Electrical Engineering

PRINCETON

Undergraduate Handbook 2009-2010

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PERSONAL WELCOME TO PROSPECTIVE MAJORS

On behalf of the faculty of the Department of Electrical Engineering, I extend a warm greeting to all students who are considering a major in Electrical Engineering. This booklet provides important information about the academic programs available within the department. I encourage you to follow up your reading of this material through discussions with department faculty and students: we are eager to provide any additional information you may need concerning departmental programs and facilities. Be sure to explore the department's web pages at the following URL: http://www.ee.princeton.edu

In the pages that follow, you will find the ELE Department course requirements and outlines of some typical academic programs pursued by students within the department. The Department cannot be described with a few facts and figures. It encompasses a vast range of topics and activities reflecting the diverse nature of the field and the interests of the students and faculty. The titles of some of our recent Independent Work projects and the faculty suggestions for Independent Work provide some perspective on department activities. Department majors can pursue their studies well beyond the boundaries of classrooms and laboratories. Arrangements have been made for students to spend time on off-campus research activities and summer jobs have provided many students with opportunities for first-hand experience with engineering design and analysis projects.

A variety of career paths are available to an Electrical Engineering graduate. There is high demand for knowledgeable electrical engineering graduates in a variety of fields including computer engineering; electronics and integrated circuits; optoelectronic engineering and optical communications; and telecommunications, signal processing, and control systems. Recent graduates have found that an electrical engineering background also forms a valuable foundation for a career in business, finance, government or professional fields.

Special certificate-granting programs, such as Engineering Physics, Engineering and Management Systems, Engineering Biology, Materials Science and Engineering, Applied and Computational Mathematics, Environmental Studies, and Woodrow Wilson School Policy Studies may be pursued in parallel with one of the departmental areas of concentration through appropriate course selections. Programs of preparation for professional study in medicine and law may also be arranged.

If you are considering ELE as a major I encourage you to visit the department's facilities and to meet with the faculty and students. We will be happy to discuss your interests and career plans with you, to answer questions about our academic programs, and to help you design a course of study that best meets your individual interests.

How do you sign up to be an ELE Major? Every prospective ELE student should see me first for some general discussions about departmental programs and procedures, and for selection of a faculty advisor. After our meeting you will meet with the advisor who will take responsibility for approving your course selections.

Bradley Dickinson
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1. OVERVIEW OF THE ELE CURRICULUM

1.1 General Information

The Department of Electrical Engineering (ELE) offers an academic program of study spanning a wide range of disciplines. The program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET, Inc. 111 Market Place, Suite 1050, Baltimore, MD 21202; Telephone: (410) 347-7700). All ELE students begin with a unifying foundation, the areas of specialization available to a student range from information theory to computers and microprocessors to solid state and opto-electronics. Students may select one of a long list of pre-defined concentrations, or tailor their own, in consultation with their faculty advisor, to suit special interests.

Students enter the department with a variety of possible career objectives in mind. Some intend to enter industry directly, others to continue their technical studies in graduate school. Many wish to take an ELE program as a background for careers in other fields ranging from business or law to medicine. Some are not sure of their future plans. Consequently, students are exposed to a wide cross-section of ELE before deciding on an area of concentration. Further, sufficient flexibility is available in planning an undergraduate program to achieve any of the varied interests and objectives students may have. Thus, for example, a student may combine ELE with studies in biology, computer science, physics, materials science and engineering, engineering and management systems, environmental studies, economics and public policy, and several other fields.

The field of Electrical Engineering encompasses a broad range of topics and activities. For example, the discipline covers the design and analysis of music and video processing systems (e.g. a CD player); the transmission of information (e.g. cellular telephones and wireless communication); the design and analysis of microprocessors and computers (e.g. the INTEL Pentium chip); and the theory and design of lasers, transistors, and the fabrication very small scale structures (e.g. optical fiber transmission systems and fast electronics for memories and displays).

The course structure for ELE majors consists of two tiers: (i) a set of basic required courses in the sophomore and junior years and (ii) a set of electives, taken in the junior and senior years. The elective courses offered by the department span a wide range of topics. Emanating from four main traditional disciplines that constitute Electrical Engineering -- (a) Communications, Signal Processing and Control; (b) Computer Engineering; (c) Optical Engineering and (d) Solid State Electronics- are areas of specialization which reflect the diversity within modern day Electrical Engineering. Some of these areas (e.g. Information and Systems, Solid State Physics or Computer Architecture) fall mainly within a single traditional discipline. Others, especially those in emerging applications, cut across traditional boundaries and draw from more than one discipline. The course structure has been designed to accommodate both kinds of interests. Finally, interdisciplinary programs offered at Princeton are taken by many ELE students in conjunction with their major.

Broadly speaking, every student in ELE will have taken a set of six basic ELE courses by graduation, in addition to elective courses in at least two of the traditional disciplines to satisfy the breadth requirement (Section 2.8), as well as a set of three or more courses in one of the areas of specialization to satisfy the concentration requirement (Section 2.9). For a description of the four traditional disciplines, see Section 2.8.

Engineering education at Princeton draws from the liberal arts programs, both for academic breadth and for a grounding in the social context that must be faced in dealing with technological challenges in the future. Globalization and sustainability are two aspects of many of the great problems of healthcare, energy and resources, education, and information technology. Princeton electrical engineering undergraduates will find their education to be a strong foundation for professional responsibility and career development. The importance attached to such a broad goal of engineering education can be appreciated from the Code of Ethics for members of the principal professional society for electrical engineering - the IEEE (Institute of Electrical and Electronics Engineers).

IEEE Code of Ethics

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

1. to accept responsibility in making decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
2. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. to be honest and realistic in stating claims or estimates based on available data;
4. to reject bribery in all its forms;
5. to improve the understanding of technology, its appropriate application, and potential consequences;
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

Approved by the IEEE Board of Directors February 2006

1.2 Prerequisites

The normal prerequisite for entering the ELE Department in the sophomore year is a freshman program that includes the required program for all students in the School of Engineering and Applied Science (SEAS) i.e., Physics 103-104 or 105-106, Mathematics 203-204 (or 201-202), Chemistry 207 (or 201), and an introductory computer science course, (COS126), or their equivalent. A student considering transferring into the department at the beginning of the junior year would normally be expected to have in addition, at least two of the sophomore ELE courses. The Departmental Representative should be consulted concerning eligibility for transfer in special cases.

