

**PROPOSAL FOR JOINT PH.D. PROGRAM IN ELECTRICAL AND  
COMPUTER ENGINEERING**

**OFFERED AS A JOINT PROGRAM BY IUPUI AND PURDUE UNIVERSITY,  
WEST LAFAYETTE CAMPUS**

**Objectives:**

Electrical and computer engineering (ECE) is a growing field which requires a strong educational background in engineering with a significant emphasis on mathematics. This program will prepare students for the expanding opportunities in this field which often require advanced degree studies. Ph.D. graduates are expected to become leaders in research and development at the forefront of their fields, applying advanced engineering techniques and theory to solve key problems.

**Summary of Requirements:**

The Doctor of Philosophy program requires extensive research and the writing of a thesis in addition to coursework. Coursework requirements for the Ph.D. degree are 21 hours beyond the master's degree. In addition, students must satisfy qualifying examination requirements, typically within one to two years after entering the Ph.D. degree program, and submit a written thesis proposal, typically within a year of passing the qualifying examination. The Ph.D. degree is awarded upon completion of the doctoral thesis.

**Clientele to be Served:**

This program is primarily designed for students holding an M.S. degree in an engineering discipline, although a limited number of students may be admitted to the program with a B.S. degree. Students with a science degree may also be eligible for the program, although they will need to develop the fundamental engineering skills needed by first taking certain prerequisite course work.

**Structure:**

The ECE Ph.D. program has existed at the Purdue West Lafayette campus for decades. Recently, a cooperative agreement between the Purdue School of Engineering and Technology, IUPUI, and the School of Electrical and Computer Engineering, Purdue University, West Lafayette was signed that establishes the rules and guidelines for participation of IUPUI in the Ph.D. Program of Purdue University for studies in the School of Electrical and Computer Engineering. This

document became operational from the perspective of Purdue University on September 29, 2003 when it was signed by John J. Contreni, Interim Dean of the Graduate School, Purdue University. A copy of the agreement is attached as Appendix A. A copy of the ECE Doctoral Program Handbook is attached as Appendix B. The joint Ph.D. program at IUPUI will basically be governed by the handbook as modified by the cooperative agreement.

#### Curriculum:

The curriculum is described in Appendix B, the ECE Doctoral Program Handbook, as modified by the cooperative agreement (Appendix A). The program is unique in that students will be resident on the IUPUI campus, with INS matters for international students handled by the IUPUI International Affairs Office. Four courses in the plan of study must be taken at West Lafayette. In the initial phase of the program, the Qualifying Exam and Preliminary Exam will be given at West Lafayette. As the IUPUI program grows, it is possible that these examinations may be given on this campus.

#### Employment Possibilities:

This program will prepare students for academic, business, manufacturing, and research careers in the electrical and computer engineering field. The industrial and governmental segments of this field in Indiana include such organizations as Delphi Automotive, Delco Electronics, and the Naval Surface Warfare Center at Crane, Indiana.

## B. PROGRAM DESCRIPTION

### 1. Description and Objectives

This is a proposal to award the degree of Doctor of Philosophy for study in a graduate program in Electrical and Computer Engineering. The program has been jointly developed by a faculty committee with representatives from the School of Electrical and Computer Engineering at Purdue University West Lafayette campus and the Department of Electrical and Computer Engineering at the IUPUI campus in Indianapolis.

The degree will be awarded by the Purdue University Graduate School through the academic unit now authorized to award the doctoral degree in Electrical and Computer Engineering, the School of Electrical and Computer Engineering at Purdue University's West Lafayette Campus. Students admitted into the program will be resident on the IUPUI campus. They will be required to take four courses at the West Lafayette campus. It is anticipated that they will take their remaining courses and perform their required research in laboratories on the

IUPUI campus under the supervision of faculty members authorized to supervise doctoral thesis work in accordance with the cooperative agreement (Appendix A).

A companion proposal for a Ph.D. program in Mechanical Engineering is being prepared for submission in coordination with this proposal.

The proposed Ph.D. program will allow students to take full advantage of the unique educational and research opportunities and resources available on the two campuses.

