interested in enrolling in a Ph.D. program, would you consider enrolling in a Ph.D. in Electrical and Computer Engineering at Oakland University?

___ Yes ___ No ___ Maybe ___ Not Applicable

4. If you are presently not interested in pursuing a Ph.D. degree at Oakland University it is because:

___You do not want to pursue a Ph.D. degree at this time.
___ You do not want to pursue a Ph.D. at Oakland University in any field, but would be interested in pursuing a Ph.D. program at another institution.
___ You do not want to pursue a Ph.D. in Systems Engineering at Oakland, but would be interested in our Ph.D. in Electrical and Computer Engineering program.

5. Which program do you think will provide you with a better chance of employment:

___ Ph.D. in Systems Engineering
___ Ph.D. in Electrical and Computer Engineering
___ No opinion

6. Other comments, if any:

SUMMARY

Results of Student Survey
Fall 2006

Total number of responses received: 64 (out of about 200 emailed)

Student Rank: 13 Masters 39 Doctoral. Also, Bachelors: 2, Others: Unknown

1. Currently, the department of Electrical and Computer Engineering (ECE) offers a Ph.D. in *Systems Engineering*. Do you think that the ECE department should offer a Ph.D. program in *Electrical and Computer Engineering* instead?

44 Yes 10 No 4 No Opinion

2. If you are interested in enrolling in a Ph.D. program, would you consider enrolling in a Ph.D. in *Systems Engineering* at Oakland University?

24 Yes 4 No 6 Maybe 22 Not Applicable*

*Note: Because they are already enrolled in it.

3. If you are interested in enrolling in a Ph.D. program, would you consider enrolling in a Ph.D. in Electrical and Computer Engineering at Oakland University?

27 Yes 5 No 4 Maybe 17 Not Applicable

4. If you are presently not interested in pursuing a Ph.D. degree at Oakland University it is because:

17 You do not want to pursue a Ph.D. degree at this time.
1 You do not want to pursue a Ph.D. at Oakland University in any field, but would be interested in pursuing a Ph.D. program at another institution.
3 You do not want to pursue a Ph.D. in Systems Engineering at Oakland, but would be interested in our Ph.D. in Electrical and Computer Engineering program.

5. Which program do you think will provide you with a better chance of employment:

9 Ph.D. in Systems Engineering
37 Ph.D. in Electrical and Computer Engineering
10 No opinion

6. Other comments, if any
(Number of respondents are shown in brackets)

Some general comments

- I am strongly in favor of a Ph.D. in ECE: **(23)**
- I am strongly in favor of a Ph.D. in Systems Engineering: **(7)**
- I want an option to graduate with a degree in either ECE or Systems Engineering: **(6)**
- I would like to have my degree earned in Systems Engineering replaced by one in ECE: **(3)**

A random sample of some detailed comments

- I have found that a Ph.D. in Systems Engineering is often confusing and/or minimized by those in industry. Too often, I find the perception that "Systems Engineering" is a catch-all term for a non-specific collection of engineering classes. I have found that it is received by industry as being viewed as less technically challenging than a degree in EE.
- The title "Systems Engineering" is somewhat old-fashioned and very general. This title encompasses all branches of engineering because we have mechanical systems, electrical systems, and so on. This goes against the spirit of specialization these days. I would strongly recommend that the name of the program be changed as suggested in the email.
- When I am asked in what area is my Ph.D. in. They still ask me again even when I answer back with "Systems Engineering". So I have to tell them in Electrical and computer engineering.
- I think a Ph.D. in ECE will way much better for our grad students than a SE one, people in academia and industry value ECE but not much the SE. I have seen this in the USA and overseas. This will benefit our graduates way much better in the future.
- Having been in industry for a number of years now with a PhD in Systems Engineering from Oakland University, my impression is that whether the PhD is in "Systems Engineering" or "Electrical and Computer Engineering" is not so critical in terms of the opinion of employers. What companies will mainly be concerned about is what you have done in your research, i.e. what *specific* areas you have worked in and what are your accomplishments in those areas. Was your research on robotics? Mechatronics? Intelligent Control? Embedded Systems? Etc. And, what are your contributions in these areas, and the quality of your contribution.
- I am currently enrolled in the Ph.D in Systems Engineering. I would be very interested in changing to the Ph.D. in Electrical and Computer Engineering. I think this would be a good move for the department.
- I just completed my Ph.D. at Oakland University and have received a very favorable reaction to the Systems Engineering title. I believe industry and the government (my employer) are more interested in application focused systems engineering than a pure technical degree.
- I think Oakland should have Ph.D. program in EE. But adding this program should be used to boost the number of faculty teaching in the program.
- A Ph.D. program in ECE is a good idea because from my view point, most of the classes I had are purely electrical engineering and so I would prefer if my degree had the name of electrical not systems engineering since system engineering could be any type of systems (Mechanical, electrical, or even biomedical engineering).
- Systems engineering is specific to certain area of interest when people talking about its phd program. Electrical and computer engineering has its own focus. Even though they have some overlap but it shoudn't prevent people from expressing their own interest and

gaining recognition specific to either dicipline only. Besides the phd in ECE will be a good marketing tool for recruiting phd students, i think.