1.3 Faculty Advisors

The ELE Departmental Representative is the nominal faculty advisor for all sophomore and upperclass students in the department. In addition, a faculty *program* advisor is assigned, providing the student with the opportunity to consult in more detail concerning both academic program matters and career advice. Students see their program advisors each semester to review their progress towards graduation and to have their course selections approved. Subsequent changes should be discussed with the program advisor whose signature is required on the course change forms prior to their submission to the Registrar. All seniors should discuss any course changes with the Departmental Representative also and obtain his signature on the course change forms. The *program* advisors for the various classes are as follows:

Class Program Advisors:

2010: S. Verdu (B308), M. Martonosi (B216), M. Shayegan (B408), P. Prucnal (B314)
2011: J. Fleischer (B320), S.Y. Kung (B230), G. Wysocki (B324)
2012: A. Houck (B424), R. Lee (B218), S. Wagner (B422)

1.4 Certificate and Special Programs

In addition to your program advisor, various ELE faculty serve as coordinating faculty for special undergraduate programs offered by the university. Some of these programs offer certificates. If you enroll (or wish to enroll) in any of these programs, you may find it helpful to consult the appropriate faculty for help in planning your curriculum.

Certificate Program:	**Coordinating Faculty**	**Office**
Engineering Biology:	B. Dickinson	B322
Engineering and Management Systems:	S. Kulkarni	B310
Engineering Physics:	A. Kahn	B420
	S. Lyon	B428
Materials Science and Engineering:	A. Kahn	B420
Woodrow Wilson Certificate:	B. Dickinson	B322
Environmental Studies:	S. Wagner	B422
Robotics and Intelligent Systems:	B. Dickinson	B322
	S. Kulkarni	B310
	P. Ramadge	B210
Applications of Computing	B. Dickinson	B322
	S. Malik	B224
Applied and Computational Mathematics	S. Verdu	B308

1.5 Outline of ELE Program Requirements

All candidates for the B.S.E. degree are required to satisfy the University and SEAS requirements. As part of this, students are advised to take an introductory computing course during the freshman year. The course structure for ELE majors consists of two tiers:

1. A set of basic required courses in the sophomore and junior years (foundations and core, below). These are intended to provide a unifying foundation.

2. A set of electives, taken in the junior and senior years. These are used to satisfy: depth in at least one area, a reasonable degree of breadth to produce a sound basis for future development, a strong design component, an engineering science component, and an oral presentation.

The specific plan of study is determined in consultation with the student's academic advisor, taking into account ABET program guidelines. All such plans must include the following:

- **Foundations:** Electrical Engineering 201, 203, 206, 208 (Section 2.4)
- **Core:** Electrical Engineering 301 and 302 (Section 2.5)
- **Upperclass Mathematics:** At least one upper class mathematics course. Not to be counted towards the concentration requirement or as a departmental. This may be MAE305/MAT301, MAE306/MAT302, ORF309/MAT309, COS 340 or other 300-level or higher mathematics course. The course selected to satisfy this requirement may not be counted towards the concentration requirement, the breadth requirement, or as a departmental. (Section 2.6)
- **Concentration:** Three courses in a chosen concentration. (Section 2.9)
- **Breadth:** At least **one** course in each of **two** general areas of Electrical Engineering. Only one of these two courses may be counted for the Concentration Requirement. (Section 2.8)
- **Engineering Science:** At least one engineering science course outside the EE department. (This course cannot be used to satisfy the concentration or the breadth requirement.) An equivalent higher-level course offered by SEAS may be substituted if approved by the departmental representative (Section 2.7)
- **Design:** At least one upper class ELE course with substantial design content beyond ELE 302. (This may be satisfied with junior or senior independent work having substantial *design component*) (Section 2.10)
- **Balance:** At least two upper class technical courses in each semester of the junior and senior years. (These may or may not be in ELE.)

- **Completeness:** Eight courses at 300-level or above including at least five ELE courses. Courses outside ELE counted towards this requirement must be closely related to the student's academic program. (Section 2.11)
- **Oral Presentation:** Each student must give an oral presentation to an audience based on classwork or independent work. (Section 2.12)
- **Independent Work:** Each student is required to complete at least one semester of independent work. (Section 2.13)

1.6 Example Program

A basic program for a student is outlined below:

No Advanced Placement in Math/Physics/Chemistry	
Freshman Year	
Math 103	Math 104
Physics 103	Physics 104
Chemistry 207	COS 126*
Elective	Elective
Sophomore Year	
Math 203(201)	Math 204(202)
ELE 201	ELE 206
ELE 203	ELE 208
Elective	Elective
Elective	Elective
Junior Year	
ELE 301	ELE 302
Departmental**	Departmental
Upper Level Math	Tech. Elective**
Elective	Elective
Elective	Elective
Senior Year	
Departmental	Departmental
Departmental	Departmental
Elective	Elective
Elective	Elective

With One Semester of Advanced Placement in Math	
Freshman Year	
Math 104	Math 203
Physics 103	Physics 104
Chemistry 207	COS 126*
Elective	Elective
Sophomore Year	
Math 204	Upper Level Math
ELE 201	ELE 206
ELE 203	ELE 208
Elective	Elective
Elective	Elective
Junior Year	
ELE 301	ELE 302
Departmental**	Departmental
Tech. Elective**	Tech. Elective
Elective	Elective
Elective	Elective
Senior Year	
Departmental	Departmental
Departmental	Departmental
Elective	Elective
Elective	Elective

*COS 126, an introductory computer programming course, is recommended in either the freshman or sophomore years, preferably in the freshman year. **"Departmental" and "Technical Elective" are technical courses, normally either ELE, Computer Science, Mathematics, Physics, other engineering courses, or courses that form part of a coherent pattern of study for students emphasizing special programs in areas such as engineering and management systems, or engineering biology (Consult the Departmental Representative for more detail). The courses labeled "Electives" may be Departmental or Technical Electives, or they may be Humanities or Social Science electives.

2. DETAILS OF ELE PROGRAM: "THE FINE PRINT"

2.1 Course Count and P/D/F

The minimum number of courses required for the BSE degree is 36 for a 4-year program (or 28 for a 3-year program for a student granted advanced standing). This corresponds to four terms with four courses and four terms with five courses. Four of these courses may be taken on a P/D/F (PASS/D/FAIL) basis as per university guidelines. However, many types of courses including: all required courses, Engineering Science, Upperclass Math, Engineering Design, all departmentals, all concentration courses, both breadth courses, and independent work may **not** be taken P/D/F.

