Program Self-Study Report

for

Electrical and Computer Engineering

Worcester Polytechnic Institute

June 24, 2002

Prepared for

Engineering Accreditation Commission
Accreditation Board for Engineering and Technology
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TABLE OF CONTENTS PAGE

A. Background Information

Overview of the Report

This report represents the initial Self Study for the Electrical and Computer Engineering (ECE) program. Since the ECE program was developed from, and is similar to, the existing Electrical Engineering program, substantial portions of the reports for the two programs are identical, and other portions differ in small but significant ways. With regard to evaluation of Objectives and assessment of Outcomes, we could have taken the approach that since the ECE program to date has produced only two graduates, evaluation/assessment is premature. However, since the ECE program is closely related to the EE program, we feel that the evaluation and assessment which has been conducted with EE students and alumni are relevant to this report. Our plans for assessing outcomes which are ECE-specific are explained.

Rationale for Introducing the ECE Major

For some time there has been recognition on the part of both students and faculty of the growing importance of computer engineering. On July 1, 1992, the name of the department was changed to Electrical and Computer Engineering, in recognition of the substantial role of computer engineering in the undergraduate and graduate curricula and research activities. In addition, a significant number of students have been pursuing courses of study with a strong computer engineering component. In academic year 1995-96 the department established a formal concentration in Computer Engineering, partially in response to student requests.

As the Undergraduate Program Committee (UPC) continued monitoring the administration of the Computer Engineering concentration, it was noted that the Computer Engineering concentration tended to cause overspecialization and narrowing of focus at the expense of breadth within ECE.

The possibility of developing an ECE major had first been raised explicitly in late 1995, when the ABET criteria for ECE programs were distributed to the department faculty. The UPC began seriously considering the implementation of an ECE major in the 1998-99 academic year. As part of this consideration, a survey was conducted in the fall of 1999 of all ECE undergraduate students regarding a number of issues, including areas of focus and preferred name of major. The survey results confirmed the UPC's concern regarding excessive focus: nearly half the students surveyed indicated a single area of focus within ECE; of those over 60% focused on computer engineering.

In the survey, students were allowed to choose from a number of options for a preferred major (see Table A-1). An ECE major was the most popular choice, with the existing EE major a close second. There was little interest in a Computer Engineering major.

Table A-1 Student Interest Survey	
Possible Major	**Percent Preferring**
Electrical and Computer Engineering	53.7%
Electrical Engineering	31.7%
EE with Computer Engineering concentration	10.3%
Computer Engineering	4.3%

In 1999, the UPC began the detailed process of developing an ECE major, with the following main points being considered:

1. The ABET criteria for ECE programs,
2. Preventing overspecialization; that is, enforcing breadth within the subdisciplines of ECE,
3. Determination of whether both EE and ECE be offered, or only a single major.

Following is a summary of the UPC's process for the decisions reached in each of these areas.

1. ABET criteria

At the time the UPC began serious consideration of the ECE major, only four accredited ECE major programs were in existence, at Carnegie Mellon, U. C. Boulder, U. Minn. Duluth, and Rutgers. The UPC reviewed these programs of study and by November, 1999, the UPC had developed a set of proposed distribution requirements meeting nearly all of the ABET criteria. The only requirement which could not be fulfilled within the existing ECE curriculum was discrete mathematics. The UPC discussed two options for meeting the discrete mathematics requirement:

- requiring an existing discrete mathematics course (MA2201) of all students, or,
- ensuring that the required discrete mathematics concepts were covered in ECE courses.

A subcommittee of the UPC studied the issue by looking into the content of MA2201 as well as coverage of discrete math concepts in the existing ECE curriculum. Further, the UPC consulted with Prof. Michael Gennert of the Computer Science department regarding their experience with MA2201. The subcommittee reported that MA2201 was not a good option: the course did not cover all of the topics necessary for ECE students, and spent time on topics not of value to ECE students. Conversely, most of the required discrete math concepts were already covered in ECE courses. For those concepts not already covered, material was moved to make room for the necessary discrete math concepts in the introductory computer engineering course EE2022.

2. Preventing overspecialization; that is, enforcing breadth within the subdisciplines of ECE

In developing the proposed distribution requirements, the UPC addressed the issue of overspecialization as revealed in the student survey. The distribution requirements for the ECE major specify that students must pass 3 courses from a list of electrical engineering courses, and 2 courses from a list of computer engineering courses. Also, both lists of approved courses are at the mid or advanced levels, assuring that students also complete the introductory core of courses which address the breadth of ECE topics. These requirements enforce breadth while allowing students the flexibility to pursue a focused course of study if so desired.

3. Should both EE and ECE be offered, or only a single major?

One option that was considered was to add the ECE major and continue offering the existing electrical engineering major. This option was rejected for two reasons:

- The danger of students in the EE major pursuing a too narrow, overly specialized undergraduate program of study. In discussions at both the UPC and departmental levels, it was clear that faculty prefer the breadth imposed by the distribution requirements for the electrical and computer engineering major.
- A practical desire that all our students have the same major, and that we avoid the potential confusion to students and difficulties of administering two majors.

The process for development of the ECE major involved extensive discussion by the ECE faculty, involvement of the ECE Advisory Board, feedback from student constituency, and consideration of practices at other universities with accredited ECE majors. As a result of this process we have made the necessary modifications to our curriculum and developed a set of distribution requirements that allow our students the traditional flexibility of the WPI education, while adhering to the requirements of the ABET criteria for ECE programs.

As part of the ECE rollout, we

- conducted an advising workshop,
- instituted the peer advising program,
- added a catalog section on the EE/ECE major differences,

all to help our students with their decision in choosing between the EE and ECE majors during the transition period.

Degree Titles

The title of the degree for the program under review is ***Bachelor of Science in Electrical and Computer Engineering***. This is a new program and this is the initial accreditation visit. Two students have graduated in this new program. Until 2001-02 the Electrical Engineering major was the only undergraduate program offered by the ECE department. In AY 2000-02 the faculty of WPI approved the addition of the program of study titled "Electrical and Computer Engineering." After accreditation has been received it is planned to phase out the EE major. The ECE faculty considered adding the Computer Engineering Major, and offering the EE and CompE degrees in parallel, but as described above, it was concluded that a single major best served our students' interests. While this document only represents the ECE major, it should be noted that the EE major is quite similar in its curriculum.

Use of the terms EE and ECE

It is appropriate to clarify the use of the terms **Electrical Engineering** and **Electrical and Computer Engineering**. Since 1992 the name of this department has been **Electrical and Computer Engineering**. Prior to that time it was Electrical Engineering. Until now, the only undergraduate program of study has been titled **Electrical Engineering.** At present we are offering both the **Electrical Engineering** and **Electrical and Computer Engineering** programs. For historical reasons all of the courses offered by the department carry the prefix **"EE."** This prefix was not changed to ECE when the department name was changed from EE to ECE for two reasons: to avoid confusing students as to the name of the accredited major, and since at the time the registrar's computer system required two-letter prefixes. This computer restriction is long gone, and the department's course prefix for all courses will change to ECE in the near future.

Throughout this report, reference will often be made to the "EE/ECE" program when referring to the past. This is appropriate since the ECE program grew out of the EE program, and our past experience with the EE program had substantial impact on the ECE program. However, the construction "EE/ECE" should **not** be interpreted to mean that the we consider these programs to be the same or interchangeable. Rather, it refers to the fact that the EE program grew into the ECE program.

Program Modes, EE and ECE Enrollment, Degrees

The undergraduate electrical engineering program is a full-time, day, on-campus program. The only two programs of study presently offered by the Electrical and Computer Engineering department are “Electrical Engineering” and “Electrical and Computer Engineering,” the subject of this report. Within the ECE major, students may pursue concentrations in several subspecialties, including power systems, microelectronics, signals and communications, control systems, and computer engineering. Total undergraduate (EE and ECE) enrollment (four years) in the fall of academic year 2001-2002 was 534 students. As of May 22, 2002, we have the following distribution of students majoring in Electrical and Computer Engineering: first-year: 117, second-year: 2, third-year: 0, transfer (year not determined): 7. The remainder of the students are majoring in EE. The low numbers of upper-class students in ECE is not surprising since students have not been encouraged to select the new major prior to the ABET visit. The undergraduate enrollment trend over the past five years has seen a slow, steady increase in the total number of students; however, preliminary data indicates that this trend will begin to reverse with the entering class of 2006. The largest concentration area, by a significant factor, has been computer engineering. In academic year 2001-2002, 115 BS degrees in electrical engineering and 2 BS degrees in electrical and computer engineering were awarded. For general information, the department awarded 31 MS and 4 PhD degrees in AY2001-2002.

Overview of the WPI Educational System

Certain aspects of WPI’s educational system are different from the common practices at other universities. Our overall system of education is referred to as the “WPI Plan,” which was developed in the late 1960’s with substantial support from the NSF and other foundations. The WPI educational philosophy emphasizes student responsibility for his/her own learning, the need to "learn how to learn," the value of teamwork and cooperation, and the value of demonstrating outcomes. This philosophy motivates the following aspects of our system:

- There are very few required courses, although "Distribution Requirements" assure that students receive exposure to the appropriate breadth of academic disciplines.
- The grading system, with one rare exception, does not include the failing grade. Students simply receive "no record" of courses that they failed to pass, or in which they would have received a "D." Recorded grades are A, B, and C. The equivalent of a failing grade (NAC for Not Acceptable) is reserved for project work where the failure of an individual student may negatively impact his/her team members. It should be noted that failure to pass courses does have significant consequences. Students who do not meet satisfactory academic progress standards are first put on warning, then probation (no financial aid), then are suspended.
- The nine-month academic year is divided into four academic terms, called A, B, C, and D. There is a fourth term (E) in the summer. All terms are exactly seven weeks in length. Terms A and B fit into the normal fall semester, and terms C and D represent the spring semester. Students normally enroll in three courses or equivalent activities each term. Hence they complete six courses per semester. The course meeting schedule is compressed, with classes meeting four or five days per week. Since students study fewer subjects at a time, they can study them more intensely.
- Each term-length course is approximately equivalent in academic content to a 3 semester hour course. Hence in one semester the student attempts the equivalent of approximately 18 semester hours (9 in the first term of the semester, and 9 in the second term)
- The unit of credit is called the "unit" and a regular course load for one term represents one unit of work. Hence, one course carries 1/3 unit of credit. Finally, 1/3 unit is approximately equal to 3 semester hours of credit.
- The Degree Requirements for graduation are simple: At least 15 units (the equivalent of 135 semester hours) of credit, completion of three major projects (in the humanities, the technology/society interface, and the major area of study), a social science component, a physical education component, and the Distribution Requirements in the major area.
- Note that the graduation requirement of 15 units is less than the normal full-time course load that would represent 16 units (4 terms of one unit each for 4 years). This provides some flexibility to the student and results in a credit requirement for graduation approximately equal to 135 semester hours.
- Projects are a major component of the WPI education, and have their own jargon. The Humanities component is called the "Sufficiency;" the society/technology project is called the "Interactive Qualifying Project" (IQP); and the senior project in the major area is called the "Major Qualifying Project" (MQP).
- Both the IQP and MQP are often performed for corporate, government, or foundation sponsors, and often by students who reside for a term at an off-campus site (as far off campus as Bangkok). These experiences are then not "academic exercises;" they are real undertakings that are valued by the sponsors. The projects do, of course, have valuable

academic content which is assured by the resident faculty advisors. The students receive credit (generally 1 unit) and grades for these projects.

An interesting historical footnote in the context of this self-study is that in its original form the WPI Plan required all students to pass a "Competency Exam" prior to graduation. This event did provide an ultimate form of outcomes assessment. Quite consistently, approximately 20 percent of students failed the exam at the end of four years of apparently satisfactory study. The exam was discontinued because the faculty concluded that it was not possible to accurately and fairly assess a four-year education in a four-day combined oral/written exam.

Actions to Correct Previous Deficiencies

Since this is an initial visit to a new program, there have obviously been no previous reports. However, the ECE program is quite closely related to the previously-existing EE program, and the report on the EE program made some comments regarding process issues which affect both programs. Hence the ABET report and our actions appear relevant.

No deficiencies (or items listed as weaknesses or concerns) were reported in the report from the previous accreditation visit in 1996 that was one of two pilot visits under Criteria 2000. The report lists many strengths of the Electrical Engineering program. However, some areas in need of improvement in the implementation of the new criteria were noted. These areas involved the lack of a complete, documented, and fully-implemented plan for the assessment of the accomplishment of each of the objectives and outcomes by students. It was noted that the curriculum appeared well-designed to implement the educational goals of the program, and that significant examples of a complete process involving assessment, data analysis, and program improvement existed, but that this process was not mature and was not fully applied across the program. Specifically, the report states, "Additional evidence for each of the outcomes (a) through (k), presented in a quantitative summary, should be available to future program evaluators." No problems were reported with regard to any Criteria other than two and three as reported above.

This report documents the continued implementation of Criteria 2000, specifically addressing the need to evaluate the educational objectives and assess the program outcomes in as quantitative a manner as possible, draw conclusions from the data, and act to improve the program. The process by which this evaluation/assessment is accomplished, and examples of the resulting program improvements, are presented.

Summary of Major Activities since Previous Visit

Following is a brief summary of the major activities in the undergraduate program since 1996.

- Comprehensive review of introductory EE/ECE curriculum resulting in the deletion and addition of courses, and reorganization of the sequence in which students enroll in courses. The following courses were substantially affected: EE 2022, Introduction to Digital Circuits and Computer Engineering, EE 2111, Physical Principles of ECE Applications, EE 2112, Electromagnetic Fields, EE 2801, Foundations of Embedded Computer Systems.

- Addition of several new courses representing state of the art material: EE 3113, RF Circuit Design, EE 3703, Real-Time Digital Signal Processing, EE 371X, Electro-Optics (permanent course number is pending).
- Addition of a team-taught course in the principles and practice of electrical and computer engineering design, EE 2799.
- Complete re-write of the ECE catalog material, with substantial enlargements and enhancements, carried out from the students' point of view and with substantial student input.
- Initiation of enhancements to the academic advising program, including a peer advising system (student initiated) and meetings by class year with faculty in advance of individual student meetings with their advisor.
- Additional ECE student space for study, group work, and extra-curricular activities.
- Major renovation of space into a "Studio Classroom" with computer, lab equipment, and modern AV capabilities.
- Continual laboratory and computer facility updating.
- Implementation of a major "Course Based Assessment" program directed by Prof. Nicoletti.
- Addition of a tenure track faculty member in the optical communications area (beginning August, 2002).
- Design and implementation of this new program titled Electrical and Computer Engineering, which will eventually replace the Electrical Engineering program.
- Enlargement of student opportunities to conduct their senior projects at off-campus locations (including foreign locations) at corporate facilities.

Program Administration

The administrative structure of the ECE department and the EE program is relatively simple. The ECE department is overseen by a department head (currently Prof. John Orr) appointed by the provost, for a five-year term, possibly renewable. The head is assisted by an associate head (currently Prof. Fred Looft) who devotes approximately 30% time to administrative duties. These persons administer the undergraduate EE and ECE programs, as well as the graduate program. They are assisted by the undergraduate program coordinator, Prof. Hossein Hakim. The department head reports to the provost. WPI is not organized into colleges, although associate provost William Durgin serves as engineering dean as appropriate. The departmental committee structure is also simple. Following are the major committees:

- Undergraduate Program Committee: overall responsibility for assessment of the undergraduate program, and recommendation (to the ECE faculty) of changes.
- Graduate Program Committee: overall responsibility for operation of the graduate program.

- Projects Committee: responsible for operation of the undergraduate projects program, assessment, and recommendation of any changes.
- Assessment Committee: responsible for organizing undergraduate assessment activities, analyzing the results, and making recommendations to the ECE faculty.
- Program Review Committee: responsible for reviewing each student's transcript for accomplishment of all requirements prior to graduation.
- Computer Planning Committee: responsible for overseeing ECE information technology infrastructure, both hardware and software, and for making recommendations for changes.
- ECE tenure committee: responsible for annual reviews of nontenured, tenure track faculty, and for participation in the deliberations at tenure review time.

Report Preparation

All ECE faculty have been involved in the preparation of this self-study and in preparing the supporting documentation. Profs. Denise Nicoletti, John McNeill, and John Orr have played the largest roles in writing and assembling this report.

Report Organization

This volume contains the Self Study and Appendix I (Supporting Tables as specified in the Self Study Instructions, Course Descriptions, and Faculty Vitae). Volume 2 contains Appendix II, the Institutional Profile. Volume 3 contains Appendix III, Supporting Data. Each Appendix in Appendix III is numbered by the Criterion to which it refers. For example, Appendix 1-1 refers to ABET Criterion 1.

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B. Accreditation Summary

Criterion 1, Students

Admissions

Undergraduate admissions is handled by the WPI Admissions department, overseen by the Director of Admissions and the Vice President for Enrollment Management. Students are admitted to WPI on the basis of their overall academic quality and evident ability to accomplish and benefit from WPI's academic program. Students are not admitted to specific programs, but are encouraged to indicate their intended area of study for planning purposes. Student quality is quite high. The class entering in fall of 2001 possessed an average combined SAT score of 1261. A relatively small number of students are admitted as transfer students. The process for reviewing previous credit is described below.

After matriculation, students are free to change their major at any time, and are encouraged to consult with their academic advisor in making such decisions.

Academic Advising

The WPI Plan results in educational experiences that are usually different for each student. Hence, advising needs to be specifically tailored for the individual, which adds a new level of complexity and responsibility for the advisor. To assist in the advising process, WPI's faculty formally endorsed in 1993 the following statement on the goals of academic advising and the responsibilities of academic advisors:

WPI Advising Guidelines

The primary purposes of WPI's academic advising program are to:

- Assist students in the development of meaningful educational plans that are compatible with their life goals,
- Help students accept responsibility for their own education,
- Aid students' professional development by providing guidance in curricular and professional choices.

An academic advisor's responsibilities include:

- Helping the student to design a program of study, interpret catalogs and degree-requirement audits, and choose among academic alternatives,
- Monitoring academic progress and recommending appropriate resources to answer questions or solve problems related to academic, career, and personal matters

New Student Orientation

The advising process begins after a student has been admitted to WPI in early May. A scheduling booklet called "Blueprint for Success" is sent to the student. The booklet is also available over the web. Students are asked to review the advice for selecting courses for the fall semester and submit these choices to the Office of Academic Advising by mid-June. This office works with the Registrar's Office and the Scheduling Office to develop appropriate schedules. Students who have access to the WEB can begin the process of modifying their schedules before arriving on campus in late August. Transfer students are advised and scheduled on an individual basis by scheduling a meeting with the Advising Office. During New Student Orientation, the five-day period before the academic year begins, students have the opportunity to review their schedule with their academic advisor and with other department representatives, such as faculty from the Humanities and Arts department, and with the peer advisor, an upper-class student who is assigned to work with the students through orientation and then assists the academic advisor during the first semester.

The goal is to help students develop an academic schedule that is oriented toward the student's goals. Further modifications to the schedule can be made up to the end of the second day of classes. New Student Orientation provides the opportunity for new students (both freshmen and transfer) to learn about WPI's special culture, including the project and team based educational system. Student orientation leaders help new students learn how WPI is different from the high school experience, especially the importance of taking responsibility for learning, managing time, and asking questions both in and out of class.

During New Student Orientation, incoming students are divided into groups of 20-25, each with its own orientation leader and faculty advisor. These groups complete an "Academic Project" during the course of the orientation program. The new students develop a web page for an imaginary WPI student, including information about his/her personality, likes and dislikes, hobbies, and, most importantly, area of study. Each group is given a specific program, including a major, and topics for each of the three projects required of WPI students.

The teams must locate all relevant information about the programs and develop a four-year plan by which the imaginary student would be able to complete the requirements. The goals for this project include helping new students understand academic scheduling options and the WPI Plan, learning to use the Web and the computer network, developing an understanding of the many extracurricular activities at WPI, learning to write a curriculum vitae that includes a personal goals statement, and creating a sense of team work and leadership skills.

First year advising

Beginning in the fall of 2001, the faculty member who serves as the advisor to the orientation project also serves as the academic advisor for the group. Thus, the orientation groups are housed together and advised together as well as oriented together. This model has been tested on a small scale during the academic years of 1999-00 and 2000-01. The results of this experiment indicated that it would be worthy of a trial for the whole freshmen class. WPI received funding from the Davis Education Foundation to support this initiative, which we call the Insight Program.

Instead of assigning academic advisors to new freshmen based on what is often a tentative indication of major field of study, new students will be assigned one of 28 "Insight Advisors" who will advise a group of 25 to 30 students who are housed together in one of the residence halls floor. These advisors represent almost all the departments at WPI, and in many cases are the senior faculty members and the most experienced advisors. At the end of the first semester, in December, the students officially declare their majors and are assigned an advisor from the department of the declared major.

With the Insights Program, freshmen advising is restructured and consists of a small number of advisors willing to make a modest but real commitment to working with groups of students, usually in their residence halls. Freshmen advising is much more about mentoring students and much less about course scheduling. Also, the student orientation leader stays with the group and becomes the "peer advisor" whose main role is to assist the academic advisor. Finally, each department designates "Department Mentors" who can help students with major-related questions and issues.

Transfer students are not part of the Insight Program. They go through the same orientation program, but are assigned an academic advisor from their department from the beginning.

In January, a small number of transfer and freshmen students are admitted. They have an abbreviated orientation program, and are assigned advisors based on their indicated major.

Advising of ECE Majors

Overview

All ECE students are provided with a faculty member of the ECE department as academic advisor. Students are always free to change their advisor, subject only to the agreement of the new advisor to accept the student. At a minimum, the role of the academic advisor is to assist the student in choosing courses and other academic activities which will meet the requirements for a degree in the desired program. The ECE department faculty have committed themselves to going beyond this minimum, and work with students to optimize their programs with respect to the students' backgrounds and goals. Further, advisors make an effort to broaden their advisees' outlooks regarding graduate school and career opportunities, as well as assisting with non-academic problems or concerns when appropriate.

Faculty advisors are supported by the Office of Academic Advising (http://www.wpi.edu/Admin/OAA/), which reports to the Assistant Provost, and by a faculty Committee on Advising and Student Life, which focuses on methods for improving the student advising system. The Office of Academic Advising assigns all academic advisors to students (http://www.wpi.edu/Admin/OAA/resources.html). The Advising Office provides support to academic advisors. All new students have an advising folder containing background information and a picture that is distributed to the initial advisor. The advisor is asked to keep grades, audit sheets, and other information in the folder and to pass the folder on if the student changes advisor.

An "Academic Advisors Handbook" is available to all advisors both as a Web document (http://www.wpi.edu/Admin/OAA/Handbook/) and hard copy. For new advisors, a half-day workshop is offered in August.

Course and Project Selection

Each year, the students and their advisors are asked to make plans for the whole of the following academic year. This process starts with Academic Advising Day in February. No classes are scheduled for this day in order to give students and advisors time to meet. Most advisors post a sign-up sheet for making appointments. At least once a year, each academic advisor discusses the student's progress toward meeting the degree requirements (listed in Appendix 1-1). Additional meetings are scheduled as needed. The ECE department added two new components to the annual EE/ECE student advising in 2001-02. On the day prior to “advising day” evening meetings were held with each of the three lower classes (excluding seniors). At these meetings faculty presented the most relevant information for students at that stage of their academic career, and answered student questions. Also, one faculty member visited each session and addressed the topic of professional ethics. These sessions were very well received by students. A final component of advising is the department undergraduate web site, http://www.ece.wpi.edu/undergraduate/, where general information and news such as schedule changes are posted.

From February until early April, the final master schedule is developed and specific project topics are proposed by faculty. Students are then asked to register for all classes and projects for the following year.

Throughout the year, grade reports are available to both students and their advisors over the Web. In addition a degree audit, also available over the Web, is used to monitor progress toward the degree. The audit lists the degree requirements that have been completed as well as the degree requirements that have not been completed.

Electrical and Computer Engineering Curricular Details

With our first-year program, students begin studying electrical and computer engineering simultaneously with their study of calculus and physics. While this presents some challenges to the teachers of these first two ECE courses, it has proven to be quite effective in motivating the close relations among physics, mathematics, and ECE. Students immediately see the applications of their mathematics and physics studies.

It is expected that all electrical and computer engineering students become familiar with the fundamental concepts in active and passive circuits, electromagnetic fields, electronic measurements, and signal analysis, as well as basic experimental and laboratory techniques. This subject matter is contained the sequence EE 2011, EE 2022, EE 2111, EE 2201, EE 2311. Further, they must gain the competence to apply the more advanced concepts in at least one of the more specialized areas of concentration in electrical and computer engineering. Students are also expected to develop some breadth in one or more areas of their own choosing. This may involve, for example, some study in social, life, computer, physical, management, or engineering sciences or in advanced mathematics.

The electrical and computer engineering section of the Undergraduate Catalog provides advising information, including typical course sequences that have been selected to lead a student toward competence in one or more of the seven specialized areas of electrical and computer engineering. The advisor can be of particular help to the student in this selection. Beyond the ECE core curriculum described above, the ECE Distribution Requirements mandate a basic level of breadth in both the "electrical engineering" and the "computer engineering" side of the profession. Beyond this minimum, the academic advisor helps the student select a sequence of courses which is neither too narrow and specialized, not too broad and diffuse. A choice from two or more related or mutually supportive areas (such as RF circuits and Communications) is usually advised. The faculty advisor and the student work out a tentative selection of courses and independent study in the freshman year, or early in the sophomore year. This program is periodically reviewed as the student defines more clearly an area of interest, and to verify satisfaction of the college and ECE course distribution requirements.

The WPI Degree Requirement Audit

The "WPI Degree Requirement Audit," available both electronically and on paper, is designed to help the student and his/her advisor keep track of progress toward both WPI's "Degree Requirements" and the specific program "Distribution Requirements" (electrical and computer engineering in this case). Referring to Appendix 1-2 (in Volume 3) for a sample audit for one of the two graduates of the class of 2002 majoring in ECE, this useful form will be described. In each category, the audit lists the number of credit units actually completed by the student (titled **UNITS**), the number required (titled **REQUIRED**), and if the number (if any) of units remaining to be completed (titled **NEEDS**). While this is not a transcript, the grades received in each activity are included. In addition to the normal letter grades, "L" indicates credit (generally for math or science) received by advanced placement. The audit form is customized for each major; however, at this time the computer programming of the customization for the new ECE major has not been completed. Hence, the notation at the top of the form advises students of this fact. The audit form begins with the overall WPI degree requirements:

- The total academic credit accumulated toward the 15 units (approximately equivalent to 135 semester hours) required for graduation,
- The 8 unit (slightly more than two academic years) residency requirement for transfer students,
- The senior project (MQP) requirement,
- The junior project (IQP) requirement,
- The Humanities (Sufficiency) course/project requirement,
- The department major requirements (detailed below),
- The Social Science requirement (2 courses, 2/3 unit),
- The Physical Education requirement (4 PE courses or substitute activities).

The form then lists the Distribution Requirements for the major. Sub-requirements in a category (such as the requirement for a sequence of at least 2 courses in physics, and at least one course in either chemistry or biology) will also be tracked. Since ECE audit form programming is not complete, several of the following requirements must currently be tracked manually. The automated form will be operational in the 2002-03 academic year.

- The overall four-unit (12 course) requirement in mathematics and basic sciences, encompassing:

  - The seven-course (2 1/3 unit) mathematics requirement (the sub-requirements for differential and integral calculus and differential equations are also tracked),
  - The three-course (1 unit) minimum in Physics, Chemistry, Biology,
  - The "general math/science" two-course requirement to bring the total number of courses in mathematics and basic sciences to 12 (4 units).

- The Engineering Science and Design category, encompassing 6 units (18 courses or course equivalents):
  - Capstone design. This requirement is normally encompassed in the senior project (MQP) but is separately audited to guarantee its presence. This is listed as incomplete due to the fact that this ECE audit is not fully computerized, but was in fact satisfied by the MQP listed under Additional Earned Credit,
  - The one-course requirement in an engineering science (ES) outside of ECE or Computer Science. This is listed as incomplete but is in fact met by the course ME 360X listed under Additional Earned Credit,
  - The one-course requirement in Computer Science at the sophomore (2000) level of above. This normally implies a de facto requirement of a prerequisite course at the first-year level (see the "Additional earned credit" section),
  - Fifteen courses or course equivalents in ECE, including the senior project (MQP),
  - A one-course technical elective which may be in any engineering or CS area,
  - Finally, the audit summarizes supporting courses such as those in the Humanities, credit which can be considered completely free electives, and any credit for which the computer system does not have a classification.

  The latter (unclassified) category is large in this case because this form is not a complete audit. The additional Distribution Requirements which ECE majors must satisfy include:

  - At least 3 courses beyond the EE core in electrical engineering topics. The sample student met this requirement with: EE2201, 2312, 3901 listed under EE Department Activities. (It is interesting to note that this student just met the minimum requirement on the electrical engineering side; without this breadth requirement the faculty fear that some students would overspecialize on the computer engineering side.)
  - At least 2 courses beyond the EE core in computer engineering topics. The sample student more than met this requirement, with the following courses: EE2801, 3801, 3803, 3815, 4801 listed under EE Department Activities.

Verification of Satisfaction of Disciplinary Degree Requirements

A Program Review Committee is established in each department. These committees review the degree audit for each student during the final year of study to ensure that each graduating student will satisfy both WPI and ABET requirements. It is important to note that the development of a program of study and the satisfaction of degree requirements are the responsibility of each student. Each Academic Advisor helps the student design a program that meets each student's individual goals as well as the degree requirements in engineering. Prior to the last semester, both the Registrar and the Program Review Committee will notify students if degree requirements are missing. Thus the students have the opportunity to adjust the schedule before the completion of the academic year. The final review to ensure that all requirements have been met is the responsibility of the Registrar.

Transfer Students

Admission of transfer students to WPI is handled by officers of the Undergraduate Admissions Department, based upon review of high school and previous college work. However, approval of all transfer credit is handled by the appropriate academic department. In some cases articulation agreements with specific colleges are in place which indicate acceptable courses for which transfer credit is automatic if the student has achieved a C grade or better. In most cases, course transfer credit is handled individually for each student. Transfer of each electrical and computer engineering course is reviewed by the department head or associate department head, who verifies the appropriateness of the course for credit as well as the degree of correspondence with WPI courses.

Criterion 2, Program Educational Objectives

Educational Objectives of the Electrical and Computer Engineering Program

The Objectives of our EE and ECE programs are identical:

> *The electrical and computer engineering department educates future leaders of the electrical and computer engineering profession, with a program characterized by curricular flexibility, student project work, and active involvement of students in their learning. Through a balanced, integrated curriculum we provide an education which is strong both in the fundamentals and in state-of-the-art knowledge, appropriate for immediate professional practice as well as graduate study and lifelong learning. Such an education also prepares students broadly for their professional and personal lives, providing the basis for effective leadership and informed citizenship. The curriculum embraces WPI's philosophy of education, and takes advantage of key components such as the Interactive Qualifying Project to develop technical professionals who possess the ability to communicate, work in teams, and understand the broad implications of their work.*
>
> *Adopted by the ECE faculty on March 28, 2001.*

The first formal adoption of a statement of Educational Objectives by the ECE faculty was on May 8, 1997. This statement has subsequently been modified in relatively minor ways, the most recent revision reflecting the addition of the new program in Electrical and Computer Engineering. We have a single Objectives statement for both programs because we view the ECE program as the natural evolution of our current electrical engineering program.

To assist in evaluating accomplishment of the overall Objectives statement, the following specific, measurable objectives may be extracted from the above statement:

- Graduates should be "leaders of the electrical and computer engineering profession,"
- Graduates should display the results of "an education which is strong both in the fundamentals and in state-of-the-art knowledge,"
- Graduate should display the results of an education which is "appropriate for immediate professional practice as well as graduate study and lifelong learning,"
- Graduates should display "effective leadership and informed citizenship,"
- Graduates should be "technical professionals who possess the ability to communicate, work in teams, and understand the broad implications of their work."

Relation of Objectives to WPI Mission

The Educational Objectives follow naturally from the Mission of WPI. The WPI Mission Statement is:

> *WPI educates talented men and women in engineering, science, management, and humanities in preparation for careers of professional practice, civic contribution, and*

leadership, facilitated by active lifelong learning. This educational process is true to the founders' directive to create, to discover, and to convey knowledge at the frontiers of academic inquiry for the betterment of society. Knowledge is created and discovered in the scholarly activities of faculty and students ranging across educational methodology, professional practice, and basic research. Knowledge is conveyed through scholarly publication and instruction.

Adopted by the Board of Trustees, May 22, 1987

The parallel nature of WPI's Mission and the EE/ECE Objectives statements is evident.

Process for Determination of Objectives

The ECE curriculum grew out of the EE curriculum which had its beginnings with the implementation of the "WPI Plan" in 1970. The WPI Plan for undergraduate education is characterized by student responsibility for his/her learning, an outcomes-orientation via three major required student projects, and by emphasis on the liberal as well as the technical and professional components of the BS degree. The EE curriculum was created to be in concert with WPI's Mission and educational philosophy which were in place prior to the formalization of Program Objectives. The formal process of establishing Objectives for the undergraduate EE/ECE program began with the departmental Strategic Planning process in 1995. That process established three dimensions (Quality, Relevance, and Opportunity) upon which we reviewed and modified our existing EE program. The first published Educational Objectives statement was adopted by the ECE faculty in 1997, and has been revised since. The current objectives were modified only slightly with the implementation of the ECE program (replacing reference to "electrical engineering" with "electrical and computer engineering.")

The departmental Undergraduate Program Committee (UPC) consisting of the department head, one faculty representative from each sub-area of electrical and computer engineering, and one undergraduate student, exercises overall responsibility for the undergraduate program, including review and proposal for modification of the Educational Objectives as needed.

Constituencies

The following have been identified as the primary constituencies of the undergraduate electrical and computer engineering program:

- Current and prospective WPI ECE students,
- ECE Faculty,
- ECE Alumni,
- Employers, particularly the immediate employers of our graduates,
- Graduate and Professional Schools where our graduates seek advanced degrees,

Of the above, the first group (current and prospective students) is clearly primary. Further, additional constituencies can be identified, ranging from the corporations who sponsor our students' projects, to the parents of our students, to society at large. Where appropriate these other groups are involved, but our desire is to restrict our constituent list to a manageable number.

Each of these constituencies has a distinct, and different, involvement in the ECE program. Additional constituents could be listed, but the indicated list is felt to be sufficiently complete. The faculty plays a dual role: as constituent, but more importantly, as the group responsible for program determination and execution. It is important to note that the faculty's first goal is to determine the ***needs*** of the various constituencies, rather than their ***desires***. This is particularly significant for prospective, and even current, students. What a person ***needs*** at a given point in time may be very different from what he or she ***wants***. The process of education, at least through the BS level, addresses the maturation of students very broadly. While an employer may be able to state his/her needs very clearly, a student may not be in such a position. This does not imply that we should not listen to our students; it just means that we must interpret what they are saying in terms of our mission as an institution. It is also evident that constituent needs exist on several different time scales. An aspect of employers' needs in electrical and computer engineering is student familiarity with the current state of technology, but this must be balanced with the education in fundamentals that will enable our graduates to adapt to the *next* technological breakthrough.

Constituent involvement in the EE/ECE program was informal in the past, and has become more formalized and regular over the past decade. The primary constituents are, and have been, our students, both current students and future students for whom we establish and improve our program. Our institution and curriculum seeks to serve a particular sub-group of potential students, those who are "talented" in the words of the WPI Mission, and those who are capable of benefiting from our educational approach. Given this set of prospective students, we have attempted to determine and to meet their needs. Additional information on our continuing process of constituent involvement is provided below.

Review of Constituent Involvement

The ECE department stays in touch with its constituencies by several means:

- Direct, two-way contact with individual constituents
- One-way contact with feedback solicited
- Indirect, via market studies, reports, etc.

<u>Prospective students</u>

The ECE department does not independently contact prospective students in a broad fashion. However, we do have significant contact via several mechanisms:

- Summer programs for junior high school and high school students (Camp Reach, Strive, Frontiers) involving intensive student-faculty contact over a period of 1 to 2 weeks,
- Campus visits by individual applicants and their parents, and departmental Open Houses, involving question and answer sessions as well as private meetings with faculty,
- High school visits, science fair participation, and similar activities by faculty.

WPI as an institution does devote considerable attention to surveys and focus groups with prospective students and their parents. One such study (the "Lipman-Hearne" Study) was recently completed. This study provides a profile of the expectations and desires of our applicant pool. As interesting and useful as this information is, it may not be directly translated into a curriculum.

Alumni

With almost 5000 living alumni, the EE/ECE programs have a rich pool of knowledgeable constituents to draw upon. Our principal means of staying in touch with Alumni is the annual department newsletter, “Transmissions,” supplemented to a growing extent by our web pages. Feedback is solicited in both media, and email is becoming popular to provide quick input. The recent initiative to move to an ECE major rather than EE has resulted in substantial feedback, mostly, but not exclusively, positive. Examples of this feedback will be available for the visitors. A recent addition (2001) to our formal alumni contacts is the annual ECE alumni award presentation and banquet, which draws a broad representation of alumni from the local region.

More formally, alumni input is solicited and collected via paper and web surveys. The ECE department initiated this effort in 1991 with a major survey of the classes of 1960, 1970, 1980, and 1998-90. This survey formed the basis of a major overhaul of the EE curriculum in 1992-93. Recently, WPI as an institution took over this effort, and conducted alumni surveys in 1999 and 2001. These surveys provide the principal quantitative data regarding evaluation of our Educational Objectives. Earlier surveys had been directed toward rather detailed comments on the curriculum, more related to Outcomes than to Objectives. The most recent survey was rewritten to relate to Objectives explicitly, and will form the model for future surveys.

Advisory Board

The ECE Advisory Board held its first meeting in November, 1985, and has met twice per year since that time. The board is composed of 12 to 14 members drawn primarily from industry, but with representation also from academia. Current membership is provided in Appendix 2-1. Guidance for our academic programs, both undergraduate and graduate, represents a major Board activity. The members are well placed in corporations of importance to the ECE department, including the computer, telecommunications, defense, and microelectronics industries. Following are topics related to the undergraduate program discussed at the past five Advisory Board meetings:

- May 3, 2002: Laboratory facilities, including the Studio Classroom and VLSI design,
- October 19, 2001: Board input on areas of emphasis with regard to improving undergraduate quality and external reputation; consideration of Educational Objectives,
- May 3, 2001: Board consideration of the level of support provided to faculty to further their professional development, research, and teaching goals,
- October 20, 2000: Board review of department Strategic Plan, including plans for introducing the ECE major, enhancing undergraduate education in information technology and optical communications,
- May 11, 2000: Board review of Educational Objectives and Program Outcomes.

Prior to the Fall, 2001 meeting the Board responded to a survey regarding their views on the importance of each aspect of our Educational Objectives. At the meeting held on October 19, 2001, the Board reviewed its response to the survey. These responses are summarized in Figure 2.2 and are discussed later in this report. The Board indicated its strong support for the new ECE major at its meeting of October 20, 2000. At the meeting of May 11, 2000, the Board reviewed the existing departmental outcomes and objectives, and indicated their agreement. However, the Board felt that the both statements were rather generic in nature, and included relatively little which specifically distinguishes the WPI EE program from those at other schools.

Faculty

Of course, all faculty are involved in delivering the EE/ECE curriculum on a day to day basis. Also, all faculty are involved in a substantive way with program assessment and evaluation. Formal means for collecting faculty input include participation on the Undergraduate Program Committee, the Projects Committee, ad hoc committees to review and recommend changes to portions of the curriculum, departmental retreats, and departmental faculty meetings, as well as their assessment input on their courses and other teaching activities. The department is sufficiently small (21 full time faculty) that the "committee of the whole" works well both for transferring information and for collecting individual input. Examples of minutes and special reports will be available for the visitors.

Students

Input from students is solicited in a formal way via student representation on the Undergraduate Program Committee, input from the student groups (IEEE, Eta Kappa Nu, and Women in ECE), senior surveys, and course evaluations. In addition to the annual senior surveys, aperiodic surveys on specific topics of the other class years are conducted. The involvement of students in the development of the ECE major has been previously described. Finally, the "open door" policies of all faculty and the department head results in a good understanding of student thinking and desires.

Corporations

The primary direct input from corporations is via the ECE Advisory Board. Also, the Career Development Center stays in close contact with a broad range of corporations and sponsors annual "Corporate Roundtables" which bring together faculty, CDC staff, and corporate representatives to discuss a particular topic of interest. This past year the topic was "Internships, Co-Op, and student project work at Corporations." Also, a substantial number (56% in 2000-01, the most recent available data) of our Senior Projects are sponsored by corporations. This puts the corporate project liaison in direct contact with the faculty advisor.