Both campuses will share in administering the goals and policies of the Ph.D. program as well as the progress of individual students. A Cooperative Agreement Oversight Committee will be established to monitor the activities and progress of the Cooperative Agreement program. The committee, comprised of members from both campuses, reports to, and makes recommendations for program revisions to, the West Lafayette Electrical and Computer Engineering Graduate Committee. In addition to the general oversight of the program, this committee has the responsibility to hear disagreements and disputes that may arise concerning this program, and mediate a resolution.

The Ph.D. in Electrical and Computer Engineering degree (PhDECE) will serve as the terminal engineering degree for those wishing to pursue a research career in this field. Ph.D. graduates will have increased depth of knowledge in general engineering subject areas plus specialized knowledge in topics related to their research. The Ph.D. will prepare students for academic positions in engineering schools as well as research and management positions in industrial or government laboratories.

It is important to recognize that the proposed program is based on a curriculum, research, and faculty infrastructure which is already in place. The need for a designated Ph.D. degree is indicated by the growth in high-technology in Central Indiana that has produced market demands for graduates from programs with this specific designation.

## 2. Admission Requirements, Student Clientele, and Financial Support

- a. Admission Requirements. Admission into the Ph.D. program in Electrical and Computer Engineering will be based on the standard policies and procedures of the Purdue University Graduate School.
- b. Prerequisites. Students entering the Ph.D. degree program would typically have a master's degree in an engineering discipline (which could be the MSECE degree). Those having a master's degree in a physical or biological science area would need to complete extensive preparatory coursework before they could be formally admitted for the Ph.D., but this pathway would be open to those willing to undertake this effort.

- c. Student Clientele. The clientele for the electrical and computer engineering program would primarily consist of recent engineering bachelor's or master's degree recipients wishing to pursue a career in this field. Those holding physical or biological sciences degrees would also be eligible under the conditions outlined in the previous section.
- d. Enrollment limits. The initial number of students in the Ph.D. program is expected to be small. As in all engineering graduate programs, enrollment will tend to be self-limited by the available financial support, the faculty's willingness to accept new graduate students, and the perceived market for graduates. Enrollment limits based on previous academic performance would not be imposed unless the number of students begins to exceed the maximum which the faculty feel can be handled without compromising program quality.
- e. Financial Support. Students will be supported by the usual sources for graduate programs in the School of Electrical And Computer Engineering, including fellowships, research assistantships, and teaching assistantships.

### 3. Proposed Curriculum

- a. Curriculum Requirements. The Ph.D. program in Electrical and Computer Engineering will have basic requirements similar to those of the School of Electrical and Computer Engineering in West Lafayette.

The minimum requirements for the Ph. D. degree are ninety semester credit hours of which thirty semester credit hours may have been earned in the Master's degree program. A minimum of forty-five of these semester hours are to be course credits (including Master's program hours). The Ph.D. qualifying examination is usually taken in the second semester of a student's Ph.D. study. This examination will be administered by the School of Electrical and Computer Engineering. The examination will include a written exam on engineering developed as one element of the qualifying examination requirement for the Ph.D. degree in Electrical and Computer Engineering.

- b. Each student's plan of study must include coursework in the student's Primary Area of study, an ECE Related Area, and Mathematics. The eight possible areas for ECE Primary or ECE Related Areas, and the core courses associated with each, are as follows:

ECE Research Areas	Core Course
Automatic Control (AC)	ECE 602
Biomedical Engineering (this is an area) (BE)	ECE 600
Communications and Signal Processing	ECE 600

Computer Engineering (CE)	ECE 608
Energy Sources and Systems (ES)	ECE 610
Fields and Optics (FO)	ECE 604
Solid State Devices and Materials (SS)	ECE 606
VLSI and Circuit Design (VC)	ECE 606/608

Each of these ECE Research Areas is governed by an Area Committee, consisting of the ECE faculty with research and/or teaching interests in that discipline. These Area Committees establish policy for students who declare the area as their Primary Area, recommended approval of new courses and course revisions for the area, and consider requests for deviations from the area policies.

The following requirements must be satisfied on all plans:

1. A minimum of 21 hours of course work beyond the Master's degree, or 42 hours beyond the Bachelor's degree for direct Ph.D. students.
2. At least 12 hours of courses from the ECE Related Area. Six of these hours may be from a Master's program.
3. At least 9 hours of mathematics course work. Three of these hours may be from a Master's program.