2.2 SEAS Requirements & ELE Prerequisites

The prerequisites for sophomores entering ELE are the same as the SEAS requirements, namely:

Physics 103-4 (or 105-6),
Mathematics 203-4 (or 201-2),
One semester of Chemistry (201/207),
A writing course, and
A computing course (COS 126)

2.3 Humanities Requirement

1) All students must complete a minimum of seven courses in the humanities and social sciences. B.S.E. students are required to take at least one course in four of the following six areas: epistemology and cognition, ethical thought and moral values, foreign language (at the 107/108 level or above), historical analysis, literature and the arts, and social analysis.

2.4 Foundations

All ELE majors are required to take ELE 201, 203, 206 and 208. These courses form the foundation of the BSE in ELE and are open to all qualified freshmen. This requirement is normally satisfied by the end of the sophomore year. In some instances, students with prior exposure to similar material may test out of one or more of these courses. In such cases, an upperlevel ELE course in the same general area must be substituted for the course before graduation. The substituted course cannot be used to satisfy any other requirement.

2.5 Core

Two upperclass courses are required of all ELE majors - ELE 301 and 302. This requirement is normally satisfied by the end of the junior year.

2.6 Upperclass Mathematics Requirement

One upperclass mathematics course is required of all ELE majors. This may be:

MAE 305/MAT 301
MAE 306/MAT 302
ORF 309/MAT 309
COS 340 or other 300 level or higher mathematics course

Many ELE students satisfy this requirement in the sophomore year though there is no requirement to do so. The course selected to satisfy this requirement may not be counted towards the concentration requirement, the breadth requirement, or as a departmental. Additional upperclass mathematics courses may be used to satisfy concentration (Section 2.9) or breadth (Section 2.8) requirements, if listed in the appropriate section, or count as a departmental (Section 2.11).

2.7 Engineering Science

An engineering course with significant scientific component must be taken outside of ELE to satisfy this requirement. Many courses can be used to satisfy this requirement. The following is a non-exhaustive list of possibilities. Note that a course largely comprising of a mathematics or applied mathematics component cannot be used to satisfy this requirement. The course used to satisfy the Engineering Science requirement cannot also be used to satisfy the concentration requirement or the breadth requirement, nor can it be counted as Departmental (see Departmental Section 2.11). If additional courses are taken from the list given below, they may be used for concentration or breadth or as departmental if applicable. Many students satisfy this requirement by their sophomore year. An equivalent or higher level course offered by SEAS may be substituted if approved by the Departmental Representative.

COS: 217, 226, 320, 402,423, 425, 444, 451, 487
CEE: 205, 303, 305, 471
CHE: 245, 246, 341, 415, 445, 447
MAE: 206 (or PHY 203/205), 221, 222, 324, 328, 344, 345, 433, 434
ORF: 307, 311, 405, 406, 417
MSE: 301, 302

2.8 Breadth Requirement

In order to satisfy the breadth requirement within ELE, at least one course in two of the following general areas in ELE must be taken (see description below and the prerequisite tree in Section 3.2). Only one of these two courses may be counted for the concentration requirement (see Areas of Concentration). The list below is indicative but not exhaustive. Note: ORF309 cannot be used to satisfy this requirement.

(A) Communications, Signal Processing, and Control:
ELE 382, 481, 482, 483, 485, 486, 488

(B) Computer Engineering/Computer Science:
ELE 375, 386, 462, 463, 465, 466, 475, 573
COS 318, 320, 333, 402, 426, 429, 432, 441, 461
Note: COS226 & COS 217, required for many upper level CS courses, do not satisfy breadth, but do satisfy the engineering science requirement. (See Section 2.7.)

(C) Solid State Electronics:
ELE 341, 342, 396, 401, 402, 441, 442
PHY 208/305 - must take both PHY 208 and PHY 305 (counts as one)

(D) Optical Engineering:
ELE 351, 352, 453, 454, 455

(A) Communications, Signal Processing and Control emphasizes the fundamental principles used in the design and analysis of signal processing systems of various kinds, e.g. CD/DVD players, cellular phones, FM radio. The department offers a variety of courses in this area covering topics such as digital filtering and signal processing, digital image processing, communication networks, control feedback etc.

(B) Computer Engineering is concerned with theory and design of digital information processing systems, e.g. various forms of processors and application specific integrated circuits (ASICs) ubiquitous in our environments, and even biological computational systems. Courses covered in this area include computer and microprocessor organization and architecture, very large scale integrated circuit design, computer-aided design, testing and fault tolerance, and computer systems.

(C) Solid State Electronics is concerned with the operation and circuit properties of modern electronic devices, e.g. fast transistors, photo-cells, integrated circuits and displays. The courses offered in this area range from basic quantum mechanics to general solid state devices, digital and analog circuits and physics of electronic materials. Often this area is taken in conjunction with the Engineering Physics or the Materials Science and Engineering Certificate.

(D) Optical Engineering concerns light and its interaction with electronics, hence the area is often termed "photonics". This area deals with the design of lasers and optical fiber systems, optical devices, and laser based communication systems. The area emphasizes both the principles of optical processes in materials and devices, and optical communication systems. Courses include electromagnetic field theory, physical optics, optical electronics and light-wave communication.

2.9 Areas of Concentration

Each student must develop depth in a specific area of concentration in the department. This can be done by fulfilling the requirements of one of the pre-defined areas of concentration listed below, **or by defining a new area in consultation with the program advisor**. Areas of concentration span the four EE disciplines discussed in the previous section. Concentrations may also be interdisciplinary and include courses from other SEAS departments as well as from related fields such as physics, chemistry and biology. However, normally two of the three courses counted as fulfilling the concentration requirement will be ELE courses or designated cognates.

For each area defined below, a student **must take the courses in bold**, then others from the list to total three or more. Graduate courses (500 level) are open to undergraduates after the completion of a permission form containing the signatures of instructor and departmental representative. The permission form is available from the undergraduate coordinator. (Titles of relevant graduate courses are listed at the end of the course list (see sect. 3.1)

Telecommunications and Networks: Basic concepts and principles of communication and communication networks. Wireless communications. **ELE486**; **ORF309**; and at least one of the following ELE 382, 485; 525; 528, 531, COS 461.

Information and Systems: Principles of communication systems, control systems, and digital signal processing. **ORF309**; (two from 382, 482, 485, 483 or MAE433 or MAE 434)**

Robotics and Control: Automatic control systems with applications to robotics and machine vision. **483 or MAE433 or MAE 434**; ORF309**; ELE 481; 488; 521, COS 402.