Graduate schools

The only continuing mechanism for input regarding graduate school needs has been via the ECE Advisory Board, and this link has been quite helpful. Three members of the Advisory Board in AY2001-02 represent academia, from Tufts, Olin, and Penn State. Our stated goal of preparing students for both immediate professional employment and for further study does result in conflicts and compromises in designing the curriculum, and having input from both "sides" is quite helpful.

Other sources

Finally, institutions such as the National Science Foundation, ASEE, the National Academy of Engineering, and the Boyer Commission devote time and attention to assessing the needs of the science and engineering professions, and to making recommendations for change in our educational system. We pay attention to those reports. The hallmarks of our program, including emphasis on outcomes, teamwork, communications skills, and student responsibility for learning are either based on, or supported by, these reports and recommendations. In fact, our program predates most of these reports[1].

Development and Review Process for the Educational Objectives

The departmental processes for determination of program objectives, and for their evaluation, have been integral parts of the departmental planning process, which has been formally conducted since 1984. This process is driven by the faculty, with substantial input from students (via membership on the Undergraduate Program Committee and consultation with the IEEE and Eta Kappa Nu student groups) and from the corporate community (primarily via our Advisory Board). Examples of the results of this work are represented above in the statements of department educational goals. Copies of documents related to department goals and the objectives-setting process will be available for the visit. The current departmental Strategic Plan is included in Appendix 2-2. Other documents will include reports documenting the change of our accredited major from electrical engineering to electrical and computer engineering, Advisory Board minutes, and minutes of the Undergraduate Program Committee.

The ECE faculty formally adopted its undergraduate assessment framework and slightly modified its program objectives on March 28, 2001. The framework (described in Section 3.1) links our outcomes first to performance criteria, and then to specific assessment tools.

The Undergraduate Program Committee oversees both policy and operational aspects of the undergraduate program, and identifies needs and opportunities for changes and program improvements. The major recent example of high-level changes (at the Program and Objectives level) is the recognition of the need to address the fact that “Computer Engineering” is now more than just a specialty within EE. This was in fact recognized by creating the new major titled Electrical and Computer Engineering that is seeking its initial accreditation.

This decision was reached after a substantial period of collection and analysis of data from our constituents, principally including students, employers, and faculty. Students overwhelmingly desired to have computer engineering explicitly listed as part of their degree, rather than choosing between EE and Computer Engineering majors. Extensive faculty discussions, reports, and retreats on the various possible means to deal with the ever-increasing breadth and depth of the ECE profession resulted in the design and implementation of the ECE major.

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[1] ***Reinventing Undergraduate Education***, the Boyer Commission, SUNY Stony Brook, 1998.
Shaping the Future, Advisory Committee to the NSF Directorate for Education and Human Resources, NSF98128, 1998.
Engineering Education for a Changing World, (The Green Report), ASEE, 1994.

Relation of Objectives to ECE Curriculum and Program Outcomes

The WPI degree requirements together with the ECE program distribution requirements, supported by academic planning and academic advising information produce a curriculum which supports our educational objectives. Table 2-1 illustrates the links between our objectives and our curriculum.

Table 2-1 Relation of Educational Objectives to Curricular Elements

Objective	Principal Relevant Curricular Components
Leaders of the electrical and computer engineering profession	Substantial independent work, including projects
An education which is strong both in the fundamentals and in state-of-the-art knowledge	Balanced selection of basic and advanced courses, substantial math/science requirements
Appropriate for immediate professional practice as well as graduate study and lifelong learning,	Balance of applications and theoretical courses, emphasis on independent learning, in projects and outside class
Effective leadership and informed citizenship	Substantial course and project work in humanities and social science, ***and*** relation of that work to the EE major
Technical professionals who possess the ability to communicate, work in teams, and understand the broad implications of their work	Requirements for major written documentation and oral presentation of project work, substantial teamwork experience, strong liberal education component

The ECE curriculum is described in detail under Criterion 4. The structure and content of the curriculum directly addresses our stated objectives. A process is in place (described below) to assure that all students complete the curriculum with appropriate standards of performance. Further, as described below, a system of ongoing evaluation is in place to collect information related to accomplishment of educational objectives over the longer term, to validate the performance of our curriculum against our educational objectives.

The curriculum and Program Outcomes should prepare students to demonstrate accomplishment of the Educational Objectives. Table 2-2 indicates the Outcomes that support each Objective.

Table 2-2 Relation of Objectives to Outcomes

ECE Educational Objectives	ECE Program Outcomes
strong in the fundamentals	3,4
strong in state-of-the-art knowledge	1,6
appropriate for immediate professional practice	1,5
appropriate for graduate study	4,8
appropriate for lifelong learning.	2,9
prepared for professional leadership	2,10
prepared for informed citizenship	2,10
develops the ability to communicate,	7
develops work in teams, and	5
develops an understanding of the broad implications of work	10,11

Outcomes:

1. Preparation for engineering practice, including the technical, professional, and ethical components
2. Preparation for future changes in electrical and computer engineering
3. A solid understanding of the basic principles of electrical engineering, computer engineering, and the relationship between hardware and software
4. An understanding of appropriate mathematical concepts, and an ability to apply them to ECE
5. An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills.
6. Demonstration of in-depth understanding of at least one specialty within ECE
7. An ability to communicate effectively in written and oral form
8. An understanding of options for careers and further education, and the necessary educational preparation to pursue those options
9. An ability to learn independently
10. The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI
11. An understanding of engineering and technology in a societal and global context.

Evaluation of Achievement of Objectives

The system used to evaluate the extent to which the educational objectives in Electrical and Computer Engineering are being met is described here. We have adopted the common view that ***Educational Objectives*** refer to characteristics and abilities demonstrated by our alumni in the initial years after completion of the EE program. We evaluate the achievement of these Objectives in three fundamental ways:

- Via data from our Outcomes Assessment process since our Program Outcomes should prepare graduates to demonstrate Educational Objectives.
- Via initial and continuing career success of our graduates
- Via a range of contacts with our alumni and corporate constituencies, principally including Alumni Surveys and Advisory Board input

Several time scales are involved in evaluation of objectives. First, we wish to determine that the curriculum is in fact providing an education which can be expected to lead to achievement of the stated objectives; second, we wish to verify that students are learning the desired aspects; third, and most significant, we wish to verify that our alumni are displaying results consistent with the objectives in their professional lives.

Following is a summary of the tools used:

- Primary evidence for accomplishment of Objectives:
    - Alumni Surveys conducted 2, 5, 10, and 15 years after graduation
    - Alumni database data: job titles, career paths,
    - Input from the Advisory Board members and other corporate contacts
- Evidence for accomplishment of Outcomes which leads to accomplishment of Objectives:
    - Section 3.6 under Criterion 3 describes the process and results of our assessment of the level of accomplishment of our program outcomes by students.

With respect to graduates of the ECE program, it is too early to conduct any analysis. However, since the ECE program represents an evolution of the EE program, we believe that presenting the following information which applies to past graduates majoring in electrical engineering is relevant.

Status and Program Improvement

Alumni Survey

Referring to Fig. 2-1, the overall results of a survey of EE alumni conducted in 2001 are reported. For the listed aspects, the respondents rated both the importance of the aspect and the preparation for that which they received at WPI. In reviewing these results we are interested in two different aspects: first, a determination of the relative importance which our alumni place on the various components of our Objectives; second, the alumni view of their preparation. With regard to program improvements, we pay the greatest attention to the areas of **high** importance in which the preparation is rated relatively **low**. It is also a matter of concern if our constituents

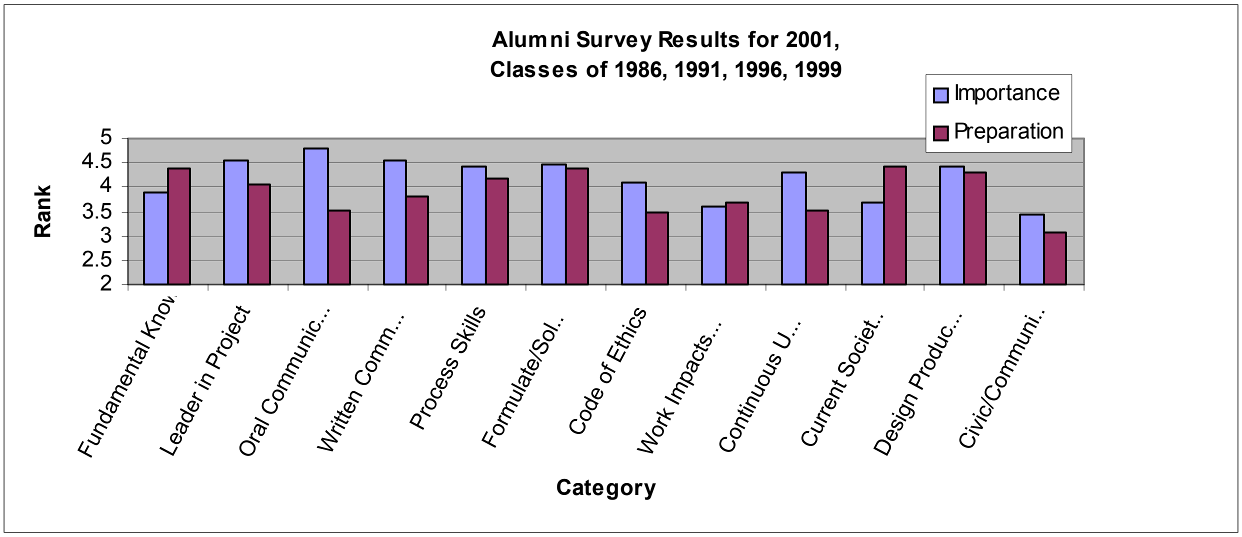


Figure 2-1 Results of survey of EE graduates of 1999, 1996, 1991, 1986.

(alumni in this case) rate an aspect of our Objectives as relatively unimportant, regardless of their view of the preparation in that element. The survey responses were collected on a 5 point scale; note that the zero to 2 range is suppressed in the figure. Overall responses were rather high, and we do not propose to establish numerical goals for performance in each category.

The following survey elements are primary for evaluation of our Educational Objectives:

- Fundamental knowledge
- Leader in project
- Oral and Written communication
- Code of ethics
- Work impacts society
- Current societal issues
- Design product/process/system
- Civic/community activities

The following elements are rated as approximately equal or higher in preparation than in importance, suggesting that no additional emphasis is needed at present:

- Fundamental knowledge
- Work impacts on society
- Current societal issues
- Design

Also, the "Work impacts on society" and "Societal issues" elements are ranked lowest in importance.

The following elements are rated as relatively high in importance, with relatively low preparation scores, suggesting that additional emphasis may be needed:

- Oral communication
- Written communication
- Leader in project
- Code of ethics

With all of the scores on these areas falling at or above 3.5 on a 5 point scale, we can conclude that this survey indicates that there are no serious issues with respect to accomplishment of these aspects of our Objectives. However, the faculty are working to strengthen student preparation in the areas listed. More details are provided under Criterion 3. In brief, the addition of EE 2799, Introduction to ECE Design, prior to beginning the senior project, and increased emphasis on ethical issues in courses and academic advising are expected to have a significant impact.

Respondents of the 2001 Alumni Survey were encouraged to provide written comments in four areas:

1. The most valuable part of their WPI education,
2. The area most in need of improvement,
3. Their student project experiences (projects are a particular focus of the WPI education),
4. Other areas.

Over 200 individual comments were received. These will be available at the visit. While it is difficult to extract statistically significant results from comments, the following appeared to represent the major areas of emphasis in each category. It should be noted that a given topic may be noted as a strength by one group of respondents, and as a weakness by another group!

1. Most valuable part of WPI education:
    - The project/teamwork experiences (by far the largest response),
    - Real-world technical education,
    - Good faculty, with large amount of student-faculty interaction,
    - Experience at attacking and solving problems.
2. Area most in need of improvement:
    - Increase in social/civic/ethical awareness,
    - More courses in state-of-the-art technology,
    - More emphasis on oral/written communication,
    - More diversity needed on campus in general,
    - More fundamentals courses and more advanced courses (apparent difference of opinion among respondents).

3. Comments on project work:
   - The technical/societal project (IQP) was felt to have been valuable in learning problem solving skills and teamwork by many respondents, but some felt it was of little value,
   - The senior capstone project (MQP) was generally viewed very favorably, for the experience in problem solving, design, and teamwork (from one respondent: "MQP – Learning how to work on a team. I failed miserably the first time. I reflect on that experience every time I'm assigned to a team."),
   - Regarding the Humanities ("Sufficiency") project, the majority of the comments indicated that the respondents believed it had little value to them, but some quite positive comments also were made (such as "I deal cross culturally very often, and my work on the Sufficiency has helped a lot.").
4. Other comments
   - Overall, 52 percent of these comments were positive (often very positive, such as "The availability of WPI professors was great," "I could not have picked a better school for my BS than WPI," "I treasure my WPI experience. It has given me many advantages over my contemporaries from other institutions," "When I attended WPI, I never really appreciated what a good college it was," and "WPI rocks.")
   - Twenty-six percent of the comments indicated some need for improvement, but not all of these related directly to the academic program. The areas where improvement was felt to be needed were widely varied, ranging from the perceived need to improve the basic math education, to the need to increase WPI's national reputation, to excessive requests for alumni contributions. No specific item was noted by more than one or two respondents.
   - Twenty-two percent of the comments were neutral, on topics such as the alumni participation in reunions.

Following is a comment from the survey which encapsulates much of what we strive for at WPI and in ECE:

> *"WPI advertised, and MORE than delivered on its promise to set the foundation for a lifetime of learning. Under the original PLAN, modified somewhat by the time I graduated in 1986, students were encouraged to experiment and pursue self learning and, in many ways, downright encouraged to take measured risks - all values very highly prized in today's workforce. That approach focused on outcomes rather than methods - allowing what we now know to be "out-of-the-box" thinking. The lack of a prescribed curriculum planted the seeds of a can-do attitude that I see in myself as well as a number of colleagues who are also WPI alums. The technical knowledge gained in the process remains useful to this day - but the move valuable 'take-aways' of the WPI education are the lack of fear of the new and different, and the confidence to tackle whatever may come."*

While no conclusions can be drawn from one comment, it does serve to highlight a key question: "Is the ECE program meeting the needs of its constituencies?" The alumni responses obviously represent the alumni constituency, and furthermore they bear on two other constituencies. These respondents were students in the past, and hence can reflect on the impact of their education on their lives and careers. Also, many are employed by our corporate constituency. The general level of satisfaction, together with suggestions of areas where more can be done, indicates that there is certainly no significant mismatch between our students' needs and the education which they receive. It is interesting that an area for improvement mentioned with some prominence in the text response section (social/civic/ethical awareness) is ranked relatively low in importance in the numerical response section. This may mean that a ***small*** number of alumni feel ***strongly*** about this topic, and hence write a comment. As faculty, we do consider this area to be an important ***need*** of our students, and we are considering ways to reduce the mismatch. As mentioned previously regarding the numerical responses, and reinforced by the textual responses, we can conclude that our educational objectives are being met.

The major concern with respect to reliance on the Alumni Survey for a significant portion of our Objectives evaluation is the low return rate, ranging between 10% and 20% for each class year. We are evaluating our method of administration (currently the web exclusively), means of contacting alumni (primarily email) and possible inducements such as a prize awarded from among those who the survey, to increase participation.

Alumni Career Data

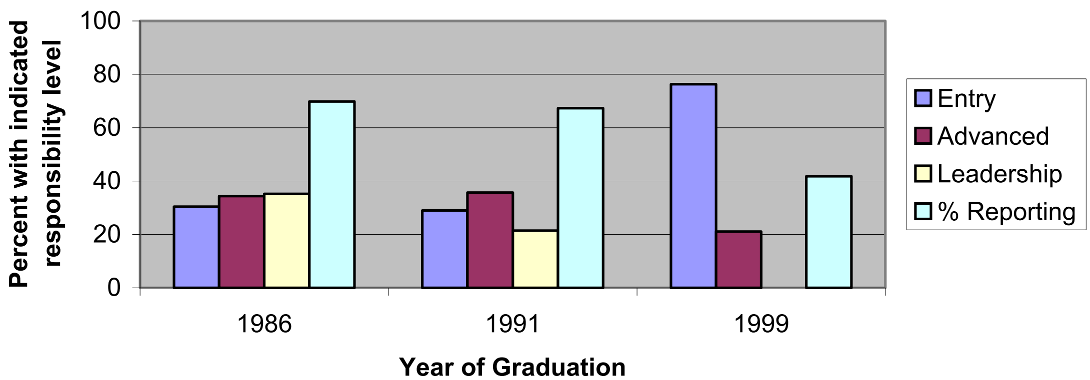
The WPI Alumni Association keeps in relatively close touch with our graduates, which results in useful information regarding overall career paths and career success. This provides a broad look at our graduates in successive years post-graduation. A review has been conducted of the BS graduates from years 1999, 1996, 1991, and 1986. Data on job types are presented in Table 2-1. It should be noted that under the best circumstances, the alumni data base will lag the actual status of our graduates due to delays in reporting. Further, some graduates cease updating their information, so the tracking of their career progress will cease at some point. Nevertheless, trends should be evident from analysis of these data. In coding this data, positions such as "systems engineer" at a corporation which engages in ECE activities was included in the "ECE positions" column. Related professions included such jobs as technical marketing positions, fighter pilot, etc. Unrelated professions included such jobs as personnel director. Inappropriate positions, given our educational objectives would have included jobs such as engineering technician. None were found.

Table 2-1 Data on Professional Status of EE Alumni

Graduation Year	**Total #**	**# with data**	**# in ECE positions**	**# in related profession**	**# in other profession**	**# consultants**	**# in inappropriate positions**
1986	179	125	80	8	10	2	0
1991	104	70	58	5	5	1	0
1999	99	38	34	0	1	3	0

Figure 2-2 shows results of an analysis of level of responsibility for the same group. Entry level jobs carried such titles as electrical engineer. Advanced level jobs carried titles such as Senior engineer. Leadership positions carried titles such as project manager. These codings are certainly imprecise, but the same algorithm was applied to all class years. The desired progression toward advanced and leadership positions as time since graduation increases is evident.

Figure 2-2 EE Alumni Database Results for the Classes of 1986, 1991, 1999



Advisory Board Input

As described above regarding constituent involvement, the ECE Advisory Board addresses at least one topic related to the undergraduate EE program at each of its twice-yearly meetings. For the Fall meeting of 2001 the Board received surveys requesting their input on the items listed in Figure 2-2. The members were asked to rate the importance of each item for a beginning engineer, and also to rate the actual preparation which they have observed in WPI graduates, if they have had that experience. A five-point scale was used. Regarding importance, 1 represented "irrelevant," 2 represented "optional (small value)," 3 represented "desirable," 4 represented "highly desirable," and 5 represented "essential." The results with respect to importance are shown in Fig 2-2. There is a considerable range, with two aspects (Global and General Education) ranked between "optional" and "desirable."

In general the Advisory Board responses are in agreement with the alumni surveys. Both indicate a significant range in perceived importance among the aspects in our Objectives (and Outcomes) statements. In particular, the general education and societal components are seen as less important than the disciplinary components, ranking between "optional" and "desirable." This result is perhaps not surprising since the survey was conducted in the context of entry-level performance as an engineer. We (the faculty) interpret these results to mean that the core disciplinary components of the electrical engineering education are pre-eminent **and** that other aspects, such as general education, global and civic awareness, form significant additional components of students' education which are valuable for life as well as for technical performance.

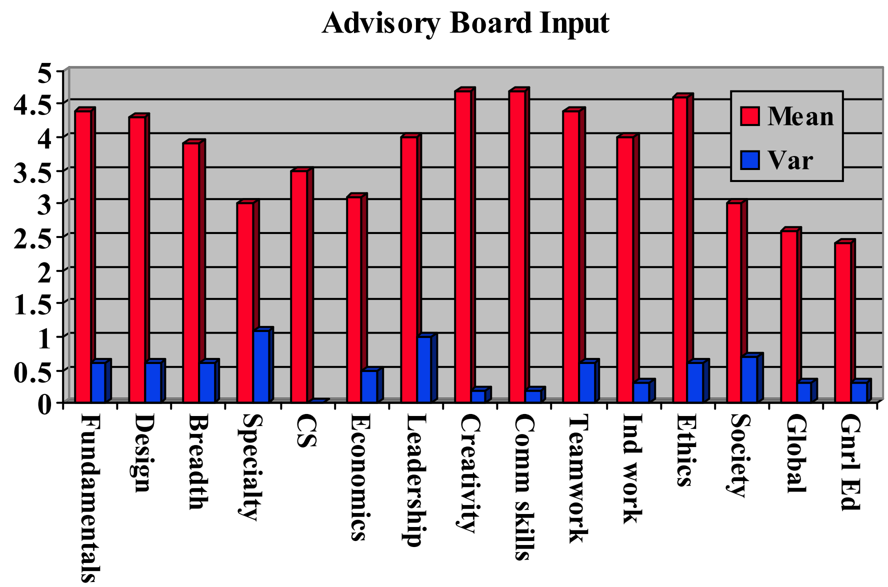


Figure 2-3 Advisory Board input regarding *importance* of major aspects.

Placement Data

Given that our Objectives and Outcomes are relevant to our corporate constituency, the success of our graduates in job placement is one indication of their success in meeting our Outcomes and likely longer-range success in meeting our Objectives. Table 2-2 presents placement rates and starting salaries for BS graduates for the past six years.

These data are very positive, both with regard to placement rate and to the starting salaries of our graduates compared to the national average.. Further, a review of the types of corporations for which our graduates went work indicates a match with the faculty's expectations. However, preliminary data for the 2001-02 academic year regarding placement success is much less positive, reflecting the highly cyclic nature of the high technology sector of the economy. This is no doubt due to the drastic contraction in the electrical and computer engineering industry, particularly in the telecommunications and networking related aspects which are major components of New England's economy. Overall, we can conclude that our graduates do meet the needs of industry for entry-level electrical and computer engineers since placement is good during normal and high-demand periods. Given the cyclic nature of high tech, no change in program objectives and outcomes will guarantee a job offer when there are few open positions in industry. This realization is presently causing the ECE faculty to think more of our students' needs than of industry's needs, in an attempt to lessen the dramatic impact on graduates' initial careers depending on when in the economic cycle they happen to graduate.

Table 2-2
EE Undergraduate Placement Data

Class	Percent Placed	Average salary	National Average
2001	92%	$56,600	NA
2000	99	$51,600	$48,700
1999	95	$47,500	$45,200
1998	96	$44,700	$42,900
1997	95	$43,000	$39,500
1996	95	$39,200	$38,400

Conclusions Regarding Objectives

While a significant amount of objective data is available regarding the manner and degree to which our graduates achieve our Educational Objectives, it is not possible (or appropriate) to attempt to quantify each aspect. Via the program outcomes, as well as the quality of the entering students and the overall educational environment during their college experience, we have confidence that our graduates are ***prepared*** to accomplish our objectives. Alumni surveys, reviews of alumni career data, and input from our corporate constituents provides evidence that our graduate ***are*** in fact accomplishing our objectives.

Criterion 3. Program Outcomes and Assessment

3.1 Outcomes of the Electrical and Computer Engineering Program

The ECE program was developed from, and is similar to, the existing Electrical Engineering program. This section of the report will contain references to results obtained for the graduates of our EE program, and will be noted as such. Differences between EE and ECE assessment plans will also be noted.

Following are the outcomes of the Electrical and Computer Engineering program as adopted by the ECE faculty on March 28, 2001. Any wording that differs from the EE outcomes is given in italics.

Based on the stated objectives, students will achieve, within a challenging and supportive environment, the following specific educational outcomes:

1. Preparation for engineering practice, including the technical, professional, and ethical components
2. Preparation for the future changes in electrical *and computer* engineering
3. A solid understanding of the basic principles of electrical engineering*, computer engineering, and the relationship between hardware and software*
4. An understanding of appropriate mathematical concepts, and an ability to apply them to E*C*E
5. An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills.
6. Demonstration of in-depth understanding of at least one specialty within E*C*E
7. Demonstration of oral and written communications skills
8. Understanding of options for careers and further education, and the necessary educational preparation to pursue those options
9. An ability to learn independently
10. The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI
11. An understanding of engineering and technology in a societal and global context

In order to execute our assessment plan, the following forms the twelfth outcome -- for the department, not its students:

12. A challenging and supportive environment

It should be noted that the ECE faculty felt it very important to include this twelfth outcome because the "ends" of an enterprise are not necessarily the only element of significance -- the means (a challenging, supportive environment) are also critical.

These objectives and outcomes are in agreement with the overall Institute Mission and Goals, and put the WPI statements in the context of electrical and computer engineering.

3.2 Relation of Program Outcomes to ABET Requirements

The twelve WPI ECE Program Outcomes encompass all of the ABET Outcomes. The mapping is not always one-to-one because of the need to implement Outcomes which match WPI's Mission and Goals. Also, some of the ABET Outcomes represent higher priorities of the WPI ECE department than others, but all are included to an appropriate level. Table 3-1 indicates the relations between the two sets using ABET's A through K scheme.

	ABET Criteria 3, Educational Outcomes										
	A	B	C	D	E	F	G	H	I	J	K
ECE Outcomes	3,4,6	4,9	5	5	5	1	7	10,11	2,8	11	1,6

Table 3-1: Relations between ABET A-K and WPI ECE Program Outcomes

The Outcomes from ABET Criterion 3 are listed here for reference:

A. An ability to apply knowledge of mathematics, science, and engineering
B. An ability to design and conduct experiments, as well as to analyze and interpret data
C. An ability to design a system, component, or process to meet desired needs
D. An ability to function on multi-disciplinary teams
E. An ability to identify, formulate, and solve engineering problems
F. An understanding of professional and ethical responsibility
G. An ability to communicate effectively
H. The broad education necessary to understand the impact of engineering solutions in a global and societal context
I. A recognition of the need for, and an ability to engage in life-long learning
J. A knowledge of contemporary issues
K. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

3.3 Relation of ECE Program Outcomes and ECE Educational Objectives

The Program Outcomes are chosen so that they are demonstrable by students upon graduation, whereas the Educational Objectives are intentionally more broad, long range, and as a consequence somewhat more difficult to measure quantitatively. Nevertheless, the Outcomes were chosen to provide an education which should lead to demonstration of the desired Objectives. For example, the "Professional Leadership" Objective is supported by the Outcomes which seek to assure a technically competent graduate (Outcomes 1, 3-6). The rest of the relationships between Outcomes and Objectives are given in Table 3-2.

ECE Educational Objectives	ECE Program Outcomes
strong in the fundamentals	3,4
strong in state-of-the-art knowledge	1,6
appropriate for immediate professional practice	1,5
appropriate for graduate study	4,8
appropriate for lifelong learning.	2,9
prepares for leadership	2,10
prepares for informed citizenship	2,10
develops the ability to communicate,	7
develops work in teams, and	5
develops an understanding of the broad implications of work	10,11

Table 3-2: Relations between WPI ECE Educational Objectives and Program Outcomes

3.4 Overview of the Curricular Development and Assessment Process

Development, implementation, and assessment of the Electrical and Computer Engineering Program are the explicit responsibility of the ECE Undergraduate Program Committee (UPC). This committee consists of 10 faculty: the committee chair, the department head ex officio, one representative of each of the ECE emphasis areas (fundamentals, computer engineering, electromagnetics, systems and controls, communications, signal processing, power systems, analog microelectronics), and one student member. This committee is assisted by the Projects Committee which oversees this crucial part of the ECE program. The UPC may appoint ad hoc committees as appropriate to address specific topics.

Departmental ad hoc committees may be formed to address major issues. A recent example is the ad-hoc committee which considered the accredited ECE major. All recommendations for changes in the undergraduate program are first voted by the UPC, and then are discussed and acted on by the entire ECE faculty. Also, major changes (such as the change to an ECE major) are discussed with the departmental Advisory Board and with the students. Minutes of the UPC meetings and ad hoc committee reports will be available at the visit.

The first step of our curriculum development has been to identify the kinds of evidence students could present to show that they have achieved a specific outcome. We then planned for ways that students can prepare for and then exhibit this evidence, multiple times whenever possible. This planning also included bringing the outcomes into the first two years of a student's program when appropriate.

Our approach to assessment has been to provide mechanisms for determining student performance throughout their academic program, to report the findings in a timely and constructive way, to determine and obtain relevant comparisons for the data received, and to provide anonymity to students as they fill out survey tools. Whenever possible, we have moved to a five-point scale, from 0 to 4.

The overall departmental process for curricular planning, assessment of results, and quality improvement is illustrated in Figure 3-1 It shows our systematic approach to assessment and program improvement, providing exchanges of information among the faculty (as committee members, course instructors, project advisors and academic advisors), students (in courses, on projects and during their extra-curricular activities), and the assessment tools (that address all of these aspects). The assessment tools are administered and the reporting done in a timely way so that the process is part of our culture, not appended to it. Details on the specific assessment tools can be found in the next section.

3.5 Outcomes Assessment

The guiding principles for the work reported here are based on the following steps for developing an assessment plan[2]:

1. Identify goals,
2. Identify outcomes,
3. Determine evidence,
4. Specify assessment methods,
5. Develop connections between evidence and assessment,
6. Determine feedback channels,
7. Conduct assessments,
8. Results of Feedback Channels

3.5.1 Identify Goals and Objectives

The result of this process can be found in the section on Criterion 2 of this report, where the Mission and Goals of WPI and the objectives for the EE program are stated.

3.5.2 Identify outcomes

Our program outcomes can be found in Section 3.1 of this report.

3.5.3 Determine evidence

We have identified the ways that our students and program can provide with regards to the different program outcomes. Most of this evidence are the outcomes of coursework, MQP, and IQP, which in turn constitute degree requirements. Other evidence is provided through student surveys and internal reporting. A listing of the evidence identified for each program outcome can be found in Appendix 3-1. The mechanisms that assess this evidence are described below in Sections 3.5.4 and 3.5.5.

[2] "Stepping Ahead: An Assessment Plan Development Guide," Gloria Rogers, Jean Sando

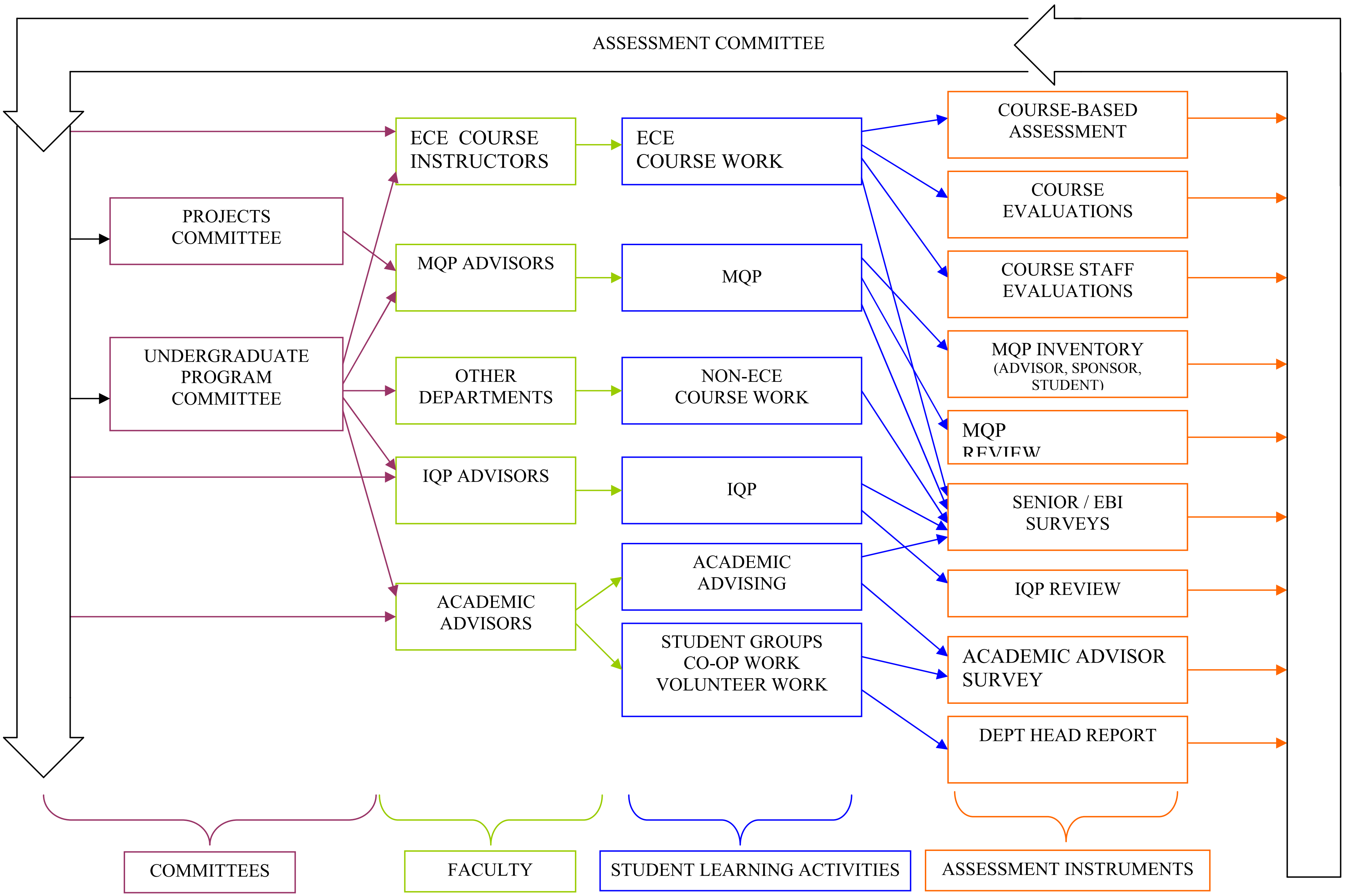


Figure 3-1: Diagram of the processes for the assessment, reporting and feedback related to Program Outcomes.

3.5.4 Specify assessment methods

This section describes the assessment tools referred to in Figure 3-1. The abbreviations used for each tool are given in boldface, and the list is sorted alphabetically by the abbreviation.

Academic Advisor surveys (**AA**) are conducted by (not on) academic advisors. Since they are performed by ECE faculty, they will be performed independent of whether the student is an ECE or EE major. They are performed during Academic Advising Day, a day-long event in February of each year when classes and extra-curricular activities are cancelled in order that students can meet with their advisors on a one-to-one basis. This type of survey was performed for the first time in February 2001 on student participation in professional organizations, and a second time in February 2002 on preparation for, interest in and knowledge of graduate school opportunities. For a given topic, four-five questions are developed that will be an both appropriate and not excessively time consuming. The surveys are presented to the faculty before Academic Advising Day to explain and refine the tool. Forms are prepared specific to each advisor to ease scoring. The return rates are 28% and 38% for 2001 and 2002 (respectively). An example of the form used and the results can be found in Appendix 3-2.

WPI course evaluations (**Course**) include data collected for the entire department (without distinction for EE or ECE students), and results presented are the percentages of responses that are Strongly Agree or Agree. The total number of responses for each question have excluded Not Application (NA) responses for lab/facilities related questions. Values are for all ECE courses in an academic year, and are compared to courses from other WPI engineering departments in the same academic year. The return rates vary from one course offering to the next, but are generally fairly high because the forms are distributed during a lecture. An example of the form used and the results can be found in Appendix 3-3.

The department head (**DH**) will develop an annual report on the support mechanisms based on information provided by the directors of those support mechanisms. An example of this report can be found in Appendix 3-4. These will continue to be performed as is because they are not dependent on whether the students involved are ECE or EE majors.

Educational Benchmarking survey of seniors (**EBI**) has been performed at WPI and other schools in 2000, 2001 and 2002. In some cases, results are presented along with our senior survey results from previous years for comparison. The original rubric used was 1 to 7. In order to present it on a scale consistent with other assessment tools, scores are rescaled to a range from 0 to 4, with 4 being the most positive; Surveys collected from 57 of our 100 ’00 graduates, 52 of our 100 ’01 graduates, and ? of our ? ’02 graduates. Data is available from all of the schools that participated in the study. Charts are shown comparing WPI to "Select 6" (MIT, Carnegie Mellon, Stevens, Boston U., Northeastern and Vanderbilt) and "Carnegie Class" (Dartmouth, George Mason, TX A&M Kingsville, U. of CO at Denver, U. of TX Dallas, FL Atlantic, Stevens, Texas Christian, U. of New Orleans, WPI). An example of the form used and the results can be found in Appendix 3-5. The data collected thus far is for EE majors only, and plans are under discussion as to how often this will be implemented in the future – either every year or on a biennial basis.

Course-based assessment (**EEXXXX**) refer to assessments done in ECE courses, where XXXX refers to the course number. Our department has targeted seven courses for course-based assessment (EE2011, EE2022, EE2201, EE2311, EE2111, EE2799, and EE2801). We developed a set of course outcomes which remain the same for each course offering. The actual coverage of material in each course will be more comprehensive than this set. Course instructors have the tasks of matching evaluated student performance (such as exam questions) to each course outcome and keeping student-specific data on performance. Copies of the assignments and examples of student work are saved and reviewed by another faculty member familiar with the course but not the course instructor. An example of one spreadsheet collected during a course offering can be found in Appendix 3-6. This assessment tool will continue as is because it includes the topics necessary for the EE and ECE programs, with additions included for discrete math topics.

Interdisciplinary and Global Studies Division (**IGSD**) report shows the distribution of EE students who complete off campus and/or sponsored projects and other assessments of the IQP. A set of recent findings can be found in Appendix 3-7. These statistics will continue to be broken down for our department's majors (EE and ECE).

MQP assessment (**MQP**) is done in a variety of ways, appropriate given the importance of this degree requirement. Since 1999, the project advisor and students are asked to complete MQP inventories near the end of each project. A campus-wide effort was undertaken in 2000 to ensure that departments were collecting the same core of information; items were added to the inventory to make it consistent with the campus-wide form. The current version of the forms can be found in Appendix 3-8. Students are asked if they give permission to share their inventories with the project advisor. If the project is sponsored, then the project advisor is urged to ask the sponsoring organization to complete a shorter MQP inventory (found in Appendix 3-6). Tabulations of some of the data collected can be found in Appendix 3-6.

Separate from these inventories, a MQP review committee provides evaluations on a range of topics. The MQP review committees have been operating biennially since 1997. A copy of their latest report can be found in Appendix 3-9.

MQP teams are required to do an oral presentation, and these presentations usually occur on one of two department-wide project presentation days. Oral presentation skills are assessed during these days by faculty in attendance. An example of one forms used and results can be found in Appendix 3-10.

These assessments will continue for the ECE program as items are included in the EE development that are appropriate for the ECE program.

Senior survey (**Senior**) is performed by the ECE department annually since 1996.). An example of the form used and the results can be found in Appendix 3-11. Changes over the years have reflected that a number of the questions have been answered by the EBI survey, and others have been added to provide a more complete assessment of the students' experience. This tool will continue in the future, and parts of the EBI survey will be replicated internally for EE and ECE students to provide multiple years' of data.

ECE TA and senior tutor evaluations (**Staff**) are completed by course instructors and collected by the department. An example of the form used and the results can be found in Appendix 3-12. These will continue to be performed as is because they are not dependent on whether the students involved are ECE or EE majors

Undergraduate Program Committee Review (**UPC Rev**) will take place on an annual basis regarding the current graduation requirements and determine how specialized a students' program could potentially be. In addition, UPC will obtain statistics on the completion of terminal courses which have been identified for each subdiscipline. This review will be identical for the EE and ECE programs.

3.5.5 Develop connections between evidence and assessment

There are two important layers of our assessment program:

1. the links between the outcomes and the ways in which students can provide *evidence* that they have achieved the outcome
2. the links between this evidence and assessment methods

An ECE framework (modified from the EE framework) (detailed in Appendix 3-13) for the assessment program was approved by UPC and then by the ECE faculty on October 17, 2001. It was agreed that it would be a *framework* for assessment so that any minor changes need not be approved by UPC before they are implemented. Some important features of this framework is that it describes where the assessment for each kind of evidence (and in turn each outcome) is performed.

3.5.6 Determine feedback channels

A general overview of the feedback channels has been shown in Figure 3-1. Table 3-3 details when and to whom the assessment results are to be reported. Oversight of the assessment reporting is provided by the ECE Assessment Committee.

Effort has been made to use the web for the paperless submission of information, presentation of data, and archiving. The main ECE Department assessment webpage is

https://www.ece.wpi.edu/resources/abet/

and from there one can find the electronic MQP inventories for faculty, students and project sponsors, reports, etc. Please note that access to any sensitive material has been restricted to ECE faculty and our ABET visitors.