The core courses cover the background material in the various ECE areas, and the student will likely need to take several of these in order to prepare for higher level courses, to prepare for the Qualifying Examination, and to provide breadth to his/her curriculum. The ECE School does not specify how many core courses must be taken.

In addition to the requirements discussed above, some students choose an "Area of Specialization." Areas of specialization available to ECE Ph.D. students are Computational Science and Engineering and Biomedical Engineering. The area of specialization will appear on the transcripts issued after the degree is posted. The area of specialization does not appear on the diploma. Fulfillment of the requirements for an area of specialization usually involves some additional coursework, or places additional restrictions on the selection of courses.

Each Ph.D. student will have an Advisory Committee co-chaired by one ECE faculty member from IUPUI and one ECE faculty member from West Lafayette. The Advisory Committee will have at least one faculty member (other than the chair) from each campus. Indianapolis faculty not now approved to serve on Advisory Committees or as co-chairs will require one-time approval by the Electrical and Computer Engineering School. The Final Examining Committee (usually the same as the Advisory Committee) will have the same basic composition.

c. Sample Curriculum. Each student's plan of study will be unique. Shown are sample plans of study for the Ph.D. program, which might be taken by typical students with electrical engineering B.S. and Master's degree respectively. Students with other interests and backgrounds would, of course, have different plans of study, but would also take a number of the courses indicated. Thesis research will be distributed throughout the student's program but credit hours are shown collected in the table.

PhD students who enter the program with a Master's degree:

Minimum Requirements	Credit Hours	Comments
ECE 699 Research	*--	ECE 699 Thesis Research. No minimum requirement. <b>Resident hours must total 60 credit hours to fulfill requirement below.</b>
4 Related-area courses	*12	Coursework from ECE related area. *This requirement may be reduced to 6 credit hours for students who took related area courses as part of their Master's studies.
3 Math Courses	*9	Selected from the <a href="#">approved list of mathematics, statistics, computer science or physics courses</a> . *This requirement may be reduced to 6 credit hours for students who took related area courses as part of their Master's studies
Total Credit Hours	60	

PhD students who enter the program **without** a Master's degree:

Minimum Requirements	Credit Hours	Comments
ECE 699 Research	*--	ECE 699 Thesis Research. No minimum requirement. <b>Resident hours must total 90 credit hours to fulfill requirement below.</b>
7 Courses	21	These courses are selected by the student with the approval of the Advisory Committee.
4 Related-area Courses	12	Coursework from ECE related area.
3 Math Courses	9	Selected from the <a href="#">approved list of mathematics, statistics, computer science or physics courses</a> .
Total Credit Hours	90	

- d. Existing Courses. Core course choices for the Ph.D. program are listed below. All of these courses are now in existence. Note that this is only a partial listing of courses available at West Lafayette and Indianapolis. Many other relevant courses could be taken by a student to complete a plan of study once the core course and required course credit hour minimums have been satisfied.

Core Courses (offered at West Lafayette)

<u>Course Code</u>	<u>Course Title</u>	<u>Times Offered</u> 1993-95
ECE 600	Random Variables	Spring 04/Fall 03
ECE 602	Lumped System Theory	Spring 04/Fall 03
ECE 604	Electromagnetic Field Theory	Spring 04/Fall 03
ECE 606	Solid State Devices	Spring 04/Fall 03
ECE 608	Computational Models & Meth.	Spring 04/Fall 03
ECE 610	Energy Conversion	Spring 04/Fall 03

Core Courses (offered at Indianapolis)

<u>Course Code</u>	<u>Course Title</u>	<u>Times Offered</u> 1993-95
ECE 600	Random Variables	Fall 2003-04
ECE 602	Lumped System Theory	Spring 2003-04
ECE 608	Computational Models	Fall 2003-04

- e. Diploma Information. The Ph.D. diploma will read: Doctor of Philosophy, Purdue University, West Lafayette, Indiana.

5. Electrical and Computer Engineering Faculty and Administration

- a. Listing. Ultimate administrative authority for the joint Ph.D. program will lie with the Dean of the Schools of Engineering. Because of the collaborative nature of the program, the Cooperative Agreement Oversight Committee has been established with representatives from both campuses. It is described in detail in the attached cooperative agreement.