Signal and Image Processing: Digital processing of signals, e.g. speech, images, and video. **ELE 482; 488**; 375; ORF309**; ELE 462; 475; 481; 527, COS 429

Digital Video and Graphics: Principles of computer graphics, animation, and video processing. **ELE 488; COS 426**; ELE 481; COS 451

Microelectronics and Integrated Circuits: Design and fabrication of Very Large Scale Integrated (VLSI) circuits. **ELE 401 and/or 402**; 462; 341; 441; 549

Electronic and Optoelectronic Materials: Science of materials related to microelectronics and opto-electronics. **ELE 342 (or PHY208 and 305*); at least one of MSE301, CHM305, MAE324**; ELE 341; 351; 441; 541; 542; 546. (At least one of the concentration courses must be in ELE)

Solid State Devices: Electronic and opto-electronic devices. **ELE 341**; 342 - highly recommended (or PHY208 and 305*); 351; 401 or 402 (count one of 401/402 only); 441; 442, 453; 540; 544; 545; 549

Solid State Physics: The physics of electrons in solids and of the interaction of solids with light. **ELE 342 (or PHY208 and 305*); 441**; 341; 351; 442, 453; 544; 545; 546

Optical Communications and Fiber Optics: Application of photonic technology to lightwave communication. **ELE 351;453;454;455**

Optical and Opto-electronic Engineering: The generation, transmission, control, detection, and applications of photons. **ELE 351**; 341; 352; 453; 454, 455; 544; 546; 551;552;553;MAE521

Computer Systems and Software: The integration of hardware and software in computers. **ELE 375**; at least one of 386, 475, 482, 572; one of COS318, COS320, COS425, COS426, COS 461

Computer Design: Structured design principles for computer-based systems. **ELE375;** 402; 462; 463; 464, 465; 466; 475; 572, 580

Computer Architecture: The principles of microprocessors and high-performance computers. **ELE 375; 475**; 386, 462; 465; 572, 580

Electronic Computer-Aided-Design (CAD): Algorithms and software used for design and analysis of integrated circuits. ELE **462**; 382; 463; 466; COS423; ORF307

Real-time Computing: Use of computers for time-critical processing and control. ELE **482**; 464; 475; (483 or MAE433 or MAE434)

*PHY208 and 305 count as one course for the concentration requirement

ORF309/MAT309 may be used to satisfy **either the upperclass Mathematics requirement **or** the concentration requirement, but not both.

2.10 Design Requirement

Engineering is a creative process involving design of systems, components, or processes to meet desired needs. Science and mathematics provide the tools that are applied to devise solutions that meet stated objectives. Throughout the Electrical Engineering curriculum, students gain experience with the fundamental elements of the design process, which include the establishment of objectives and criteria, synthesis, analysis, implementation, testing, and evaluation. Beginning in the four sophomore core courses, creativity and design experience are introduced by means of open-ended problems, the study and use of modern design software tools, and laboratory work. These courses include material on the detailed description of complex signal processing systems, on semiconductor fabrication and processing, and on CAD software for circuit and logic design. In the junior year, ELE 302 takes each student through all phases of a design project, emphasizing hands-on experience while providing classroom guidance. In elective courses taken by juniors and seniors, design experience is intertwined in ways appropriate to the various subjects being taught.

The Design Requirement insures that each student's program includes a substantial design exposure that builds on that provided in ELE 302. At least one upperclass ELE course with substantial engineering design content beyond ELE 302 must be selected. These courses include 352, 375, 401, 402, 454, 462, 463, 475, 482, 483, COS 426, and COS 436. This requirement may also be satisfied with junior or senior independent work (see sect. 2.13) *with substantial design content*.

2.11 Departmentals

A minimum of two technical courses must be taken each semester during the junior and senior year. These are referred to as departmentals. At least 5 of these must be ELE courses. These technical courses may consist of any 300, 400, or 500 level course in ELE, or any course 300 level or higher in MAE, CHE, CEE, ORF, COS, MAT, PHY, MSE, CHM, EEB/MOL which is closely related to the student's academic program. In special cases, selected courses in other may be counted as technical electives. Such a situation may arise if the courses are integral to the student's academic program (e.g. ECO courses for someone in Engineering Management Systems interdisciplinary certificate program).

2.12 Oral Presentation Requirement

Each graduating student must make a 15 minute oral presentation on some technical work done in a class or in an independent project. If the class or independent project requires an oral presentation, it is sufficient to get a form (giving the date and topic of the presentation) signed by the instructor and give it to the program advisor. Otherwise, the student must contact her or his program advisor and set up an oral presentation. Following the presentation, the advisor signs a form giving the date and topic of the presentation. (Note: It is the responsibility of the STUDENT to discuss the oral presentation requirement with the program advisor and to arrange for its fulfillment.) The independent work poster presentation does not meet the oral presentation requirement.

2.13 Independent Work/Thesis

Independent projects or research projects outside of normal structured lecture or laboratory courses are a valuable educational experience. Such projects are often extremely challenging on both a personal and academic level, but are also extremely fulfilling. **All EE majors are required to complete at least one semester of independent study, normally in the Senior year.** Independent work cannot be used to fulfill the breadth or concentration requirements. Each student doing independent work will be required to give a poster presentation during a 90-minute session given at the end of each semester.

Selecting a Project Topic

Each March, the Department makes available a list of suggested topics for the following Fall and Spring, compiled from forms submitted by the faculty, indicating whether they are one-term or two-term projects, whether they can satisfy the design requirement, and whether they involve mostly library, laboratory or computer work. Students may also suggest their own topics. By the end of the preceding term, students must submit their choice of topic and faculty member to the undergraduate coordinator for the Fall and/or Spring. If the student is not able to obtain a firm commitment from a faculty advisor, it is a good idea to submit a second or third choice of topic and faculty advisor as a backup. The undergraduate representative, with the assistance of the faculty, will then make the final assignment of students to faculty, trying to satisfy student requests and yet maintain a reasonable distribution of students among all faculty members.

The faculty advisor can be from outside the EE department. The primary advisor can also be from outside the University (e.g. a local company). In that case a secondary-advisor should also be selected from among the Princeton Faculty.

Enrolling in Independent Work

To enroll in one semester of Independent work you must:
1. Register for ELE 497 (fall) or ELE 498 (spring)
2. Prior to the start of the semester have agreed with a faculty advisor on a project and have this information recorded in the Undergraduate Program office.