Assessment Method	**Performed When**	**Reported To Whom**			
		UPC	ECE faculty	Course instruc-tors	Projects Comm.
Academic Advisor surveys	One-topic out of the total number will be explored by academic advisors annually each Academic Advising Day	X	X		
Course Evaluations	Statistics compiled biannually	X	X		
Course-based: EE2011, EE2111, EE2201, EE2801	Every A, C and D term (for EE2011)	X	X	X	
Course-based: EE2022, EE2311, EE2799	Every B and D term	X	X	X	
Course-based: summer review	Summer of odd-numbered years for EE2011, EE2022, EE2111; Summer of even-numbered years for EE2311, EE2201, EE2799 and EE2801. Examples can be found in Appendices 3-14 and 3-15	X	X	X	
Department Head Reports	Annually	X	X		
EBI/Senior Survey	Every D term	X	X		X
IGSD Report	Annually	X	X		X
MQP inventories	Every B and D terms	X	X		X
MQP review	Summer of odd-numbered years	X	X		X
TA and senior tutor evaluations	Every term for every course with an assigned TA and/or senior tutor	X	X		
UPC Report	Annually	X	X		

Table 3-3: Reporting and time table for assessment tools

3.5.7 Conduct assessments

The assessment plan has followed the framework and schedule presented in earlier sections of this report *for EE students*, and we plan to do the same for ECE students. Much of the numerical results for EE students can be found in Appendices 3-2 to 3-12. We have decided to implement the majority of our reporting aspect of the assessment plan by organizing the results of the various assessment tools into reports on individual outcomes rather than reporting on the assessment methods separately. This has allowed easier determination of the larger picture and recommendations to address any problems uncovered. The most recent set of these twelve reports are provided in Appendices 3-16 to 3-27. The reports include recommendations and action items at the beginning of each report. For detailed information about a specific assessment tool, check the corresponding Appendix (3-2 to 3-12).

3.5.8 Results of Feedback Channels

This section documents *some* of the results that have been attained through our process of assessment, reporting, and action, mostly aimed at the EE program, but whose positive effects will carry over to the ECE program

- Assessment of the MQP in '97-99 showed room for improvement in the area of demonstration of knowledge of contemporary issues (refer to Appendix 3-22). To meet this challenge, two undergraduate courses were developed. EE3703 "Real-Time Digital Signal Processing" was developed and offered as an experimental course in 2000-01 and 2001-02, and adopted as a permanent course for offering initially in 2002-03. This course provides a basic introduction to the principles of real-time digital signal processing (DSP). EE3711 "Introduction to Electro-Optics" was developed as an experimental course in 2001 and will offered again in 2002. This course introduces students to the important field of photonic devices and their application.
- An ad hoc Curriculum Review Committee (CRC) was formed in 1998-99. The charge to the committee was as follows:
    - Review the existing ECE curriculum in light of the department's educational objectives, and recommend any necessary course changes,
    - Consider computer engineering-engineering-specific issues, such as changing the major to Electrical and Computer Engineering, or offering a separate Computer Engineering major,
    - Consider other related curriculum issues that may arise, such as changing distribution requirements for the degree,
    - Consider assessment issues as related to any proposed curriculum changes.
- The committee gathered information from the ECE Faculty, ECE , ECE Alumni, and compared our program to other universities. The ECE faculty survey identified the following problems with the existing ECE Curriculum, including that the existing set of core courses was too large and unworkable. The proposed (and later accepted) curriculum reduces the core by one course, repackaging material from EE2013 and EE2014 into EE2111 and EE2112. A new design course, EE2799 (also described in the next bullet item) was planned to draw on the background material from all four core courses, so students see the benefits of taking these courses.
- While our MQP program has always been successful to a large degree, some aspects that should be addressed by a majority of our projects have been insufficiently represented. These include economic ehtical, sustainability and manufacturability considerations (refer to Appendix 3-16). To meet this challenge, EE2799 was developed in '99-00.

Fundamental steps of the design process are practiced, including the establishment of objectives and criteria, synthesis, analysis, manufacturability, testing, and evaluation. Course-based assessment was developed to measure how well EE2799 is meeting some of these goals – specifically student-specific data is retained for student's ability to:

- Demonstrate knowledge of the steps involved with the engineering design process,
- Demonstrate the ability to apply the engineering design steps to the decomposition, solution and implementation of an unbounded design problem,
- Demonstrate an understanding of the organizational issues associated with engineering design,
- Demonstrate an understanding of the relevance of ethics, reliability, safety and regulatory issues into the design process,
- Demonstrate a working knowledge of the financial, schedule, legal and other administrative elements of the design process,
- Demonstrate the ability to effectively use written communications to report project status and results,
- Demonstrate the ability to effectively use oral communications to report project status and results.

- The questions about academic advising recently added to the senior survey showed that faculty could do more to understand student's personal growth and that more information should be provided to students. A successful faculty workshop was held in January 2002, led by the Director of WPI's Counseling and Student Development. Academic advising information is broadcast to the community through targeted student meetings and the web.
- Since the start of the senior surveys in '96, seniors showed that they gave low ratings for the value of their CS courses and their ability to write software. EE2801 (Foundations Of Embedded Computer Systems) was introduced to meet this needs. It introduces the assembly language programming concepts that are needed to develop microprocessor and microcontroller-based computer systems without needing the CS course background.
- Reflection on an earlier version of the MQP inventories showed that the important characteristic of the ability to use math was lumped together with mathematics, science and engineering. The inventories were changed by adding a separate question regarding math. Appendix 3-15 showed that there was room for improvement in student math skill, and an analysis of our course offerings revealed that discrete mathematics was an area lacking in depth. Topics on discrete math were added to EE2022 in '01-02.
- Data showed that students would like and need more information on opportunities in graduate school. A Graduate Research Day (highlighting activities of our current graduate students) was held in Spring '02 at a time and location conducive to undergraduates participating in the activities. More programming is planned for the 2001-2002 academic year.

- Feedback from some faculty members revealed that the meaning of 'contemporary issues' in the MQP Inventory (see Appendix 3-6) lacked clarity. This has recently been addressed – see Appendix 3-28: Clarification of 'Contemporary Issues'.
- The department has continued to support the student groups, in particular contributing to the creation of a new student space sponsored by the "Women in ECE" group.

3.6 Completion of Program Outcomes

Since the ECE program has just two graduates, it is not appropriate at this time to make broad statements about the statistics related to our ECE graduates. Therefore, we have reported below the results for our EE program graduates.

The Outcome Reports (in Appendices 3-16 to 3-27) are a systemic evaluation of our program, organized to look for strengths and weaknesses. This section looks at the data from a different standpoint to answer a different question – on an individual student basis, is our program meeting its desired outcomes? This analysis is documented below for each of the twelve EE program outcomes. References are made to assessment results – which can be checked by looking at the appropriate appendix for the assessment tool or the appendix for the corresponding outcome report.

Our assessment of MQPs by advisors is used throughout this section. This is done by examining the percentage of projects that have a given quality at least to a 'somewhat' extent, and the percentage of student performances' judged to be on a level of 2 out of 4 -- see Appendix 3-8 for rubric definitions. These percentages are reported below for the data received for 00-01 and 01-02.

The following sections also show the corresponding ABET Criterion, listed at the beginning of the appropriate paragraph. In some cases, the ABET Criterion are mapped to more than one of our EE program outcomes, as explained in Table 3-1.

3.6.1 Outcome 1: Preparation for engineering practice, including the technical, professional, and ethical components

The ECE program outcome #1 is a combination of three streams: technical, professional and ethical.

ABET Criterion 3K: While the technical aspects are also parts of other outcomes, the assessments from the MQP advisors show that 98% in '02 and 100% in '01 of our MQPs had the quality of using modern engineering tools for engineering design and analysis. 95% in '02 and 100% in '02 of the students were able to perform at a minimally-acceptable level. This means that this sub-outcome is clearly met.

ABET Criterion 3F: Smaller percentages of the projects drew upon the quality professional and ethical responsibility (76% and 88%), but 95% of the students performed at a level of 2 out of 4. Although the results for EE2799 show that this sophomore-level course is not always resulting in appropriate student performance on professional and ethical components, the MQP assessment shows that students as a group are meeting this outcome.

In summary, our program of EE2799, IQP and MQP experiences are allowing students to meet these ECE program and ABET outcomes.

3.6.2 Outcome 2: Preparation for future changes in electrical and computer engineering

ABET Criterion 3I (partial): Through the EBI survey, seniors report highly on the degree to which their engineering education enhanced their ability to recognize the need to engage in lifelong learning. Although student participation in professional organizations is lower than it could be, but the percentage increases from 48% to 72% if one looks at seniors only. It is encouraging to see our graduating seniors committed to learning, the key component to preparing for future changes.

3.6.3 Outcome 3: A solid understanding of the basic principles in electrical engineering, computer engineering, and the relationship between hardware and software

ABET Criterion 3A (partial): Appendix 3-4 details the course-based assessment process, which is the basis of our outcomes assessment for understanding basic principles of EE. Examining only the ’01 and ’02 EE graduates, the overall, average success rate is 75%, meaning that of the outcomes attempted by a given student, he/she performed at a level of 3 or 4 (“Applies appropriate strategy or concepts without significant errors” or “Demonstrates a complete and accurate understanding of the important concepts”) 75% of the time on average. The standard deviation is 20%. The histogram in Appendix 3-4 shows that the distribution is narrow and (in a positive sense) skewed to the right. 16 of the 84 students (19%) successfully achieved all of the course outcomes attempted, and only 9 students 11% achieved less than 60%. In an ideal world, this success rate would be 100% -- but 75% means that this outcome is being met in a minimal sense. It is worth commenting that the data set for this particular set of measurements will be larger as more students take these introductory courses now that course-based assessment is in place.

3.6.4 Outcome 4: An understanding of appropriate mathematical concepts, and an ability to apply them to ECE

ABET Criterion 3A (partial): The MQP data shows that 94-99% of our MQP projects require that students perform analysis, and 93-97% of the students are performing at least a minimal level. Other results are also high, although mathematics is often assessed along with other qualities (such as science and engineering).

ABET Criterion 3B: Similarly, the MQP data for analyzing and interpreting data show that 98-100% of our MQP projects require that students perform these tasks, and that 81-94% of the students are performing at least a minimal level.

These results (along with others reported in the appendices) demonstrate that our students are meeting these ECE program and ABET Criterion 3 outcomes at a fundamental level

3.6.5 Outcome 5: An understanding of the engineering design process, and ability to perform engineering design, including the needed teamwork and communications skills

ABET Criterion 3E: Although the results for EE2799 show that this sophomore-level course is not always resulting in appropriate student performance on the demonstration of the knowledge of the steps involved with the engineering design process, the MQP assessment shows that 99-100% of the MQPs had the quality of "identify, formulate and solve engineering problems," and 95-100% of our students achieved this evidence.

ABET Criterion 3C: Similarly, 98-100% of the MQPs required the ability to design a system, component or process to meet design criteria, and 93-100% of our students were able to do this in their MQP. Only a small fraction of the projects assessed indicated negligible content from the set of economic, environmental, sustainability, manufacturability, ethical, health & safety, social, political considerations.

ABET Criterion 3D: 92% of our students are working with students from other departments in performing IQP's, indicating that the IQP is satisfying our desire to provide a multidisciplinary experience for almost all of our students. Our senior surveys (internal and nationally-normed) show that our seniors assess themselves very well on this quality (on average no less than 3 on a scale from 0 to 4, with 4 being the most positive).

Overall, these ECE program and ABET Criterion 3 outcomes are being met by a preponderance of our students.

3.6.6 Outcome 6: An in-depth understanding of at least one specialty within ECE

ABET Criterion 3A and K (partial): Appendix 3-17 shows that the MQP experience along with our upper-level courses is providing ample opportunity for our students to demonstrate an in-depth understanding of at least one (and often more than one) specialty.

3.6.7 Outcome 7: Demonstration of oral and written communications skills

ABET Criterion 3G: The MQP data shows that the writing skills was at least somewhat important for 99-100% of our MQPs and 100% of the students met our minimum standards for performance The oral presentation assessment shows that 99-100% of the students applied strategy or concepts without significant errors. Clearly, this ECE program (and ABET Criterion 3) outcome is being met.

3.6.8 Outcome 8: Understanding of options for careers and further education, and the necessary educational preparation to pursue those options

ABET Criterion 3I (partial): Appendix 3-19 shows that in terms of the options available in graduate school, this outcome is being only partially met. While WPI is evaluated as outperforming other schools, the scores leave a good deal of room for improvement. To meet this challenge, our department has developed some programming that will be expanded on in the near future.

3.6.9 Outcome 9: An ability to learn independently

ABET Criterion 3B (partial): Recent MQP review results showing that 95-100% of the projects required designing and conducting experiments, and 95-100% of students showed this ability.

All of the projects were assessed to use and develop creativity, and the student performance on this shows that 93-97% of our students were sufficiently creative in their MQP. 98% of the projects in '01-02 required students to use an ability to use resource materials to support project work, and 94% of them were able to do this. Therefore, these ECE and ABET Outcomes are clearly being accomplished.

3.6.10 Outcome 10: The broad education envisioned by the WPI Plan, and described by the Goal and Mission of WPI

ABET Criterion 3H (partial): All of our graduates fulfill the degree requirements for the Sufficiency and IQP, providing them with a broad education. Furthermore, the relationship of the Mission of WPI (listed in Criteria 2) to our program outcomes revolves around preparation for careers, civic contribution, leadership, and lifelong learning. These aspects are discussed in all of the other outcomes – with the exceptions of demonstration of an understanding of the importance of civic contributions. Appendix 3-21 shows that our senior student satisfaction with extracurricular activities and leadership opportunities within the engineering program is improving over time, and reported to be higher than at other institutions. This, along with the wealth of information for the other outcomes, shows that this outcome is being met by our students as a group.

3.6.11 Outcome 11: An understanding of engineering and technology in a societal and global context

ABET Criterion 3H (partial): The data presented in Appendix 3-22 shows that overall, the results are positive. For measurements of societal and global context, trends are increasing positively over time, and our students are having comparable experiences when compared to other students at WPI and better experiences when compared to students at other schools.

ABET Criterion 3J: Results on 'contemporary events' have been improving, and are expected to continue to improve as the impact of our course adoptions (EE3703 and EE3711) are experienced.

3.6.12 Outcome 12: A challenging and supportive environment

This desired outcome is different than the other eleven in that it is for the program, not the students. It is also the most appropriately measured on a relative basis since this assessment is relies heavily on the reaction of students, who we assume are comparing our environment to others that they experience on campus. The wealth of assessment data shows that our department is meeting this goal – both in the amounts of challenge and support absolutely and relative to each other.

Criterion 4, Professional Component

Preparation for Engineering Practice

The ECE program Distribution Requirements (Table 4-1), together with the WPI Degree Requirements (Appendix 1-1), implement an education in science, mathematics, engineering science, engineering design and general studies that meets or exceeds the expectations of the ABET criteria. The ECE Distribution Requirements mandate 4 units (12 courses) in mathematics and basic science, which is equivalent to slightly more than one year of study. Seven courses must be in mathematics. Physics must be included, with at least a two-course sequence. Finally, at least one course in either chemistry or biology must be included.

Table 4-1 Program Distribution Requirements for the Electrical and Computer Engineering Major

Requirement	Minimum Units	Semester Hour Equivalent
Mathematics (must include differential and integral calculus, differential equations, and probability and/or statistics	7/3	21
Physics (at least two courses)	2/3	6
Chemistry and/or Biology (at least one course in either)	1/3	3
Additional Math, Physics, Biology or Geology	2/3	6
Total Mathematics and Basic Sciences	**4**	**36**
Electrical Engineering courses (from approved list)	1	9
Computer Engineering courses (from approved list)	2/3	6
ECE elective courses (either in EE or CompE)	7/3	21
ECE Major Qualifying Project (MQP)	1	9
CS course at sophomore level or above	1/3	3
Engineering Science Course outside EE at sophomore level or above	1/3	3
Engineering course in EE or other engineering area	1/3	1/3
Capstone Design Experience (generally within the MQP)	0*	0*
Total Engineering Science and Design	**6**	**54**
Total EE Distribution Requirements	**10**	**90**

*Note: Capstone Design Experience is usually included in the Senior project credit. If the senior project does not contain sufficient design experience, the student must register for additional design work for additional credit of at least 1/3U (3 hours).

Six units, 18 courses, equivalent to one and one half years, must be completed in engineering topics, with at least five of those units (15 courses or course equivalents) in electrical and computer engineering topics. At least one course must be in Computer Science at the sophomore level or above, and at least one course must be in an engineering area outside of EE or Computer Science.

Details on the ECE courses are provided in the Appendix. Student transcripts and transcript audits for the two ECE graduates to date will be made available to the visitors. Figure 4-1 shows the flow chart of ECE courses which is a primary academic advising tool. Noting that ***no*** ECE courses are specifically required, the faculty have designed the courses and their inter-relationships to provide student flexibility while assuring that sufficient breadth and grounding in the fundamentals is maintained. Students are prevented from over-specializing by the policy of restricting the number of courses offered in a given specialization. Even so, with the breadth of computer engineering, we saw the necessity to offer a large number of computer engineering courses and the resulting lack of breadth in some students' transcripts. This is one factor that motivated the introduction of the ECE program which mandates breadth across both EE and Computer Engineering.

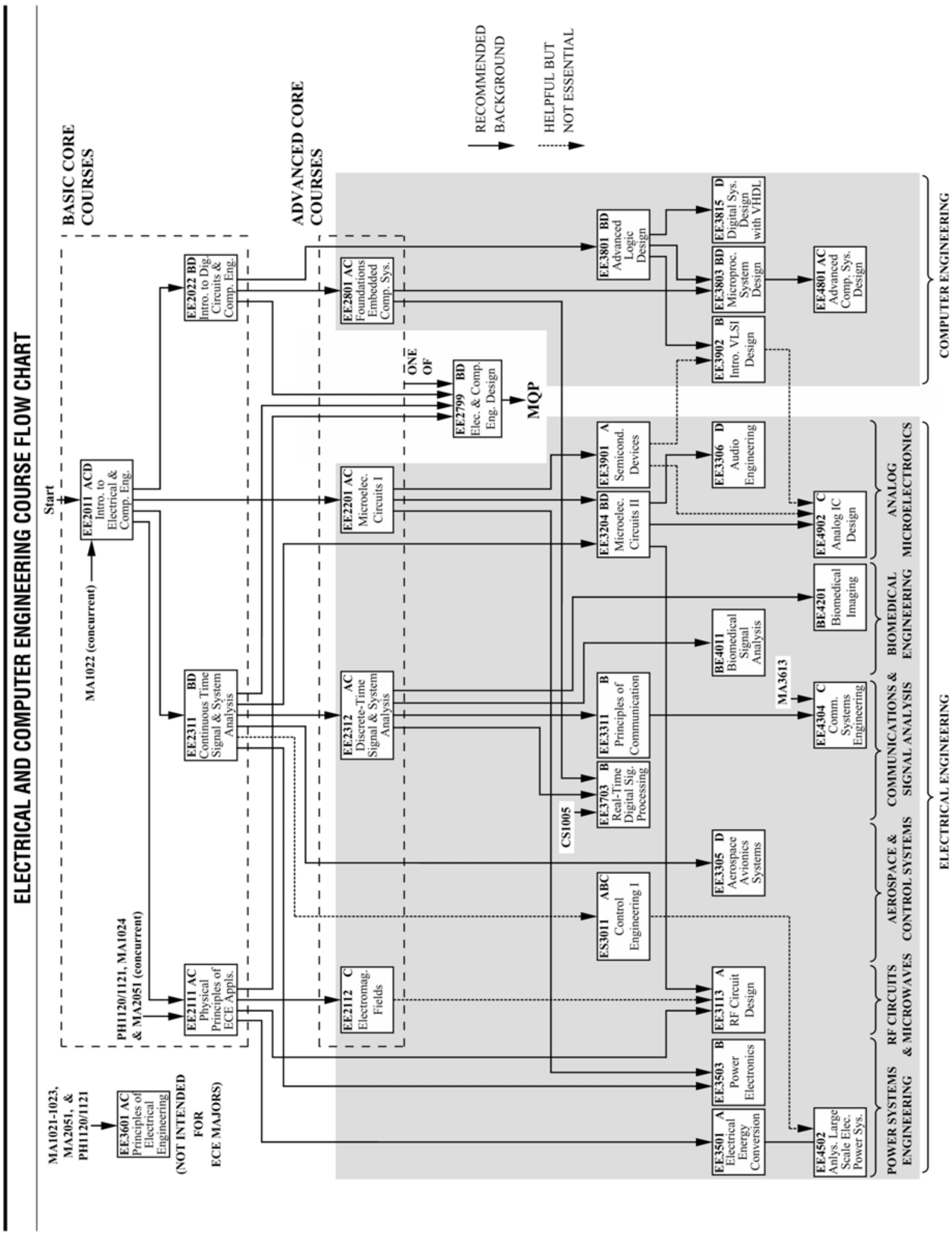
Computer Science Component

Computer Science has long been an essential component of electrical engineering students' programs, and we maintain close working relationships with the Computer Science department. These relationships are evidenced in several ways:

- The "ECE/CS Coordinating Committee" which includes the heads of both departments and two additional faculty representatives from each department. This committee meets quarterly to review and coordinate programs.
- Cross-listed courses between the two departments. At present all such courses are at the graduate level, but we have had cross-listed courses at the undergraduate level
- Faculty with joint appointments. Presently three ECE faculty (Profs. Paar, Pahlavan, and Sunar have affiliate appointments in CS) and one CS faculty member (Prof. Gennert) has an affiliate appointment in ECE. Prof. Gennert is certainly qualified for this appointment with degrees in both CS and EE from MIT.

The requirement for only one CS course at the sophomore level or above represents a minimum. It should be noted that the required knowledge for second-year courses effectively results in students also completing a first-year course in CS. Also, as a result of assessment performed in the EE program, the instruction in assembly language which had previously been accomplished via a CS course was moved into the ECE course in embedded systems (EE2801), allowing the CS courses to concentrate on other topics.

Figure 4-1 ECE Course Flow Chart



Design Experience Component

Design experience, particularly in large-scale projects, is central to the ECE program. A degree requirement for all WPI students is the completion of a senior project ("MQP") equivalent in time and credit to three 3-semester hour courses. This project may be completed over the courses of the senior year in parallel with course work, or it may be completed in one term (one half semester) of full-time work, either on campus or at a residential project site. This senior project, together with the junior-level project ("IQP") and Humanities project ("Sufficiency") provide ample opportunities for student to both learn and demonstrate many of the EE educational outcomes. A major biennial review of the MQP provides assessment data, analysis, and recommendations for this central component. An important aspect of this assessment is the degree to which all of the senior projects contain the desired components of engineering design. The most recent review (completed in the summer of 2001) presented the following conclusions and recommendations, the implementation of which is now being planned by the Undergraduate Program Committee:

Conclusions:

- *The general educational goals of the MQP are being met.*
- *The design content of projects is high—as it should be—and is consistent with capstone-design expectations.*
- *Some elements of the ABET design definition—namely, factors such as: safety, reliability, aesthetics, ethics, and social impact—are not currently emphasized as well as they should be.*
- *Documentation quality must be improved substantially.*
- *The principal documentation deficiency continues to be a lack of adequate descriptions of the results of analysis, simulation, and trade-off studies used to synthesize the design from established specifications and objectives.*
- *There continue to be instances where the issuance of one unit of credit is questionable.*
- *The mathematics and design-simulation levels, while improved, remain below expectations.*
- *Most of grades awarded are consistent with the apparent academic accomplishment.*

Recommendations:

- *Every project team should be required to clearly establish a set of specifications and design objectives early in the MQP process. These specifications and objectives should be specific, measurable, and traceable to the phenomenology of the problem being solved.*
- *In the conduct of projects, material must be developed to demonstrate that the design that will be implemented is theoretically justified. Specifically,*

analytical results, simulation, and a comparison of analytic and simulated results where appropriate should be developed.

- *The faculty should make a concerted effort to maintain the number of corporate-sponsored projects.*
- *The faculty should be mindful that 1 unit of MQP credit is the equivalent of 3 courses for each student involved in the project.*
- *The faculty must ensure that peripheral issues such as economics, reliability, safety, ethics, and social impact are addressed in the MQP. While it is expected that the new design course will increase student ability to address these issues, continued faculty vigilance is essential.*
- *The faculty must encourage students to fully document their projects from start to finish. This should include the original derivation of a solution, test plans, results, and conclusions. In addition, each report should include an executive summary and an advisor-written one-page summary sheet.*
- *To assure that all ABET design expectations are satisfied, the areas specified in tables 1 and 2 should be addressed in each MQP report. It is expected that since the majority of projects focus on designs which parallel or improve on existing products issues like safety, reliability, economics, and ethics play an important role in the selection of a technical solution. In areas where this is true, it should be highlighted.*
- *The faculty should provide students with copies of the forms that will be used to assess the overall quality and completeness of their projects.*

These conclusions and recommendations are presented verbatim in this self-study to demonstrate that serious self-assessment is taking place. The fact that improvements are recommended does not imply that the current student outcomes fail to meet minimal standards!

Examples of these senior projects and biennial reviews will be available for the visitors.

Design components are also integrated throughout the ECE courses, as indicated in the course descriptions in the Appendix. In spite of this substantial attention to design education, the biennial senior project reviews indicated a consistent weakness by students in the quality of their design work. In retrospect, the faculty recognized that the very small-scale and specialized designs incorporated in courses cannot provide the breadth of experience needed in product design. This weakness was addressed by the addition of a course whose sole purpose is to teach the principles and practice of Electrical and Computer Engineering design, EE 2799. This course is team-taught by two or three faculty depending on enrollment. The faculty are chosen based both on their own personal experience with design (one faculty member is our Professor of Practice who spent over 20 years leading a technical group at Mitre Corporation) and to assure that both analog and digital expertise is represented. This course is required by faculty before registering students for their senior project work (even though it is not a formal WPI course requirement) and it has been extremely popular with students.

General Education

The "WPI Plan" integrates a broad college education with each student's major area of study. A review of the Mission and Goal of WPI will demonstrate the importance given to what is typically called "General Education." These goals are implemented with an extensive set of requirements in the Humanities and Social Sciences (separately), culminating in projects in an area of the humanities and in some technology/society (Interactive Qualifying Project, IQP) area. This latter project, the IQP, typically relates the student's major area of study to an area of the humanities, with the emphasis on the human and social side, not the technical side. Examples include the politics of nuclear waste disposal, the tradeoffs between government expenditures on high-tech medical research rather than public health, and the value of a human life. Examples of these IQP and Sufficiency reports will be available. Equivalent semester hours of credit for these components are: Humanities: 18; Social Science: 6; IQP: 9, a total of 33 semester hours.

Beyond the substantial credit requirement, we feel that these components are well designed in themselves, and that they inter-relate in ways that multiply their value. For example, the study of language or Asian culture in the Humanities portion may be put to use by a student conducting his/her Interactive Project in San Juan or Bangkok. It should be noted that ECE faculty are substantially involved as project center directors and advisors for the Interactive Projects, both on campus at residential sites in the U.S. and abroad.

Criterion 5, Faculty

The ECE department includes 21 tenured or tenure-track faculty positions. This represents approximately 20 FTE when faculty assignments outside of the ECE department are taken into account. In addition, one position is vacant with a search planned for AY2002-03. We also make use of two full-time non tenure track faculty and two part-time faculty in our undergraduate program. These non tenure track faculty come from quite different backgrounds. Our full-time Instructor is MS-degreed, with substantial industry experience, and is a superb teacher. The part-time Instructor is a PhD student who has shown a real ability and interest in teaching. Our adjunct professor is a private consultant who shares his expertise with students in one course per year. Finally, the Professor of Practice position is reserved for someone with both a real interest in teaching and a substantial career in the practice of electrical engineering. The heart of our program will always be the full-time, tenured/tenure track faculty, but these other faculty also make important and distinctive contributions. The Instructor positions provide excellent experience for future professors, under the guidance of our experienced faculty. The adjunct faculty bring their wealth of commercial experience to the classroom.

The number of faculty is adequate to deliver the undergraduate program with the quality that we expect, as well as to deliver our graduate program, engage in research, and pursue professional development. Presently, our student-to-faculty-ratio is approximately 24:1. This is based on the FTE faculty number, divided by the FTE student number, including all undergraduate EE and ECE students, full-time graduate students, and pro-rated part-time graduate students. Faculty are certainly very busy, and the long-term implications of carrying out such a diverse and high-quality program of undergraduate and graduate education, and research, with this number of faculty, causes some concern.

The ECE faculty are well qualified for development and delivery of the Electrical and Computer Engineering program. The undergraduate program described by the WPI Plan places special demands on faculty. Not every person who would be appropriate for a traditional program is suited for the faculty at WPI. Some of the necessary faculty attributes are: breadth of knowledge and interests; deep interest in both teaching and research; interest in close, frequent interaction with students, and interest and ability in engineering design as well as engineering science. We have been quite successful at identifying, recruiting, and ultimately tenuring such persons. Our interview process includes a teaching seminar as well as the traditional research seminar. It also includes one-on-one visits between the candidate and as many faculty as feasible, for the benefit of both the candidate and his/her potential colleagues. Also, we have found that previous industrial experience has been extremely helpful to new faculty, both in the engineering knowledge which it provides, and in bringing a maturity of perspective.

Following are some specific highlights on items listed in the Criteria:

Education: A broad range of excellent undergraduate and graduate schools are represented by our faculty.

Diversity of backgrounds: There is good diversity in such aspects as country or region of origin, previous academic experience, theoretical or practical orientation, age, and industrial experience. At present we have one female faculty member, and one African-American faculty. We are working to add more women and minorities to the faculty.

Breadth across the subdisciplines of ECE: The range of faculty expertise matches the educational program. However, it would be highly desirable to add more faculty in the computer engineering area, the most popular specialization among students. Following is a summary of the principal areas of expertise of the full-time faculty:

- Prof. Bromberg: Communications (leaving WPI as of 7/1/02)
- Prof. Brown: Communications, computer engineering
- Prof. Clancy: Signal processing, computer engineering
- Prof. Clements: Systems engineering, power engineering
- Prof. Cyganski: Signal processing, computer engineering
- Prof. Duckworth: Computer engineering
- Prof. Emanuel: Power systems, power electronics
- Prof. Hakim: Signal processing
- Prof. Labonte: ECE fundamentals, analog electronics, ECE design
- Prof. Looft: Computer engineering
- Prof. Ludwig: RF design, electromagnetics
- Prof. Makarov: Signal processing, numerical modeling, antennas
- Prof. McNeill: Analog and mixed signal design
- Prof. Michalson: Computer engineering

- Prof. Nicoletti: Signal processing
- Prof. Orr: Communications, signal processing
- Prof. Pahlavan: Communications
- Prof. Pedersen: Signal processing
- Prof. Sunar: Cryptography, computer engineering
- Prof. Vaz: ECE fundamentals, signal processing
- Prof. Whitmal: Digital signal processing, computer engineering

One new faculty member (Dr. Brian King) will be joining the department in AY 2002-03, with specialization in optical communications, an area of substantial need. Dr. King also has substantial expertise in computer engineering.

Faculty depth in Computer Engineering: Maintaining a sufficient number of faculty proficient in the computer engineering area has been a departmental priority for many years, given the large amount of student interest and the centrality of computer engineering across the curriculum and the profession. The move to the ECE major highlights the importance of this. Currently eight faculty, as indicated on the above list are active in computer engineering. This number is more than sufficient to deliver the computer engineering courses. However, many of these faculty also work in other areas, and the department continues to have a high priority goal of adding more faculty whose principal specialty is in computer engineering.

Engineering Experience: Most of the faculty have significant commercial engineering experience. This has been extremely helpful in bringing the "real world" of engineering into the classroom and project environments.

Teaching experience: Among our faculty, the number of years of teaching experience ranges from one to over 30. Overall, the faculty have a rather even distribution of experience within that range. There is also a good range of experience within each subarea of EE, so that new faculty are generally not "starting from scratch" in their specialty area. Four of the full-time faculty have won the prestigious and competitive Trustees' Award for Outstanding Teaching.

Ability to communicate: This parameter represents diverse attributes, ranging from English language ability to inter-personal skills, to the ability to motivate a large class. All faculty possess good basic abilities in English communications, and as demonstrated by teaching awards and student evaluations, many have exceptional abilities to reach everyone in their classes in ways that stimulate learning.

Enthusiasm for developing more effective programs: This is demonstrated by the number of new courses and other initiatives that have been introduced recently. The largest such effort is the complete overhaul of the introductory courses, putting a four-course sequence beginning in the freshman year in place. Other innovations include the new design course, redevelopment of the signals courses, continual updating of the computer engineering courses, and the substantial assessment program.

Scholarship: Fifteen faculty published a technical paper or made a scholarly presentation in the most recent year for which data are available. A total of approximately 20 journal papers, 50 conference papers are published annually, as well as an average of close to one book per year and several patents per year. Thirty-seven external proposals were submitted in 2000-01 and 17 grants totaling $1.9M were received. The intensity of scholarly activity among faculty varies widely; the most significant factor is that *essentially all* faculty are engaged in significant scholarship, and *all* are engaged in undergraduate education.

Participation in professional societies: Several faculty are very active in professional societies, particularly the IEEE, as indicated in the Appendix. These activities include work on standards committees, organizing of conferences, and editing of journals, in addition to paper publication.

Registration as professional engineers: Traditionally, registration has not been widespread among electrical engineers, and this is reflected on the ECE faculty. At present, four faculty are registered.

Faculty resumes are included in the Appendix. WPI sets basic expectations with regard to teaching, scholarship and service as defined in our Faculty Handbook. Untenured faculty are reviewed every year with direct oral and written feedback from the Department Tenure Committee. The teaching quality of the tenured faculty is also reviewed by department heads. All faculty submit annual reports reviewed by department heads and the Provost. Annual merit raises at WPI are determined by these reviews of performance, with particular attention to the quality of teaching.

Recent Faculty Changes

Tables 3 and 4 in Appendix I reflect the faculty status during Academic Year 2001-02. The following changes will have occurred for Academic Year 2002-2003:

- Adam Elbirt, half-time Instructor, has completed his PhD and has left. His Instructor position is occupied by Ahmad Hatami who arrived in January, 2002.
- R. James. Duckworth will have returned to active status from leave.
- Reinhold Ludwig will have returned from half-year sabbatical.
- John McNeill will be on full-year sabbatical.
- Brian King will have joined WPI on the tenure track.
- Matthew Bromberg will have left WPI.
- Nathaniel Whitmal will be on one-year leave.
- A search for two additional faculty will be underway.

Criterion 6, Facilities

The electrical and computer engineering program is housed in Atwater Kent Laboratories, a 44,000 square foot facility. The Electrical and Computer Engineering department has exclusive use of 36,000 square feet. This building was apparently the first building to be constructed in the United States (in 1907) specifically to house an electrical engineering program. It was completely renovated and substantially expanded in 1980. Within this building are 5,400 square feet of classrooms (used principally by the ECE department), and 15,000 square feet of teaching laboratories. The remaining space includes offices, conference and seminar rooms, and support space (including the electronics and computer shops.). This space is adequate at present, but tight. Given our project program and growing faculty research, the need for laboratory space continually increases.

The Atwater Kent building houses one lecture hall (200 seats), two amphitheater-style classrooms (80 seats each), and one small classroom (25 seats). Most ECE classes are taught in the Atwater Kent building. This is important to facilitate demonstrations, and also to maintain a sense of student-faculty community. In addition, several seminar and conference rooms are available for use by students and faculty to accommodate small-group meetings. There is also a variety of public lounge space, including one area dedicated as an undergraduate ECE student lounge. The student chapters of IEEE and Eta Kappa Nu are provided office space and computer support.

Computational Facilities

WPI and the ECE department have made a substantial commitment to computational infrastructure and resources. In summary, the College Computer Center operates a high-speed (100 MBPS backbone) campus network with an extensive array of workstations and PC's available to the campus community. Complete internet access is also provided. All rooms in the ECE building have both Category 5 and fiber media, and a wireless network is being installed in the summer of 2002. All computer access is free. The ECE department provides over 80 PC's and a variety of Unix workstations for student use. Of course, many students own their own computers, and make extensive use of them (the residence halls are completely networked). In addition, WPI has made a commitment to make hardware and software resources available to all students. Particularly regarding professional-quality software, students could not be expected to purchase these resources.

The WPI campus is connected to an NSF Internet2 site via a GigaPoP OC3 connection. The network infrastructure supports 100 Mbytes/s connections, providing seamless interactive communication from one computational resource to another.

One full-time professional staff person and several part-time staff are dedicated to departmental hardware, software, and network support.

Laboratory Education

As has been previously discussed, laboratory education is an integral part of the ECE program, so that planning for laboratory facilities receive the same attention as the lecture components of the curriculum. Indeed, course content and lab facility revisions occur together. In addition, the Undergraduate Program Committee and the Projects Committee regularly review the facilities available to undergraduates for the experimental components of their project work.

The overall aspects of planning for laboratory instruction can be summarized as follows:

1. Determination of needed educational components, and needed facilities and equipment.
2. Integration of laboratory instruction with the overall undergraduate ECE program and maintenance of relevance to the modern practice of electrical and computer engineering.
3. Provision of appropriate space, laboratory furniture, etc.

4. Provision of resources for equipment acquisition.
5. Provision of staff and facilities for equipment maintenance.
6. Provision of faculty and teaching assistance for the delivery of laboratory education.
7. Assessment of level of quality of laboratory education.

Following is a summary of the responsible entities for implementation of this plan:

The Undergraduate Program Committee has overall responsibility for determining the academic activities which require laboratory facilities. The Projects Committee has similar responsibility regarding students projects, primarily the MQP. This encompasses items 1 and 2

The department head and associate head are responsible for items 3 through 6, working with the ECE Electronics Shop manager regarding the details

The Assessment Committee is responsible for item 7.

In general, the ECE department's philosophy is to integrate the laboratory experiences within the regular courses, rather than to offer free-standing laboratory courses. This course-laboratory integration provide tight coupling between the lecture and laboratory material. Hence, in most cases laboratories are designed and redesigned along with the lecture material. Two good examples of this are the introductory EE course sequence, and the Computer Engineering sequence. Over 50% of the EE courses contain formal laboratory components.

The department and the university understand the mutual responsibilities for provision of laboratory resources. Three general sources exist for laboratory resources:

- Regular ECE department funds
- Institute resources, provided as part of the annual capital budgeting process.
- Grants of various kinds, including corporate gifts in kind, government grant programs, and individual donations.

Regular departmental funds for equipment acquisition total approximately $50,000 annually. In addition, via the Institute's capital budgeting process, additional resources are allocated for both equipment and facilities. On average, approximately $40,000 per year in equipment is added via this route. Significant laboratory facilities upgrading (HVAC, safety) is also regularly budgeted.

Considerable faculty effort is required with respect to the third category of resources (corporate and alumni contacts, formal and informal corporate, proposals, proposals to government agencies, etc.). Major recent donations have been received from Altera, Texas Instruments, Xylinx, and Intel.

The total equipment and facilities resources required annually to keep pace with both technical obsolescence and wear and tear are formidable. However, a review of our facilities will show that via all the routes described above, the needs are being met.

Laboratory floor space and equipment are generally adequate. Laboratories are arranged so that student groups contain only two students. Laboratory teaching is quite time-intensive, and a major commitment of faculty and teaching assistant time is made to this aspect of our program. Further, it is supported by professional and technician-level technical staff.

Assessment of the quality of laboratory education is accomplished via internal reviews, student evaluations, oversight by the department Advisory Board, and surveys of alumni. The Undergraduate program Committee regularly reviews our laboratory program, and the ECE Computer Resources Committee addresses computer hardware and software needs specifically. Also, laboratory teaching forms an important aspect of the periodic peer review of teaching which is performed for all departmental faculty.

Undergraduate Laboratory Facilities

Integration of laboratory with classroom work is fundamental to the undergraduate ECE program. Beyond scheduled lab sections, all labs are open from 8:00 a.m. to 5:00 p.m. Monday through Friday, and the major labs are open every evening and on weekend afternoons and evenings, until midnight when demand warrants. Following is a summary of the major individual undergraduate laboratory facilities.

AK 113, Computer Engineering Lab

Basic ECE Lab (AK 212A: EE 2011, 2022, 3601)

The intent of this laboratory is to provide an introduction to basic electronics instrumentation and measurement techniques, and to provide hands-on experience with real circuits and components. Modern basic instrumentation (digital oscilloscope, digital voltmeter, function generator, power supply) is provided at each student station (Eighteen two-student stations). In addition, a Pentium PC with A/D-D/A interface and software (Spice, Mathcad, Maple, C compiler) is provided at each station. The instrumentation is completely adequate for this task.