The School of Electrical and Computer Engineering at West Lafayette has over 80 faculty members. The Department of Electrical and Computer Engineering at IUPUI has 16 faculty members. Each of them has the potential for being involved in this program. Administrative matters will be handled by the Head of the School of ECE at West Lafayette and the Chair of the Department of ECE at IUPUI. The chairs of the ECE Graduate Committees on the two campuses will also play key roles.

- b. New faculty positions. No new faculty positions are required to initiate the Ph.D. program on either campus. However, it is expected that as funded research grows with the result of increased research funding support for faculty, additional faculty may be justified in the longer term.

## 6. Learning Resources

- a. Existing Resources. The University and Engineering libraries contain an excellent collection of electrical and computer engineering books and supporting periodicals including the *IEEE Transactions*. Because of the cross-disciplinary nature of much of the research, the libraries in the Schools of Medicine and Dentistry at IUPUI will also be important resources. Research laboratories in the Department of Electrical and Computer Engineering will be available, and will be upgraded as support becomes available.
- b. Need for Additional Learning Resources. No new laboratories, library materials, or other resources are needed to initiate the ECE joint Ph.D. program. As the program grows, it can be expected that new facilities will be developed using external funding to maintain the quality of the program.

## 7. Other Program Strengths

- a. Special Features. The proposed joint Ph.D. program in Electrical and Computer Engineering builds on an existing strong foundation. The faculty in the Department of Electrical and Computer Engineering at IUPUI are conducting internationally-known research, and students have conducted M.S. graduate work in the department's research laboratories. The department's location in Indianapolis provides special opportunities for research with leading manufacturing and pharmaceutical organizations in the area such as Eli Lilly, Roche Diagnostics, Delphi Automotive, and Delco Electronics. A primary feature of this program is that it will couple this existing strength with the superb faculty and resources of the School of Electrical and Computer Engineering in West Lafayette. This will enhance our ability to be competitive for students and research funding in the coming years.

- b. Anticipated Collaborative Arrangements. The program will collaborate most closely with the existing joint Ph.D. program in Biomedical Engineering, and with the joint Ph.D. program in Mechanical Engineering which is being proposed. No formal relationships with other parties are planned.

## C. PROGRAM RATIONALE

The field of Electrical and Computer Engineering is an expanding full-fledged engineering discipline. Engineers have fundamental and practical skills which contribute to the solution of numerous problems in manufacturing, electronics, information technology, transportation, construction, medicine, and the service industry.

Indiana has long been a leader in the manufacturing, transportation, and electronics sectors, with many such companies located in the state, including several major international corporations. Accordingly, there is a wide array of needs and opportunities for Electrical and Computer Engineering program graduates in Indiana.

- 1. Institutional Factors.
  - a. Compatibility with the Institution's Mission. The proposed program fits within the roles of IUPUI and Purdue as major research campuses. Furthermore, research, graduate education, and the transfer of technology are among the primary missions fulfilled by both campuses for the State of Indiana and the nation. Purdue is recognized as having one of the nation's leading engineering programs. This is made possible by graduate students and faculty working together in high-quality programs such as the one proposed here.
  - b. Planning Process. Electrical and Computer Engineering faculty from the two campuses began regular meetings in 2002 to consider the initiation of a joint Ph.D. program in this field. A cooperative agreement was crafted between the Purdue School of Engineering and Technology, IUPUI, and the School of Electrical and Computer Engineering, Purdue University, West Lafayette. The bulk of the work was done by members of the ECE West Lafayette Graduate Committee. After ratification by the Graduate Committees and Faculties on both campuses, it was signed by the School Head at West Lafayette and the Department Chair at IUPUI. Following signatures by representatives of the Engineering Deans on both campuses, the agreement became operational from the perspective of Purdue University on September 29, 2003 when it was signed by John J. Contreni, Interim Dean of the Graduate School, Purdue University. A copy of the agreement is attached as Appendix A.

Since this graduate program in Electrical and Computer Engineering is an extension of existing Master's activity, and since the West Lafayette campus has approved it, it can be implemented whenever program approval is received. We currently plan to begin in the Fall of 2004.