Senior Independent Work Funds

Limited funding is provided by both the School of Engineering as well as the Dean of the College's office for independent work requiring financial support for acquisition of data, or other special requirements. In addition, the Electrical Engineering Department provides independent work/senior thesis funding. Awards are typically modest and not all proposals can be funded. Talk with your advisor if you feel you may qualify for this support. Remember, however, that the application deadline is relatively early, implying that you must already have a good idea of what you need and why it requires support. If you would like to apply, you must submit a one or two page proposal, including a budget, to your advisor who must then write a letter of support and pass it on to the Departmental Representative.

Satisfying the Design Requirement

A design-oriented project can satisfy the EE design requirement. Your project advisor will determine whether or not your particular project satisfies this requirement. To have your project satisfy this requirement, you must first obtain approval from your advisor, based on a written project plan submitted with your sign-up form prior to beginning your work. Your plan must include appropriate specifications and a description of constraints. Final approval of satisfying the design requirement will be signified by your advisor checking the appropriate box on your final report grade form.

P/D/F, Breadth, Concentration and Departmental Course

Independent work cannot be taken P/D/F, cannot be used to fulfill the EE breadth or concentration requirements but it can be counted as a Department course.

The Four Graded Elements of Independent Work

During the semester you need to complete the following four graded elements of Independent Work:

	Element	**Due on**	**Weight**
1)	Detailed Outline	Friday of the 4th week of classes	10%
2)	Interim Report	Friday of the week after break week.	15%
3)	Poster Presentation	First Friday of reading period	15%
4)	Final Report	Dean’s date	60%

Both a unbound *signed hard copy* and an *electronic copy* of the outline, interim and final reports must be turned in to the UNDERGRADUATE COORDINATOR no later than 5:00 p.m. on the date indicated. The student is responsible for providing a copy of the report to their advisor(s). A late submission will incur a penalty. Instructions on final report formatting can be found in the Student's Guide to Independent Work.

Two Semester Projects

A single, two-semester independent project may be carried out by mutual agreement of the student and faculty member before the beginning of the project. In this case, you should enroll in ELE 497 in the fall and ELE 498 in the spring and carry out the project over two semesters. The deadlines for written materials are the same in each semester, as indicated above, except that: The final report at the end of the first semester is replaced by a progress report due on the same day.

Based on the submitted material, a course grade will be given for both the fall (ELE 497) and spring semesters (ELE 498). In the event that you fail to continue with the second semester you should be sure turn in a final report on Dean's date in the Fall. Note that the amount of work accomplished in one semester on what was intended to be a two semester project may make it difficult to attain a good grade. Terminating a two semester project after one semester should be very carefully discussed with your advisor.

Additional important information on the requirements for Senior independent work are provided in a document entitled, the "Senior Independent Work Guide," available either in the EE undergraduate office or on the EE website.

Senior Thesis

In some cases, a two-semester independent project may be recommended for a senior thesis by a committee of two faculty (advisor plus one other). The Senior thesis is due on "Dean's Date" in the Spring of Senior year. You will need to hand in one signed, **UNBOUND** copy to the Undergraduate Office as well as an electronic copy. It is the student's responsibility to provide a copy to your independent work advisor. **ALL PAGES** must be numbered including the cover page and illustrations, etc. A copy of your thesis will be archived to the Mudd Library. A Senior thesis must include an oral presentation to the two faculty, and submission of bound copies as per university regulations.

2.14 Academic Progress

So far, we have talked about requirements in terms of what courses to take. However, the BSE degree in ELE also requires a minimum performance level. Students majoring in the Electrical Engineering Department are expected to maintain a C average in their Sophomore ELE program courses and in the Departmental courses in the Junior and Senior years. Should a student drop below a C average, the department will recommend an appropriate action to the University Faculty Committee on Examinations and Standing that an Academic Warning be issued or that withdrawal from the University be required.

2.15 Honors

The "Departmental Standing," which determines eligibility for graduation and the awarding of graduation Honors, is based on the average grade of the eight of the Departmental courses with the best grades. At least a C average is required for graduation and a B+ average is required to be eligible for Honors. The awarding of Honors, High Honors, and Highest Honors is determined by a vote of the faculty based on performance in all technical courses, with independent project/thesis work normally given special consideration.

2.16 Interdisciplinary Programs

Interested students may combine their work in ELE with that in other departments through interdisciplinary Certificate Programs such as Engineering and Management Systems, Engineering Physics, Materials Science and Engineering, Engineering Biology, Environmental Studies, Applied and Computational Math, and the Woodrow Wilson School (WWS by application only).

Students fulfilling a Certificate Program will receive a special certificate upon graduation. In some cases, the programs closely overlap with defined areas of concentration within ELE. In other cases students should consult with their advisors to develop an ELE program which best combines their ELE interest with the interdisciplinary program.

For further information on the interdisciplinary program you are interested in, read the undergraduate announcement and consult the special program advisor listed in Section 1.4. Additional material may be obtained by contacting the Director of the Program (listed in the Undergraduate Announcement).

3. COURSES AND PREREQUISITES

3.1 List of ELE Courses

The list of undergraduate and graduate courses offered by the ELE department for ELE majors is given below. Following the course list is the prerequisite tree for undergraduate courses, whose main branches follow closely the four areas of breadth in ELE.