Student Project Lab (AK 111, AK 212B: Projects)

The primary location of this lab is in AK 111, with additional facilities in AK 212B. This lab consolidates facilities for student project work in an area adjacent to the ECE department Electronics Shop, for ease of supervision and assistance to students. Equipment (PC's, development systems, schematic capture and printed circuit layout systems, cross-assemblers, logic analyzers, etc.) is provided to support a broad range of projects, with particular emphasis on computer engineering projects. The lab is well equipped, although the necessity to split it between two rooms is somewhat inconvenient.

Computer Engineering Course Lab (AK 113: EE 2801, 3801, EE 3803, 4801)

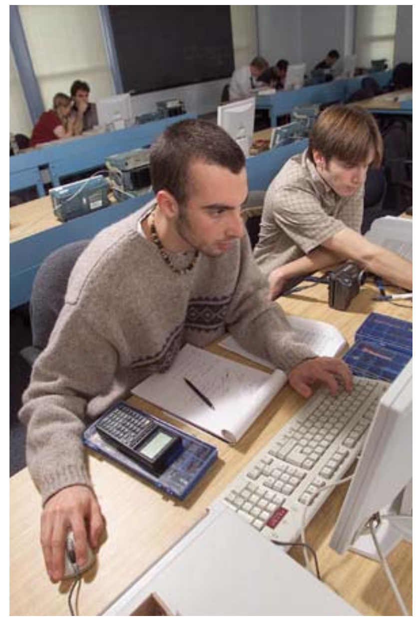
Each station in this lab is equipped with a "target" PC system with custom interface board, upon which to conduct experiments, a modern logic analyzer (shared by two stations), and standard instrumentation (oscilloscopes, etc.). In addition, PC's running development software are located in the room, as well as software and programming support for Xilinx and Altera programmable logic devices. These facilities are quite adequate although constant equipment maintenance and upgrading is required.

Electromechanical Energy Conversion Lab (AK 004: EE 3501)

WPI-designed stations are provided, equipped with compact commercial motor-generator sets, and, standard measuring instruments. These are adequate at present given the small demand, but are in need of updating.

Studio Classroom (AK 227, EE 2201, 3204, 3703, 3902)

This newly-renovated space combines a modern AV classroom with laboratory facilities including PCs and standard laboratory instruments (digital oscilloscopes, digital multimeters, power supplies) in comfortable learning environment. Both traditional 3-hour lab sections and combined lecture-lab ("Studio") courses are taught in this room.



AK 227, Studio Classroom

Student PC Lab (AK 120C: Projects, Homework)

This laboratory provides general-purpose Pentium Personal Computers for undergraduate student use. Software includes language compilers, Spice, Mathcad, Maple, EE-CAD design and simulation programs, and schematic capture and printed circuit board layout programs. This facility currently provides 16 PCs; this number is increased on an annual basis to keep up with student needs. These PCs are supplemented by College Computer Center facilities. Although student ownership of computers is encouraged, we have made a commitment to providing hardware and software to meet students' computational needs. Given the need for commercial-quality software and the attendant cost and licensing problems, as well as the hardware requirements of some software, it would be infeasible for students to provide this personally.

Specialized Laboratories

Following are brief summaries of specialized laboratories operated by individual faculty or faculty groups. These labs are very much available to undergraduate students, particularly for their senior projects. In addition to the listed labs, a new faculty member joining us in the Fall of 2002 will be developing a lab in photonics.

Cryptography & Information Security (CHRIS) Laboratory

The CRIS Laboratory conducts research and development in cryptography and its applications. Lab personnel work on fast software algorithms and efficient hardware architectures. The lab is equipped with industry-standard development tools for ASIC and FPGA target hardware. Another focus is the integration of cryptography and data security into new communication networks, including the design and implementation of security protocols for wireless networks, with an emphasis on wireless LANs.

Center for Sensory and Physiologic Signal Processing — $C(SP)^2$

Faculty and students within the $C(SP)^2$ apply signal processing, mathematical modeling and other electrical and computer engineering skills to study issues related to human sensation and physiology. Currently, the major focus areas are hearing, tactile reception and electromyography (EMG).

Center for Wireless Information Networking Studies (CWINS)

The Center for Wireless Information Network Studies (CWINS) is a major facility for modeling and performance analysis in all aspects of wireless networking. The core competence of the center is in indoor radio channel propagation measurement modeling and in the development of testbeds and tools for design and performance monitoring of wireless indoor networks.

New England Center for Analog and Mixed Signal IC Design (NECAMSID)

NECAMSID has been established as a complete integrated circuit design and test environment to serve multiple needs of graduate and undergraduate students and research sponsors. The facilities include comprehensive high-speed (up to 2.5 GHz) analog test and measurement equipment, which can be used to characterize a wide range of devices and circuits. Current areas of interest include the design of highly accurate oscillator circuits for communication systems, high-speed imaging (CCD) circuits, and mixed-signal characterization.

RF Electronics and Image Analysis Laboratory

The mission of this laboratory is the development of RF/MW electronic systems and all aspects associated with computer-driven data acquisition, network communications, numerical analysis and processing, and visualization. The lab is equipped with numerous SUN, SGI, and Compaq workstations. Network analyzer, LCR meters, power sources, and associated equipment is available for RF development work. The lab has access to commercial, academic, and public domain software in RF circuit design, image analysis and display.

Convergent Technologies Center (CTC)

The laboratories in this center combine diverse expertise for the exploration of the emerging and converging technologies of computing, communications and cognition. The Polaroid Machine Vision Laboratory (PMVL) and the Network Computing Applications and Multimedia (NETCAM) laboratory focus on the development of new algorithms and moving emergent technologies into commercial, medical and defense related applications for their sponsors.

Power Electronics and Power Systems Laboratory

The power electronics laboratory has been established for simulation of a large variety of linear, non-linear and time-varying loads, including transistor and thyristor controlled loads. It contains transducers and instrumentation for a wide range of voltages, currents and frequencies. The Power Systems Laboratory provides a computational environment for research in large-scale systems, including state estimation and fast solution methods.

Satellite Navigation Laboratory

This laboratory provides facilities for work on civilian uses of satellite systems, especially the Global Positioning System. Receivers, signal processors and computers are provided for work on the utilization of the DOD GPS system for civilian purposes, especially aircraft navigation and landing.

Ultrasonics Laboratory

This laboratory is equipped with a broad range of ultrasonic transducers, data acquisition and processing systems, and support equipment for experimental verification of theory. Areas of interest include inverse methods for ultrasound, atherosclerotic plaque classification by means of ultrasound, and ultrasound-based osteoporosis detection

Access to Modern Engineering Tools

Software

Appendix 6-1 contains a list of the major software available to all undergraduate students. Students may access this software via our computer labs (open evenings and weekends) and over the WPI network from their own PCs. Appendix 6-2 shows the organization of software with regard to the design process, proceeding from initial design through simulation, schematic capture, and printed circuit board layout.

Hardware

Modern hardware tools range from 20 GHz Spectrum Analyzers to facilities for working with surface-mount components in student project work. Following is a list of major equipment additions over the past five years:

Recent Equipment Additions, AK-113 Digital/ Microprocessor Laboratory:	
Description	**Quantity**
Agilent PC based Logic Analyzers	5
PC's, K7, 800 Mhz, 128 MB	10
Tektronix TDS210 Oscilloscope	10
Tektronix CFG253 Function Generator	10
Tektronix CDM250 Digital Multimeter	10
Tektronix CPS250 Dual Power Supply	10
QIK Start PIC development systems	10
BP Universal EPROM Programmer upgrade kits	3
LEAP Systems buffered ISA expansion boards	10

Recent Equipment Additions, AK-120C ECE PC Laboratory:	
Description	**Quantity**
PC's, K7, 800Mhz, 128MB	16
QIK Start PIC development systems	16

Recent Equipment Additions, AK-227 Studio Classroom:	
Description	**Quantity**
MS-6215 Mini-PC, 1.3Ghz, 512 MB	26
Tektronix TDS210 Oscilloscope	26
Tektronix CFG253 Function Generator	26
Tektronix CDM250 Digital Multimeter	26
Tektronix CPS250 Dual Power Supply	26
Texas Instruments TMS320C DSP development systems	20

Recent Equipment Additions, AK-212A Basic ECE Laboratory:	
Description	**Quantity**
Tektronix TDS210 Oscilloscope	18
PC's, Pentium	18

Recent Equipment Additions, AK-111, AK-212B Projects Laboratory:	
Description	**Quantity**
Agilent PC based Logic Analyzers	2
PC's , Pentium, 200 Mhz	12
HP 882C Deskjet Printer	2
Epson C80 Inkjet Printer	2
HP33120A Arbitrary Waveform Generator	1

Recent Additions, Misc. Classroom/Laboratory Equipment Related software:	
Description	**Quantity**
Licenses for MultiSim 2001, Simulation Software	50
Licenses for UltiBoard 2001, PC Board Layout Software	5

A complete equipment inventory will be available for the visitors.

Provisions for Maintaining and Servicing Laboratory Equipment.

One engineering-level and one technician-level person work under the direction of an MS level electrical engineer in the Electrical and Computer Engineering Shop to construct, maintain and calibrate equipment used in teaching and research laboratories, and to distribute components. They are assisted by undergraduate work/study students. Also, a professional-level computer engineer is responsible for computer hardware and software support; he is assisted by part-time student help. In total, four full-time technical and professional-level personnel are employed in the department in support of the laboratories. A line item in the department budget provides funds for repair parts and outside maintenance and calibration as necessary. Not including external grants and special allocations from the Provost, the regular ECE departmental budget (personnel, capital equipment, parts and supplies) for equipment acquisition and maintenance is over $300,000 annually. Approximately 75% of this amount represents support for the undergraduate program.

Criterion 7, Institutional Support and Financial Resources

WPI was founded as an engineering college, and that tradition and sense of commitment to engineering is strong today as well, even though the institution has broadened itself considerably over the past 137 years. WPI's financial details are reported elsewhere. While more resources are always desirable, adequate finances are available in all major areas (faculty and non-faculty personnel, space, facilities, and equipment). More details are provided in the specific categories. Table 5 in Appendix 1 summarizes the major categories of departmental expenditures over the past three years.

With respect to leadership, WPI is blessed with a straightforward administrative structure, and these positions are occupied by persons who understand and value engineering education. Our President, Provost, and Associate Provost are all engineers. At a university, leadership comes from the faculty as much as from the administration, and WPI has a strong tradition of faculty governance in academic matters. The vision of the both the faculty and administrative leadership was clear 30 years ago when the WPI Plan was created, adopted, and implemented. Over the past 30 years the leadership necessary to continue the implementation, revise the details as necessary, and maintain the fundamental educational objectives, has always been present. Finally, the leadership and administrative structure has a tradition of stability; the present president, provost, and department heads have held their positions for 7, 6, and 14 years respectively.

Faculty Resources

Resources to enable the faculty to do its work (in both teaching and scholarship) are almost as necessary as the faculty themselves. Specifically, these take the form of funds for equipment (for teaching and research), supplies (components, copying, telephone, etc.), support services (secretarial, technician), and travel. All of these are adequate. For example, sufficient funds have always been available to support faculty travel to conferences where a paper was to be presented, or for other specific purposes. Sufficient funds are available to provide secretarial support, copying, telephone usage, etc., for faculty without the necessity of an accounting and charging bureaucracy.

With respect to attracting new faculty, our compensation, as demonstrated by external surveys, is quite competitive. We provide start-up funding for laboratory equipment, travel, and summer support. A review of the resumes of our faculty will demonstrate that they are quite well-qualified. It also demonstrates substantial stability of the faculty, as well as a healthy range of years of experience and time at WPI.

Facilities, Equipment Support Personnel, and Institutional Services

WPI maintains a program of continuous upgrading of laboratories and classrooms through its capital budget. Equipment budgets (both capital and expensed) are maintained by departments and the Provost. Faculty are also quite successful in achieving donation and grant funding for laboratories and equipment. A description of campus-wide resources and computing equipment is supplied in ***Appendix II, Institutional Profile***. Department-specific resources were described in the previous section.

The department employs 7 full-time support personnel: 3 secretaries, 2 senior engineers (one supervising the electronics shop and one supervising the computer operations), one junior engineer, and 1 technician. In addition, approximately 2 FTE in part-time employees are utilized. These persons support all of our activities: undergraduate, graduate, and research. The undergraduate program is our largest activity, and is adequately supported by this team. However, they are busy to say the least!

Major institutional services include: Computational facilities, Library resources, Registrar, Instructional Media Center, and Physical Plant Services. All of these are described in Appendix II, and all are of vital importance to electrical and computer engineering.

With regard to computation, the ECE department provides most of the student computational needs. These are supplemented with PC's and UNIX workstation in the campus computer center. The most vital aspect of the computer center's services are the network infrastructure (both hardware and software) and the internet access which the CCC provides. The infrastructure recently underwent a major upgrade to meet growing network traffic, and to replace obsolete equipment. WPI is connected to both the commodity Internet (T3 speed) and to Internet2.

Library services are very good, both with respect to undergraduate needs, and those of the faculty and graduate students. The book collection is up-to-date, and the journal collection is quite substantial for an institution of our size. Also, the library has been quite pro-active in making available (at low or no cost) electronic searching and full-text retrieval.

The Registrar (technically the department of Projects and Enrollment Services) has a formidable job, with five terms per year (four during the academic year, one in the summer), a major off-campus program, and many individualized projects. Student transcripts at WPI carry rather detailed descriptions of student projects, since they represent such a substantial component of each student's education. These services are carried out quite well.

The Instructional Media Center houses a TV studio for video production, both live and taped, a Picturetel live videoconference facility, and loaner equipment to support campus AV needs. The center installs and supports computer projection systems in several large classrooms, including one in the EE building.

The division of Plant Services is responsible for cleaning, maintenance, and renovations to all WPI buildings and buildings. All of these functions are extremely important to maintain an efficient and productive educational environment, and they are carried out quite well.

Criterion 8 Program Criteria

This section is organized to respond to each section of the Electrical and Computer Engineering Program Criteria.

Breadth and Depth

> ***The structure of the curriculum must provide both breadth and depth across the range of topics implied by the title of the program.***

Given WPI's policy of avoiding prescriptive curricula, this requirement cannot be satisfied by giving students a list of required courses. Rather, the number of electrical and computer engineering courses called for by the distribution requirements, the number (relatively small) of courses offered by the department, the topical organization and structure of the offerings, and the requirement for the culminating design experience of the MQP, assure that students will study at least one area of electrical and computer engineering at an advanced level, and gain exposure with less depth to several areas of electrical and computer engineering. Review of the EE program course flow chart in will show that all paths

The depth requirement is addressed and assessed specifically as Program Outcome 6. The section on Criterion 3 describes the assessment process and results. The breadth requirement is addressed by Program Outcomes 1, 2, 3, and 5, each addressing a different aspect of this important component of the students' education. Outcome 1 addresses breadth in the context of professional practice, including aspects ranging from ethics to knowledge of modern engineering tools. Outcome 2 addresses the breadth necessary to understand and participate in the continuing technical change process that is implicit in electrical and computer engineering. Outcome 3 specifically addresses the necessary knowledge across the basic principles of electrical and computer engineering. Outcome 5 relates to the design process, in which a broad understanding of electrical and computer engineering is needed to produce a useful product.

Science, Mathematics, and Design

> ***The program must demonstrate that graduates have: knowledge of probability and statistics, including applications appropriate to the program name and objectives; and knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives.***
> ***Programs containing the modifier "electrical" in the title must also demonstrate that graduates have a knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics. Programs containing the modifier "computer" in the title must also demonstrate that graduates have a knowledge of discrete mathematics.***

Mathematics Aspects

The importance of mathematics to electrical and computer engineering is indicated by its status in the distribution requirements, where seven courses in mathematics are required. Some students take more than this minimum. Our requirements do explicitly state that students must complete courses in differential and integral calculus and differential equations. Most students complete the requirement with four Calculus courses, one Differential Equations course, a probability/statistics course, and then a selection among courses in Linear Algebra, Vector Calculus, Complex Variables, and Numerical Analysis. Within these mathematics courses there is substantial emphasis on engineering applications; several of them also have a computer laboratory component, generally based on Maple.

Following is a summary of the specific application of mathematics topics (beyond differential and integral calculus) that are integral to electrical and computer engineering courses. Some examples of the specific applications are given

EE2111: Matrices, Probability (introduction to EE applications), Differential Equations (circuit analysis with energy storage)

EE2112: Vector Calculus (electromagnetics)

EE2799: Statistics (system performance specifications)

EE3311: Complex Variables

EE3901: Probability and Statistics (quantum effects, energy level distribution, etc.)

EE3305: Probability and Statistics (error probability)

EE3306: Probability and Statistics (acoustic noise, hearing damage probability), statistical quality control)

EE3803: Statistics (system performance over range of parameter variations)

EE4304: Probability (noise, probability of error)

EE4502: Linear Algebra (numerical analysis, state equations)

MQPs: specific projects include advanced math topics appropriate to the project. In addition to those topics listed above, data security MQPs include number theory and abstract algebra

The mathematics component of the student project work is quite significant. The most common math component of the Interactive Qualifying Project is Statistics. For the MQP, each biennial review measures the amount and level of mathematics used in these projects. From the most recent MQP Review (2001) it was determined that most MQPs made substantial use of advanced-level mathematics. Twenty-one percent used mathematics at the level of differential and integral calculus. Forty-four percent made use of math concepts at the level of differential equations or linear algebra, 23 percent used concepts from math courses at the junior level, and 13 percent included math topics from the senior level.

A review of transcripts will verify that students complete the required mathematics courses. The ability to apply knowledge and techniques from these courses is verified as described under Outcome 4 of the EE Program Outcomes.

Discrete Mathematics

In the development of the ECE major, the Undergraduate Program Committee set up an *ad hoc* discrete mathematics subcommittee with the following charge:

1. Determine topics that constitute discrete math required for ECE
2. Determine coverage of topics in existing courses
3. Identify best "home" for topics not covered

After research on definitions of discrete math from organizations such as MAA and ACM/IEEE, the following were identified as the discrete mathematics topics essential for our ECE graduates:

- Sets / Functions
- Boolean algebra
- Proofs
- Graph theory
- Matrices
- Analysis of algorithms
- Sequences / recurrence relations
- Probability / combinatorics

Although there was coverage of discrete math topics in existing courses (e.g. Boolean algebra in EE2022), some of the topics identified (e.g. graph theory, analysis of algorithms) were not covered in ECE courses. Of topics not covered in ECE courses, some were covered in courses outside ECE (e.g. analysis of algorithms in CS2005, the course virtually all students take to satisfy the CS distribution requirement).

To find a "home" for the remaining topics, the UPC considered a number of options, including requiring an existing discrete mathematics course (CS2022/MA2201) of all students. After looking into the content of CS2022/MA2201, the subcommittee recommended against this option: the course did not cover all of the topics necessary for ECE students, and spent time on topics not of interest to ECE students.

The option finally recommended by the subcommittee, and chosen by the UPC and ECE faculty, was to cover the necessary discrete math topics within appropriate ECE courses. The final motion creating the ECE major incorporated revised course descriptions reflecting these changes. With these revised descriptions, coverage of discrete math concepts maps to course work as follows:

Topic	**Courses**
Sets / Functions	EE2022
Boolean algebra	
Proofs	
Graph theory	EE2801
Matrices	MA2071
Analysis of algorithms	CS2005
Sequences / recurrence relations	EE2312
Probability / combinatorics	MA2631 or MA3613

Although WPI's educational philosophy limits the use of required courses, the distribution requirements were written so as to ensure that virtually all students satisfying the distribution requirements complete all of the courses listed in the table.

Note that the list in the table is not exhaustive; examples of discrete math concepts also covered in upper level courses include:

- EE2799: Probability
- EE3703: Sequences, recurrence relations
- EE3801: Boolean algebra, proofs
- EE3901: Graph theory
- EE4304: Probability
- EE4502: Matrices, graph theory
- EE4801: Analysis of algorithms

Science Aspects

As described under Criterion 4 of the General Criteria, all students complete a set of courses in the basic sciences, including at a minimum one course in Chemistry and two in Physics. Most students complete three or four courses in Physics, and a growing number are including a course in Biology. Similarly, all students complete course work in the engineering sciences in three general areas: electrical and computer engineering, computer science, and one or more aspects of mechanical engineering. Student understanding of, and ability to apply knowledge from, these areas is verified as described under Outcomes 1, 3, and 5. The design course, EE2799, and the senior project (MQP) provide substantial experience with design of complex systems. This is verified via the Course Based Assessment and the MQP reviews.

Design Aspects

Design is an important component of the ECE program, and has been discussed previously in some detail. The biennial senior project ("MQP") reviews specifically address aspects of project magnitude and the technical content and level with respect to expectations for an entry-level engineer. Refer to the most recent MQP review in Appendix 3-9. An appropriate level of both breadth across the design process and depth in accomplishing a given set of design objectives is assured via the combination of the design course (EE2799) and the team-based senior project.

Summary and Comments regarding the ECE Program

The background, supporting data, constituent involvement, and conclusions in the faculty's decision to move to an ECE program has been previously presented. This Program Criteria section is the appropriate place to make some comments about what the ECE program is and is not:

- The ECE program must meet all of the General and Program Criteria
- The ECE program is ***not*** the concatenation of an EE program with a Computer Engineering program. It is by its nature broader and less deep than either of these more

narrowly-focused programs would be. We believe that for our students, the appropriate place for that specialization is an MS program.

- The ECE program contains ***more*** breadth requirements than our previous EE program, to address two concerns: that some students interested in Computer Engineering were receiving insufficient breadth across electrical engineering, and that some students on the electrical engineering side were receiving insufficient exposure to computer engineering, which in our view is now essential to all those entering the profession.
- The faculty have decided after consultation with the CS department (which has considerable experience with discrete math) to incorporate discrete math topics within specific ECE courses, rather than requiring a Mathematics course in discrete math. We will assess the results of this approach and make changes if needed.
- At the time that the ECE major was under discussion, Carnegie Mellon University was revamping its Electrical and Computer Engineering programs, changing to an integrated ECE program. As stated in CMU's report on their new program in 1995,[3] "Now we have merged all our degrees back into a single integrated B.S.E.C.E. This explicitly recognizes evolutionary trends in the discipline and in industry to emphasize the commonality across electrical and computer engineering, and not the differences."

[3] *Electrical and Computer Engineering at Carnegie Mellon – a New Curriculum*, Robert W. White, editor, ECE Dept., CMU, 1995.

Appendices

Appendix I

Appendix I-A Supporting Tables

Table 1. Basic-Level Curriculum

Note: See notes at end of table on second page.

Term (A, B, C, or D) and year of program	Course (Department, Number, Title)	Category (Credit Hours)			
		Math & Basic Sciences	Engineering Topics *Check if Contains Significant Design (✓)*	General Education	Other
A-1	Math 1021	3	( )		
A-1	Physics 1110	3	( )		
A-1	Humanities Elective		( )	3	
B-1	Math 1022	3	( )		
B-1	Physics 1120	3	( )		
B-1	Humanities Elective		( )	3	
C-1	Math 1023	3	( )		
C-1	Chemistry 1010	3	( )		
C-1	EE 2011		3 ( )		
D-1	Math 1024	3	( )		
D-1	Humanities Elective		( )	3	
D-1	EE 2022		3 ( )		
A-2	Math 2051	3	( )		
A-2	Computer Science 1005		( )		3
A-2	EE 2111		3 ( )		
B-2	Math 2071	3	( )		
B-2	Humanities Elective		( )	3	
B-2	EE 2311		3 ( )		
C-2	Social Science Elective		( )	3	
C-2	Math 3613	3	( )		
C-2	EE 2801		3 (✓)		
D-2	EE 3801		3 (✓)		
D-2	Physics 1140	3	( )		
D-2	Social Science Elective		( )	3	
A-3	IQP Project		( )	3	
A-3	Humanities Elective		( )	3	
A-3	EE 2312		3 ( )		
B-3	IQP Project		( )	3	
B-3	Sufficiency Project		( )	3	
B-3	EE 2799		3 (✓)		

(continued on next page)

Table 1. Basic-Level Curriculum (continued)

(Electrical Engineering)

Term (A, B, C, or D) and year of program	Course (Department, Number, Title)	Category (Credit Hours)			
		Math & Basic Science	Engineering Topics *Check if Contains Significant Design (✓)*	General Education	Other
C-3	IQP Project		( )	3	
C-3	EE 2201		3 (✓)		
C-3	ES 3011		3 ( )		
D-3	EE 3803		3 (✓)		
D-3	CS 2005		3 ( )		
D-3	EE 3204		3 (✓)		
A-4	MQP Project		3 (✓)		
A-4	ME 3601		3 ( )		
A-4	EE 4801		3 (✓)		
B-4	MQP Project		3 (✓)		
B-4	Free Elective		( )		3
B-4	Free Elective		( )		3
C-4	MQP Project		3 (✓)		
C-4	MA 2611	3	( )		
C-4	Physical Education (generally distributed over all years)		( )		3
D-4	Optional Elective		( )		
D-4	Optional Elective		( )		
D-4	Optional Elective		( )		
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		36	54	33	12
OVERALL TOTAL FOR DEGREE	135				
PERCENT OF TOTAL		27%	40%	24%	9%
Totals must satisfy one set	Minimum semester credit hours	32 hrs	48 hrs		
	Minimum percentage	25%	37.5 %		

Note that instructional material and student work verifying course compliance with ABET criteria for the categories indicated above will be required during the campus visit.

Note: The above program is typical, but does not represent the ***required*** schedule for any student. However, the amounts of credit in each column **are** required for each student, so that ABET requirements are certain to be met.

Table 2. Course and Section Size Summary

Electrical Engineering

Course No.	Title	No. of Sections offered in Current Year	Avg. Section Enrollment	Type of Class[1]			
				Lecture/ discussion	Laboratory	Recitation	Other
EE 2011	Intro. to Electrical and Comp. Engineering	9	26	*75*	25		
EE 2022	Intro. to Digital Circuits and Comp. Engineering	6	31	*75*	25		
EE 2111	Physical Principles of ECE Applications	2	66	100			
EE 2112	Electromagnetic Fields	1	42	100			
EE 2201	Microelectronic Circuits I	4	32	75	25		
EE 2311	Continuous-Time Signal and System Analysis	2	78	100			
EE 2312	Discrete-Time Signal and System Analysis	2	69	100			
EE 2799	Electrical and Computer Engineering Design	6	20	50	50		
EE 2801	Foundations of Embedded Computer Systems	6	24	75	25		
EE 3113	Intro. to RF Circuit Design	1	28	100			
EE 3204	Microelectronic Circuits II	4	25	75	25		
EE 3305	Aerospace Avionics Systems	1	28	100			
EE 3306	Audio Engineering	1	29	75	25		
EE 3311	Principles of Communication	1	60	100			
EE 3501	Electrical Energy Conversion	1	5	100			
EE 3503	Power Electronics	1	12	100			

Table 2. Course and Section Size Summary Continued

Electrical Engineering

Course No.	Title	No. of Sections offered in Current Year	Avg. Section Enrollment	Type of Class[1]			
EE 3601	Principles of Electrical Engineering	4	40	75	25		
EE 3703	Real-Time DSP	1	26	75	25		
EE371X	Electro-Optics	1	29	100			
EE 3801	Advanced Logic Design	6	21	75	*25*		
EE 3803	Microprocessor System Design	4	15	75	*25*		
EE 3815	Digital System Design with VHDL	3	20	75	*25*		
EE 3901	Semiconductor Devices	1	35	100			
EE 3902	Introduction to VLSI	1	44	75	*25*		
EE 4304	Communication Systems Engineering	1	29	100			
EE 4801	Advanced Computer System Design	2	29	75	*25*		
EE 4902	Analog Integrated Circuit Design	1	46	75	*25*		
ES 3011	Control Engineering	1	40	100			

1. Enter the appropriate percent for each type of class for each course (e.g., 75% lecture, 25% recitation).

Table 3. Faculty Workload Summary

(Electrical Engineering)

Faculty Member (Name)	FT or PT (%)	Classes Taught, AY 2001-2002 Undergraduate term (A, B, C, D) or graduate semester (F, S) are listed	Total Activity Distribution[2]		
			Teaching	Research	Other[3]
Bitar	FT	EE2201-A, EE3204-B, EE2201-C, EE2022-D	100		
Bromberg	FT	EE581-F, EE503-S, EE534-S	80	20	
Brown	FT	EE533-F, EE3803-B, EE3803-D	80	20	
Campbell	PT 15%	EE 3306-D	100		
Clancy	FT	EE596A-F, EE 2011-A, EE596B-S, EE2011-D	80	20	
Clements	FT	PS1-F, EE504-F, ES3011-B, PS2-S	80	20	
Cyganski	FT	EE530A-F, EE2011-C	80	20	
Duckworth	FT	EE574-S			100
Elbirt	PT 50%	EE3801-B, EE4801-C	100		
Emanuel	FT	EE 3501-A, EE3503-B, EE2111-C, EE2799-D	100		
Hakim	FT	EE2312-A, EE2312-C	80		20 (admin)
Hatami	PT 25%	EE3801-D Term	100		
Labonte	FT	EE2111-A, EE3305-B, EE2799-D, EE3204-D	100		
Looft	FT	EE2801-A, EE2801-C, EE3902-D	75		25 (admin)

Table 3. Faculty Workload Summary Continued

Faculty Member (Name)	FT or PT (%)	Classes Taught, AY 2001-2002 Undergraduate term (A, B, C, D) or graduate semester (F, S) are listed	Total Activity Distribution[2]		
			Teaching	Research	Other
Ludwig	FT	EE3113-A, EE2112-C, ½ year sabbatical	40	10	50 (sabbatical)
Makarov	FT	EE519G-F, EE3601-A, EE3601-C	80	20	
McNeill	FT	EE3901-A, EE4902-C	80	20	
Michalson	FT	EE2801-A, EE4801-A, EE2799-B, EE2799-D	100		
Nicoletti	FT	EE2022-B, EE3311-B, EE2311-D	80		20 (admin)
Orr	FT	EE 4304-C	50		50 (admin)
Pahlavan	FT	EE506A-F, EE539S-S	80	20	
Pedersen	FT	EE 371X-B, EE512-S, EE630-S	80	20	
Sunar	FT	EE578-F, EE3815-D	80	20	
Vaz	FT	EE2311-B	50		50 (admin)
Whitmal	FT	EE503-F, EE370X-B, EE539A-S	80	20	

1. Indicate Term and Year for which data apply.
2. Activity distribution should be in percent of effort. Faculty member's activities should total 100%.
3. Indicate sabbatical leave, etc., under "Other."

Table 4. Faculty Analysis

(Electrical Engineering)

Name	Rank	FT or PT	Highest Degree	Institution from which Highest Degree Earned & Year	Years of Experience			State in which Registered	Level of Activity (high, med, low, none)		
					Govt./ Industry Practice	Total Faculty	This Institution		Professional Society (Indicate Society)	Research	Consulting/ Summer Work in Industry
Bitar, S.	Adj.	FT	M.S	WPI, 1995	10	1	1		none	none	med
Bromberg, M.	Asst.	FT	PhD	UC Davis, 1990	10	2.5	2.5		low (IEEE)	high	med
Brown, D.R.	Asst.	FT	PhD	Cornell, 2000	5	2	2		med (IEEE)	high	med
Campbell, R.	Adj.	PT	B.S	WPI, 1958	41	14	14	MA	med (Acous Soc. Amer)	low	high
Clancy, E.	Asst.	FT	PhD	MIT, 1991	12	2	2		med (IEEE)	high	low
Clements, K.	Prof.	FT	PhD	Poly. Inst. Brooklyn, 1970	8	28	28		med (IEEE)	high	med
Cyganski, D.	Prof.	FT	PhD	WPI, 1981	2	21	21		low (IEEE)	high	low
Duckworth, R. J.	Assoc.	FT	PhD	Univ of Nottingham, 1984	8	15	12		low (IEEE)	low	high
Elbirt, A.	Inst.	PT	PhD	WPI, 2002	7	1	1		low (IEEE)	high	med
Emanuel, A.	Prof.	FT	D.Sc	Technion, Israel, 1969	9	25	25	MA	high (IEEE)	high	low
Hakim, H.	Assoc	FT	PhD	Purdue, 1982	8	15	15		med (IEEE)	low	none
Hatami, A.	Inst	PT	MS	Univ. Calgary, 1997	10	0.5	0.5		none	high	low
Labonte, R.	Adj.		MS	WPI, 1959	38	9	9		low (IEEE)	none	none

Table 4. Faculty Analysis Continued

Name	Rank	FT or PT	Highest Degree	Institution from which Highest Degree Earned & Year	Years of Experience			State in which Registered	Level of Activity (high, med, low, none)		
					Govt./ Industry Practice	Total Faculty	This Institution		Professional Society (Indicate Society)	Research	Consulting/ Summer Work in Industry
Looft, F. J.	Prof.	FT	PhD	U. Michigan 1979	2	22	22		low (IEEE)	med	low
Ludwig, R.	Assoc.	FT	PhD	Colorado St. U. 1986	1	12	12		med (IEEE)	high	med
Makarov, S.	Assoc.	FT	DrSc	St Petersburg State, 1995	1	14	4		med (IEEE)	high	med
McNeill, J.	Assoc.	FT	PhD	BU 1994	5	8	8		med (IEEE)	high	med
Michalson, W.	Assoc.	FT	PhD	WPI 1989	8	8	8		med (ION)	high	med
Nicoletti, D.	Assoc	FT	PhD	Drexel 1991	1	8	8		med (IEEE)	med	low
Orr, J.	Prof.	FT	PhD	U Illinois 1977	10	22	22		med (IEEE)	med	low
Pahlavan, K.	Prof.	FT	PhD	WPI, 1979	2	17	14		med (IEEE)	high	med
Pedersen, P.	Prof.	FT	PhD	U Utah 1976	1	23	12	PA	med (IEEE)	high	low
Sunar, B.	Asst	FT	PhD	Oregon State 1998	1	2	2		med (IEEE)	high	med
Vaz, R.	Assoc.	FT	PhD	WPI 1987	4	15	15		low (IEEE)	low	none
Whitmal, N.	Asst.	FT	PhD	Northwestern, 1997	6	5	3		low (IEEE)	high	low

Instructions: Complete table for each member of the faculty of the program. Updated information is to be provided at the time of the visit. The level of activity should reflect an average over the current year (year prior to visit) plus the two previous years.

Note: ."high" research activity represents regular publication of journal and conference papers, research funding, and advising of thesis students.

Table 5. Support Expenditures

(Electrical Engineering)

Fiscal Year	1	2	3	4
	2000	2001	2002	2003
Expenditure Category				
Operations[1] (not including staff)	$140,581	$123,077	$97,409	$101,144
Travel[2]	$15,754	$25,321	$23,732	$22,550
Equipment[3]	$92,100	$256,000	$130,400	$80,000
Institutional Funds	$75,800	$82,000	$94,000	$60,000
Grants and Gifts[4]	$16,300	$174,000	$36,300	$20,000
Graduate Teaching Assistants	$343,304	$334,913	$403,906	$404,000
Part-time Assistance[5] (other than teaching)	$58,765	$66,402	$71,002	$40,000

Instructions:

Report data for the engineering program being evaluated. Updated tables are to be provided at the time of the visit.

Column 1: Provide the statistics from the audited account for the fiscal year completed 2 years prior to the current fiscal year.

Column 2: Provide the statistics from the audited account for the fiscal year completed prior to your current fiscal year.

Column 3: This is your current fiscal year (when you will be preparing these statistics). Provide your preliminary estimate of annual expenditures, since your current fiscal year presumably is not over at this point.

Column 4: Provide the budgeted amounts for your next fiscal year to cover the fall term when the ABET team will arrive on campus.

Notes:

1. General operating expenses to be included here.
2. Institutionally sponsored, excluding special program grants.
3. Major equipment, excluding equipment primarily used for research. Note that the expenditures under "Equipment" should total the expenditures for Equipment. If they don't, please explain.
4. Including special (not part of institution's annual appropriation) non-recurring equipment purchase programs.
5. Do not include graduate teaching and research assistant or permanent part-time personnel.

Appendix I-B, Course Syllabi

COURSE DESCRIPTION

EE 2011 INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEERING
Academic Year 2001–02

Catalog Data:

EE 2011 Introduction to Electrical and Computer Engineering
Cat. I
The objective of this course is to expose new electrical engineering students (including first year students) to the broad field of electrical engineering, introducing basic concepts of circuits and systems and their applications. Experiments based on practical devices are used to reinforce basic concepts and develop laboratory skills, as well as to provide system-level understanding. The use of circuit simulation tools for analysis and design is introduced.

Topics: Basic concepts of electrical circuits, linear circuit analysis, op-amp circuits, simple transients, phasor analysis, amplifiers, frequency response, filters.

Recommended background: high school physics.

Textbook: *Electrical Engineering: Principles and Applications*, 2nd Edition, Allan R. Hambley, Prentice Hall, 2002.

Course Outcomes:

At the completion of this course the students should be able to:

- Write and understand Kirchhoff's current and voltage laws,
- Solve for voltage, current and power in resistive DC circuits,
- Find Thévenin's and Norton's equivalents,
- Model dependent sources and operational amplifiers in DC circuits,
- Manipulate complex numbers and phasors in the context of steady state AC circuits,
- Determine the impedance of resistor-capacitor-inductor circuits;
- Build and test simple electronic circuits,
- Independently learn to simulate simple electronic circuits using circuit simulation tools,
- Solve circuits incorporating first-order transients.

<u>Note:</u> Course outcomes 1–6 are assessed each time EE2011 is offered during the regular academic year. These outcomes have been assessed via the performance on one or more exam questions, each of which is written to cover the objectives of only one outcome. The assessments are then independently reviewed (by a faculty member not directly involved in the teaching of the course). The review completed during the summer of 2001 identified

outcome three as an overall weakness for the students. Based on this concern (as well as course evaluation feedback directly solicited from the students), the D-term 2002 offering of the course placed additional emphasis on the material associated with outcome 3. In particular, Thévenin /Norton equivalents were given additional lecture emphasis, additional homework coverage, and are now included on all three exams (they were only covered on two exams in the past). Assessment from this term still shows this outcome to be the weakest of the six, however this outcome has improved (compared to the A-term 2001 offering) relative to the other outcomes.

Relation to ECE Program Outcomes:

Outcome	**Level**	**Means by which students demonstrate proficiency**
1	High	Homework, exams, labs
2	Low	Homework, labs (Independent learning of circuit simulator)
3	High	Homework, exams, labs
4	High	Homework, exams, labs
5	Medium	Homework, labs (Group learning encouraged)
6	Low	Homework, exams, labs
7	Low	Labs
8	Low	Homework, labs, lectures
9	Medium	Homework, labs (Independent learning of circuit simulator)
10	Low	Homework, exams, labs
11	Medium	Ethics case study laboratory

Computer Usage: All course materials delivered on the web; MultiSim circuit simulator.

Laboratory Component: Introductory laboratory sessions introduce students to wiring basic electronic components (resistors, capacitors, inductors, operational amplifiers, diodes, transistors) and using laboratory equipment (power supplies, multi-meter, oscilloscope).

Engineering Science/Design Content: Engineering Science 95%
Engineering Design 5%

Students also complete an introductory ethics "laboratory" to raise their awareness of ethical issues in engineering practice.

Prepared by David Cyganski March 8, 2002

COURSE DESCRIPTION

EE 2022 INTRODUCTION TO DIGITAL CIRCUITS AND COMPUTER ENGINEERING
Academic Year 2001-02

Catalog Data:

EE 2022 Introduction to Digital Circuits and Computer Engineering

Cat. I

The objective of this course is to expose students (including first year students) to basic electrical and mathematical concepts that underlie computer engineering while continuing an introduction to basic concepts of circuits and systems in a hands-on environment. Experiments representing practical devices introduce basic electrical engineering concepts and skills which typify the study and practice of electrical and computer engineering. In the laboratory, the students construct, troubleshoot, and test analog and digital circuits that they have designed. They will also be introduced to the nature of the interface between hardware and software in a typical microprocessor based computer.

Topics include: Sets, functions, Boolean algebra, digital switching logic, the transistor as switch, circuit design of logic gates, design of combinational logic circuits, software and hardware interfacing including analog/digital and digital/analog conversion.

Recommended background: EE 2011 and MA 1022

Textbook: *Digital Logic – Applications and Design*, John M. Yarbrough, West Publishing Co., 1997.