- I think it will be a mistake to allow the Ph.D. in Systems Engineering to merge with ISE completely because it will diminish the value of my earned degree.
  (Note: Similar comments were made by 2 students)
- I do believe the name of the degree should be changed from Systems to ECE, in order to better reflect the content, at least in most cases. On the other hand, I do see value in a PhD with Systems emphasis, though I understand that would be available through the new ISE department. .
- Few job requirements postings say "Systems Engineering" rather they ask for "Electrical Engineering".
- Ph.D. in Electrical and Computer Engineering is more appropriate. Also, it is universally recognized and understood for what it stands for.
- I have found my studies in Systems Engineering to be extremely useful in the real world. Continuing to build my knowledge and skills in Systems Engineering through a Ph.D. is very exciting and will set me apart from competitors that have Computer Engineering degrees.
- It seems that looking at a career in education, departments want individuals whose Ph.D. matches that of the department (mostly ECE/EECS,etc with few that advertise systems). In industry, Electrical and Computer Engineering implies the systems concept (or idea of combined relationship between the two), but in terms that would probably be more recognizable by individuals in hiring companies. HR folks as a rule are loosely in touch with the jobs they are hiring for. That is just my initial gut reaction to the name change. Since it sounds like the content will remain the same, perhaps gut reaction is the primary concern.
- If the department is required to have one and not the other, the ECE degree may get more mileage, but I fear that the graduates will be too narrowly focused.
- I think that the *Ph.D. in Electrical and Computer Engineering* is more common, specific and more self described in the job market than *Ph.D. in Systems Engineering*. The meaning of *Systems* generally is very broad, i.e. Industrial systems, Manufacturing systems, Control systems, Computer systems etc.
- The title Systems Engineering seems vague. Not knowing what department offered the degree, one would not know which field of engineering the systems degree applies. Systems engineering could apply to electrical, computer, mechanical, or industrial engineering. But, who is to say it should apply to any specific field. Anyone of the previously mentioned fields involves systems, and thus involves systems engineering. Therefore, it does not make sense that the department of ECE should be the sole owner of a Systems Engineering Ph.D., but not even offer an ECE Ph.D. I most definitely think the department of ECE should offer a Ph.D. in ECE; as should, the department of mechanical engineering offer a Ph.D. in ME. I also think that a systems engineering Ph.D. offer by the department of ECE is going to be biased toward ECE, as it should. It is offered through the department of ECE, but should not get the title Systems Engineering. As stated above, a Ph.D. entitled systems engineering would imply the Ph.D. holder has a degree related to the engineering of systems, which applies to any field of engineering. In the case of the ECE department, or any other department of engineering for that matter, the study of systems within a field of engineering is a subset or concentration within that field. For example, a Ph.D. in ME could have a concentration in thermodynamics, fluid/heat transfer, joining and fastening, or mechanical systems. For the ECE department, a Ph.D. in ECE would be much more appropriate. This Ph.D. could then have a concentration in electrical and/or computer systems. With that said, to which department does a Ph.D. titled systems engineering

belong. First of all there might not be an appropriate department to take the title since the title applies to any field of engineering. However, if a Ph.D. with this title is to be offered then, to answer the previous question, one needs to look at the most basic elements of each field of engineering each department possess'. After that investigation, I think most will find that a Ph.D. in systems engineering naturally belongs to the department of industrial engineering. In a most basic sense, industrial engineering studies processes. The word processes could be a synonym for systems. In addition, the process/system could be anything. The processes could be related to mechanical, electrical, computer engineering, or any combination of the three. Therefore, a systems engineering Ph.D. offered from the ISE department will unbiased to the other three fields. The degree can be kept to its most basic level, the engineering of systems (any system).

- I am currently enrolled in the PhD program under the title of Systems Engineering and wonder how common this title is. Also, if the content is the same as other Universities PhD in EE, then it would be better to align the title that is more recognizable.
- I may be biased, I chose to go to OU for graduate school ONLY because of the System's Engineering degree. I enjoy Systems much more than ECE, and would not consider OU if Systems Eng was not offered. I am surprised OU does not offer both degrees. I thought a PhD in ECE was already available (but I have not looked into this option).
- The PhD in system engineering is not desirable in middle east and the Persian golf regions. The PhD in Electrical and computer Engineering is strongly desirable in these regions as well in other regions of the world. The PhD curriculum at Oakland University is actually Electrical and Computer Engineering oriented more than Systems Engineering. Therefore, I strongly recommend to offer a PhD in Electrical and computer Engineering as soon as possible.
- Based on the Master's curriculum differences, I feel the Systems Engineering degree offers more flexibility for the student. Personally, the Systems Engineering Program allowed me to broaden my knowledge into some new areas while deepening it in others. I would probably be looking for a similar opportunity in a Ph.D. program.
- Systems engineering is a broad field of study that can encompass many facets of research. Many businesses either do not relate to Systems engineering as a practice of merit or are do not fully understand the underlying concept. I believe a Ph.D. titled Electrical and Computer Engineering would hold more clout for employment potential and peer acceptance in your specific field of study.