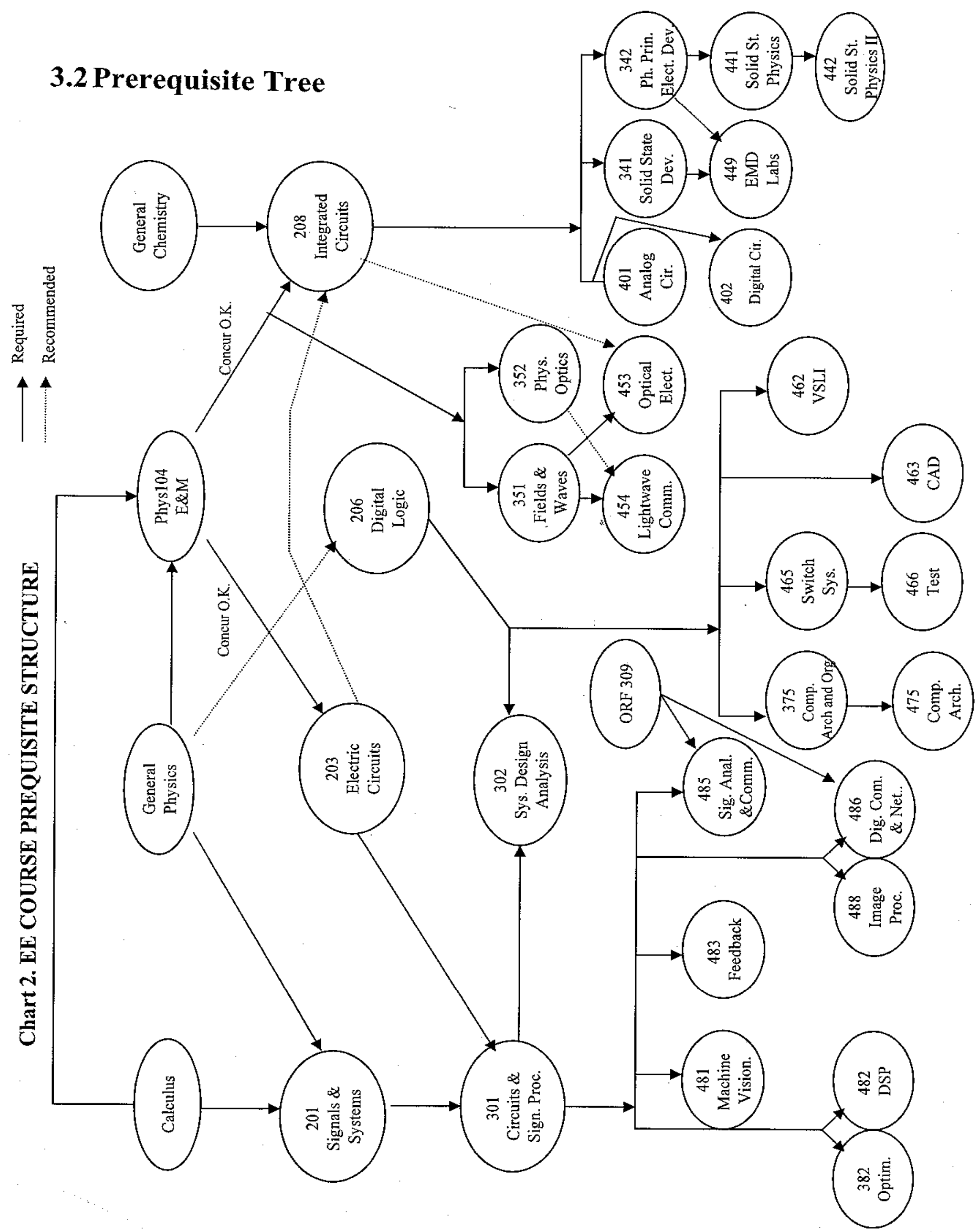
201 Introduction to Electrical Systems and Signals
203 Electronic Circuits
206 Introduction to Logic Design
208 Integrated Circuits: Practice and Principles
211 Digital Systems and Microprocessors
218 Learning Theory and Epistemology (PHI 218)
222A, 222B The Computing Age
301 Circuits and Signal Processing
302 System Design and Analysis
341 Solid State Devices
342 Physical Principles of Electronic Devices
351 Electromagnetic Field Theory and Optics
352 Physical Optics
375 Computer Architecture and Organization (COS 375)
382 Distributed Algorithms and Optimization Methods for Engineering Applications
386 Cyber Security (also EGR 386)
391 (also EGR 391)The Wireless Revolution: Telecommunications for the 21st Century

397 Junior Independent Work (Fall)
398 Junior Independent Work (Spring)
401 Analog Electronics
402 Digital Electronics
412 Electrical Engineering Design Laboratory
441 Solid State Physics - I
442 Solid State Physics - II
449 Materials and Solid State Devices Laboratory
453 Optical Electronics
454 Photonics and Lightwave Communications
462 Design of VLSI Systems (also COS 462)
463 Computer-Aided Design of Systems (also COS 463)
465 Switching and Sequential Systems
466 Digital System Testing
475 Computer Architecture (also COS 475)
481 Machine Vision
482 Digital Signal Processing
483 Feedback Systems
485 Signal Analysis and Communication Systems
486 Digital Communications and Networks
488 Image Processing
491 High-Tech Entrepreneurship (also EGR 491, ORF 491)
497 Senior Independent Work (Fall)
498 Senior Independent Work (Spring)

Given below is a partial list of graduate courses open to advanced undergraduate with permission of program advisor and instructor.

521 Linear System Theory
523 Nonlinear System Theory
524 Theory of Statistical Inference
525 Random Processes in Information Systems
526 Digital Communications and Systems
527 Selected Topics in Signal Processing
528 Information Theory
529 Theory/Phys Foundations/Random Processes
530 Theory of Detection and Estimation
531 Communication Networks
532 Adaptive Systems
533 Multiuser Communication Theory
534 Fiber-Optic Communication Systems
535 Machine Learning and Pattern Recognition
538 Wireless Communications: Signal Processing Principles
540 Organic Materials for Photonics & Electronics
541 Electronic Materials
542 Surface Properties of Electronically Active Solids
543 Transport Processes in Solids
544 Physics and Technology of Heterojunctions
545 Electronic Devices
546 Optical Properties of Solids
549 Physics and Technology of VLSI
550 Scaling of VLSI Devices
553 Nonlinear Optics
554 Solitons in Photonic and Quantum Systems
563 Electronic Design Automation
571 Digital Neurocomputing
572 Processor Architectures for New Paradigms
573 Cellular and Biochemical Computing Systems
577 Low Power IC and System Design
579 Pervasive Information Systems
580 Advanced Topics in Computer Engineering

3.2 Prerequisite Tree



4. EXAMPLES OF TYPICAL B.S.E. PROGRAMS

In this section, you will see examples of some typical BSE programs. Given below is a General Program, whereas the subsequent pages contain specific examples. These examples are indicative, not exhaustive. Your program should be tailored in consultation with your program advisor to suit your specific needs and interests while taking into account your advanced placement status.

4.1 General Program*

Fall		Spring	
Freshman			
Math	104	Math	203
Phys	103	Phys	104
Chem.	207	COS	126
Writing Elective		Elective	
Sophomore			
ELE	201	ELE	206
ELE	203	ELE	208
Math	204	Upperclass Mathematics	
Elective		Elective	
Elective		Elective	
Junior			
ELE	301	ELE	302
Concentration 1-Breadth 1		Breadth 2	
Engineering Science		Elective	
Elective		Elective	
Elective		Elective	
Senior			
Concentration 2		Concentration 3	
Departmental		Departmental	
Elective		Elective	
Elective		Elective	

*This program as well as the ones that follow assumes one semester of advanced placement in Mathematics. Without advanced placement, the upperclass mathematics and engineering science requirement may be delayed one semester.