Course Outcomes:

At the completion of this course the students should achieve:

- The ability to express numbers using different bases (binary, octal, and hexadecimal).
- An understanding of how to perform arithmetic operations (addition, multiplication, subtraction) using binary numbers.
- To perform basic operations of Boolean algebra.
- An understanding of how to simplify logic expressions using Karnaugh maps.
- The ability to design, build and test combinational logic circuits to perform a given task or operation.
- To be able to consider the practical limitations of circuits (such as fan-out and propagation delay).
- To understand the physical nature of logic design, specifically the interface between a logic circuit and other circuit elements.
- To understand how a transistor is used for the implementation of Boolean algebra (inversion and the nand operation).
- To understand how to set up and solve combinatorics problems.

- An understanding of the computer-engineering topics within the Electrical and Computer Engineering curriculum.
- An understanding of how the computer-engineering topics are similar to and different from related mathematics and computer science curricula.

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, lab exercises, term paper assignments
2	Medium	Use of current lab equipment, term paper assignments
3	High	Homework, exams, lab exercises
4	High	Homework, exams, lab exercises
5	Medium	Working with lab partners
6	High	Homework, exams, lab exercises
7	High	Term paper assignments
8	Low	Term paper assignments
9	Medium	Homework, lab exercises, term paper assignments
10	High	Term paper assignments
11	Medium	Term paper assignments

Computer Usage: Use of a digital logic simulator (Xilinx) is incorporated into several laboratory assignments. Introductory instruction is given. Students are encouraged to compare lab results with those predicted by computer simulations.

Laboratory Component: Students are required to complete weekly laboratory exercises which reinforce topics covered in lecture.

Term Paper Component: Students are required to complete weekly written assignments on various topics related to electrical and computer engineering, to better prepare them for the future. These written assignments are then combined into one final term paper.

Engineering Science / Design Content: Engineering Science 70%
Engineering Design 30%

Students complete weekly homework and lab exercises, some of which require a design component. Lab exercises require students to breadboard their designs, test them, and compare measurement results to theory.

Prepared by Stephen J. Bitar May 7, 2002

COURSE DESCRIPTION

EE 2111 PHYSICAL PRINCIPLES OF ECE APPLICATIONS
Academic Year 2001-2002

Catalog Data:

EE 2111 Physical Principles of ECE Applications
Cat. I
In this course students will learn the practical applications of electromagnetics and their relation to basic DC and AC circuit theory. The meaning of electric and magnetic field concepts is explained and placed in context with capacitive and inductive circuits. Exploiting those concepts leads to a host of practical devices such as transformers, motors, and generators. In addition, measures to minimize the influence of stray electric and magnetic fields are analyzed as part of various shielding and grounding strategies. The electric and magnetic circuit aspects are then presented as linear first-order systems in the time and frequency domains. Issues such as time-constants, impedance, and superposition are explained in detail. Building upon these basic concepts, second-order systems consisting of mixed capacitive and inductive systems are analyzed in terms of their resonance effects. The second-order system description will then be applied to develop the basic transmission line theory as required in high-speed digital design.

Recommended background: EE 2011, introductory physics courses such as PH 1120 or PH 1121, MA 1024 and MA 2051 (concurrent).

Textbooks: *Electrical Engineering, Principles and Applications*, A.R. Hambley, Prentice Hall, 2002, 2nd Edition.
Fundamentals of Applied Electromagnetics, F. T. Ulaby, Prentice Hall, 2001, 2001 Media Edition.

Course Outcomes:

At the completion of this course, students should achieve:

- Ability to use complex numbers,
- Understand the role and effects of capacitors on circuit performance,
- Understand the role and effects of inductors on circuit performance,
- Ability to analyze transients of first-order circuits,
- Ability to analyze transients of second-order circuits,
- Ability to apply the principles of nodal, mesh and superposition techniques,
- Mastery of a software package (Pspice) used for circuit analysis,
- Ability to analyze frequency response and recognize resonance behavior,
- Basic understanding of transmission lines principles.

Relation to ECE Program outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Home Works, Exams, Projects
2	High	Home Works, Projects, Demonstrations
3	Medium	Home Works, Exams, Projects
4	Medium	Home Works, Exams, Projects, Demonstrations
5	Medium	Home Works, Projects
6	High	Home Works, Exams, Demonstrations
7	Low	Home Works, Projects
8	Low	Class Lectures
9	Medium	Home Works, Projects
10	Medium	Home Works, Exams, Projects, Demonstrations
11	Medium	Home Works, Projects

Computer Usage: Matlab and Pspice

Laboratory Component: Class Demonstrators. Extensive use of Pspice

Engineering Science/Design Content: Engineering Science 75%
Engineering Design 25%

Prepared by Alexander E. Emanuel March 7, 2002

COURSE DESCRIPTION

EE 2112 ELECTROMAGNETIC FIELDS
Academic Year 2001-02

Catalog Data:

EE 2112 Electromagnetic Fields

Cat. I

The object of this course is a comprehensive treatment of electromagnetic engineering principles covering the entire application spectrum from static to dynamic field phenomena.

The starting point will be the basic electric and magnetic field definitions of Coulomb and Bio-Savart leading to Gauss's and Ampere's laws. They form the foundation of electro- and magnetostatic fields. Students will examine capacitive and inductive systems and relate them to lumped element circuit models. By introducing temporal and spatial magnetic flux variations, Faraday's law is established. The engineering implications of this law are investigated in terms of transformer and motor actions. Incorporation of the displacement current density into Ampere's law and combining it with Faraday's law will then culminate in the complete set of Maxwell's field equations. As a result of these equations, students will develop the concept of wave propagation in the time and frequency domain with practical applications such as wireless communication, radar, global positioning systems, and microwave circuits.

Recommended background: EE 2111

Textbook: *Fundamentals of Applied Electromagnetics*, Fawwaz T. Ulaby, Prentice-Hall, 2000.

Course Outcomes:

At the completion of this course the students should achieve:

- A solid understanding of the meaning of fields and their usefulness.
- An understanding of voltage and current waves in transmission line systems.
- An appreciation of reflection, transmission, standing waves, and power flow concepts.
- A clear notion of the differences between lumped and distributed circuit theory.
- An understanding of how vector calculus and integral theorems apply to basic electromagnetic field phenomena.
- An understanding of coordinate transformations, line, surface, and volume integration in the context of electromagnetic field computations.
- An appreciation of dynamic and static fields behaviors.
- An understanding of the integral and differential forms of Maxwell's equations.
- An understanding of boundary and initial conditions.

EE 2112 page 2

- An understanding of how dielectric and magnetic media influence the field equations.
- A better understanding of how mathematics and physics courses are interrelated with electrical engineering courses.

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	Medium	Homework, exams
2	High	Homework, exams
3	High	Homework, exams
4	High	Homework, exams
5	Low	Homework
6	Medium	Homework, exams
7	Medium	Exam
8	Low	Homework
9	Medium	Homework
10	Medium	Homework
11	None	-

Computer Usage: MATLAB, MathCad; some students use C/C++.

Laboratory Component: No formal laboratory, but students are walked through a complete design

Engineering Science/Design Content: Engineering Science 85%
Engineering Design 15%

The course has a number of in-class experimentation such as measurements of transmission line effects with a network analyzer, determination of field properties of coils, operation of various sensing elements. In addition, short videotapes of design measurements at Philips Semiconductors are shown.

Prepared by Reinhold Ludwig March 27, 2002

COURSE DESCRIPTION

EE 2201 MICROELECTRONIC CIRCUITS I
Academic Year 2001-02

Catalog Data:

EE 2201 Microelectronic Circuits I
Cat. I
This course is the first of a two-course sequence in electronic circuit design. It begins with a substantive treatment of the fundamental behavior of semiconductor materials and moves on to the semiconductor diode, the bipolar transistor, and the field-effect transistor. Laboratory exercises are provided to reinforce the theory of operation of these devices. Numerous circuit applications are considered, including: power supplies, transistor amplifiers, and FET switches.

Topics include: The p-n junction, diode operation, transducers, rectification, voltage regulation, limiting and clamping circuits, transistor operation, biasing, small-signal and large-signal models, transistor amplifiers, and switching applications.

Recommended Background: EE 2011

Textbook: *Microelectronic Circuits*, 4^{th} Edition, Adel S. Sedra and Kenneth C. Smith, Oxford University Press, 1998.

Course Outcomes:

At the completion of this course, the students should achieve:

- An understanding of fundamental semiconductor physical concepts and the performance of the p-n junction.
- An understanding of diode operation and performance.
- An ability to analyze diode circuits and to design and implement diode applications.
- An understanding of field-effect transistor operation and performance.
- An ability to analyze field-effect transistor circuits and to design and implement field-effect transistor applications.
- An understanding of bipolar junction transistor operation and performance.
- An ability to analyze bipolar junction transistor circuits and to design and implement bipolar junction transistor applications.

EE 2201 page 2

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, lab exercises, lab reports
2	Medium	Use of current lab equipment
3	High	Homework, exams, lab exercises, lab reports
4	High	Homework, exams, lab exercises, lab reports
5	Medium	Working with lab partners, co-authoring lab reports.
6	High	Homework, exams, lab exercises, lab reports
7	Medium	Lab reports
8	None	
9	Medium	Lab exercises
10	Low	Lab exercises, lab reports – breadth of topics
11	None	

Computer Usage: No formal software instruction is given, however, students are encouraged to compare lab results with electronic circuit simulators (Electronic Workbench, Multisim, Pspice, etc.).

Also, in generating lab reports, students are required to present actual oscilloscope waveforms taken in lab (using digital cameras), plotting data (e.g. Excel, MATLAB), and comparing results to theoretical predictions. Wordprocessing skills are assumed.

Laboratory Component: The laboratory component of the course is extensive. Students are required to complete weekly lab exercises and weekly lab reports.

Engineering Science / Design Content: Engineering Science 60%
Engineering Design 40%

Students complete six homework and lab exercises which require a design component. Lab exercises require students to breadboard their designs, test them, and compare measurement results to theory. Each student team presents their results in formal lab reports, completed weekly.

Prepared by Stephen J. Bitar March 8, 2002

COURSE DESCRIPTION

EE 2311 CONTINUOUS-TIME SIGNAL AND SYSTEM ANALYSIS
Academic Year 2001-02

Catalog Data:

EE 2311. Continuous-Time Signal and System Aanalysis
Cat. I
This course provides an introduction to time and frequency domain analysis of continuous time signals and linear systems. Topics include signal characterization and operations; singularity functions; impulse response and convolution; Fourier series; the Fourier transform and its applications; frequency-domain characterization of linear, time-invariant systems such as filters; and the Laplace transform and its applications.

Recommended background: EE 2011, MA 1022

Suggested background: MA 2051

Textbook: *Signal Processing and Linear Systems,* B. P. Lathi, Berkeley-Cambridge Press,1998.

Course Outcomes:

At the completion of this course the students should achieve:

- Characterize signals and systems using commonly-accepted terminology.
- Relate frequency-domain descriptions of signals and systems to their characteristics in the time domain.
- Use frequency-domain techniques to solve input/output problems for linear, time-invariant systems.
- Use software tools to model and analyze signals and systems.
- Convey effectively ideas and concepts through writing.
- Apply existing knowledge and use educational resources in order to learn new concepts and tools on their own.
- Reflect constructively on their educational experiences, and assess critically the value of those experiences.

EE 2311 page 2

Relation to ECE Program Outcomes :

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, projects
2	Medium	Homework, projects
3	High	Homework, exams, projects
4	High	Homework, exams, projects
5	Medium	Projects
6	Low	Projects
7	High	Homework, exams, projects
8	Medium	Discussed but not demonstrated
9	High	Projects
10	Medium	Reflective writing assignments
11	None	Discussed but not demonstrated

Computer Usage: MATLAB, Simulink.

Laboratory Component: No formal laboratory, but students make extensive use of analysis and simulation tools.

Engineering Science/Design Content: Engineering Science 75%
Engineering Design 25%

The "Discovery Projects" in this course were developed to achieve several objectives: they alleviate the crowding of topics in the course, introduce the use of modern computer tools, focus on independent learning, and emphasize writing and professional presentation of results. These three projects involve advanced topics and computer tools that are for the most part not touched on in the classroom; the students are expected to learn on their own using tutorial resources. The projects are done individually.

There is also a substantial amount of homework. Exams are closed-book, closed-notes, with no calculators allowed. All assignments (homeworks, exams, projects) involve some writing, some including substantive essays and reflective pieces. There is a constant and conscious focus on conceptual understanding and critical thinking; students are challenged to describe ideas and apply them to new situations, rather than simply to perform calculations and solve simple problems.

Prepared by Richard F. Vaz January 4, 2002

COURSE DESCRIPTION

EE 2312 DISCRETE-TIME SIGNAL AND SYSTEM ANALYSIS
Academic Year 2001-02

Catalog Data:

EE 2312 Discrete-Time Signal and System Analysis
Cat. I
This course provides an introduction to the time and frequency domain analysis of discrete-time signals and linear systems. Topics include sampling and quantization, characterization of discrete-time sequences, the discrete-time Fourier transform, the discrete Fourier transform and its applications, the Z transform and its applications, linear and circular convolution, characterization of FIR and IIR discrete-time systems, and the analysis and design of discrete-time filters. Projects include topics such as sampling and quantization; application of the DFT to signal and system analysis and design; and digital filter design and simulation.

Recommended background: EE 2311.

Textbook: *Signal Processing & Linear Systems*, L.P. Lathi, Bekleley Cambridge Press, 1998.

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of sampling theorem, aliasing problem, and signal reconstruction process.
- An understanding of quantization process and its impact on signal quality.
- An understanding of characterization of discrete-time signals and systems.
- The ability to analyze discrete-time systems in time-domain.
- An understanding of DTFT and DFT and their applications.
- The ability to analyze discrete-time systems in frequency-domain.
- The ability to use Z-transform to solve difference equations.
- An understanding of FFT and its applications.
- An understanding of the characteristics of FIR and IIR filters.
- The ability to use computers for design of digital filters.
- An appreciation for the use of computers in digital signal processing.
- An improved ability to communicate their understanding and results in written form.

Relation to ECE Program Outcomes :

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, projects
2	Medium	Projects
3	Medium	Homework, exams, projects
4	High	Homework, exams, projects
5	Medium	Projects
6	Medium	Homework, exams, projects
7	Medium	Projects
8	None	
9	Medium	Projects
10	Low	Projects
11	None	

Computer Usage: DADiSP, GoldWave, and MATLAB

Laboratory Component: No formal laboratory, but students make extensive use of several signal processing software.

Engineering Science/Design Content: Engineering Science 75%
Engineering Design 25%

The course assignments include four projects where the students use different signal processing software to apply their knowledge to processing of audio signals. The projects are completed by students in teams of size two and culminate with written reports.

Prepared by Hossein Hakim October 26, 2001

COURSE DESCRIPTION

EE 2799 ELECTRICAL AND COMPUTER ENGINEERING DESIGN
Academic Year 2001-02

Catalog Data:

EE 2799 Electrical and Computer Engineering Design (1/3 U)
Cat. I
The goal of this course is to provide experience with the design of a system, component, or process. Basic sciences, mathematics, and engineering sciences are applied to convert resources to meet a stated objective. Fundamental steps of the design process are practiced, including the establishment of objectives and criteria, synthesis, analysis, manufacturability, testing, and evaluation. Students work in small teams and are encouraged to use creativity to solve specific, but open-ended problems, and then present their results.
EE 2799 is strongly recommended for all students as a preparation for the design element of the MQP. It is anticipated that EE 2799 will be of most benefit to students when taken well in advance of the MQP (late sophomore year or early junior year).

Recommended background: EE 2022, EE 2111, and EE 2311; MA 2611 or MA 3613; and at least one of EE 2112, EE 2201, EE 2312, EE 2801.

Textbooks: *Engineering by Design*, G. Voland, Addison-Wesley, 1999.
Engineering Design for Electrical Engineers, A.D. Wilcox, Prentice Hall, 1990.

Course Outcomes:

At the completion of this course the students should be able to:

- Demonstrate knowledge of the steps involved with the engineering design process
- Demonstrate the ability to apply the engineering design steps to the decomposition, solution and implementation of an unbounded design problem
- Demonstrate an understanding of the organizational issues associated with engineering design.
- Demonstrate an understanding of the relevance of ethics, reliability, safety and regulatory issues into the design process.
- Demonstrate a working knowledge of the financial, schedule, legal and other administrative elements of the design process
- Demonstrate the ability to effectively use written communications to report project status and results.
- Demonstrate the ability to effectively use oral communications to report project status and results.

EE 2799 page 2

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, project
2	High	Homework, exams, project
3	Medium	Homework, project
4	Medium	Exams, project
5	High	Homework, exams, project
6	Medium	Homework, project
7	High	Homework, exams, project
8	High	Project
9	High	Homework, project
10	High	Homework, exams, project
11	High	Homework, exams, project

Computer Usage: Computer usage varies depending on the design approach taken by each student group. All groups use word processing and presentation software at a minimum. Many groups use C/Assembly language programming, Spice, Multisim or other design tools.

Project Component: The project requires students to solve an open-ended design problem. Each problem requires interacting with something in a physical environment (ie. Temperature, humidity, pressure, troque, etc.). Project solutions may be digital, analog or a combination of both. Projects are completed by 3 person teams.

Course Website: http://www.ece.wpi.edu/~wrm/Courses/EE2799

Engineering Science/Design Content: Engineering Science 10%
Engineering Design 90%

Prepared by William R. Michalson January 25, 2002

COURSE DESCRIPTION

EE 2801 FOUNDATIONS OF EMBEDDED COMPUTER SYSTEMS
Academic Year 2001-02

Catalog Data:

EE 2801 Foundations of Embedded Computer Systems
Cat. I.
This course introduces the assembly language programming concepts that are needed to develop microprocessor and microcontroller-based computer systems. Beginning with the fundamentals of computer architecture and organization, students learn assembly language and how assembly language programs running on microprocessors are used to solve problems that require interactions between a computer and the physical world. Students in this course will also learn about the hardware and software structure of a modern computer system and how hardware, software, and the passage of time must be managed in an embedded system design. Other issues that will be addressed as appropriate include overall embedded system development, software maintenance, programming for reliability, and product safety.

Topics: Microprocessor and microcontroller architecture, assembly language programming, program development and test tools, cross-compilation, linking, loading, operating system interfaces, hardware/software dependencies, and time and resource management.

Lab Exercises: Design and implementation of assembly language programs for embedded applications such as real-time controllers, burglar alarms, and signal processing.

Recommended Background: EE 2022 (for ECE students, CS 2011 is acceptable for CS students), MA 1022, and an introductory physics course such as PH 1110 or PH 1111.

Textbook: *The 8086 Microprocessor: Programming and Interfacing The PC*, Ayala K. J., Delmar Publishers, 1994

Course Outcomes:

At the completion of this course, the student should:

- have the ability to recognize, justify and perform software/hardware *design tradeoffs*
- have the ability to recognize, justify and assess system *resource needs*
- have a knowledge of *8086 assembly language*
- have a knowledge of *PIC assembly language*
- have the ability to *develop* sw/hw solution to an embedded system design problem
- have the ability to *verify* correctness of a sw/hw solution to a complex embedded system design problem

EE 2801 page 2

- have a basic knowledge of microprocessor system *architecture*
- have a knowledge of *structured design and programming methodologies*
- have a knowledge of *discrete mathematics*, particularly for numerical algorithms

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	high	homework, exams, lab assignments
2	high	all course components, but particularly homework
3	medium	all course components
4	medium	homework, exams (numerical methods)
5	high	homework and lab assignments
6	high	all course components
7	medium	detailed lab reports
8	medium	homework and lab assignments
9	high	all course components
10	low	all course components are but one part of the broad education envisioned by the WPI plan
11	medium	lab/homework assignments pertinent to systems designed and implemented societal/global use

Computer Usage:

Turbo Assembler, Turbo Debugger, various text editors, Turbo Linker, MP-LAB (Microchip: PIC Compiler and down loader), MP-LAB (Microchip: in-circuit debugger)

Laboratory Component:

The laboratory component of this course is based on the development of (first half of the course) 8086 assembly language programs that require students to develop algorithms that solve specific problems, and on the development of (second half of the course) PIC microcomputer algorithms that reflect current embedded system design, implementation and control problems. The 8086 programs are implemented in a PC environment. The PIC programs are implemented on a stand alone PIC demonstration board where programs are created, assembled and downloaded from a host PC based system.

Engineering Science/Design Content: Engineering Science 30%
Engineering Design 70%

Prepared by: Fred J. Looft March 7, 2001

COURSE DESCRIPTION

EE 3113 INTRODUCTION TO RF CIRCUIT DESIGN
Academic Year 2001-02

Catalog Data:

EE 3113 Introduction to RF Circuit Design
Cat. I
This course is designed to provide students with the basic principles of radio frequency (RF) circuit design. It concentrates on topics such a designing tuning and matching networks for a analog and digital communication, satellite navigation, and radar systems.
After reviewing equivalent circuit representations for RF diodes, transistors, FETs, and their input/output impedance behavior, the course examines the difference between lumped and distributed parameter systems. Characteristic impedance, standing waves, reflection coefficients, insertion loss, and group delay of RF circuits will be explained. Within the context of Maxwell's theory the course will then focus on the graphical display of the reflection coefficient (Smith Chart) and its importance in designing matching circuits. Students will learn the difference between SPICE and monolithic and microwave integrated circuit analysis and design (MMICAD) modeling. Biasing and matching networks for single and multistage amplifiers in the 900 – 2,000 MHz range are analyzed and optimized in terms of input/output impedance matching, insertion loss, and group delay.
Recommended background: EE 2111, EE 3204
Suggested background: EE 2112

Textbook: *RF Circuit Design: Theory and Application*, R. Ludwig and P. Bretchko, Prentice-Hall, 2000.

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of the high-frequency behavior of lumped circuit elements.
- A clear notion of the differences between lumped and distributed circuit theory.
- An appreciation of how the Smith Chart is applied as a theoretical and practical analysis tool for matching, gain, and stability considerations.
- A basic understanding of two-port network description, cast in Z, Y, h, ABCD forms, and its application to RF system engineering.
- An understanding of how the scattering parameters are used to analyze the RF system behavior.
- An understanding of key semiconductor principles and how they affect the high-frequency operation of active devices.
- An understanding of DC biasing, RF/DC decoupling and their effects on the high frequency characterization of the active devices.
- A clear understanding of the design of input and output matching networks.
- An appreciation of the design approach of a constant gain RF amplifier.

- An improved ability to communicate his/her understanding and results in oral and written form.
- An understanding of the ways in which the topics of this course relate to Math, Physics, and fundamental ECE courses.

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams
2	High	Homework, exams
3	High	Homework, exams
4	High	Homework, exams
5	Medium	Homework
6	High	Homework, exams
7	Medium	Exam
8	Low	Homework
9	Medium	Homework
10	Low	Homework
11	None	-

Computer Usage: MATLAB and the industry-standard RF circuit simulator Advanced Design System (ADS).

Laboratory Component: No formal laboratory, but students are walked through a complete design of an RF amplifier project that combines all course goals (component selection and characterization, transistor biasing, S-parameter determination, matching network construction, stability analysis, unilateral gain design approach, ADS circuit performance simulation)

Engineering Science/Design Content: Engineering Science 65%
Engineering Design 35%

Students have to develop matching network designs based on the ZY Smith Chart for practical circuits. Furthermore, they have to apply Matlab codes from the textbook, and they have to develop their own (extensive) codes for a wide range of transmission line and RF circuit problems. The course will illustrate to students that analog circuit design at high operating frequencies requires wave phenomena as covered in physics (emphasis on optics) and electromagnetic fields (emphasis on EM wave).

Prepared by Reinhold Ludwig October 31, 2001

COURSE DESCRIPTION

EE 3204 MICROELECTRONIC CIRCUITS II
Academic Year 2001-02

Catalog Data:

EE 3204 Microelectronic Circuits II
Cat. I
This course is the second of a two-course sequence in electronic circuit design. More complex circuits are analyzed and the effects of frequency and feedback are considered in detail. The course provides a comprehensive treatment of operational amplifier operation and limitations. The use of Bode plots to describe the amplitude and phase performance of circuits as a function of operating frequency is also presented. In addition, the concepts of analog signal sampling, analog-to-digital conversion and digital-to-analog conversion are presented along with techniques for interfacing analog and digital circuitry. Laboratory exercises are provided to reinforce student facility with the application of these concepts to the design of practical circuits.

Topics include: transducers, differential amplifiers, inverting / non-inverting amplifiers, summers, differentiators, integrators, passive and active filters, the Schmitt trigger, monostable and astable oscillators, timers, sample-and-hold circuits, A/D and D/A converters.

Recommended Background: Introductory electronic circuit design and analog signal analysis as found in EE 2201 and EE 2311.

Textbook: *Microelectronic Circuits*, 4th Edition, Adel S. Sedra and Kenneth C. Smith, Oxford University Press, 1998.

Course Outcomes:

At the completion of this course, the students should achieve:

- An understanding of operational amplifier (op-amp) function and performance.
- An ability analyze, design, and implement linear amplifier applications utilizing op-amps including inverting and non-inverting amplifier circuits and sum and difference amplifiers.
- An ability to analyze, design, and implement linear filter applications utilizing op-amps.
- An ability to analyze, design and implement integration and differentiating functions using op-amp circuitry.
- An ability to analyze, design and implement comparator and Schmitt trigger functions using op-amp circuitry.
- An ability to analyze, design, and implement monostable and astable oscillators and timers utilizing op-amps.
- An ability to analyze, design, and implement sample-and-hold circuitry using switching transistors and op-amp circuitry.

- An ability to analyze, design, and implement D/A and A/D functions utilizing digital components and op-amp circuitry.

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, lab exercises, lab reports
2	Medium	Use of current lab equipment
3	High	Homework, exams, lab exercises, lab reports
4	High	Homework, exams, lab exercises, lab reports
5	Medium	Working with lab partners, co-authoring lab reports.
6	High	Homework, exams, lab exercises, lab reports
7	Medium	Lab reports
8	None	
9	Medium	Lab exercises
10	Low	Lab exercises, lab reports – breadth of topics
11	None	

Computer Usage: No formal software instruction is given, however, students are encouraged to compare lab results with electronic circuit simulators (Electronic Workbench, Multisim, Pspice, etc.).

Also, in generating lab reports, students are required to present actual oscilloscope waveforms taken in lab (using digital cameras), plotting data (e.g. Excel, MATLAB), and comparing results to theoretical predictions. Wordprocessing skills are assumed.

Laboratory Component: The laboratory component of the course is extensive. Students are required to complete weekly lab exercises and weekly lab reports.

Engineering Science / Design Content: Engineering Science 60%
Engineering Design 40%

Students complete six homework and lab exercises which require a design component. Lab exercises require students to breadboard their designs, test them, and compare measurement results to theory. Each student team presents their results in formal lab reports, completed weekly.

Prepared by Robert Labonté May 4, 2002

COURSE DESCRIPTION

EE 3305 AEROSPACE AVIONICS SYSTEMS
Academic Year 2001-02

Catalog Data:

EE 3305 Aerospace Avionics Systems
Cat. I
This course is intended for students interested in obtaining a systems-level perspective of modern aerospace communications, navigation, and radar systems. The fundamental theory of operation of these systems is presented along with current-day applications of them.
Topics: The functional operating principles and techniques of communications, navigation (including GPS), and radar systems; performance expectations for antenna, transmitter, receiver, and transmission-line components; error sources and their effect in combination on both individual component and aggregated system performance; earth-shape approximations and their influence on system design and operation; tropospheric and ionospheric effects on radio-wave propagation; and achievable overall system accuracies.

Recommended Background: MA 1022, and PH 1120 or equivalent, and EE 2311. With extra work, this course can be successfully completed by non-EE students. The basic concepts of electromagnetic-wave propagation and antennas will be introduced as needed.

Textbook: There is no textbook for this course. A collection of appropriate journal and textbook excerpts will be provided to augment the information presented during lectures.

Course Outcomes:

Students will develop a systems-level understanding of the principles and operation of modern communications, surveillance, and navigation avionics systems. As well, students will develop evaluation and design skills associated with: signal-detection criteria; the effects of tropospheric and ionospheric propagation on system performance; and methods for computing overall-system energy budgets and accuracy.

In particular, students will develop proficiency with all of the following specific topics:

- Aerospace avionics regulations, principles, and regulation authorities
- Earth-shape approximations and reference ellipsoids
- Distance and bearing calculations over a spherical and an elliptical Earth
- Direction Finding {polar, triangulation, and trilateration]
- Parameter estimation and composite error computation
- Electromagnetic-wave propagation {conduction, diffraction, refraction, multipath interference]
- Antenna Fundamentals [dipole, parabolic, Cassegrain, and arrays]
- Path-loss calculations and energy budgets
- Receivers and post-detection processing

- Probability-of-detection and probability-of-false-alarm calculation
- Beacon and transponder principles and operation
- Hyperbolic navigation systems [Omega, Decca, Loran A/C]
- Satellite navigation systems [GPS and Glonass]
- Communication and radar systems [coherent and non-coherent]

Relation to ECE Program outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams
2	Low	Homework
3	High	Homework, exams
4	High	Homework, Exams
5	Medium	Homework
6	High	Homework, Exams
7	Low	Written elements of homework assignments
8	None	
9	Low	Homework
10	Low	Breadth of homework assignments
11	Low	Breadth of homework assignments

Computer Usage: Use of Maple, Mathematica, or equivalent tool to accomplish the calculations needed to complete problem-set assignments.

ABET Category Content: Engineering Science—75%
Engineering Design— 25%

Prepared by: Robert C. Labonté January 9, 2002

COURSE DESCRIPTION

EE 3306 AUDIO ENGINEERING
Academic Year 2001-02

Catalog Data:

EE 3306 Audio Engineering
Cat. I
Intended to provide an advanced student a thorough understanding of the theory and practice of electronic systems used for the recording and reproduction of speech and music, and of the nature and control of acoustic noise.

Topics: sound, applied acoustics, devices and systems associated with the recording and reproduction of speech and music. Feedback amplifiers. Measurement of sound; techniques for the control of acoustic noise. Selected laboratory exercises.

Recommended background: EE 2201, EE 2311, EE 3204 or equivalent.

Textbook: *Acoustics,* Leo L. Beranek, Acoustical Society of America, 1996.

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of human perception of speech and music and how excessive noise and reverberation affects intelligibility,
- An appreciation of the fundamental principles of sound propagation in air and in enclosures,
- An appreciation of the problems in acoustic measurements and techniques,
- An understanding of the tradeoffs associated with delivering a high level of speech intelligibility in our inter-lingual and aging population,
- An understanding of the effects of high noise on hearing loss,
- An understanding of loudspeaker design and application, especially with respect to directivity and frequency response,
- An understanding of the fundamental principles of computer acoustic modeling and analysis of performance spaces and of loudspeaker systems,
- An appreciation of what can go terribly wrong in an audio system (read: any system) due to the operational failure of one component,
- An appreciation of the ways in which the topics of this course relate to the rest of ECE and to their careers.

Relation to ECE Program Outcomes:

Outcome	**Level**	**Means by which students demonstrate proficiency**
1	High	Homework, labs
2	Medium	Measurement labs
3	Low	Homework, quizzes
4	High	Homework, quizzes, labs
5	Medium	Projects
6	High	Homework, quizzes, labs
7	Medium	Lab reports
8	Low	Weakly demonstrated
9	Medium	Homework, lab reports
10	Medium	Labs
11	High	Labs

Computer Usage: EXCEL, CATT, MLSSA, SMAART

Laboratory Component: Six laboratory exercises including one site visit to an orchestra hall and one visit to a venue for acoustic measurements with extensive follow-on computer analysis. The other labs are: acoustic terminology, instrumentation and measurements, speech intelligibility, loudspeaker driver parameter extraction and a purposefully deficient opamp-based audio mixer.

Engineering Science/Design Content: Engineering Science 50%
Engineering Design 50%

Students become aware of the difficulties in predictive modeling of acoustic spaces and of loudspeaker systems. The disagreements between reality and computational results are discussed in detail. The statistical nature of human perception to sound stimuli is extensively explored with respect to designing audio systems. The social and legal implications of inadequate speech intelligibility are explored.

Prepared by Richard H. Campbell June 3, 2002

COURSE DESCRIPTION

EE 3311 PRINCIPLES OF COMMUNICATION
Academic Year 2001-02

Catalog Data:

EE 3311 Principles of Communication

Cat. I

This course provides an introduction to analog and digital communications systems. The bandpass transmission of analog data is motivated and typical systems are analyzed with respect to bandwidth considerations and implementation techniques. Baseband and passband digital transmission systems are introduced and investigated. Pulse shaping and intersymbol interference criteria are developed in relation to the pulse rate transmission limits of bandlimited channels. Finally, digital carrier systems and line coding are introduced in conjunction with applications to modern transmission schemes.

Recommended background: EE 2311 and EE 2312.

Textbook: *Communications Systems*, Simon Haykin (4th Edition), John Wiley, 2001

Course Outcomes:

At the completion of this course the students should achieve:

- A review of the basic concepts from previous courses (Fourier transforms and Fourier series, ideal sampling, quantization)
- The understanding of the time average operator for the computation of average value and power
- Knowledge of how to use the basic concepts of complex envelope notation
- The ability to anticipate the time-domain properties of modulated waveforms
- The ability to determine the bandwidth and average power modulated waveforms
- A basic understanding of how to generate and detect modulated waveforms
- An understanding of the different kinds of Amplitude and Angle Modulation
- An understanding of the concepts underlying the superheterodyne receiver, frequency and time division multiplexing
- An understanding of baseband and bandpass digital communications waveforms
- An understanding what intersymbol interference (ISI) is and how to reduce it
- An introduction to using the power spectral density via a time-average approach
- Knowledge about a communications topic relevant to the current state of the profession using concepts from within and without the course
- An enhanced ability to communicate in oral and written form

EE 3311 page 2

Relation to ECE Program Outcomes :

Outcome	Level	Means by which students demonstrate proficiency
1	High	Case study
2	High	Case study
3	High	Homework, exams
4	High	Homework, exams
5	Medium	Case study
6	High	Homework, exams
7	Medium	Case study
8	Low	Case study
9	High	Case study
10	Low	Case study
11	Low	Case study

Computer Usage: Students used the computer package of their choice to generate their homework solutions

Laboratory Component: No formal laboratory.

Engineering Science/Design Content: Engineering Science 80%
Engineering Design 20%

Reference to any web-based materials which belong specifically to the course.
Extensive use of the web was made using http://pickerel.wpi.edu/~webtools/EE3311.

Prepared by Denise Nicoletti January 27, 2002

COURSE DESCRIPTION

EE 3501 ELECTRICAL ENERGY CONVERSION
Academic Year 2001-02

Catalog Data:

EE 3501 Electrical Energy Conversion
Cat. I
The course is designed to provide a cohesive presentation of the principles of electric energy conversion for industrial applications and design. The generation, transmission and conversion of electric energy, as well as basic instrumentation and equipment associated with electric energy flow and conversion are analyzed.

Topics: Review of poly-phase circuits. Transformers and instrumentation for power and energy measurements. Rotating machines. Electromechanical transients and stability. Switchgear equipment. Selected laboratory experiments.

Recommended background: EE 2111

Textbook: *Foundations of Electric Power*, J.R. Cogdell, Prentice Hall, 1999.

Course Outcomes:

At the completion of this course the students should achieve:

- Understanding power and energy flow in networks with sinusoidal waveforms.
- Understanding three-phase systems.
- Reinforcing physical principles of magnetism, magnetic circuits, Faraday law and Lorenz force.
- Understanding principles of electrical energy conversion into mechanical and vice-versa.
- Understand the electromechanical characteristics of the three basic types of motors.
- Develop an improved ability to simulate electromechanical systems
- Develop skills needed for engineering design and project work.

EE 3501 page 2

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Discussions, project, exercises
2	Medium	Project, discussions
3	High	Discussions, computer simulations, project
4	Medium	Homework, oral exams, projects
5	Medium	Project, computer simulations
6	High	Project, class demonstrations
7	Medium	Project
8	Medium	Project
9	Medium	Project
10	Medium	Project
11	Medium	Project

Computer Usage: PSpice

Laboratory Component: No formal laboratory, but students witnessed demonstrations of all the basic types of machines and were invited to connect, start, adjust and make observations. On the spot discussions, questions and answers, were carried.

Engineering Science/Design Content: Engineering Science 50%
Engineering Design 50%

This was a very small class (five students).

Prepared by Alexander Emanuel November 5, 2001

COURSE DESCRIPTION

EE 3503 POWER ELECTRONICS
Academic Year 2001-02

Catalog Data:

EE3503 Power Electronics
Cat. I
This course is an introduction to analysis and design of power semiconductor circuits used in electric motor drive, control systems, robotics and power supplies.

Topics: Characteristics of thyristors and power transistors. Steady-state performance and operating characteristics, device rating and protection, commutation, grating circuits, ac voltage controllers, controlled rectifiers, dc/dc converters and dc/ac inverters.

Recommended background: EE 2201, EE 2311 or equivalent.

Textbook: *"Introduction to Power Electronics,"* Daniel W. Hart, Prentice Hall, 1997.

Course Outcomes:

At the completion of this course the student should achieve:

- A clear understanding of electric energy conversion principles and basic power conditioning techniques.
- The actual course was taught with a high emphasis on the use of PSpice, thus advancing their skills on modeling power electronics circuits.
- Through the study of a significant number of practical examples the student developed design skills that helped optimize converter operation and selection of components.
- A practical project helped bridge linear control techniques with electronic circuits and energy conversion applications.
- The project helped the students to realize that electrical engineering is not an isolated field, but requires a thorough understanding of heat-transfer, power quality, engineering economics and marketing.

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, Project, Class Notes
2	High	Project, Class Notes, Examples, Homework
3	High	Examples, Simulations
4	Low	Circuits Analysis
5	High	Project, Simulations
6	High	Homework, Exams, Project
7	Medium	Project
8	Medium	Examples, Homework
9	Medium	Homework, Project
10	Medium	Homework, Project
11	None	

Computer Usage: PSpice

Laboratory Component: No formal laboratory. A few demonstrations.

Engineering Science/Design Content:

Engineering Science 25%
Engineering Design 75%

Prepared by A.E. Emanuel December 22, 2001

COURSE DESCRIPTION

EE 3601 PRINCIPLES OF ELECTRICAL ENGINEERING.
Academic Year 2001-02

Catalog Data:

EE 3601 Principles of Electrical Engineering
Cat. I
Intended for students other than electrical engineers, this course is oriented towards developing competence in electrical engineering concepts on the level that the technology interfaces directly with their own discipline. The course is designed specifically to help students meet that challenge through the development of a broad systems perspective and an understanding of the principal elements of electrical engineering technology. The expectation is that students completing the course will be able to handle adequately the electrical aspects of a broad range of application topics. In addition, and most important, they will be prepared to work effectively with electrical engineers on the joint solution of complex problems.

Topics covered during the course include: direct current (DC) circuit analysis and design, alternating current (AC) circuit analysis and design, circuit design using operational amplifiers, and electric machines and power systems. Selected laboratory projects are included to emphasize the direct application of the information presented in lectures.

Recommended background: MA 1021-1023, MA 2051, PH 1120/1121 or equivalent

Textbook: *Electrical Engineering*, 2^{nd} Edition, Allan Hambley, Prentice Hall, 2001

Course Outcomes:

At the completion of this course the students should achieve:

- Basic practical understanding of electrical circuits
- Ability to build a basic circuit for a specific sensor (thermistor, metal detector, acoustic sensor, basic RF sensor)
- Ability to understand various problems connected to electronic design

EE 3601 page 2

Relation to ECE Program Outcomes: NA

Computer Usage: C (optional)

Laboratory Component: Significant laboratory component (4 labs and one extra lab)

Engineering Science/Design Content: Engineering Science 75%
Engineering Design 25%

Students are working in the lab. Extra lab time (totally 5 hours per week) is offered. Some of them (10%) do extra projects.

Prepared by Sergey N. Makarov March 7, 2002

COURSE DESCRIPTION

EE 3703 REAL-TIME DIGITAL SIGNAL PROCESSING
Academic Year 2001-02

Catalog Data:

EE 3703 Real-Time Digital Signal Processing
Cat. I
This course provides a basic introduction to the principles of real-time digital signal processing (DSP). Topics include: structured analysis of real-time systems, design of real-time DSP architectures, sampling and quantization of continuous-time signals, design and implementation of FIR and IIR digital filters, and theory and application of the Fast Fourier Transform (FFT). The emphasis of the course is on the design and implementation of DSP algorithms. The algorithms are implemented on personal, portable DSP boards that the students can either program in the lab or purchase for use on their home computers. This course features an interactive studio format with mini-lectures and labs integrated into two-hour sessions. This format allows the students to try out the algorithms and methods shown in class immediately, with the instructor nearby to lend assistance and advice.