- c. Impact on Other Academic Programs. Since the joint Ph.D. program is a logical outgrowth of existing activity in the Department of Electrical and Computer Engineering, its impact on other programs at IUPUI should be negligible.
- d. Utilization of Existing Resources. Increased collaboration among those involved in electrical and computer engineering research could lead to some increase in resource sharing, particularly with respect to specialized laboratory equipment and computing facilities. However, there is already a significant amount of such sharing. A more probable benefit is that establishment of the program will allow a broader base for the sharing of expenses when new equipment is purchased for both educational and research purposes.

## 2. Student Demand: Enrollment Projections.

There are currently approximately 70 graduate students enrolled in the Electrical and Computer Engineering Department at IUPUI at the Master's level. Entry into the Ph.D. program will come via the existing application process at West Lafayette. Over one thousand students apply for the ECE Ph.D. program there each year. Fewer than 100 are accepted into the program. Initially, it is expected that 3-5 students will be admitted to the IUPUI campus during the first two years. By the tenth year of the program, it is expected that about 5-6 Ph.D. students will be admitted each year, resulting in a steady-state population of about 20-30 Ph.D. students. It is not expected that the courses developed for this program would serve as service or elective courses for a significant number of students in other majors.

## 3. Transferability

Transferability of credits at the graduate level is typically limited to some extent due to the specialized nature of the curricula. Within these limitations, one would expect students to be able to transfer credits on the same basis as in the existing graduate programs in the School of Engineering and Technology.

## 4. Demand and Employment Factors

Indiana is a primary source of electronics and information technology products in the automotive, pharmaceutical, consumer electronics, and other industries. Major Indiana companies include Delphi Automotive, Delco Electronics, Eli Lilly,

Roche Diagnostics, and other industries. Numerous smaller specialty companies have Indiana operations. The Purdue School of Engineering and Technology at IUPUI has traditionally provided graduates for these industries. Current trends in the electronics and computer industries indicate that more graduates with Ph.D. degrees will be needed in the future as the technology becomes more sophisticated and pervasive. Engineering graduates with this specialty will be needed in all areas of this field including education, research, development, manufacturing, and sales.

#### 5. Regional, State, and National Factors

- a. Comparable Programs. Except for Notre Dame, Purdue University offers the only Ph.D. program in Electrical and Computer Engineering in the State of Indiana. Other Big-Ten schools offer the degree, including Ohio State University and the University of Illinois Urbana-Champaign, which are the closest programs to Indianapolis.
- b. External Agencies. Graduate programs in engineering are typically not licensed or accredited. The undergraduate engineering programs at IUPUI are fully accredited by the Accreditation Board of Engineering and Technology. Graduate program quality is assured by the quality of faculty involved, the high admission and graduate standards, and the administrative oversight provided by the School Chairs and Deans in the Schools of Engineering and Technology and the Graduate School.

#### D. PROGRAM IMPLEMENTATION AND EVALUATION

Since the proposed joint Ph.D. program in Electrical and Computer Engineering is an evolutionary outgrowth of existing activity at IUPUI and West Lafayette, it can be implemented as soon as administrative procedures are put in place. Some currently enrolled undergraduate and Master's students may apply for the program, while new students will be recruited by advertising and through personal contacts.

It should be noted that the Ph.D. program at West Lafayette already has over 1,000 applicants per year. The application forms (paper as well as Web-based) will be modified to allow students to select the IUPUI campus as their first choice.

External funding will be sought from industry, government agencies, and private foundations to provide the financial support needed to fully develop and maintain a program of highest quality. Collaboration with colleagues at West Lafayette will enhance these efforts.

Program evaluation will be accomplished through internal as well as external reviews. The external reviews will include those provided by the existing Electrical and Computer Engineering Advisory Committee, which includes

members from industry, government, and academia. This will provide regular input and critique from those who hire the program graduates.

The ECE Graduate Committee at West Lafayette will conduct a review of the cooperative agreement every three years, or more frequently at its discretion. The purpose of this review is to (1) determine whether the program is meeting its goals of providing the best educational and research opportunities for ECE students and promoting strong collaborative programs between the campuses, (2) determine whether its continuation is warranted and the best interests of the two campuses, and (3) revise the program to correct any problems that may have arisen.

In addition, the establishment of a joint Ph.D. program in Electrical and Computer Engineering will inevitably mean that it will be ranked by one of the groups which produce such rankings. This will provide an independent measure of the program's success and reputation.