Notes: In the specific examples that follow, the following abbreviations are used:

b1, b2:	Breadth in ELE
c1, c2, c3:	Concentrations in ELE
D:	Departmental
d:	Engineering Design
e:	Engineering Science
m:	Upperclass Mathematics
p:	Interdisciplinary program requirement
w:	University writing requirement

4.2 Signal and Image Processing

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys 104	ELE 203	ELE 208
Chem 207	COS126	Math 204	COS 217 (e)
Elective (w)	Elective	Elective	Elective
		Elective	Elective
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 488 (D,c3)	ELE 498 (D)
ORF 309 (m)	ELE 482 (b2,c1,D) c2	Depart. (D,d)	Depart. (D)
ELE 375 (D,b1, c1)	Elective	Elective	Elective
Elective	Elective	Elective	Elective
Elective	Elective		

4.3 Information Systems with EMS Certificate

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys 104	ELE 203	ELE 208
Chem 207	COS126	Math 204	ORF 307 (p,e)
Elective (w)	Econ 102 (p)	ORF 245 (p)	MAE 305 (m)
		Elective	Elective
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 485 (D,c3)	ELE 486 (D)
ORF 309 (D,c1,b1)	ELE 482 (D,c2)	ORF 411 (d,p)	ELE 498 (D,p)
ELE 375 (D,b2,d)	ORF 405 (p,D)	Elective	Elective
Elective	Elective	Elective	Elective
Elective	Elective		

4.4 Computer Systems Software

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys 104	ELE 203	ELE 208
Chem 207	COS126	Math 204	COS 217 (e)
Elective (w)	Elective	Elective	COS 226/Elective
		Elective	Elective
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 475 (D,c3)	ELE 462 (D)
ELE 375 (D,c1,b1,d)	ELE 402 (D,b2)	ELE 497. (D)	Depart. (D)
COS 340 (m)	Elective/COS 226	Elective	COS 318 (D,c2)
Elective	Elective	Elective	Elective
Elective	Elective		

4.5 Real-Time Computing with Woodrow Wilson Certificate**

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys104	ELE 203	ELE 208
Chem 207	COS 126	Math 204	COS 217 (e)
Elective (w)	Econ 102 (p)	Econ 303 (p,D)	WWS 304 (p)
		Elective	POL 321 (p)
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 483 (D,c2,b2)	ELE 498 (D)
ELE 375 (D, b1)	ELE 482 (D,c1,d)	ELE 475. (D, C3)	Depart. (D)
Math 305 (m)	WWS 301 (p)	WWS 303 (p)	WWS 321 (p)
WWS 401 (p)	WWS 402 (p)	Elective	Elective
Elective	Elective		

**A Woodrow Wilson Thesis is required in addition to the 36 courses. If the thesis has a technical component, one semester of departmental credit (ELE 497/498) may be allowed.

4.6 Solid State Devices

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys104	ELE 203	ELE 208
Chem 207	COS 126	Math 204	MAE 206 (e)
Elective (w)	Elective	Elective	Elective
		Elective	Elective
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 441 (D,c3)	ELE 402 (D,d)
ELE 341 (D,c1,b1)	ELE342 (D,c2)	ELE 497 (D)	Depart. (D)
ELE 352 (D,b2)	Math 301 (m)	Elective	Elective
Elective	Elective	Elective	Elective
Elective	Elective		

4.7 Solid State Physics with Engineering Physics

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys104	ELE 203	ELE 208
Chem 207	COS 126	Phys 203 (p,e)	Phys 208 (p)
Elective (w)	Elective	Math 204	Math 301 (m)
		Elective	Elective
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 441 (D,c2,b2)	ELE 442 (p,D)
Phys301(D, p)	Phys 304 (D,p)	ELE 453 (D,c3)	ELE 498 (p,D,d)
Phys 305 (D,p,c1)	Math 302 (p,D)	Elective	Elective
ELE352 (D,b1)	Elective	Elective	Elective
Elective	Elective		

4.8 Optical & Optoelectronic Engineering or Optical Communication & Fiber Optics

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys104	ELE 203	ELE 208
Chem 207	COS 126	Math 204	COS 217 (e)
Elective (w)	Elective	Elective	Elective
		Elective	Elective
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 453 (D,c3)	Depart. (D,d)
ELE 352 (D,c1,b1)	ELE 351 (D,c2)	ELE 341 (D,b2)	ELE 498 (D)
Math 301 (m)	Elective	Elective	Elective
Elective	Elective	Elective	Elective
Elective	Elective		

4.9 Electronic & Optoelectronic Materials with MSE Certificate

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys104	ELE 203	ELE 208
Chem 207	ORF201	Math 204	Chem 204
Elective (w)	Elective	Elective	Math 301 (m)
		Elective	Elective
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 441 (D,c3)	Depart. (D)
ELE 352 (D,b1)	ELE 351 (D,b2,c2)	MSE 300 (D,p)	ELE 498 (D,p,d)
Chem 305 (p,D,c1)	MSE 200 (p,e)	Elective	Elective
Elective	Elective	Elective	Elective
Elective	Elective		

4.10 Microelectronic & Integrated Circuits with Engineering Biology**

Freshman		**Sophomore**	
Fall	**Spring**	**Fall**	**Spring**
Math 104	Math 203	ELE 201	ELE 206
Phys 103	Phys104	ELE 203	ELE 208
Chem 207	Chem 202 (p)	EEB 211 (p)	MOL 214 (p)
Elective (w)	COS 126	Math 204	COS 217 (e)
		Elective	Elective
Junior		**Senior**	
Fall	**Spring**	**Fall**	**Spring**
ELE 301 (D)	ELE 302 (D)	ELE 401 (D,c1,d)	ELE 402 (D,c2)
MOL 342 (p,D)	ELE 342 (D,b1)	ELE 497 (p,D)	ELE 462 (D,c3,b2)
Math 301 (m)	EEB 324 (p,D)	MOL 457 (p,D)	Elective
Elective	Elective	Elective	Elective
Elective	Elective		

**For a pre-medical program, organic chemistry (CHE 303, 304) should be taken in the Junior year.

5. Independent Work

Independent projects or research outside of a normal structured lecture or laboratory course are a valuable educational experience, and are highly recommended for all students at either the junior or senior level. The projects are often extremely challenging on both a personal and academic level, but also extremely fulfilling. If a design-oriented independent project is not selected, then one 300 or 400-level course having a substantial engineering design component must be taken in addition to ELE 302. Independent work must not be taken P/D/F. Independent work cannot be used to fulfill the breadth or concentration requirements. Each **senior** doing independent work will be **required** to give a poster presentation during a 90-minute session given at the end of each semester (Friday during Reading Period).