Recommended background: EE 2312, EE 2801, CS 1005 or equivalent.

Textbooks: *Digital Signal Processing: Laboratory Experiments Using C and the TMS320C31 DSK*, Rulph Chassaing, John Wiley & Sons, 1999.

Digital Signal Processing using Matlab, Vinay K. Ingle and John G. Proakis, Brooks/Cole, 2000.

Course Outcomes:

At the completion of this course, students should have the abilities to:

- Use structured analysis methods to design algorithms for real-time DSP applications,
- Use MATLAB to simulate behavior and predict performance of DSP algorithms,
- Use DSP hardware to sample continuous-time signals, process them as digital signals, and resynthesize the signals in the continuous-time domain,
- Design and implement FIR and IIR filters that meet given frequency-domain specifications,
- Design and implement conventional radix-2 FFT algorithms, Use the FFT for spectrum analysis and fast convolution.
- Communicate their understanding and results in oral and written form.
- Understand the ways in which the topics of this course relate to the rest of ECE and to their careers

EE 3703 page 2

Relation to ECE Program Outcomes :

Outcome	Level	Means by which students demonstrate proficiency
1	High	Exams, projects
2	Medium	Projects
3	High	Exams, projects
4	High	Exams, projects
5	High	Projects
6	High	Exams, projects
7	Medium	Projects
8	Medium	Weakly demonstrated – projects
9	High	Exams
10	Medium	Projects, breadth of assignments
11	None	

Computer Usage: Extensive use of C and assembly language. Software packages include MATLAB and the Texas Instruments C31 assembler and compiler.

Laboratory Component: All class sessions are conducted in the laboratory, and use a combination of lecture and mini-lab exercises. At the end of the term, two sessions were devoted solely to lab work.

Engineering Science/Design Content: Engineering Science 50%
Engineering Design 50%

Students are given four open-ended design projects. Both analysis and design are involved, and the projects culminate with written reports and demonstrations to teaching assistants. The projects are completed by 2 or 3-person teams.

Prepared by Nathaniel A. Whitmal, III January 23, 2002

COURSE DESCRIPTION

EE 371X INTRODUCTION TO ELECTRO-OPTICS
Academic Year 2001-02

Catalog Data:

EE 371X Introduction to Electro-optics
Cat. I
The aim of the course is to give students the opportunity to learn the fundamentals of optoelectronics and principles of the optoelectronic devices operation. First, relevant topics regarding optical wave propagation and modulation of light will be reviewed. Next, the course will cover key electro-optical components, used in modern technology: Display devices; lasers, especially the semiconductor laser, and their applications; photodetectors, and optical fibers. Finally, the course will present fiber optical communication systems. Additional applications will be covered in the student projects.

Recommended background: PH 1140, EE 2311, EE 2201

Textbook: *Optoelectronics — An Introduction*, 3rd edition, J. Wilson and J. Hawkes, Prentice Hall Europe, 1998.

Course Outcomes:

At the completion of this course the students should achieve:

- Understanding of wave phenomena, including polarization, reflection refraction, and interference
- An appreciation of basic optical components (mirrors, lenses)
- Solid background in modulation of light, including birefringence, electro-optic effect, Kerr modulators, and magneto-optic devices
- A working knowledge of display devices based on photoluminescence and cathodoluminescence
- Good understanding of light emitting diode, LED materials, liquid crystal display
- Fundamental understanding of the concept of lasers, Einstein relations, absorption of radiation, population inversion, optical feedback and mirrors
- An appreciation of the different laser types: Gas lasers, liquid dye laser, doped insulator laser, and semiconductor laser
- An in-depth understanding of the semiconductor laser
- A working knowledge of the optical fiber, incl. mode propagation, dispersion and attenuation
- Understanding of the different types of optical fibers: Single mode, multi-mode, and graded index, and their specific applications
- Introduction to the basic concepts of optical communication: analog vs. digital; repeaters, couplers and switches; multiplexing techniques

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, projects and exam
2	Moderate	Researching project material
3	High	Homework, projects and exam
4	High	Homework, projects and exam
5	Moderate	Team work for project; oral pres. and written docum.
6	High	Homework, projects and exam
7	High	Project; oral presentation and written documentation
8	Low	Manifested in project and special assignments
9	High	Researching for project which extended over 7 weeks
10	None	
11	Low	Discussion of technological developments

Computer Usage: Computational software required for some homework

Laboratory Component: None

Engineering Science/Design Content: Engineering Science: 70%
Engineering design: 30%

Each student selects a product where electro-optics plays a central role. These projects are group projects with two students in each group. The student will in particular investigate the electro-optics components of the product, but also in general investigate signal or image processing aspects, mechanical aspects, etc. The project aspect of the course will consist of both a written report (15 pages typically)and a 10 min presentation. The project is intended to be developed for the full duration of the course, with components of the project due as follows:

End of week 2: Outline of the project report; list of key literature (2 -3 pages)
End of Week 4: General description of the function of the main components of the product (4 - 6 pages)
End of week 6: Detailed description and analysis of the electro-optics aspects of the product (several pages)
Last day of class: Full project report due

Examples of project topics: CD player; digital scanner; bar code reader; optical character recognition hardware; stereolithography; pulse-oximetry; remote control for consumer electronics, laparoscopy surgery instruments

Prepared by Peder C. Pedersen January 4, 2002

COURSE DESCRIPTION

EE 3801 ADVANCED LOGIC DESIGN
Academic Year 2001-02

Catalog Data:

EE 3801 Advanced Logic Design
Cat. I
This course introduces students to the design of the complex logic systems underlying or supporting the operation of computer systems and interfaces. Students learn how to use advanced computer-aided design tools to develop and simulate logic systems consisting of MSI components such as adders, multiplexers, latches, and counters. The concept of synchronous logic is introduced through the design and implementation of Mealy and Moore machines. Students will also learn how to use programmable logic devices to implement customized designs.

Topics: Review of logic gates and design and simplification of combinational circuits. Arithmetic circuits, MSI devices, analysis and design of sequential circuits, synchronous state machines and programmable logic.

Lab exercises: Design, analysis and construction of combinational and sequential circuits, use of computer-aided engineering software for schematic entry and digital analysis, introduction to hardware description languages and programmable logic devices.

Recommended background: EE 2022 (for ECE students) or CS 2011.

Textbook:

Digital Design, Principles and Practices 3rd Edition, John F. Wakerly, Prentice Hall, 2001

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of logic minimization and the different types of logic representation.
- An appreciation of the fundamental principles of state machine design and analysis using practical examples.
- An understanding of MSI components and their application to fast prototyping.
- An appreciation of the significance of static hazards and an understanding of their elimination.
- An appreciation of the organization and operation of memory systems.
- An understanding of the significance of programmable logic.
- An understanding of the application of the course content in logic design.
- An improved ability to communicate his/her understanding and results in oral and written form.
- An understanding of the ways in which the topics of this course relate to the rest of ECE and to their careers.

EE 3801 page 2

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, labs
2	Medium	Labs
3	High	Homework, exams, labs
4	High	Homework, exams, labs
5	Medium	Labs
6	Medium	Homework, exams, labs
7	Medium	Labs
8	Medium	Labs
9	Medium	Labs
10	Low	Labs
11	Low	Homework, labs

Computer Usage: Xilinx Foundation Tools

Laboratory Component: Laboratories allow students to design, test, and build actual circuits that demonstrate the concepts discussed during class lectures.

Engineering Science/Design Content: Engineering Science 50 %
Engineering Design 50 %

Students perform laboratory experiments based on the material from this and previous courses. These experiments involve both analysis and design and require written reports. Experiments are performed by 2-person teams.

Prepared by Adam J. Elbirt January 11, 2002

COURSE DESCRIPTION

EE3803 MICROPROCESSOR SYSTEM DESIGN
Academic Year 2001-02

Catalog Data:

EE 3803. Microprocessor System Design
Cat. I
This course builds on the computer architecture material presented in EE 2801. It covers the architecture, organization and instruction set of simple 16-bit microprocessors. The interface to memory (RAM and EPROM) and I/O peripherals is described with reference to bus cycles, bus timing, and address decoding. Emphasis is placed on the design, programming and implementation of interfaces to microprocessor systems.

Topics: bus timing analysis, memory devices and systems, IO and control signaling, bi-directional bus interfaces, instruction execution cycles, interrupts and polling, addressing, programmable peripheral devices, interface design issues.

Laboratory exercises: Use of the PC and BIOS/DOS for program design exercises. Use of the PC ISA bus for advanced IO design and programming, advanced use of BIOS/DOS and mixed language programming, standard bus timing, and interface design and implementation.

Recommended background: EE 2801 and EE 3801 or an equivalent background in advanced logic design, microprocessor architecture, and programming

Textbooks: *The 8088 and 8086 Microprocessors: Programming, Interfacing, Software, Hardware and Applications*, Third Edition, Walter A. Triebel and Avtar Singh, Prentice Hall, 2000
The Indispensable PC Hardware Book, Hans-Peter Messmer, Addison-Wesley, 1997.

Course Outcomes:

At the completion of this course, the students should achieve:

- An understanding of the "top-down" design process for structured software and hardware development.
- A better understanding of assembly language programming for the x86 Intel architecture.
- A better understanding of the internal architecture of the 8088 and 8086 microprocessors.
- An understanding of machine code generation for the x86 Intel architecture.
- An understanding of the interface between software and hardware in the PC context with emphasis when and how to use BIOS, DOS, or direct hardware access.
- An understanding of memory addressing modes for the x86 Intel architecture including when and how to use them.
- An understanding of the 8088/8086 memory interface including address decoding, bus demultiplexing, buffering, current and voltage requirements, and timing.

- An understanding of common memory devices including ROM, PROM, EPROM, EEPROM, SRAM, and DRAM.
- An understanding of the 8088/8086 I/O interface including current and voltage requirements, memory mapped vs. I/O mapped I/O, address decoding, buffering, polling, handshaking, and timing.
- An understanding of common x86 peripheral chips including the 8255 Programmable Peripheral Interface and 8253 Timer/Counter.
- An understanding of direct memory access (DMA) and the 8237 DMA controller.
- An understanding of interrupts including interrupt prioritization, the interrupt vector table, and how to write an interrupt service routine.

Relation to ECE Program Outcomes

Outcome	Level	Means by which students demonstrate proficiency
1	Medium	Laboratory assignments, homework, exams.
2	High	Laboratory assignments, homework, exams.
3	Medium	Laboratory assignments, homework, exams.
4	Low	Laboratory assignments, homework, exams.
5	High	Laboratory assignments.
6	High	Laboratory assignments, homework, exams.
7	High	Laboratory assignments.
8	Medium	Laboratory assignments, homework, exams.
9	Medium	Homework, exams
10	Low	Laboratory assignments.
11	None	

Computer Usage:
1. Turbo Assembler (tasm) for assembling source code.
2. Turbo Linker (tlink) for linking source code.
3. Turbo Debugger (td) for debugging source code.
4. HyperTerminal for testing serial communications.
5. ISA bus prototyping boards for development and interfacing of custom hardware.

Laboratory Component: 3 hours of scheduled laboratory per week. During this time (and also during additional open-lab hours), students develop software and custom hardware solutions to laboratory assignments.

Engineering Science/Design Content: Engineering Science 20%
Engineering Design 80%

Prepared by D.R.Brown May 4, 2002

COURSE DESCRIPTION

EE 3815 DIGITAL SYSTEM DESIGN WITH VHDL
Academic Year 2001-02

Catalog Data:

EE 3815 Digital System Design with VHDL
Cat. I
This is an introductory course on the use of VHDL for the design, synthesis, modeling, and testing of VLSI devices. VHDL is an IEEE standard that is used by engineers to efficiently design and analyze complex digital designs. The course will show how to write VHDL models that can be automatically synthesized into integrated circuits such as FPGAs (Field Programmable Gate Arrays).

Topics include: hardware description languages, VHDL, system modeling and synthesis of digital circuits, VLSI, field programmable gate arrays, simulation and testing.

Laboratory Exercises: Exercises will include writing VHDL models of combinational and sequential circuits, synthesizing these models to FPGAs by automatic place and route, simulating the design, and developing and writing test-benches in VHDL.

Recommended background: EE 3801 and experience with programming in a high-level language such as C (CS 1005 and/or CS 2005) or Pascal.

Textbook: *Introductory VHDL, From Simulation to Synthesis*, Sudhakar Yalamanchilli, Prentice Hall Press, 2001

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of VHDL for the design, synthesis, modeling, and testing of VLSI devices.
- An ability to model complex digital circuits in VHDL.
- An appreciation of the fundamental principles of digital system design with modeling languages.
- An appreciation of the organization and operation of complex digital systems.
- An understanding of the tradeoffs among ASIC and FPGA technologies.
- An understanding of the application of the course content in digital systems design.
- An understanding of the ways in which the topics of this course relate to the rest of ECE and to their careers

Relation to ECE Program Outcomes :

Outcome	Level	Means by which students demonstrate proficiency
1	High	Laboratories, homework, exams
2	Medium	Laboratories
3	High	Laboratories, homework, exams
4	Medium	Laboratories, homework
5	High	Laboratories
6	Medium	Laboratories, homework, exams
7	Medium	Laboratories
8	Medium	Weakly demonstrated
9	Medium	Laboratories, homework
10	Low	Laboratories
11	None	

Computer Usage: Xilinx Foundation Tools, Mentor Graphics ModelSim

Laboratory Component: Five intensive laboratory sessions are scheduled. Students form two person teams. Laboratory descriptions are handed out one week in advance. Teams are required to complete the analysis and design phases prior to the lab session. In the lab session, each team is required to explain their design and demonstrate its operation. After realizing a design complying with the lab description, each team is expected to turn in a final lab report that describes the design in detail, and summarizes the conclusions.

Engineering Science/Design Content: Engineering Science 50%
Engineering Design 50%

The course introduces basic topics in digital hardware design, as well as modeling, simulation and synthesis in VHDL. Advanced methods for testing and verification are discussed. A comparative overview of target hardware technologies such as ASIC and FPGA are presented. Students complete a design in each laboratory based on the material from this and previous digital design courses. Each laboratory assignment is quite intensive requiring many individual components to be build and realized.

Prepared by Berk Sunar May 10, 2002

COURSE DESCRIPTION

EE 3901 SEMICONDUCTOR DEVICES
Academic Year 2001-2002

Catalog Data:

EE3901 Semiconductor Devices
Cat. I
The purpose of this course is to introduce students to the physics of semiconductor devices and to show how semiconductor devices operate in typical linear and nonlinear circuit applications. This material complements the electronics sequence of courses and will draw illustrative examples of electronic circuit applications from other courses.

Topics: carrier transport processes in semiconductor materials. Carrier lifetime. Theory of p-n junctions. Bipolar transistors internal theory, dc characteristics, charge control, Ebers Moll relations; high frequency and switching characteristics, hybrid-pi model; n- and p channel MOSFETS, CMOS.

Recommended background: EE 2201

Textbook: *Semiconductor Devices Fundamentals,* Pierret, Addison Wesley, 1996.

Course Outcomes:

After successfully completing EE3901, the students should achieve:
Knowledge of terminology: be familiar with the terms associated with the following:

- Fabrication of semiconductor devices
- Analysis of charge carriers in semiconductors
- Operation of basic devices: p-n junction diode, bipolar junction transistor (BJT), and field-effect transistor (FET or MOSFET)

Example: identify features of an energy band diagram for a semiconductor
Conceptual understanding: for each basic device, understand the concepts associated with the terminology well enough to

- Draw a simplified diagram of device physical construction
- Explain how the device is fabricated
- Explain qualitatively how the device works
- Explain the basic circuit model of the device

Example: for the diode, be able to sketch a cross-sectional view of the device, explain how it is made, how charges flow in response to an externally applied voltage, and how this leads to a circuit model with “on” and “off” regions of operation

Ability to apply concepts: use understanding of device operation to explain deviations from the ideal and second-order effects
Example: explain why the output of the BJT is not a perfect current source in the active region of operation

EE 3901 page 2

Relation to ECE Program Outcomes:

Outcome	Level	Means by which student demonstrate proficiency
1	High	Homework, exams
2	Low	Not demonstrated
3	High	Homework, exams, anonymous in-class quizzes
4	High	Homework, exams, anonymous in-class quizzes
5	Low	Homework
6	High	Homework, exams, anonymous in-class quizzes
7	Low	Homework, Exams
8	None	
9	Low	Homework, exams
10	Low	Homework, exams
11	None	

Computer Usage: No formal computer use mandated; many homework problems suggest computer use.

Laboratory Component: None

Engineering Science/Design Content: Engineering Science 100%
Engineering Design 0%

Prepared by John A. McNeill October 18, 2001

COURSE DESCRIPTION

EE 3902 INTRODUCTION TO VLSI DESIGN
Academic Year 2001-02

Catalog Data:

EE 3902 Introduction to VLSI Design
Cat. I
This course provides an introduction to the fundamental principles of VLSI circuit design. Emphasis is placed on the design of basic building blocks of large-scale digital integrated circuits and systems, where students will acquire hands-on design experience using a professional design platform.

Topics: Overview of VLSI fabrication technology, basic CMOS digital circuits, transistor-level and mask-level design, complex logic gates, modular building blocks, adder arrays, serial and parallel multipliers, data path components, register arrays, clock signal generation and distribution, timing, ASIC design guidelines, system integration, IC testing and testable design strategies. Laboratory exercises will concentrate on designing full-custom digital building blocks, integrating the modules into functional chip designs, and standard-cell based ASIC design flow.

Recommended background: EE 3801

Textbook: *PHYSICAL DESIGN OF CMOS INTEGRATED CIRCUITS USING L-EDIT*, Uyemura, J. P. PW Publishing, 1995
MODERN VLSI DESIGN - SYSTEM ON CHIP DESIGN, Wolf, W., Prentice Hall, Third Edition, 2002

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of the design and layout of typical CMOS integrated circuits.
- An understanding of the analysis of CMOS integrated circuits using SPICE and appropriate device parameters extracted using MOSIS fabrication results.
- An appreciation of the different types of CMOS circuits (pseudo NMOS, dynamic, CPL, TG, pre-charge logic, etc), how they are designed, where they are typically used, and the advantages and disadvantages of each.
- An understanding of the tradeoffs among design type, power and performance in digital circuit design.
- An understanding of the CMOS fabrication process.

EE 3902 page 2

Relation to ECE Program Outcomes :

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, Exams, Project/labs
2	High	Homework, Exams, Project/labs
3	High	Homework, Exams, Project/labs
4	Medium	Lecture, Labs, Project
5	Medium	Labs, Project
6	High	Labs, Project
7	High	Labs, Project
8	Medium	Visiting Lecturer, Labs, Project
9	High	Labs, Project
10	Medium	Labs, Projects, Visiting Lecturer
11	Low	Visiting Lecturer

Computer Usage: Use of Tanner Tools (L-Edit, T-Spice and W-Edit) to create, test and analyze CMOS circuits.

Laboratory Component: Major Laboratory Assignments due nearly every week. Two week project assigned at the end of the course.

Engineering Science/Design Content: Engineering Science 50%
Engineering Design 50%

Students choose project topics and complete open-ended design projects based on the material from this and previous courses. Both analysis and design are involved, and the projects culminate with written and oral presentations. The projects are completed by primarily 2 person teams.

Prepared by: Fred J. Looft May 8, 2002

COURSE DESCRIPTION

EE 4304 COMMUNICATION SYSTEMS ENGINEERING
Academic Year 2001-02

Catalog Data:

EE 4304 Communication Systems Engineering
Cat. I
This course introduces the theory and performance analysis of communication in noise. The mathematical treatment of noise as a random process is developed in the context of baseband and passband transmission systems. The performance of analog transmission systems is developed and the tradeoff between bandwidth and performance is exposed. The optimum PCM receiver is derived and introduces the general concept of decision theory and signal space representation of decision systems. A treatment of coding theory for error detection, correction and compression leads to the development of Shannon¹s information theory and the ultimate performance of digital transmission systems. Finally, concepts that underlie modern digital data computer network systems are introduced.

Recommended background: EE 3311 and MA 3613

Textbook: *Communication Systems*, 4th Edition, Simon Haykin, John Wiley, 2001

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of the analysis of random processes, and the investigation of the effects of noise in communication systems,
- An appreciation of the fundamental principles of modern communication systems analysis and design using practical examples
- An appreciation of the organization and operation of communication networks, both circuit switched and packet switched
- An understanding of the tradeoffs among power, bandwidth, and performance in both digital and analog communications.
- An understanding of the application of the course content in communications systems design
- An improved ability to communicate his/her understanding and results in oral and written form
- An understanding of the ways in which the topics of this course relate to the rest of ECE and to their careers

EE 4304 page 2

Relation to ECE Program Outcomes :

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, projects
2	Medium	Projects
3	High	Homework, exams, projects
4	High	Homework, exams, projects
5	Medium	Projects
6	High	Homework, exams, projects
7	Medium	Projects
8	Medium	Weakly demonstrated – projects
9	Medium	Projects
10	Low	Projects, breadth of assignments
11	None	

Computer Usage: MATLAB, Simulink. Some students use C, C++

Laboratory Component: No formal laboratory, but students make extensive use of analysis and simulation tools.

Engineering Science/Design Content: Engineering Science 75%
Engineering Design 25%

Students choose project topics and complete open-ended design projects based on the material from this and previous courses. Both analysis and design are involved, and the projects culminate with written and oral presentations. The projects are completed by 2 or 3-person teams.

Prepared by John A. Orr March 7, 2002

COURSE DESCRIPTION

EE 4801 ADVANCED COMPUTER SYSTEM DESIGN
Academic Year 2001-02

Catalog Data:

EE 4801 Advanced Computer System Design
Cat. I
This course continues the development of microprocessor and microcontroller-based systems. This course focuses on the design of standalone embedded and high-performance microprocessor systems. Students are introduced to advanced concepts in microprocessor architecture and will design, implement, and program a complete embedded computer system. The importance of designing a system suitable for production will be covered, including issues such as Design for Manufacture (DFM), design for test, reliability, and regulatory compliance including product safety.

Topics: Advanced microprocessor architecture, microprocessor timing, microcontrollers, embedded systems, interrupts, DMA, CACHE and memory system controllers, real-time system design issues, high-performance system and peripheral buses, DFM, reliability.

Lab exercises: Design of a complete, standalone microcontroller based-system, mixed language programming, embedded system debugging, design of systems with real-time requirements.

Recommended background: EE 3803 or equivalent.

Textbook: *The 8088 and 8086 Microprocessors: Programming, Interfacing, Software, Hardware, and Applications, 3rd Edition,* W. Triebel and A. Singh, Prentice-Hall, 2000.

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of advanced microprocessor architectures including 16 and 32 bit systems, RISC and CISC architectures, and pipelining.
- An appreciation of the fundamental principles of bus expansion, bus standards, and transmission line effects at high switching rates.
- An understanding of advanced interface design and organization, including interrupt controllers, DMA controllers, and microcontrollers.
- An appreciation of system design.
- An appreciation of analog-to-digital and digital-to-analog I/O.
- An understanding of the design principles for memory systems.
- An understanding of the application of the course content in computer system design.
- An improved ability to communicate his/her understanding and results in oral and written form.

- An understanding of the ways in which the topics of this course relate to the rest of ECE and to their careers.

Relation to ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, labs
2	High	Homework, exams, labs
3	Medium	Homework, exams
4	High	Homework, exams, labs
5	High	Homework, exams, labs
6	Medium	Homework, exams
7	High	Homework, exams, labs
8	Medium	Labs
9	Medium	Labs
10	Low	Labs
11	Low	Labs

Computer Usage: C and Assembly Language

Laboratory Component: Laboratories allow students to design, test, and build actual circuits that demonstrate the concepts discussed during class lectures.

Engineering Science/Design Content: Engineering Science 50 %
Engineering Design 50 %

Students perform laboratory experiments based on the material from this and previous courses. These experiments involve both analysis and design and require written reports. Experiments are performed by 3-person teams.

Prepared by Adam J. Elbirt March 1, 2002

COURSE DESCRIPTION

EE 4902 ANALOG INTEGRATED CIRCUIT DESIGN
Academic Year 2001-02

Catalog Data:

EE 4902 Analog Integrated Circuit Design
Cat. I
This course introduces students to the design and analysis of analog integrated circuits such as operational amplifiers, phase-locked loops, and analog multipliers.

Topics: integrated circuit building blocks: current mirrors and sources, differential amplifiers, voltage references and multipliers, output circuits. Computer-aided simulation of circuits. Layout of integrated circuits. Design and analysis of such circuits as operational amplifiers, phase-locked loops, FM detectors, and analog multipliers. Laboratory exercises.

Recommended background: familiarity with the analysis of linear circuits and with the theory of bipolar and MOSFET transistors. Such skills are typically acquired in EE 3204 and EE 3901.

Textbook: *Analog Integrated Circuit Design*, Johns and Martin, John Wiley, 1997

Course Outcomes:

At the completion of this course the students should achieve:

- An understanding of the "top-down" design process as applied to analog integrated circuits: how system-level performance parameters flow down to requirements at the functional block level (e.g. op-amps, comparators) and the transistor level.
- An understanding of basic transistor-level amplifier architectures, and the analysis techniques necessary to design for target specifications such as gain, bandwidth, stability (phase margin), etc.
- An ability to design a circuit by hand analysis, refine the design through use of software simulation tools such as SPICE, and test, measure, and verify performance of an implementation of the design in a laboratory circuit.
- An ability to communicate technical results (from simulation and lab work) clearly and accurately in written form.
- An appreciation of the fundamental principles of semiconductor physics underlying transistor-level circuit design.
- An appreciation of integrated circuit fabrication technology, and how the rapid advance of fabrication technology affects circuit design.

EE 4902 page 2

Relation to ECE Program Outcomes :

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams, studio lab work
2	Medium	Homework, studio lab work
3	High	Homework, exams, studio lab work
4	High	Homework, exams, studio lab work
5	High	Homework, exams, studio lab work
6	High	Homework, exams, studio lab work
7	Medium	Homework, studio lab work
8	Low	Weakly demonstrated – homework
9	Medium	Homework, exams
10	None	
11	Low	Homework

Computer Usage: SPICE circuit simulation, Cadence physical design (layout), spreadsheet use for display and analysis of experimental results

Laboratory Component: The course is taught in studio format, with contact time allocated approximately as follows:
40% Lecture (develop theory)
25% Simulation (use SPICE to predict performance, refine theoretical prediction)
35% Lab work (circuit test and measurement, results compared to theory and simulation)

Engineering Science/Design Content: Engineering Science 50%
Engineering Design 50%

Prepared by John A. McNeill May 2, 2002

Course syllabus: see http://www.ece.wpi.edu/~mcneill/4902/4902outline2002.html

Course web page: see http://www.ece.wpi.edu/~mcneill/4902

COURSE DESCRIPTION

ES 3011 CONTROL ENGINEERING I
Academic Year 2001-02

Catalog Data:

ES 3011 Control Engineering I
Cat. 1
Characteristics of control systems. Mathematical representation of control components and systems. Laplace transforms, transfer function, block and signal flow diagrams. Transient response analysis. Introduction to the root locus method and stability analysis. Frequency response techniques including Bode, polar, and Nichols plots.

Recommended background: MA 2051, PH 1120, PH 1121

Textbook: *Modern Control Systems,* 9th edition, Dorf and Bishop, Prentice Hall

Course Outcomes:

At the completion of this course, students should achieve:

- An understanding of the analysis of linear feedback control systems
- An understanding of the correspondence of frequency-domain and time-domain properties
- An understanding of the effects of feedback on system stability
- An ability to choose design parameters of a feedback control system in order to meet either frequency domain or time domain performance specifications
- An understanding of the application of the course content control system design
- An understanding of the way in which the topics of this course relate to the rest of their engineering discipline and to their careers.

ES 3011 page 2

Relation to the ECE Program Outcomes:

Outcome	Level	Means by which students demonstrate proficiency
1	High	Homework, exams
2	Low	Homework
3	High	Homework, exams
4	High	Homework, exams
5	Medium	Homework
6	High	Homework, exams
7	Medium	Homework
8	High	Homework, exams
9	Medium	Homework
10	Low	Homework
11	None	

Computer Usage: MATLAB, Control system toolbox

Laboratory Component: No formal laboratory, but students make extensive use of MATLAB

Engineering Science/Design Content: Engineering Science 67%
Engineering Design 33%

Prepared by Kevin Clements May 2, 2002

Appendix I-C, Faculty Curriculum Vitae

1. **Name:** Stephen J. Bitar **Academic Rank:** Adjunct Instructor

2. **Educational Record:**
B.S. Electrical Engineering, Worcester Polytechnic Institute, 1985
M.S. Electrical Engineering, Worcester Polytechnic Institute, 1995

3. **Service/Positions at WPI:**
2001-present Adjunct Instructor

4. **Other Professional Experience:**
1997 - Pres. Electronic Consultant - Analog and Digital Circuits, Power Electronics. Most Recent Client: Adaptations Co., Needham, MA
1995 - 1999 Electronics Instructor, Assabet Valley Regional Vocational High School, Marlboro, MA
1989 - 1994 Electrical Engineer / Courseware Manager, ATech Training, Inc., Sterling, MA
1985 - 1989 Electronics Design Engineer, Raytheon Co., Marlboro - Toshiba America, Burlington - General Electric, Wilmington

5. **Consulting, patents, etc.:**
1997 Adaptations Co., Needham MA
Low Voltage/High Current AC Power Regulator
1989-1994 ATech Training Inc., Sterling MA
Electronic Fuel Injection Signal Simulation Board
Electronic Distributor-less Ignition Signal Simulation Board
Electronic Air Bag Signal Simulation Board

6. **Registration:** Not registered

7. **Publications of Last Five Years:** None

8. **Scientific and Professional Societies:**
- IEEE

9. **Honors and awards:**
- Recipient of the Eta Kappa Nu - 2001 Outstanding Professor Award

10. **Institutional and Professional Service in the Past 5 Years:**
- Electronic Design, Electronic Troubleshooting, Circuit Simulation

11. **Professional Development Activities in the Past 5 Years:**

Prepared by Stephen Bitar

1. Name: Matthew C. Bromberg **Academic Rank:** Assistant Professor, ECE

2. Educational Record:

PhD. Electrical Engineering, University of California at Davis, 1990
M.S. Electrical Engineering, University of California at Davis, 1988
M.A. Mathematics, University of California at Berkeley, 1986
B.S. Engineering Math, University of California at Berkeley, 1983

3. Service/Positions at WPI:

Assistant Professor of ECE, January 2000 - present

4. Other Professional Experience:

1992 - 2000 Systems Engineer, Radix Technologies, Mountain View, CA
1990 - 1992 Electrical Engineer, ARGOSystems, Sunnyvale, CA
1987 - 1990 Research Assistant, University of California at Davis

5. Consulting, patents, etc.:

Highly Bandwidth-Efficient Communications, Patent Application submitted by AT&T Corp. (Pending)

6. Registration: None

7. Publications of Last Five Years:

1. M. Bromberg, "Copy/DF Approaches to Interference Cancellation and Superresolution DF in Groundbased Surveillance Systems", Phase III, Year 2 Final report, SBIR Contract Number DAAAB 10-93-C-0018, Data Item Number A002, Radix Technologies, Mountain View, CA, May 1996.
2. B. Agee, S. Bruzzone, M. Bromberg "Exploitation of Signal Structure in Array-Based Blind Copy and Copy-Aided DF Systems", International Conference on Acoustics, Speech and Signal Processing, May 1998.
3. M. Bromber, B. Agee "Direction Finding for Unstructured Emitters in the Presence of Structures Interferers", International Conference on Acoustics, Speech and Signal Processing, May 1998.

8. Scientific and Professional Societies: None specified

9. Honors and awards:

- Recipient of the TOPS award and fellowship for outstanding graduate students at University of California at Davis

10. Institutional and Professional Service in the Past 5 Years:

11. Professional Development Activities in the Past 5 Years:

Prepared by Matthew Bromberg

1. **Name:** D. Richard Brown III **Academic Rank:** Assistant Professor, ECE

2. **Educational Record:**
PhD Electrical Engineering (Math minor), Cornell University, 2000
MS Electrical Engineering, University of Connecticut, 1996
BS Electrical Engineering, University of Connecticut, 1992

3. **Service/Positions at WPI:**
2000 – present Assistant Professor, ECE

4. **Other Professional Experience:**
9/01 – Pres. Consultant, Litchfield Communications Inc., Watertown, CT
8/01 – 9/01 Consultant, Aware Inc., Bedford, MA
4/99 – 5/99 Research Internship, Applied Signal Technology, Sunnyvale, CA
5/92 – 1/97 GE Industrial Systems, Plainville, CT
Product Owner, Controls Technology Group
Project Leader, New Product Introduction Group
Design Engineer, Power Management Group

5. **Consulting, patents, etc.:** None

6. **Registration:** Not registered

7. **Publications of Last Five Years:**

1. D.R. Brown, "Improved Multistage Parallel Interference Cancellation Using Limit Cycle Mitigation," accepted to appear in the Proceedings of the *36th Annual Conference on Information Sciences and Systems*, March 2002, Princeton, NJ.
2. M. Bromberg and D.R. Brown, "The Use of Programmable DSPs in Antenna Array Processing," *The Application of Programmable DSPs in Mobile Communications* (A. Gatherer and E. Auslander editors) Wiley 2002.
3. D.R. Brown and C.R. Johnson Jr., "SINR, Power Efficiency, and Theoretical System Capacity of Parallel Interference Cancellation," *Journal of Communication and Networks*, Volume 3, Number 3, September 2001, pp. 228-237.
4. D.R. Brown, S. Verdu, H.V. Poor, and C.R. Johnson Jr., "Multiuser Detection for Out-of-Cell Cochannel Interference Mitigation in the IS-95 Downlink," *Journal of VLSI Signal Processing*, Volume 30, Number 1--3, January-March 2002, pp. 217-233.
5. D.R. Brown, M. Motani, V.V. Veeravalli, H.V. Poor, C.R. Johnson Jr., "On the Performance of Linear Parallel Interference Cancellation," *IEEE Transactions on Information Theory*, July 2001.
6. C.R. Johnson, Jr., P. Schniter, I. Fijalkow, L. Tong, J.D. Behm, M.G. Larimore, D.R. Brown, R.A. Casas, T.J. Endres, S. Lambothorian, H.H. Zeng, A. Touzni, M. Green, and
7. J.R. Treichler, "The Core of FSE-CMA Behavior Theory," *Unsupervised Adaptive Filtering*, S. Haykin, ed. (Wiley, 1999).

8. C.R. Johnson, Jr., P. Schniter, T.J. Endres, J. Behm, D.R. Brown, and R.A. Casas, "Blind Equalization Using the Constant Modulus Criterion: A Review," *Proceedings of the IEEE*, Special Issue on Blind System Identification and Estimation, October 1998.

8. Scientific and Professional Societies:

- IEEE
- Phi Kappa Phi National Honor Society

9. Honors and awards:

- WPI Electrical and Computer Engineering Department Satin Award 2002
- Sigma Phi Epsilon Faculty Appreciation Award 2002
- IEEE Teaching Assistant of the Year Award, Cornell Chapter, 1997
- GE Best Practice in EHS Design Integration Award, 1994
- GE Stock Option recipient, 1993, 1994
- GE Elfun Partners in Education Award, 1993
- GE Elfun Community Service Award, 1993

10. Institutional and Professional Service in the Past 5 Years:

- Developed and taught EE533, "Advances in Digital Communications" in Fall 2001
- Developed and taught EE504, "Analysis of Deterministic Signals and Systems" in Fall 2000
- Taught EE3803, "Microprocessor System Design" in B-term 2000, D-term 2001, B-term 2001, and D-term 2002
- Developed and taught a short course entitled "An Introduction to Digital Signal Processing" for General Electric internal course curriculum in 1995
- Graduate Program Committee member, academic year 2001-2002
- Undergraduate Project Committee member, academic year 2000-2001
- Served as reviewer for IEEE Transactions on Communications, IEEE Signal Processing Letters, IEEE Transactions on Signal Processing, and IEEE Journal on Selected Areas in Communications

11. Professional Development Activities in the Past 5 Years:

Prepared by D.R. Brown

1. **Name:** Richard H. Campbell **Academic Rank:** Adjunct Professor

2. **Educational Record:**
B.S. Electrical Engineering, Worcester Polytechnic Institute, 1958

3. **Service at WPI:**
1958-1960 Acoustics Lab Staff
1964-1974 Invited Lecturer, Acoustics and Audio Engineering
1983 - Present Adjunct Professor

4. **Other Professional Experience:**
1958-1961 Staff member, WPI Acoustics Laboratory, under William B. Wadsworth
1961-1969 NASA Projects Gemini and Apollo, David Clark Co., Inc., Worcester, MA
1961-1972 Audio and acoustic product development including sound-power communications, David Clark Co., Inc., Worcester, MA.
1970-1972 Chair, Audio Engineering Society Technical Council
1977&1990 Two, three-year chairmanships of a Federal Advisory Commission (RTCA)
1981-Pres. Adjunct Professor, Acoustics and Audio Engineering, ECE Department, Worcester Polytechnic Institute (WPI), Worcester, MA.
1992-Pres. Member, ASA Technical Committee on Architectural Acoustics and ASA Technical Committee on Education
1994-1997 Chair, Greater Boston Chapter, ASA
2001-Pres. Board Member, ASA Foundation

5. **Consulting, patents, etc.:**
Consulting Engineer, 1960 -

6. **Registration:**
Registered Professional Engineer, Massachusetts 25341

7. **Publications of the last five years:**
   1. ASA 133, Penn State, Plenary Lecture, *Hot Topics in Acoustics*, "Auralization", 1997
   2. ASA 137, Berlin (with Driscoll and Reuter), "The Geometric Room Model as a Surround Sound Auralization Resource", 1999
   3. 17th ICA, Rome, "Using Room Acoustic Model Tools to Determine Surface Diffusion Effectiveness", 2001

8. **Scientific and Professional Societies:**
- Acoustical Society of America
- National Council of Acoustical Consultants
- Audio Engineering Society, Fellow
- American Loudspeaker Manufacturers Association International
- National Academy of Recording Arts & Science, Associate Member

9. Honors and Awards:

10. Institutional and Professional Service in the Past 5 Years:

11. Professional Development Activities in the Past 5 Years:

- 1998 - ASA 136, Norfolk (with Kleiner and Svensson), "Short Course on Auralization"
- 1999 - Tanglewood '99, Instructor, session on Auralization (with Kleiner) and also the session on Stage Acoustics (Ozawa Hall).
- 1999 - ASA 137, Berlin, Co-Chair (with Peter Svensson), "Architectural Acoustics and Signal Processing in Acoustics: Verification of Auralization and Modeling Programs II"
- Chair, Falmouth Economic Development and Industrial Corporation

Prepared by Richard H. Campbell

1. **Name:** Edward (Ted) A. Clancy **Academic Rank:** Assistant Professor

2. **Educational Record:**
   Ph.D. Electrical Engineering, Massachusetts Institute of Technology, 1991
   M.S. Electrical Engineering, Massachusetts Institute of Technology, 1987
   B.S. Electrical Engineering, Worcester Polytechnic Institute, 1983

3. **Service at WPI:**
   2000 – Present Assistant Professor

4. **Other Professional Experience:**
   1999-2000 Senior Engineer, Radar Systems, Raytheon, Bedford, MA
   1994-1999 Researcher, Liberty Mutual Research Center for Safety and Health, Hopkinton, MA
   1993-1994 Senior Research Scientist, Aspect Medical Systems, Framingham, MA
   1991-1993 Research Scientist, Colin Research America, Cambridge, MA
   1985-1991 Research Assistant, Teaching Assistant and Post-Doctoral Fellow, Massachusetts Institute of Technology, Cambridge, MA
   1983-1985 Design Engineer, General Electric Co., Wilmington, MA
   Summers
   Engineering Assistant, Raytheon, Co., Bedford, MA Armed Forces Communications & Electronics Association Fellow

5. **Consulting, patents, etc.:** None

6. **Registration:** Not registered

7. **Publications of the last five years:**
   1. Clancy EA, Morin EL, Merletti R, "Sampling, Noise-Reduction and Amplitude Estimation Issues in Surface Electromyography," J Electromyo Kinesiol 12(1): 1–16, 2002
   2. Clancy EA, Quinn PM, Miller JE, "Using Case Studies to Increase Awareness of, and Improve Resolution Strategies for, Ethical Issues in Engineering," 31st ASEE/IEEE Frontiers in Education Conference, Reno, NV, pp. S1E-20-S1E-25, October 10–13, 2001
   3. Clancy EA, Bouchard S, Rancourt D, "Estimation and Application of Electromyogram (EMG) Amplitude During Dynamic Contractions," IEEE Eng Med Biol Mag 20(6): 47-54, 2001
   4. Clancy EA, Farry KA, "Adaptive Whitening of the Electromyogram to Improve Amplitude Estimation," IEEE Trans Biomed Eng 47(6): 709-719, 2000
   5. Clancy EA, Hogan N, "Probability Density of the Surface Electromyogram and its Relation to Amplitude Detectors," IEEE Trans Biomed Eng 46(6): 730-739, 1999
   6. Clancy EA, "Electromyogram Amplitude Estimation with Adaptive Smoothing Window Length," IEEE Trans Biomed Eng 46(6): 717-729, 1999
   7. Hashemi L, Webster BS, Clancy EA, "Trends in Disability Duration and Cost of Workers' Compensation Low Back Pain Claims (1988–1996)," J Occ Environ Med 40(12): 1110- 1119, 1998

8. Courtney TK, Clancy EA, "A Descriptive Study of U.S. OSHA Penalties and Inspection Frequency for Musculoskeletal Disorders in the Workplace," Am Ind Hygiene Ass J 59(8): 563-571, 1998
9. Clancy EA, "Factors Influencing the Resubstitution Accuracy in Multivariate Classification Analysis: Implications for Study Design in Ergonomics," Ergonomics 40(4): 417-427, 1997

8. Scientific and Professional Societies:

- IEEE
- The International Society of Electrophysiology and Kinesiology (ISEK)
- American Society of Engineering Educators (ASEE)

9. Honors and Awards:

- New Faculty Fellow, Frontiers in Education Conference, 2001
- Joseph Samuel Satin Distinguished Fellow, Worcester Polytechnic Institute, 2001-2002
- Elevated to Senior Member grade, IEEE, 1998

10. Institutional and Professional Service in the Past 5 Years:

- Co-Editor, Ergonomics Special Issue: Festschrift in Honour of Stover Snook, Vol. 42, No. 1, January 1999
- Ad hoc reviewer for: Ergonomics, Human & Ecological Risk Assessment, IEEE Transactions on Biomedical Engineering, International Journal of Industrial Ergonomics, Journal of Rehabilitation Research and Development, Medical & Biological Engineering & Computing, Medicine and Science in Sports and Exercise

11. Professional Development Activities in the Past 5 Years:

- Feb 2002 - Co-presented WPI CEDTA seminar discussion “Teaching Ethics”
- Jan 2002 - Attended WPI CEDTA seminar/discussion “Students Talk Back.”
- 1/8/2002 - Attended “New Advisors Workshop” presented by WPI Academic Advising
- 1/7/2002 - Attended department training on “Helping Students in Trouble”, presented by WPI Student Development and Counseling
- 11/20/2001 - Attended department training session for new ECE faculty on Academic Advising
- Oct 2001 - Attended and presented paper at 2001 ASEE/IEEE Frontiers in Education Conference
- Dec 2000 - Attended WPI CEDTA seminar/discussion “Educational Assessment Basics”

Prepared by Ted Clancy

1. **Name:** Kevin A. Clements **Academic Rank:** Professor

2. **Educational Record:**
B.S. Electrical Engineering, Manhattan College, 1963
M.S. Systems Science, Polytechnic Institute of Brooklyn, 1966
Ph.D. Systems Science, Polytechnic Institute of Brooklyn, 1970

3. **Service at WPI:**
1970 – 1974 Assistant Professor of EE
1974 – 1979 Associate Professor of EE
1979 – 1983 Professor of EE
1983 – 1988 Professor of EE and Head
1988 – 1989 Sabbatical Leave
1988 – present Professor of EE:
1991 – 1993 Dean of Graduate Studies & Research

4. **Other Professional Experience:**
1968 – 1969 Singer-General Precision Co., Little Falls, NJ, Project Engineer
1963 – 1968 General Electric Co., Advanced Guidance Systems Engineer

5. **Consulting, patents, etc.:**
- Oak Ridge National Laboratories, Oak Ridge, TN, 1989-1991
- Electric Power Research Institute, Palo Alto, CA, 1991-1993
- Power Technologies, Inc. Schenectady, NY, 1970 - present
- Alphatech, Inc, Burlington, MA 1991 – 2001
- Foxboro Co., Foxboro, MA 2001

6. **Registration:** Not registered

7. **Publications of the last five years:**
   1. 'Topology Error Identification Using Normalized Lagrange Multipliers', IEEE Transactions on Power Systems, May 1998. (Co-author: Antonio Simoes Costa)
   2. 'An Efficient Interior Point Method for Sequential Quadratic Programming Based Optimal Power Flow', IEEE Transactions on Power Systems, November 2000, pp1179-1183. (Co-authors: Imad Nejdawi and Paul Davis)
   3. 'Power System Topological Observability Analysis Including Switching Branches', IEEE Transactions on Power Systems., May 2002. (Co-authors: Antonio Simoes Costa and Elizete Laurenco)
   4. 'Stochastic OPF via Benders Method', IEEE Porto PowerTech 2001 Conference, September 2001, (Co-authors: L.M. Kimball and P.W. Davis)
   5. 'Comparison of Approaches to Identify Topology Errors in the Scope of State Estimation Studies', IEEE Porto PowerTech 2001 Conference, September 2001, (Co-authors: Antonio Simoes Costa, J. Pereirta, J Saraiva, and V. Miranda)

8. Scientific and Professional Societies:

- Fellow, Institute of Electrical and Electronic Engineers
- Sigma Xi
- Eta Kappa Nu

9. Honors and Awards:

- WPI Trustee's Award for Creative Scholarship
- Who's Who in America

10. Institutional and Professional Service in the Past 5 Years:

- Power Systems Engineering Committee
- Editorial Board IEEE Transactions on Power Systems, 2001-2002
- Computer and Analytical Methods Subcommittee
- WPI Committee on Appointments and Promotions

11. Professional Development Activities in the Past 5 Years:

Prepared by Kevin Clements

1. **Name:** David Cyganski **Academic Rank:** Professor

2. **Educational Record:**

B.S.	Electrical Engineering, Worcester Polytechnic Institute, 1975
M.S.	Electrical Engineering, Worcester Polytechnic Institute, 1977
Ph.D.	Electrical Engineering, Worcester Polytechnic Institute, 1981

3. **Service at WPI:**

1989-Present	Professor of ECE
1991-1992	Vice Provost
1989-1991	Vice Pres. Info. Systems
1987-1989	Chief Information Officer
1985-1989	Associate Professor of EE
1981-1985	Assistant Professor of EE
1979-1981	Instructor of EE
1977-1978	Adjunct Professor of EE:

4. **Other Professional Experience:**

1978-1979	Design Engineer, Real Time Intelligence Corporation, Shrewsbury, MA.
1977-1978	Member of Technical Staff, Bell Telephone Laboratories, N. Andover, MA
1976-1977	Part-Time Instructor, Worcester Polytechnic Institute, Worcester, MA.

5. **Consulting, patents, etc.:**
   - New England Electric System, Westborough, MA. 1982.
   - Phoenix Electric, Waltham, MA. 1985-1987.
   - Walker Scientific Corporation, Worcester, MA. 1981-1984.

6. **Registration:** Not registered

7. **Publications of the last five years:**
   1. Information Technology: Inside and Outside, D. Cyganski, J.A. Orr with R.F. Vaz, Prentice Hall, 2000
   2. John A. Orr, David Cyganski, ``Fire Fighter Location Tracking and Status Monitoring Performance Requirements," Fire and Emergency Services Technologies Innovation Conference, 28-30 March 2001, Natick Soldier Center, Natick, MA.
   3. I.F. Progri, W.R. Michalson, J.A. Orr, D. Cyganski, ``A System for Tracking and Locating Emergency Personnel Inside Building," Proceedings of ION GPS 2001, Salt Lake City, Utah, Sept. 11-14, 2001.
   4. David Cyganski, Bill Page, ``Quaternions, Torsion and the Physical Vacuum: Theories of M. Sachs and G. Shipov Compared", Vigier III Conference, August 21-25, 2000, University of California, Berkeley.
   5. David Cyganski, J. Kilian, D. Fraser, ``Performance of an ATR Index Module Against MSTAR Data," Proceedings of IEEE 1999 Radar Conference, Waltham, MA, April 20-22, 1999.

6. Brian Hazzard, David Cyganski, Steve Dempsey, Eric Fryland, ``Performance of Asynchronous, Variable Bit Rate Communications over ATM: A Comparison with DDI," IEEE LCN 97, The 22nd Annual Conference on Computer Networks, Nov 1997, Minneapolis, Minnesota.
7. Michael J. Andrews, David Cyganski, ``The XUDP Protocol for Timely Multimedia Transport," Third Technical Conference on Telecommunications R\&D in Massachusetts, November 13, 1997.
8. Brent E. Modzelewski, David Cyganski, Marian V. Underwood, ``Interactive-Group Object-Replication Fault Tolerance for CORBA," The Third Conference on Object-Oriented Technologies and Systems, Portland, Oregon, June 16-20, 1997, pp. 241-244.
9. Charles L. Feldman, Sergio Waxman, Olusegun J. Ilegbusi, Zhenjun Hu, David Cyganski, James Kilian, Richard W. Nesto, Peter H. Stone, "Determination of Flow Field Patterns and Shear Stress on Endothelium in Human Coronary Arteries in vivo," American Heart Association Meeting on Vascular and Myocardial Aspects of Ischemic Heart Disease. February 22-25, 1998. Hyatt Regency lake Tahoe Resort and Casino, Incline Village, Nevada.
10. David Cyganski, Jim Kilian, Debra Fraser , ``Baseline Performance of the LSD/DOA ATR against MSTAR Data," paper 3370-43, Algorithms for Synthetic Aperture Radar Imagery V, AeroSense '98, April 14-17, 1998, Orlando, Florida.
11. W.S. Page and D. Cyganski, ``An Example of the use of Maple in Mathematical Electrodynamics: The solutions in `Toward an Understanding of Electromagnetic Phenomena' by Valeri Dvoeglazov and Myron W. Evans are not realizable." Poster Session at Causality and Locality in Modern Physics and Astronomy: Open Questions and Possible Solutions, Vigier II Conference, Toronto, Canada, August 25-29, 1997.
12. Brian Hazzard, David Cyganski, Steve Dempsey, Eric Fryland, ``Performance of Asynchronous, Variable Bit Rate Communications over ATM: A Comparison with FDDI," IEEE LCN 97, The 22nd Annual Conference on Computer Networks, Nov 1997, Minneapolis, Minnesota.
13. Michael J. Andrews, David Cyganski, ``The XUDP Protocol for Timely Multimedia Transport," Third Technical Conference on Telecommunications R&D in Massachusetts, November 13, 1997.
14. Brent E. Modzelewski, David Cyganski, Marian V. Underwood, ``Interactive-Group Object-Replication Fault Tolerance for CORBA," The Third Conference on Object-Oriented Technologies and Systems, Portland, Oregon, June 16-20, 1997, pp. 241-244.
15. Witold Jachimczyk, David Cyganski , ``Enhancements of Pose-tagged Partial Evidence Fusion SAR ATR," AeroSense '97, Conference 3070, Algorithms for Synthetic Aperture Radar Imagery IV, April 1997, Orlando, Florida.

8. Scientific and Professional Societies:

- IEEE
- SIGMA XI member (Scientific Research Honorary Organization)
- ETA KAPPA NU member (Electrical Engineering Honor Society)
- TAU BETA PI member (Engineering Honor Society)
- SIGMA PI SIGMA member (Physics Honor Society)

9. Recent Honors and Awards (Past five years):

- Named the Weston Hadden Chair.
- Received the Robert H. Goddard Award for Outstanding Professional Achievement from the WPI Alumni Association.
- Chosen by the students in the ECE department in May 99 as the ECE Outstanding Project Advisor of the year.

10. Institutional and Professional Service in the Past 5 Years:

- 2001-Present: Chairman of the ECE Graduate Program Committee.
- ECE Department Undergraduate Program Committee – 1995-2000
- ECE Department Strategic Plan Committee - 2000
- Member of the Committee on Governance – 1997-2000
- Chairman of the Plan Implementation Committee 1997-1998
- Member of the Strategic Plan Steering Committee and liason for the
- Graduate Program Task Force – 1996-1997

11. Professional Development Activities in the Past 5 Years:

- Co-developed and co-taught two courses as part of WPI's continuing education program:
  - Information Technology for Financial Managers January 26-28, 2000.
    - ID 525 197 - Business Assessment of Information Technologies, Module 1: September 1-2, 1999, Module 2: March 10-11, 2000.
    - ID 525 197 - Business Assessment of Information Technologies, Module 1: July 25-27,2000, Module 2: November 10-11, 2000.
- Developed and taught twice a two-day course on the distributed processing development 1 language and system of the Common Object Request Broker Architecture: October 22-23, 1998 and May 17-18, 1999.

Prepared by David Cyganski

1. **Name:** Adam Elbirt **Academic Rank:** Instructor

2. **Educational Record:**
PhD Electrical and Computer Engineering, WPI, 2002
MEng Electrical Engineering, Cornell University, 1993
BSEE Electrical Engineering, Tufts University, 1991

3. **Service at WPI:**
2001 – Present Instructor

4. **Other Professional Experience:**
1998 – 2000 Teaching Assistant/Research Assistant, ECE Department, WPI
1998 – 1998 Senior Software Engineer, Viewlogic Systems, Incorporated
1997 – 1998 Technical Evangelist, Viewlogic Systems, Incorporated

1996 – 1997 Senior Programmable Solutions Engineer, Viewlogic Systems, Incorporated

1995 – 1996 Senior Design Engineer/East Coast Software Coordinator, MKS Instruments
1994 – 1995 Design Engineer, MKS Instruments
1993 – 1994 Design Engineer, Sensis Corporation
1991 – 1992 Member of Technical Staff, Raytheon Corporation

5. **Consulting, patents, etc.:**
- February 2001 – Present, Hardware Guru, NTRU Communications and Content Security

6. **Registration:** Not registered

7. **Publications of the last five years:**

1. AJ Elbirt, C Paar, "An Efficient Reconfigurable Architecture for Symmetric-Key Cryptography", submitted to IEEE Transactions on Very Large Scale Integration (VLSI) Systems.
2. AJ Elbirt, C Paar, "COBRA – A Reconfigurable Architecture for Symmetric-Key Algorithms", submitted to the Fourth Annual Workshop on Cryptographic Hardware and Embedded Systems.
3. AJ Elbirt, W Yip, B Chetwynd, C Paar, "An FPGA-Based Performance Evaluation of the AES Block Cipher Candidate Algorithm Finalists", IEEE Transactions on Very Large Scale Integration (VLSI) Systems, June, 2001.
4. AJ Elbirt, W Yip, B Chetwynd, C Paar, "An FPGA Implementation and Performance Evaluation of the AES Block Cipher Candidate Algorithm Finalists", presented at the Third Advanced Encryption Standard Candidate Conference, April 13-14, 2000, New York, New York.

5. AJ Elbirt, C Paar, "An FPGA Implementation and Performance Evaluation of the Serpent Block Cipher", Proceedings of the Eighth ACM/SIGDA International Symposium on Field Programmable Gate Arrays, presented as an extended session, February, 2000, Monterey, California.
6. AJ Elbirt, C Paar, "Towards an FPGA Architecture Optimized for Public-Key Algorithms", Proceedings of the SPIE International Symposium on Voice, Video, and Data Communications, presented September 20, 1999, Boston, Massachusetts.
7. AJ Elbirt, "Implementation of a PCI Bus Target Interface in a High Density FPGA", Proceedings of the Seventh Annual PLD & FPGA Conference & Exhibition, presented May 14, 1997, Ascot, United Kingdom.

8. Scientific and Professional Societies:
- IEEE Member 1995-present
- ACM/SIGDA Member 1999-present

9. Recent Honors and Awards:
- Eta Kappa Nu Electrical Engineering Honor Society Member 2002-present

10. Institutional and Professional Service in the Past 5 Years:
- Served on the ECE Department Academic Honesty Committee

11. Professional Development Activities in the Past 5 Years:
- PhD completion

Prepared by Adam Elbirt

1. **Name:** Alexander E. Emanuel **Academic Rank:** Professor, ECE

2. **Educational Record:**
D.Sc Technion Israel Institute of Thecnology, Haifa, 1969
M.Sc Technion Israel Institute of Thecnology, Haifa, 1965
B.Sc Technion Israel Institute of Thecnology, Haifa, 1963

3. **Service/Positions at WPI:**
1982 - present Professor
1978-1982 Associate Professor
1974-1978 Assistant Professor

4. **Other Professional Experience:**
1958-1961 Electrotehnica, Bucharest, Romania,Quality Control Assistant Engineer.
1962-1963 Ohm Electric Company, Haifa, Israel Transformers and Small Motors Designer.
1969-1974 High Voltage Engineering, Burlington, MA. Research and Development Senior Engineer.Design and Testing of High Voltage Equipment.

5. **Consulting, patents, etc.:** None

6. **Registration:**
Professional Engineer, MA 29198, 07/28/1978

7. **Publications of Last Five Years:**
1. A.E.Emanuel, *True and False Energy Saving Devices*, IEEE Trans. on Industry Applictions, Vol.33, No.6, Nov/Dec 1997, pp.1439-43. (Received the R.H.Lee 1998 IEEE Industrial and Commercial Power Systems Award).
2. A.E.Emanuel, J.A. McNeill *Power Quality*, Annual Review of Energy and the Environment, Vol.22, 1997, pp.263-303.
3. P. De Andrea, G.R. Miller, A.E.Emanuel, *Adjustable Speed Drives may Disturb Metal Detectors Performance*, IEEE Trans. on Industry Applications, Vol.35, No.3, May/June 1999, pp.725--29.
4. E.J. Davis, A.E.Emanuel, D.J. Pileggi *Harmonic Pollution Metering: Theoretical Consideration*, Proceedings of IEEE PES Summer Meeting, July 1999, Edmonton, Alberta, Vol.I, pp.367--72. IEEE Transactions on Power Delivery, Vol. 15, No.1, January 2000, pp.14-18.
5. E.J. Davis, A.E.Emanuel, D.J. Pileggi *Evaluation of Single--Point Measurements Method for Harmonic Pollution Cost Allocation*", Proceedings of IEEE PES Summer Meeting, July 1999, Edmonton, Alberta, Vol.I, pp.373--78. IEEE Transactions on Power Delivery, Vol. 15, No.1, January 2000, pp.19-23.
6. Zahedi, A.E.Emanuel, "Estimation of the Maximum Admissible Level of Third Harmonic Current in 13.8 kV Feeders", International Journal of Power and Energy Systems, Vol.19, No.1, February 1999, pp.7--10.

Alex Emanuel Page 2

7. I.M. Nejdawi, A.E.Emanuel, D.J. Pileggi *HarmonicsTrend in NE USA: A Preliminary Survey*, IEEE Trans. on Power Delivery, Vol.14, No.4, Oct. 1999, pp.1488--1494.
8. A.E.Emanuel, *Apparent Power Definitions for Three—Phase Systems*, IEEE Trans. on Power Delivery, Vol.14, No.3, July 1999, pp.767-72.
9. J.A. Orr and A.E. Emanuel, *On the Need for Strict Second Harmonic Limits*, IEEE Trans. on Power Delivery, Vol.15, No.3, July 2000, pp.967--71.
10. A.E. Emanuel, *Practical Aspect of Active and Generating Powers in Nonsinusoidal Situations: Some Questions*, European Transactions on Electrical Power, ETEP vol.11, Nov/Dec 2001, pp.375-81.
11. Z. Cakareski and A.E. Emanuel, *Poynting Vector and the Quality of Electric Energy*, European Transactions on Electrical Power, ETEP vol.11, Nov/Dec 2001, pp.371-74.
12. A.E. Emanuel, *Harmonics in the Early Years of Electrical Engineering: A Brief Review of Events, People and Documents,*" Proceedings of the 9th International Conference on Harmonics and Quality of Power, Oct. 2000, Orlando, Florida, pp.1--7. Best Paper Award.
13. Jose Policarpo and A.E. Emanuel, *Induction MotorThermal Aging Caused by Voltage Distortion and Imbalance: Loss of Useful Life and its Estimated Cost,* Proceedings of IEEE Industrial and Commercial Power Systems, New Orleans, LA, May 2001, pp.105--114. (Best Paper Award). IEEE Trans. on Industry Applications, Vol.38, No.1, Jan. 2002, pp.12--20.
14. A.E. Emanuel, *Nonactive Power Due to Randomness*, IEEE Power Engineering Review, August 2001, pp.43--45.
15. A.E. Emanuel, *Arguments in Support of the Buchholz—Goodhue Apparent Power Definition*, Proceedings of the 7th Int.Conference on Optimization of Electrical and Electronic Equipment. Brasov, Romania, May 2000, pp.271--8. and Journal of Electrical Engineering, Vol.1, No.2, Oct. 2001, pp.26--31, http://www.jee.ro

8. Scientific and Professional Societies:

- IEEE
- Scientific Society of North America: Member 1978

9. Honors and awards:

- The 1982 Board of Trustees Award for Outstanding Teaching.
- The 1986 Board of Trustees Award for Outstanding Researcher and Creative Scholarship.
- The 2001 Board of Trustees Award for Outstanding Advising.
- George I. Alden Professor of Engineering 1988-1992.
- Weston Hadden Professorship in Electrical and Computer Engineering 1996--1999.
- Seven IEEE Prize Papers.
- Fellow of the Institute of Electrical and Electronics Engineers, 1997.
- IEEE Power Systems Instrumentation and Measurements Committee, Individual Service Award 1997.
- IEEE Working Group Recognition Award 1998.
- IEEE Outstanding Working Group Chairman 1992.
- IEEE Outstanding Working Group Chairman 1996.
- John Mungenast International Power Quality Award, 1999

10. Institutional and Professional Service in the Past 5 Years:

- WPI Committee on Promotion and Academic Freedom (1996-1999).
- WPI Faculty Review Committee (2001-2003).
- WPI Selection of Outstanding Teacher.
- ECE Department Advisory Committee
- Chairman IEEE Standard 120, "Master Test Code for Electrical Measurements in Power Circuits"
- Chairman IEEE Steering Committee of International Conference on Harmonics and Quality of Power (1984--2000)
- Chairman IEEE Std. P1459 "Standard Definitions for the Measurements of Electric Power Quantities under Nonsinusoidal Situations"(1995--present).
- IEEE PES Fellow Review Committee (2001-present).

11. Professional Development Activities in the Past 5 Years:

- University of Minnessota: NSF Sponsored Workshop, Simulations of Power Electronics Circuits (1998)
- University of Milan: Workshop on Power Definitions and Measurements (1998 and 2000).

Prepared by Alex Emanuel

1. **Name:** Hossein Hakim **Academic Rank:** Associate Professor

2. **Educational Record:**
   Ph.D. Electrical Engineering, Purdue University, 1982
   MS Electrical Engineering, Purdue University, 1977
   BS Electrical Engineering, Sharif Univ. of Tech (Tehran, Iran), 1975

3. **Service/Positions at WPI:**
   7/89 - Present Associate Professor, ECE Department
   7/84 – 6/89 Assistant Professor, ECE Department

4. **Other Professional Experience:**
   1994 – 1999 Chairman, Interdisciplinary and Global Studies Department, WPI
   1990 – 1994 Global Program Officer, WPI
   1982 – 1984 Assistant Professor, EE Department, Gonzaga University, Spokane, WA

5. **Consulting, patents, etc.**
   - 1985 - 1989, Consultant, Aircraft Instruments Department, General Electric.

6. **Registration:** Not registered

7. **Publications of Last Five Years:** None

8. **Scientific and Professional Societies:**
   - ASEE
   - IEEE

9. **Honors and awards:** no recent awards or honors

10. **Institutional and Professional Service in the Past 5 Years:**
    - Chaired the Committee on Advising and Student Life.
    - Served in the ECE Assessment Committee and the ECE Undergraduate Program Committee.
    - Served as the ECE Undergraduate Program Coordinator.
    - Served as faculty advisor to the IEEE Student Branch.

11. **Professional Development Activities in the Past 5 Years:**
    - Attended eight different workshops to learn the latest developments in the areas of DSP Hardware and Software. These workshops were organized by National Science Foundation, Texas Instruments, DSP Development Corp., National Instruments, and MathWorks.

Prepared by Hossein Hakim

1. **Name:** Ahmad Hatami **Academic Rank:** Instructor

2. **Educational Record:**
   9/97– 5/99 Worcester Polytechnic Institute (WPI)
   9/96 – 9/97 M.S. in Communication and Computer Networking, University Of Calgary
   Master of Science in Project Management (not completed)
   9/96 – 9/97 Southern Alberta Institute Of Technology (SAIT), Networking certificate
   9/84 – 10/89 University Of Tehran, Bachelor of Science in electrical engineering

3. **Service at WPI:**
   2002 – Present Instructor

4. **Other Professional Experience:**
   12/01 – Present Instructor for logic design and embedded systems
   2/01 – 12/01 Sr. Software Engineer, Sycamore Networks
   5/99 – 3/01 Senior Software Engineer, Ascend Communications/Lucent Technologies
   1/99 – 5/99 Software Engineer Co-Op, 3COM Corp.
   11/96 – 9/97 Computer Hardware Engineer, Future Shop Ltd. (Calgary-AB Canada)
   9/96 – 2/97 Software Engineer, WiLAN (Calgary-AB Canada)
   11/90 – 7/96 Technical Office Engineer, IIND Corp
   9/89 – 10/90 Hardware & Software Coordinator, MINISTRY OF INTERIOR

5. **Consulting, patents, etc.:** None

6. **Registration:** Not registered

7. **Publications of the last five years:**
   1. Handoff in Hybrid Mobile Data Networks", IEEE Personal Communications Magazine, pp 34-47, Vol. 7 No. 2, April 2000
   2. Analytical Framework for Handoff in Non-Homogeneous Mobile Data Networks Proceedings of PIMRC'99, pp. 760-764, Osaka, Japan, September 1999.
   3. Fuzzy Logic, Neural Networks, and other Algorithms for Handoff in Wireless Networks. Proc. of Third International ICSC Symposium on Fuzzy Logic and Applications, Rochester, June 1999

8. **Scientific and Professional Societies:** None

9. **Recent Honors and Awards:** No recent honors or awards

10. **Institutional and Professional Service in the Past 5 Years:**

11. **Professional Development Activities in the Past 5 Years:**

Prepared by Ahmad Hatami

1. **Name:** Robert C. Labonté **Academic Rank** Professor of Practice

2. **Educational Record:**
   B.S., Worcester Polytechnic Institute, Electrical Engineering, 1954

3. **Service at WPI:**

1997 to Present	Professor of Practice
1993-1997	Visiting Associate Professor
1982-1993	Adjunct Professor

4. **Other Professional Experience:**

1959 -93 The MITRE Corporation, Bedford MA.

1992-93	Department Manager, Security and Intelligence Engineering
1989-91	Department Manager, Computing Research an Technology
1986-89	Associate Dept. Head, Surveillance and C^3 Software
1984-85	Associate Dept. Head, Mgt. Information Systems & Software.
1982-84	Associate Dept. Head, Information System Integration.
1980-82	Associate Dept. Head, System Architecture.
1979-80	Site Leader, NASA Headquarters.
1975-79	Group Leader, Applied Technology.
1972-75	Group Leader, Command & Control Communications.
1968-72	Group Leader, Airborne Warning & Control. (AWACS Design team)
1966-68	Technical Staff, NATO HQ. and U. S. Embassy, Paris, France.
1964-66	Technical Staff, Systems Integration Directorate.
1959-64	Technical Staff, SAGE Air Defense System Department.

1955-59 Technical Staff, MIT Division of Laboratories (Lincoln Laboratory).
1956-57 U. S. Navy.

5. **Consulting, patents, etc.:** None

6. **Registration:** Not registered

7. **Publications of the last five years:** None

8. **Scientific and Professional Societies:** IEEE

9. **Recent Honors and Awards:** None

10. Institutional and Professional Service in the Past 5 Years:

- Member of the ECE Department Undergraduate Program Committee.
- Chairman of the ECE Department Projects Committee.
- Department ombudsman for Academic Honest
- Chairman and long-term member of the WPI Communications Committee -previously known as the WPI Publications Committee.
- Member of the Executive Board of the WPI Alumni Association
- Participant in the New Faculty Mentoring Program and the "Food for Thought" seminar series.

11. Professional Development Activities in the Past 5 Years:

Prepared by Robert C. Labonté

1. Name: Fred J. Looft **Academic Rank:** Professor

2. Educational Record:

Ph.D. Electrical Engineering, Univ. of Michigan, 1979
MS Computer, Info. and Control Engineering, Univ. of Michigan, 1976
MS Electrical Engineering, Univ. of Michigan, 1974
BS Electrical Engineering, Univ. of Michigan, 1973

3. Service/Positions at WPI:

7/91 – Pres. Coordinator for Graduate Activities
7/98 – Pres. Associate Department Head
7/89 – Pres. Professor, ECE
7/85 – 6/89 Associate Professor, ECE
9/80 – 6/85 Assistant Professor, ECE

4. Other Professional Experience:

1990 – 1991 Johns Hopkins University, Bard Laboratory (12 months), sabbatical
1979 – 1980 Member of the Technical Staff, Bell Laboratories Inc., North Andover, MA
1978 – 1979 NASA Space Shuttle Experiment, Project Engineer, Univ. of Michigan, Ann Arbor, MI
1973 – 1979 Various technical consulting positions encompassing signal processing, circuits and systems design, computer programming and interfacing, Ann Arbor, MI

5. Consulting, patents, etc.: None

6. Registration: Not registered

7. Publications of Last Five Years:

1. F. J. Looft and W. W. Durgin, "The WPI / Goddard Space Flight Center Projects Program" - FIE, Boston, November 2002
2. F. J. Looft and J. A. Orr "Computer and Communications Networks Graduate Program" - FIE Boston, November 2002

8. Scientific and Professional Societies:

- IEEE – Senior Member
- Etta Kappa Nu

9. Honors and awards: No recent awards or honors

10. Institutional and Professional Service in the Past 5 Years:

- FRONTIERS "Frontiers in Science and Math" is a WPI summer program for students between their junior and senior years in high school. The students elect a two-week study program from the areas offered as part of the Frontiers program. I teach a two-week Electrical Engineering program. Summers involved: 1990, 1991, 1992 (with STRIVE students), 1993, 1994 (with D. Nicoletti), 1995 – 1996 (with D.N.), 2001 and 2002 (committed)
- Senior Project Lab Coordinator
- ECE Graduate Program Committee
- Internal Advisory Committee
- CS/ECE Coordinating Committee
- Computer Engineering Specialization Coordinator
- Numerous Alumni and visiting HS Guidance Counselor presentations
- Numerous visiting parents/students presentations

11. Professional Development Activities in the Past 5 Years:

- Tanner Tool (VLSI) Corporate Tutorial – November, 2001
- Developed new VLSI course for ECE (and retrained myself)

Prepared by Fred J. Looft

1. **Name:** Reinhold Ludwig **Academic Rank:** Professor

2. **Educational Record:**

Ph.D.	Colorado State University, Electrical Engineering, 1986
M.S. (Dipl.-Ing.)	University of Wuppertal, Electrical Engineering, 1983

3. **Service/Positions at WPI:**

1986 – 1990	Assistant Professor of Electrical Engineering
1990 – 1996	Associate Professor of Electrical and Computer Engineering
1996 – present	Professor of Electrical and Computer Engineering

4. **Other Professional Experience:**

June 1993 - July 1993	NSF Workshop on Symbolic Computations, Rose-Hullman, Terra-Haute, IN
July 1992 - August 1993	Sabbatical leave at Medical Division of Hewlett-Packard Corporation
May 2001 – Dec. 2001	Techno Venture Management, Boston, MA.

5. **Consulting, patents, etc.:**

- United Technologies, East Hartford, CT, January 1994 - January 1995.
- Walker Scientific, Corporation, September 1993 - December 1995.
- The Gillette Company, Boston, MA, May 1998 – Present
- Insight Neuroimaging System, Worcester, May 1999 – present

6. **Registration:** Not registered

7. **Publications of Last Five Years:**

1. G. Bogdanov and R. Ludwig, "A Coupled Multi Transmission Line Model for Transverse Electromagnetic RF Coils," in Journal of Magnetic Resonance in Medicine, Vol 47, 3, pp. 579 – 593, 2002.
2. R. Ludwig, P. Bretchko, and S. Makarov, "Magnetic and Eddy Current Effects in an Open-Loop Pulsed Hysteresis Graph System for the Magnetization of Rare-Earth Magnets," to appear in IEEE Transactions in Magnetics, 2002.
3. R. Ludwig, G. Leuenberger, S. Makarov, D. Apelian, "Electric Voltage Predictions and Correlation with Density Measurements in Green-State Powder Metallurgy Compacts," to appear in Journal of Nondestructive Evaluation, 2002.
4. P. Bretchko and R. Ludwig, " Open-Loop Pulsed Hysteresis Graph System for the Magnetization of Rare-Earth Magnets, " IEEE Transactions on Magnetics, Vol. 36, No. 4, pp. 2042 – 2051, July 2000.
5. S. Makarov, R. Ludwig, P. Bretchko, "Electromagnetic Separation Techniques in Metal Casting. I. Conventional Methods," IEEE Transactions on Magnetics, Vol. 36, No. 4, pp. 2015 – 2021, July 2000.
6. G. Bogdanov, R. Ludwig, and W. R. Michalson, "A New Apparatus for Non-destructive Evaluation of Green-State Powder Metal Compacts Using the Electrical Resistivity Method," Journal of Measurement Science and Technology, Vol. 11, pp. 157 – 166, January 2000.

7. S. Makarov, R. Ludwig, and D. Apelian, "Resonant oscillation of a liquid metal column driven by electromagnetic Lorentz force sources," Journal of Acoustical Society of America, 105 (4), pp. 2216-2225, April 1999.

8. Scientific and Professional Societies:

- Institute of Electrical and Electronic Engineers (IEEE)
- American Society of Nondestructive Testing (ASNT)
- American Society for Engineering Education (ASEE)
- Sigma Xi
- Eta Kappa Nu

9. Honors and awards:

- Samuel Satin Distinguished Fellowship, ECE department, WPI – 1988.

10. Institutional and Professional Service in the Past 5 Years:

- Committee on Graduate Studies and Research, 1989 – 1992
- Committee on Tenure and Academic Freedom 2001 - 2005

11. Professional Development Activities in the Past 5 Years:

Prepared by Reinhold Ludwig

1. **Name:** Sergey N. Makarov **Academic Rank:** Associate Professor

2. **Educational Record:**
DrSci Wave Physics, Acoustics, St. Petersburg State University, Russia, 1995
PhD Applied Math, St. Petersburg State University, Russia, 1985
MS Applied Math, Leningrad State University, USSR, 1982
BS Applied Math, Leningrad State University, USSR, 1982

3. **Service/Positions at WPI:**
1998-2000 Research Professor, Metal Processing Institute
July 2000-present Associate Professor, ECE

4. **Other Professional Experience:**
1986-1996 Research Staff Scientist, Mathematics and Mechanics Dept., St. Petersburg State University
1996-1998 Professor of Mathematics and Mechanics, St. Petersburg State University
Research work in Germany:
Physikalisch-Technische Bundesanstalt (1 year) Braunschweig
Paul-Drude Institut fuer Festkoerperelektronik (1.5 years) Berlin
Research work at Hanscom AFB-AFRL (this summer) Hanscom, MA

5. **Consulting, patents, etc.:**
One patent pending

6. **Registration:** Not registered

7. **Publications of Last Five Years:**
    1. S. Makarov, *Antenna and EM Modeling with Matlab*, Wiley, NY, 2002, ISBN: 0-471-21876-6.
    2. S. Makarov, "MoM antenna simulation with *Matlab*: RWG basis functions," *IEEE Antennas and Propagation Magazine*, vol. 43, no. 5, pp. 100-107, October 2001.
    3. S. Makarov, R. Ludwig, and D. Apelian, "Electromagnetic separation techniques in metal casting. II. Separation with superconducting coils," IEEE Trans. on Magnetics, vol. 37, No 2, 2001, pp. 1024-1031.
    4. S. Makarov, R. Ludwig, and D. Apelian, "Electromagnetic separation techniques in metal casting.
I. Conventional methods," IEEE Trans. on Magnetics, vol. 36, No 4, 2000, pp. 2015-2021.
    5. S. Makarov, R. Ludwig, and D. Apelian, "Identification of depth and size of subsurface defects by a multiple-voltage probe sensor: analytical and neural network techniques," Journal of NDE, vol. 19, No. 2, pp. 67-80, 2000.
    6. S. Makarov, R. Ludwig, J. Resnik, and D. Apelian, "The effect of a short pulse of current on small particles in a conducting fluid," *Journal of NDE*, vol. 18, No. 3, pp. 99-102, 1999.
    7. S. Makarov, R. Ludwig, and D. Apelian, "Electromagnetic visualization technique for non-metallic inclusions in a melt," *Measur. Sci. Tech.*, vol. 10, pp. 1047-1053, 1999.

8. S. Makarov, R. Ludwig, and D. Apelian, "Resonant oscillation of a liquid metal column driven by electromagnetic Lorentz force sources," *J. Acoust. Soc. Am.*, vol. 105(4), pp. 2216-2225, 1999.
9. S. Makarov and M. Ochmann, "An iterative solver of the Helmholtz integral equation for high-frequency acoustic scattering," *J. Acoust. Soc. Am.*, vol. 103, no. 2, pp. 742- 750, 1998.

8. Scientific and Professional Societies:

- IEEE - Antennas and Propagation
- IEEE - Communications Society
- ACES - Applied Computational Electromagnetics Society
- Eta Kappa Nu

9. Honors and awards: No recent honors or awards

10. Institutional and Professional Service in the Past 5 Years:

- Reviewer for:
  - IEEE Antennas and Wireless Propagation Letters
  - IEEE Transactions on Neural Networks
  - ACES Journal
  - Journal of Acoustical Society of America
- Member of library vision committee (WPI)

11. Professional Development Activities in the Past 5 Years:

Prepared by Sergey Makarov

1. **Name:** John A. McNeill **Academic Rank:** Associate Professor

2. **Educational Record:**
Ph.D. Electrical Engineering, Boston Univ., 5/94.
M.S. Electrical Engineering, Univ. of Rochester, 10/91.
A.B. Engineering Sciences, Hanover College, 6/83

3. **Service/Positions at WPI:**
7/00 - present Associate Professor
8/94 - 6/00 Assistant Professor

4. **Other Professional Experience:**
1/89 – 8/90 Electronics Section Head
9/87 – 12/88 Analog Group Leader
3/86 – 9/87 Design Engineer, Adaptive Optics Associates (Cambridge, MA)

7/83 – 3/86 Design Engineer, Analogic (Wakefield, MA)

5. **Consulting, patents, etc.:**
- Patent 6,218,846: "Multi-probe impedance measurement system and method for detection of flaws in conductive articles," with Jennifer Stander and Reinhold Ludwig
- Patent 5,418,498: "Low Jitter Ring Oscillators," with Lawrence M. DeVito, Analog Devices Semiconductor, Inc.

Consulting:
- Metrologic Instruments (Cambridge, MA) [October, 2001 - January, 2002] Design of low noise detector circuitry for laser ranging system.
- Teradyne (Boston, MA) [July, 2000 - October, 2000] Design of low-jitter circuitry for GHz-speed digital test systems.
- American Power Conversion (Billerica, MA) [May 1998 - August 1998] Design of bipolar mixed signal integrated circuits.
- PerkinElmer Optoelectronics (Sunnyvale, CA) [January 1996 - August 1996] Design of low noise CMOS mixed signal integrated circuits.
- MIT Center for Space Research (Cambridge, MA) [May 1995 - December 1995] Designed 20-bit current-input analog-to-digital converter (ADC) with 100nA full-scale for measurement of solar wind in satellite instrumentation system. ADC noise measured at 2 parts per million rms.
- Analog Devices (Wilmington, MA) [June, 1994 - September, 1994] Designed 155 MHz phase-locked loop synthesizer IC. First silicon met noise performance design specification to within 10% of goal.

6. **Registration:** Not registered

7. **Publications of Last Five Years:**

1. Y. Toh and J. McNeill, "Single-ended to differential converter for multiple-stage single-ended ring oscillators," accepted for publication, IEEE Journal of Solid-State Circuits, March, 2002.

2. J. McNeill, A Simple Method for Relating Time- and Frequency-Domain Measures of Oscillator Performance (Invited Paper), Proceedings of the 2001 IEEE Southwest Symposium on Mixed Signal Design (SSMSD2001), Austin, TX, February, 2001.
3. J. McNeill, M. Lawler, G. Levesque, J. Ruiter, J. Noon, "A 50A, 1-us-rise-time, programmable electronic load instrument for measurement of microprocessor power supply transient performance," Proceedings of the 2000 IEEE Instrumentation and Measurement Technology Conference (IMTC2000), Baltimore, MD, May, 2000.
4. J. Stander, J. McNeill, and R. Ludwig, "Multi-Probe Impedance Measurement System for Nondestructive Evaluation and Test of 'Green State' Powder Metallurgy Parts", IEEE Transactions on Instrumentation and Measurement, vol. 47, no. 5, pp. 1367-1371, October, 1998.
5. J. McNeill, "Jitter in ring oscillators," IEEE Journal of Solid-State Circuits, vol. 32, no. 6, pp. 870-879, June, 1997.

8. Scientific and Professional Societies:

- IEEE

9. Honors and awards:

- Received Eta Kappa Nu Outstanding Electrical Engineering Professor Award, 1998, 2000
- Received WPI Board of Trustees' Award for Outstanding Teaching, 1999
- Received National Science Foundation CAREER award, 1997
- Received 1995 Joseph Samuel Satin Distinguished Fellowship for outstanding young professor in Electrical and Computer Engineering Department.

10. Institutional and Professional Service in the Past 5 Years:

- Member of Editorial Review Committee
- IEEE Journal of Solid-State Circuits
- IEEE Transactions on Circuits and Systems
- IEEE Transactions on Instrumentation and Measurement
- Chair, ECE Dept. Undergraduate Program Committee (1997-8; 1999-2002)

11. Professional Development Activities in the Past 5 Years:

- Attended International Solid State Circuits Conference (ISSCC), 1997-2001.
- Brought grad students to conference to improve their professional development as well.

Prepared by John McNeill

1. **Name:** William R. Michalson **Academic Rank:** Associate Professor

2. **Educational Record:**
   Ph. D. Electrical Engineering WPI, 1989
   M. S. Electrical Engineering WPI, 1985
   B. S. Electrical Engineering Syracuse University, 1981

3. **Service/Positions at WPI:**
   7/98-Present Associate Professor of Electrical Engineering
   7/92-7/98 Assistant Professor of Electrical Engineering
   9/91-7/92 Visiting Assistant Professor of Electrical Engineering.
   1/90-9/91 Adjunct Assistant Professor of Electrical Engineering.

4. **Other Professional Experience:**
   1981-1991 Raytheon Company, Equipment Division

5. **Consulting, patents, etc.:**

Consulting:

- 2002 - Elonex I.P. Holdings, LTD. and Elonex PLC, Phase II litigation; Expert witness for defendants Daewoo, LG Electronics, Compal, Delta, Chuntex/CTX, Tatung, Lite-On and Acer.
- 2002 - Storage Computer Corporation vs. Seagate Technology LLC; Expert witness for the defendant in matters involving US Patent RE 34,100.
- 2001 - Raytheon Company; Development of techniques for implementing a fault tolerant computer system using software implemented fault tolerance (SIFT).
- 2001 - TVM Techno Venture Management;

Patents:

- Pending: An N-Channel Auto-Calibrating Surround Sound System
- US 5,987,380 Hand-held GPS-mapping device; Continuation in part issued 11/16/99.
- US 5,902,347 Hand-held GPS-mapping device; issued 5/11/99.

6. **Registration:** Not registered

7. **Publications of Last Five Years:**

1. I.F. Progri and W.R. Michalson, “Performance Evaluation of a Multi-frequency DS-CDMA System for Indoor Applications,” in review, IEEE Transactions on Communications.
2. L. Polizzotto and W. R. Michalson, “The Technical, Process, and Business Considerations for Engineering Design,” *Frontiers In Education 2001,* October 2001.
3. J.M. Hill and W.R. Michalson, “The Principle of a Snapshot Navigation Solution Based on Doppler Shift,” *Institute of Navigation GPS 2001,* September 2001.
4. I. Progri , J. M. Hill and W. R. Michalson, “The Impact of the Carrier Frequency, the Transmitted Data Rate, and the Receiver's Sampling Rate on the Navigation Accuracy,” *Institute of Navigation Annual Meeting,* June 2001.

5. J. M. Hill and W. R. Michalson, "Design of a Stable Discrete Time Costas Loop," *Institute of Navigation National Technical Meeting,* January 2001.
6. W. R. Michalson, J. A. Orr and D. Cyganski, "A System for Tracking and Locating Emergency Personnel Inside Buildings," *Institute of Navigation GPS 2000,* September 2000.
7. W. R. Michalson and I. Progri, "Assessing the Accuracy of Underground Positioning Using Pseudolites," *Institute of Navigation GPS 2000,* September 2000.
8. G. Bogdanov, W. R. Michalson, and R. Ludwig, "A new apparatus for non-destructive evaluation of green-state powder metal compacts using the electrical resistivity method," *Measurment Science and Technology*, IOP Publishing, vol. 11, pp. 157-166, January 2000.
9. J. Sedgwick, W. R. Michalson, and R. Ludwig, "Design of a Digital Gauss Meter for Precision Magnetic Field Measurements," *IEEE Transactions on Instrumentation and Measurement*, vol. 47, no. 4, pp. 972-977, August 1998.
10. J. Stander, J Plunkett, W. Michalson, J. McNeill, and R. Ludwig, "A Novel Multi-Probe Resistivity Approach to Inspect Green-State Powdered Metallurgy Compacts," *Journal of Non-Destructive Evaluation*, vol. 16, no. 4, pp. 205-214, 1997.

8. Scientific and Professional Societies:

- Institute of Navigation
- Society for Information Display
- Institute of Electrical and Electronics Engineers (Senior Member)
- Eta Kappa Nu

9. Honors and awards:

- ION Best Paper award, ION-GPS 1996
- Joseph Samuel Satin Distinguished Fellow, 1994
- Aldo Miccioli Scholar, 1985

10. Institutional and Professional Service in the Past 5 Years:

- Developed EE2799 – ECE Design
- Developed EE2801 – Foundations of Embedded Systems

11. Professional Development Activities in the Past 5 Years:

Prepared by William R. Michalson

1. **Name:** Denise Wawrzynski Nicoletti **Academic Rank:** Associate Professor

2. **Educational Record:**
   Ph.D. Electrical Engineering, Drexel University, Philadelphia, Pennsylvania, 1991
   MS Electrical Engineering, Drexel University, 1988
   BS Electrical Engineering, Drexel University, 1986

3. **Service/Positions at WPI:**
   1991-1997 Assistant professor
   1997- Pres. Associate professor: 1997.

4. **Other Professional Experience:**
   6/99-12/99 Visiting Scientist, Bose Corporation, Framingham, Massachusetts
   6/86-6/91 Research Assistant, Signal Processing Laboratory, Drexel University
   9/87-8/90 Teaching Fellow, Electrical and Computer Engineering Department, Drexel

5. **Consulting, patents, etc.:** None

6. **Registration:** Not registered

7. **Publications of Last Five Years:**
   1. D. Nicoletti, "An analysis of the effectiveness of the admissions policy for an outreach program for girls in engineering," accepted to the Journal of Women and Minorities in Science and Engineering, December 2001.
   2. D. Nicoletti, K. Keenaghan "Stimulating the professional development of introductory-level engineering students," accepted to the Frontiers in Education Conference, November 2002.
   3. D. Nicoletti, "Monitoring long term effects of an outreach program for girls," accepted to the Frontiers in Education Conference, November 2002.
   4. C. Demetry, D. Nicoletti, K. Mix, K. O'Connor, and A. Martin, "Who Dunnit?: Learning Chemistry and Critical Thinking Through Hands-On Forensic Science, " The New England Association of Chemistry Teachers (NEACT) Journal, Winter – Spring 2002 issue.
   5. D. Nicoletti and J. A. Orr, "An Implementable/Sustainable Outcomes Assessment Process for an Electrical Engineering Program," American Society for Engineering Education Conference presentation, June 2001.
   6. D. Nicoletti, "Lessons Learned While Inspiring Young Girls to Pursue Engineering," American Society for Engineering Education Conference presentation, June 2000. Hoffman, H. Ault, C. Demetry, D. Nicoletti, "Teaching Disability Awareness and Universal Design to Middle School Students," Designing for the 21st Century 2000 Conference Proceedings, http://adaptenv.org/21century/proceedings5.asp
   7. M. Gomez-Morante, D. Nicoletti, "A Wavelet-Based Differential Transformer Protection," IEEE Power Engineering Society Transactions, v. 14, no. 4, pp. 1351-1358, 1999.

8. D.Nicoletti, C. Demetry, “Community Service Design Projects as an Introduction to Engineering Problem Solving for Middle School Girls,” National Science Foundation Grantees Conference, 1998.
9. C. Demetry, D. Nicoletti, “REACH: An Engineering Summer Camp for Middle School Girls,” Frontiers in Education Conference, 1997.
10. Kwong Ki Yau (D. Nicoletti, advisor), “Split-spectrum Processing for Nondestructive Testing,” UT Online Journal, August 1997 edition, http://www.ultrasonic.de/article/splitspec/splitspec.htm.
11. Nicoletti, A. Anderson, “Determination of grain-size distribution from ultrasonic attenuation: transformation and inversion,” Journal of the Acoustical Society of America, v. 101, n. 2, pp. 686-689, 1997.

8. Scientific and Professional Societies:

- IEEE
- Acoustical Society of America
- American Society of Nondestructive Testing
- Society of Women Engineers
- American Association of University Women
- Women in Engineering
- Programs Advocates Network
- Tau Beta Pi Honor Society
- Eta Kappa Nu Honor Society
- Sigma Xi.

9. Honors and awards:

- WPI – IEEE Community Service Awards in April, 2002.
- “Who's Who Among America's Teachers,” 1998.
- WPI Joseph Satin Distinguished Fellow, 1993
- WPI Eta Kappa Nu Outstanding Professor of the Year Award, 1992

10. Institutional and Professional Service in the Past 5 Years:

- Member of the Electrical and Computer Engineering Assessment (1997-), Undergraduate Program (95-) Committees
- Member of the WPI Committee on Academic Policy (1993-94, 95-98)
- Faculty consultant for the New Student Orientation (1992-2000).
- Director for Camp REACH, a summer engineering camp for seventh-grade girls.
- Organizer of WPI’s Women in Electrical and Computer Engineering (WECE).
- Co-instructor for the electrical engineering component of the Frontiers program, summers of 94-97

11. Professional Development Activities in the Past 5 Years:

- Attended the Chautaqua short courses “Increasing the Retention of Under-Represented Groups” in 2000 and “Achieving Excellence in Minority Engineering Education” in 93

Prepared by Denise Nicoletti

1. **Name:** John Andrew Orr **Academic Rank:** Professor (tenured) Department Head

2. **Educational Record:**

B.S.	University of Illinois, Urbana, IL, Electrical Engineering, 1969
M.S.	Stanford University, Palo Alto, CA, Electrical Engineering, 1970
Ph.D.	University of Illinois, Urbana, IL, Electrical Engineering, 1977

3. **Service at WPI:**

1977-1981	Assistant Professor of Electrical Engineering
1981-1986	Associate Professor of Electrical Engineering
1986-pres	Professor of Electrical Engineering
1988-pres	Department Head of Electrical and Computer Engineering

4. **Other Professional Experience:**

1974-1977	Radio Research Lab, University of Illinois: Research Assistant
1969-1974	Bell Telephone Laboratories, Holmdel, New Jersey: Technical Staff
1985-1986	Massachusetts Institute of Technology Lincoln Laboratory, Visiting Scientist, sabbatical position, Aug.

5. **Consulting:**
- Invited Facilitator for ABET EC 2000 preparation, ECE Department, Northeastern University, March 9, 2001.
- Villanova University, External evaluator regarding preparation for ABET Criteria 2000 evaluation, September 25, 1998.
- Suffolk University, Consultant regarding ABET accreditation of the program in Electrical Engineering, 1995.
- Massachusetts Institute of Technology Lincoln Laboratory, 1986 - 1989.
- New England Electric System, Westborough, MA, 1982.
- Electronics for Medicine/Honeywell, Worcester, MA, 1981.
- GTE-Sylvania, Communications Systems Division, Needham, MA, 1978.

6. **Registration:** None

7. **Publications of last five years:**

1. F. J. Looft, J. A. Orr, "Computer and Communications Networks MS Graduate Program," Frontiers in Education 2002, Boston, MA, Nov. 7-9, 2002, under review.
2. J. A. Orr, "The ECE Major: Why is it so Rare?" Frontiers in Education 2001, Oct 10-13, 2001, Reno, NV.
3. J. A. Orr, D. Nicoletti," An Implementable/Sustainable Outcomes Assessment Process for an Electrical Engineering Program," ASEE 01, Albuquerque, NM, June 24-27, 2001.
4. J. A. Orr, D. Cyganski, "Fire Fighter Location Tracking and Status Monitoring Performance Requirements," Fire and Emergency Services Technologies Innovation Conference, Natick Soldier Systems Center, March 28-30, 2001.

5. D. Cyganski, J. A. Orr, with R. Vaz, *Information Technology: Inside and Outside*, Prentice Hall, 2001.
6. A. E. Emanuel, J. A. Orr, “An Improved Method of Simulation of the Arc Voltage-Current Characteristic,”, International Conference on Harmonics and Quality of Power, Orlando, October 1-4, 2000.
7. W. R. Michalson, J. A. Orr and D. Cyganski, “A System for Tracking and Locating Emergency Personnel Inside Buildings,” Institute of Navigation GPS 2000, September 2000.
8. J. A. Orr, A. E. Emanuel, “On the Need for Strict Second Harmonic Limits,” *IEEE Transactions on Power Delivery*, Vol 15, No. 3, pp 967-971, July, 2000.
9. J. A. Orr, R. Vaz, “ECE Department Preparations for a Second EC2000 Visit,” Frontiers in Education Conference, Oct. 18-21, 2000, Kansas City.
10. S. Kerns, J. A, Orr, "ABET Engineering Criteria 2000, the Evaluators' Perspective," Frontiers in Education Conference 1999, San Juan, November 10-13, 1999.
11. J. A. Orr, G. Gerhard, J. Regan, H. Tharp, "Enhanced Pre-Visit Communication Under Criteria 2000," Frontiers in Education Conference 1999, San Juan, November 10-13, 1999.
12. John A. Orr, David Cyganski, "Information Engineering Across the Professions, A New Course for Students Outside EE," Frontiers In Education, Tempe, Arizona, Nov. 4-7, 1998.
13. J. A. Orr, A. E. Emanuel, “On the Need for Strict Second Harmonic Limits,” International Conference on Harmonics in Power Systems, Athens, Greece, Oct. 14-16, 1998.
14. J. A. Orr, "ABET Criteria 2000: Institutional Preparation and Experience," Frontiers In Education, Pittsburgh, November 5-8, 1997.
15. J. A. Orr, D. Cyganski, R. Vaz, "Teaching Information Engineering to Everyone," ASEE Annual Meeting, Milwaukee, June 15-18, 1997

8. Professional society membership:

- Institute of Electrical and Electronic Engineers
- American Society of Engineering Education
- Eta Kappa Nu
- Tau Beta Pi

9. Honors and Awards:

- Joseph Samuel Satin Distinguished Fellow in Electrical Engineering, Academic Year 83-84.
- Weston Hadden Professor of Electrical Engineering, 1988 - 1993.
- Senior Member of the Institute of Electrical and Electronics Engineers, 1990 -present.
- George I. Alden Professor of Electrical Engineering, 1993 - 1998.

10. Institutional and Professional Service, past 5 years

- Evaluator for accreditation of EE programs, Accrediting Board for Engineering and Technology (ABET), 1992-present, ABET Criteria 2000 Evaluator, 1997-present.
- Member of the Board of Directors of the International Engineering Consortium (IEC), March, 2001-present.
- General Chair, Frontiers in Education (FIE) 2002, 1998-present.
- IEEE CEAA (Committee on Engineering Accreditation Activities), elected member, January, 2001 – present.
- IEEE Educational Activities Board, Chair, Finance Committee, 1999-2000, Member, 1998-2000.
- President, National Electrical Engineering Department Heads' Association (NEEDHA), July 1, 2000-July 1, 2000; Vice President, July 1, 1999-July 1, 2000, member of the Board of Directors, July 1, 1994 - present.

11. Professional development activities, past 5 years:

- Participant in one-day workshop on off-campus project advising, May 15, 2001
- Participant in educational assessment workshops on WPI campus (Oct. 26, 1998 and two follow-up sessions) and at Rose Hulman
- Development of expertise in academic program planning and assessment for engineering accreditation (ABET Criteria 2000), including participation in the ASEE Conference on Assessment, Washington DC, September 19-20, 1997, and ABET Evaluator Training Session, St. Louis, September 5-6, 1997

Prepared by John A. Orr

1. **Name:** Kaveh Pahlavan **Academic Rank:** Associate Professor

2. **Educational Record:**
Ph.D. EE Dept., Worcester Polytechnic Institute, Worcester, MA, 1979
MS EE Dept., University of Teheran, Teheran, Iran, 1975
BS EE Dept., University of Teheran, Teheran, Iran, 1975
Graduate Student in Digital Systems, University of Oklahoma, 1975

3. **Service/Positions at WPI:**

1991-PRESENT	Director of the CWINS, WPI
1990-PRESENT	Professor of ECE, WPI
1987-1990	Associate Professor of EE
1985-1987	Assistant Professor of EE

4. **Other Professional Experience:**
1983-1985 Director of Advanced Developments, INFINET, INC., Andover, MA
1979-1983 Assistant Professor of ECE, Northeastern University, Boston, MA

5. **Consulting, patents, etc.:** None

6. **Registration:** Not registered

7. **Publications of Last Five Years:**

1. K. Pahlavan, Committee Member, The Evolution of Untethered Communications, National Academy Press 1997.
2. A. Zahedi A. and K. Pahlavan, "Natural Hidden Terminal and Throughput of a Wireless LAN", IEE Electronic Letters, Apr. 1997.
3. M. Hassan-Ali and K. Pahlavan, "Site-Specific Wideband Indoor Channel Modeling Using Ray-Tracing Software", IEE Electronics Letters, Nov., 1997.
4. K. Pahlavan, A. Zahedi, P. Krishnamurthy, Evolving Wireless LAN Industry Products and Standards, part of Wireless Communications, S. Glisic and P. Leppanen, Kluwer Academic Publishers, 1997.
5. K. Pahlavan, P. Krishnamurthy and J. Beneat, "Wideband Radio Propagation Modeling for Indoor Geolocation Applications", IEEE Communications Magazine, April 1998.
6. R. Ganesh, K. Pahlavan and Z. Zvonar (editors), Wireless Multimedia Network Technologies, Kluwer Academic Publisher, 1999 (edited book)
7. A. Zahedi and K. Pahlavan, "Wireless Terminals", Handbook of Telecommunications, John Wiley and Sons, 1999.
8. R. Tingley, and K. Pahlavan, "Propagation Measurement Using Antenna Array", Electronics Letters, Vol. 35 15 , 22 July 1999 , Page(s): 1211 -1212
9. A. Zahedi, K. Pahlavan, P. Krishnamurthy, "Wireless Networks", Handbook of Telecommunications, John Wiley and Sons, 1999.
10. R. Ganesh, K. Pahlavan and Z. Zvonar, Wireless Multimedia Network Technologies, Kluwer Academic Publisher, 1999 (edited book)
11. A. Salo, K. Pahlavan, and J-P Salmenlaita, R&D Programs in Electronics and Telecommunication: ETX, TLX, INVITE and Telectronics, TEKES, Finland, 2000.

12. Pahlavan K., Krishnamurthy P., Hatami A.,Ylianttila M., Mäkelä J., Pichna R. & Vallström J., Handoff in Hybrid Mobile Data Networks. (invited paper) IEEE Personal Communications Magazine, vol. 7, no. 2, April 2000, pp. 34-47.
13. A. Zahedi and K. Pahlavan, "Capacity of a Wireless LAN with Voice and Data Services", IEEE Trans. on Communications, July 2000.
14. R. Ganesh and K. Pahlavan (editors), Wireless Network Deployment, KAP, 2000.
15. R. Tingley and K. Pahlavan, "Measurement of the Time-Space Characteristics of Indoor Radio Channel", IEEE Trans on Instrumentation and Measurements, September 2000.
16. K. Pahlavan, X. Li, M. Ylianttila, and M. Latva-aho, "Wireless Data Communication Systems", Chapter 9 of Wireless Communication Technologies: New Multimedia Systems, Edited by R. Kohno, S. Sampei, and N. Morirnaga, Kluwer Academic Publishers, 2000.
17. K. Pahlavan and P. Krishnamurthy, Principles of Wireless Networks – A Unified Approach, Prentice Hall, 2002.
18. K. Pahlavan, J. Beneat, and X. Li, Trends in Wireless Indoor Networks, Wiley Encyclopedia of Telecommunications, Edited by John Proakis, John Wiley and Sons, 2002.
19. K. Pahlavan, X. Li, and J. Makela, "Indoor Geolocation Science and Technology", IEEE Comm Soc. Mag., Feb. 2002.
20. M.H. Ali and K. Pahlavan, "A New Statistical Model for Site-specific Indoor Radio Propagation Prediction based on Geometric Optics and Geometric Probability", IEEE JSAC on Wireless Networks, Jan 2002.

8. Scientific and Professional Societies:

9. Honors and awards:

- 2000 Fullbright-Nokia Scholar visiting University of Oulu, Finland
- 1999-2000 Nokia Fellow
- 1996 Fellow of the IEEE
- 1993-1996 Weston Hadden Professor of ECE, WPI

10. Institutional and Professional Service in the Past 5 Years:

- Organizer, and Program Chairman, IEEE workshop on wireless local area networks, WPI, May 9-10, 1991 and Oct. 24-25, 1996, WPI.

11. Professional Development Activities in the Past 5 Years:

- Editor-in-Chief, International Journal of Wireless Information Networks.
- Organizer and technical program chairman, IEEE International Symposium on Portable, Indoor, and Mobile Radio Communications, Oct. 19-21, 1992, Boston, MA, and Sept. 8-11, 1998, Boston, MA and N. American liaison for 1991 (London, UK), 1993 (Yokohama, Japan), 1994 (Hague, Netherlands), 1995 (Toronto, Canada), 1996 (Taipei, Taiwan), 1997 (Helsinki, Finland), 1999 (Osaka, Japan)
- Technical program committee member of the IEEE International Symposium on Spread Spectrum Techniques and Applications, 1990 (UK), 1992 (Japan), 1994 (Finland), 1996 (Germany), 1998 (S. Africa).
- Technical program committee member of more than 10 other international conferences.

Prepared by Kaveh Pahlavan

1. **Name:** Peder C. Pedersen **Academic Rank:** Professor

2. **Educational Record:**
B.S.E.E. Aalborg Eng. College, Aalborg, Denmark, 1971
M.E. (bioeng.) Univ. of Utah, Salt Lake City, Utah, 1974
Ph.D. (bioeng.) Univ. of Utah, Salt Lake City, Utah, 1976

3. **Service/Positions at WPI:**
1990 - Present Professor of ECE
1987 - 1990 Assoc. Professor of ECE

4. **Other Related and Professional Experience:**
1983 -1987 Assoc, Professor of ECE, Drexel University, Philadelphia
1976 -1983 Assistant Professor of ECE, Drexel University, Philadelphia

5. **Consulting, patents, etc.:**
- Patent awarded, through Drexel University, entitled "Ultrasound Scanner for Breast Cancer Examination", U.S. Patent No. 4,206,763. Date of patent: June 10, 1980.
- Patent awarded, through Worcester Polytechnic Institute, for a patent, "Digital Sweep Generator," U.S. Patent No. 4,943,779. Date of patent: July 24, 1990

6. **Registration:**
Registered as Professional Engineer in Pennsylvania

7. **Publications of Last Five Years:**
   1. S.K. Jespersen, P.C. Pedersen and J.E. Wilhjelm, "The Diffraction Response Interpolation Method," IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, Nov. 1998, pp. 1461 - 1475.
   2. P.C. Pedersen, "Ultrasound measurements," in The Measurement, Instrumentation and Sensors handbook, Ed. J.G. Webster, Dec. 1998, pp. 26-33 to 26-57.
   3. P.C. Pedersen, Z. Cakareski, and J. Hermanson, "Ultrasonic monitoring of film condensation, with application in reduced gravity," Ultrasonics, February 2000, pp.486 - 490.
   4. J.E. Wilhjelm, P.C. Pedersen and S. Mehl Jacobsen, The influence of roughness, angle, range and transducer type on the echo signal from planar interfaces," IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, March 2001, pp. 511 - 521.
   5. P.C. Pedersen and A. Grebe, "Application of time delay spectrometry for rough surface characterization," Ultrasonics, Vol. 39, pp. 101 - 108, March 2001.
   6. Z. Cakareski and P.C. Pedersen, "Statistics of the integrated backscatter estimate from moving blood, IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, Nov. 2001, pp. 1555 - 1567.
   7. P.C. Pedersen and Z. Cakareski, "Determination of ultrasound backscatter level of vascular structures, with application to arterial plaque characterization," 24th International Symposium on Acoustical Imaging, Santa Barbara, CA, Sept. 23–25, 1998, pp. 273 - 280.
   8. P. C. Pedersen and L. Wan, "Optimization of Pulse-Echo Array Transducer System for Identification of Specified Targets," 26th International Symposium on Acoustical Imaging, Windsor, Canada, Sept., 2001

8. Scientific and Professional Societies:
- Institute of Electrical and Electronics Engineers
- American Association of the Advancement of Science
- Acoustical Society of America

9. Honors and awards:
- Satin Award for the 1998 - 1999 Academic year

10. Institutional and Professional Service in the Past 5 Years:
- Member of Graduate Program Committee, ECE (1995- present)
- Member of Faculty Hiring Committee, ECE (2001 – 2002)
- Member of ECE Tenure Committee, (2001-2002)
- Helped set up a cooperative agreement between WPI and Engineering College of Copenhagen. 2000
- Member of the ECE Department's Strategic Plan Development Committee, 2000 – 2001
- Member and chair of At-Large Committee on Tenure and Academic Freedom, 1997-2000

11. Professional Development Activities in the Past 5 Years:
- WPI Teaching Technology Fellow, 2001 – 2002, engaging in application of teaching technology
- Fall 2001, develop new course in Electro-Optics (EE 371x) which is outside my area of expertise
- Spring Semester 2002, develop new graduate level course in Signal Processing (EE 630) which required me to study new topics, such as wavelets and time-frquency estimation

Prepared by Peder Pedersen

1. **Name:** Berk Sunar **Academic Rank:** Assistant Professor, ECE

2. **Educational Record:**
   Ph.D. Electrical/Comp. Engineering, Oregon State Univ., 12/98
   BS Electrical/Electronic Eng., Middle East Tech. Univ. (Ankara, Turkey), 6/95

3. **Service/Positions at WPI:**
   9/00 – present Assistant Professor, ECE

4. **Other Related and Professional Experience:**
   1998-2000 Security Architect, Secured Information Technologies Inc.
   1999-2000 Consulting Experience, Time-Warner EMS. Inc. Bank of America, Interscore Inc.

5. **Consulting, patents, etc.:**

Consulting:

- rTrust Inc. (formerly Secured Information Technologies Inc.
  Senior Security Architect
    - Development and productization of the rTrust Renewable Cryptographic Engine (RCE) toolkit.
    - Security and Electronic-Commerce Consulting Services to bank of America, InterScore Inc. and Time-Warner Electronic Media Services (know B3 Inc.)
    - Designed and implemented Digital Coupon and Digital Gift Certificate Technologies for Time-Warner Inc. Electronic Media Services and InterScope Inc.

Patents:

- C.K. Koc and B. Sunar. Methods and Apparatus for Multiplication in a Galois Field GF (2^m), and Encoders and Decoders using Same. US Patent Nr. 6,343,305, January 29,2002

6. **Registration:** Not registered

7. **Publications of Last Five Years:**

1. B. Sunar. Improved modular arithmetic for special moduli, submitted for publication
2. B. Sunar, E. Savas, and C.K. Koc. Efficient conversion algorithms for composite field representations, submitted for publication
3. B. Sunar and C.K. Koc. An efficient optimal normal bias type II multiplier, *IEEE Transactions on Computers,* 50(1):83-87, January 2001
4. B. Sunar. *Fast Galois Field Arithmetic for Elliptic Curve Cryptography and Error Control Codes.* Ph.D. Thesis, Department of Electrical and Computer Engineering, Oregon State University, November 6, 1998
5. C.K. Koc and B. Sunar. Low-complexity bit-parallel canonical and normal basis multipliers for a class of finite fields. *IEEE Transactions on Computers,* 47(3), March 1998

6. C.K. Koc and B. Sunar. Low-complexity bit-parallel canonical and normal bias multipliers for a class of finite fields. *Proceedings of 1998 IEEE International Symposium on Information Theory,* pages 294-294, MIT, Cambridge, MA August 16-21, 1998
7. M. Aydos, B. Sunar, and C.K. Koc. An elliptic curve cryptography based authentication and key agreement protocol for wireless communication. *2nd International Workshop on Discrete Algorithms and Methods for Mobile Computing and Communications,* Dallas, Texas, October 30, 1998
8. B. Sunar and C.K. Koc. Mastrovito multiplier for all trinomials. *IEEE Transactions on Computers,* 48(5):522-527, May 1999
9. E. Savas, B, Sunar, and C.K. Koc. Efficient conversion algorithms for binary and composite fields. Technical Report, Secured Information Technology, Inc., 14 pages, July 1999

8. Scientific and Professional Societies:

- IEEE
- International Association of Cryptologic Research (IACR)
- Association for Computing Machinery (ACM)

9. Honors and awards:

- Reseacrh Award: National Science Foundation Infrastructure Technology Research, “ITR: ImplementingPublic-Key Cryptosystems for Secure Information Infrastructure.” a 3 year research grant amounting $436,000

10. Institutional and Professional Service in the Past 5 Years:

- Director of the Cryptography and Information Security (CRIS) Laboratory at WPI. The CRIS laboratory produces cutting edge research in the field of applied cryptography and provides the perfect setting for upbringing of next generation security experts.
- Director for the General Dynamics Project Center (sponsored by General Dynamics Corporation, Communications Systems Division, Needham, MA). The center provides Major Qualifying Project opportunities to over 10 undergraduate students each year.

11. Professional Development Activities in the Past 5 Years:

- Reviewer of the National Science Foundation Directorate
- Reviewer for the following journals and conferences: IEEE Transactions on Computers, IEEE Transactions on VLSI, Journal of Computing and Information Technology, RSA Data Security Conference, Cryptographic Hardware and Embedded Systems
- Program Committee member for Cryptographic Hardware and Embedded Systems Conference (CHES 2002)

Prepared by Berk Sunar

1. **Name:** Richard F. Vaz **Academic Rank:** Associate Professor

2. **Educational Record:**
Ph.D. Electrical Engineering, Worcester Polytechnic Institute, 1987
M.S. Electrical Engineering, Worcester Polytechnic Institute, 1984
B.S. Electrical Engineering, Worcester Polytechnic Institute, 1979

3. **Service/Positions at WPI:**
1998 - present Associate Dean, Interdisciplinary and Global Studies Division
1997-1998 Co-Chair and Director of Program Development, IGSD
7/94 - present Associate Professor
9/90 - 6/94 Assistant Professor
9/87 - 6/90 Visiting Assistant Professor
9/83 - 6/87 Instructor

4. **Other Related and Professional Experience:**
1979 – 1981 Systems Engineer, Raytheon Company
1981 – 1982 Test Engineer, GenRad, Inc.
1982 – 1983 Teaching Assistant, WPI

5. **Consulting, patents, etc.:**
MITRE Corporation, 1988 - 1993
UNESCO, 1993 - 1994

6. **Registration:** Not registered

7. **Publications of Last Five Years:**
    1. "Multi-target Discrimination with LSD/DOA-based ATR", B.K. Hill, D. Cyganski, and R.F. Vaz, Proceedings of IS\&T/SPIE Symposium on Electronic Imaging: Science and technology, January, 1996
    2. "SAR ATR via Pose-Tagged Partial Evidence Fusion", B.K. Hill, D. Cyganski, and R.F. Vaz, Proceedings of SPIE 1996 Symposium on OE/Aerospace Sensing and Dual Use Photonics, Orlando, Florida, April, 1996
    3. "A Course in Information Engineering Across the Professions", J.A. Orr, D. Cyganski, and R.F. Vaz, Frontiers in Education Conference, November 1996, Salt Lake City
    4. "High Expectations: A Passport to Student Success," J. McNeill and R. Vaz, Ninth International Conference on the First Year Experience, July, 1996, St. Andrews, Scotland
    5. "Teaching Information Engineering to Everyone", J.A. Orr, D. Cyganski, and R.F. Vaz, ASEE Annual Meeting, June 1997, Milwaukee
    6. "Integrating Mixed Signal IC Design Research into a Project-based Undergraduate Microelectronics Curriculum," J. McNeill and R. Vaz, Proceedings of the 1997 IEEE Computer Society International Conference on Microelectronic Systems Education (MSE'97), Arlington, VA, July, 1997
    7. "The WPI Global Perspective Program: Preparing for Assessment and ABET 2000", R. Vaz and N. Mello, Proceedings of FIE '98, Tempe, Arizona, November, 1998

8. "Impacts of Advising Projects Abroad," W.W. Durgin, W. Jamison, L. Schachterle, R. Vaz, Second Global Engineering Workshop, Crystal City, VA, November, 1998
9. "An Energy Use Assessment of Ifrane City", J. Boudreau, N.J. Kociuk, D. Li, B.Raissouni, T. El-Korchi, and R. Vaz, Proceedings of GlobeEx, Las Vegas, July, 2000
10. "ECE Department Preparations for a Second ABET EC2000 Visit," J.A. Orr and R.F. Vaz, Proceedings of FIE 2000, Kansas City, October, 2000
11. "Chemical Engineers Solving Global Problems", D. DiBiasio, N. Mello, and R. Vaz, Proceedings of AiChE Annual Meeting 2000, Los Angeles, November, 2000
12. "Connected Learning: Interdisciplinary Projects in International Settings", Richard Vaz, Liberal Education, Winter, 2000
13. *Information Engineering Across the Professions*, David Cyganski and John A. Orr with Richard F. Vaz, Prentice-Hall, 2000
14. "Teaching Signals and Systems through Portfolios, Writing, and Independent Learning", R.F. Vaz and N. Arcolano, PROCEEDINGS OF ASEE 2001, Albuquerque, NM, June, 2001

8. Scientific and Professional Societies:

- Member, Eta Kappa Nu Honor Society, 1983-present
- Member, Sigma Xi Research Honor Society, 1991-present
- Member, Tau Beta Pi Honor Society, 1993-present
- IEEE: Chair, Student Activities, Worcester Chapter, 1990-2000
- Member, ASEE
- Member, AAC&U

9. Honors and awards:

- Eta Kappa Nu Outstanding EE Professor Award, 1989-90, 1993-94, 1994-95, 1996-97
- Alpha Phi Omega Service to Students Award, 1997
- EMSEP WPI Faculty Member of the Year, 1997-98
- WPI Trustees Award for Outstanding Teaching, 1992-93
- Tau Beta Pi (now WPI Trustees') Outstanding Academic Advisor Award, 1998-99
- Eta Kappa Nu Award for Outstanding Contributions to the ECE Department, 1999-2000

10. Institutional and Professional Service in the Past 5 Years:

- Liaison to AACU Greater Expectations Leadership Consortium, 2000 - present
- Member, AAC&U Working Group on Integrated Learning, 2001-present
- Member, Advisory Board, US Mobility in Asia Pacific, 2000-present
- WPI Committee on Advising and Student Life, 1998 – 2001
    - Chair, 1998 – 1999
- WPI Committee on Governance, 1995 – 1998
    - Secretary, 1995-1996
    - Chair, 1996-1997
- WPI Committee on Academic Policy, 1992 - 1995 and 2001 – present
- Co-Director of the WPI Venice Project Center since 1994 and of the ECE MQP Project Program in Limerick, Ireland since 1995
- Chair, WPI Strategic Plan Task Force on Global Opportunities, 1997
- Chair, PIC Subcommittee on Global Opportunities, 1998
- WPI Project Board, 1995-1997; IGSD Advisory Board, 1994-1997
- Faculty Consultant, WPI Freshman Orientation Program, 1990-2000
- WPI Insight Advisor, 2001
- Faculty Advisor, Tau Beta Pi Honor Society, 1993 - 2002
- Faculty Advisor, Tau Kappa Epsilon Fraternity, 1998 – present
- ECE Undergraduate Program Committee, 1989 - 1990, and 1993 – present
- Elected Member, ECE Internal Advisory Committee, 1993 - 1995 and 1996-2000
- Elected Member, ECE Tenure Committee, 1998-2000
- Advisor, WPI IEEE Student Branch, 1990 - 2000

11. Professional Development Activities in the Past 5 Years:

- Team Leader, AAC&U Workshop on Sustainable Innovation, Summer 2001
- Attended and presented at approximately 20 professional conferences, workshops, and colloquia in past 5 years

Prepared by Richard Vaz

1. **Name:** Nathaniel A. Whitmal, III **Academic Rank:** Assistant Professor, ECE

2. **Educational Record:**
PhD Electrical Engineering, Northwestern University, 1997
MS Electrical Engineering, Northwestern University, 1993
MS Engineering Management, Gordon Institute of Tufts University, 1990
BS Electrical Engineering, MIT, 1986

3. **Service/Positions at WPI:**
1999 – present Assistant Professor, ECE

4. **Other Professional Experience:**
7/97 – 7/99 Assistant Professor, CS, DePaul University, Chicago, IL
9/95 – 9/96 Monsanto Faculty Intern, Northwestern University, Evanston, IL
6/95 – 9/95 Research Internship, Motorola Corporation, Schaumburg, IL
2/86 – 7/92 Member of Technical Staff, Bose Corporation, Framingham, MA

5. **Consulting, patents, etc.:** None

6. **Registration:** Not registered

7. **Publications of Last Five Years:**
   1. N.A. Whitmal, "Implementation and evaluation of a studio-style course in real-time digital signal processing," accepted for the ASEE Annual Conference & Exposition, Montreal, 2002.
   2. N.A. Whitmal and A. Vosoughi, "Recruitment-of-loudness effects in attenuative noise reduction algorithms, " accepted for the 143rd meeting of the Acoustical Society of America, Pittsburgh, 2002.
   3. M.A. Trenas, J.C. Rutledge, N.A. Whitmal, "Wavelet-based noise reduction and compression for hearing aids." Proceedings of the IEEE 21st International Conference of the IEEE Engineering in Medicine and Biology Society, October, 1999.
   4. N.A. Whitmal, J.C. Rutledge, "Noise reduction in hearing aids: a case for wavelet-based methods," Mini-symposium on "New Advances in Time-Frequency and Wavelet Methods," Proceedings of the IEEE 20th International Conference of the IEEE Engineering in Medicine and Biology Society, October, 1998. *Invited paper*.
   5. N.A. Whitmal, J.C. Rutledge, L.A. Wilber, "An evaluation of wavelet-based noise reduction for digital hearing aids," Proceedings of the IEEE 19th International Conference of the IEEE Engineering in Medicine and Biology Society, October, 1997.

8. Scientific and Professional Societies:

- IEEE
- ASA
- Eta Kappa Nu National Honor Society

9. Honors and awards:

- Joseph Satin Faculty Fellowship: WPI ECE Dept., May 2000
- Amoco Faculty Award: DePaul School of CTI, September 1998
- Monsanto Faculty Internship: Northwestern ECE Dept., September 1995

10. Institutional and Professional Service in the Past 5 Years:

- Developed and taught EE539, "Real-Time Digital Signal Processing (Graduate)" in Spring 2001.
- Developed and taught EE3703, "Real-Time Digital Signal Processing (Undergraduate)" in B-term 2000, D-term 2001, and B-term 2002.
- Revised and taught EE503, "Digital Signal Processing" in the Fall semesters of 1999, 2000, and 2001.
- Taught EE2022, "Introduction to Digital Circuits and Computer Engineering" in D-term of 2000.
- Undergraduate Program Committee member, 1999 - present
- WPI / Mass. Academy Liaison Committee member, 2000 - present
- Taught 13 courses on various topics (e.g., DSP, data analysis, algorithm design) at DePaul University from 1997-1999.
- Served as reviewer for grant proposals for NSF's Division of Undergraduate Education in 1997.

11. Professional Development Activities in the Past 5 Years:

- Attended the NSF-funded "New Century Scholars" workshop in August of 2000 at Stanford University.

Prepared by Nathaniel Whitmal

Appendix II

Institutional Profile: In Volume 2

Appendix III

Supporting Data: In Volume 3