A design-oriented independent project must receive prior approval from the Departmental Representative on the basis of a written project plan submitted with the sign-up form. The plan must include appropriate specifications and a description of constraints. The final project report must discuss the relevant elements of the design process, such as the establishment of objectives and criteria, synthesis, analysis, implementation, testing, and evaluation.

Most students in EE undertake at least one semester of independent work. The following two subsections give some idea of the range of opportunities available.

5.1 Examples of Recent Undergraduate Independent Work

- Considering Relays in CDMA Networks: A Game Theoretic Approach
- Optical Neuron
- The United States as a Net Exporter of Energy in 2050
- Engineering Highly Selective Peptitdes for Target Analytes in Biomimetric Nanosensor
- Propagation of Non-diffractive Beams through Photorefractive Media.
- Using Artificial Neural Networks for Two Text Recognition
- Optical Hydrodynamics
- Inferring Neural Connectivity from Spiking Data
- Coral Proxy
- Self-Sufficient Autonomous Sailboat for Trans-Atlantic Passage
- Quantum Information Theory and Compression

5.2 Faculty Suggestions for Independent Projects

The following topics have been suggested by the faculty as possible projects for undergraduate independent work. These topics reflect their current interests and should serve as starting points for discussion between you and the faculty.

R. Bhatt B430; 8-1819
ravin@ princeton.edu

- Quantum calculations for semiconductor materials
- Monte Carlo simulation of magnetic models
- Theory of disordered electronic systems
- Two dimensional electron gases and quantum Hall effect.
- Diluted Magnetic Semiconductors - Materials for Spintronics

R. Calderbank B318; 8-8962
calderbk@princeton.edu

- Quantum computing and Quantum cryptography
- Coding and Information Theory
- Wireless Signal Processing
- Network anomaly detection
- Compressive sensing and one-pixel cameras
- Sensor Networks

M. Chiang B328; 8-5071
chiangm@princeton.edu

- Wireless Internet access through Wi-Fi hot-spot and 3G cellular phone systems.
- Comparative study of broadband Internet access technologies: DSL, Cable modem, and Fiber to the curb.
- Network reliability and evolvability modeling and analysis for telecom, power-grid, and biological networks.
- Robust and distributed algorithms for nonlinear optimization of communication systems

S. Chou B412; 8-4416;
chou@princeton.edu

- Nanofabrication technologies and IC processing
- Nanoscale electronics (single
- electron transistors and MOSFETs)
- Nanoscale optoelectronics
- (subwavelength optical elements,
- photodetectors, modulators, and lasers)
- Nanoscale magnetic devices
- (quantized magnetic disks, GMR,
- AMR, and sensors)
- Applications of nanotechnology in polymers and materials.

P. Cuff B316; 8-2213
cuff@princeton.edu

- Shannon's two-way channel.
- Numerical optimization of information theoretic rate regions.
- FPGA rendering of fractals.
- Musical instrument vocoding.
- Comparison of collaborative information resources: Wikipedia; Digg; Slashdot; forums; etc.

B.W. Dickinson B322;8-4644
bradley@princeton.edu

- Audio signal processing related to binaural hearing and sensory perception of spatial location and movement.
- Computer software for exercising abilities to change focus of attention in two and three dimensions.
- Modeling of sensory integration processes such as those involving ambient vision, proprioception, and vestibular system.

J. Fleischer B320; 8-8963
jasonf@princeton.edu

- Optical shock waves
- Digital holography
- Nonlinear signal processing

C. Gmachl B326; 8-7489
gmachl@princeton.edu

- High Efficiency Quantum Cascade lasers
- Mid-infrared materials with negative refraction
- Design of high throughput Quantum Cascade laser testing
- Single-mode Quantum Cascade lasers for specific applications

A. Houck B424; 8-2571
aahouck@princeton.edu

- Fabrication of novel superconducting circuits for quantum computation
- Programming FPGA’s for microwave signal analysis
- Genetic algorithms for precise control of superconducting quantum bits
- Fabrication of nanostructures on high purity sapphire substrates

N.K. Jha B220; 8-4754
jha@princeton.edu

- Circuits and architectures for nanotechnologies
- Reversible logic synthesis
- Thermal analysis and optimization of ICs
- Microprocessor testing
- Secure embedded systems

A. Kahn B420; 8-4642;
kahn@princeton.edu

- Scanning Tunneling Microscopy on organic molecular thin films
- Design, building and testing of organic light emitting diodes
- Direct and inverse photoemission spectroscopy on organic molecular thin films

S. Kulkarni B310; 8-6727;
kulkarni@princeton.edu

- Algorithms in signal, image, and video processing
- Pattern recognition, learning, and adaptive systems
- Problems in discrete geometry and geometric reconstruction
- Applications of the above areas to econometrics and finance

S.Y. Kung B230; 8-3780;
kung@princeton.edu

- Study on machine learning models for bioinformatics with applications to microarray data mining and/or protein sequence classifications.
- Study on machine learning models for multimedia information processing and pattern recognition applications

R. Lee B218, 8-1426;
rblee@princeton.edu

- Digital Rights Management (DRM), while preserving fair use: file sharing, new business models, and anti-piracy technologies.
- Wireless security.
- Security protocols, cryptographic algorithms and hardware architectures for e-cash.
- Viruses, worms and Trojan horses.
- Denial of Service attacks and countermeasures.
- Design, evaluation and optimization of a media processor (see palms.ee.princeton.edu/plx).
- Smart card technology.

B. Liu B330; 8-4628
liu@princeton.edu

- Image and Video Processing and Analysis
- Image Registration
- Super Resolution

S. Lyon B428; 8-4635;
lyon@princeton.edu

- Studying relaxation and scattering processes of electrons in semiconductors
- Properties of the interface between silicon and silicon di-oxide
- Excitation of surface plasmons on diffraction gratings
- Control of experiments by microprocessors and small laboratory computers
- Charge-coupled Device (CCD) arrays for low light level detection.
- Light emission from Si MOSFETs

S. Malik B224; 8-4625;
sharad@princeton.edu

Undergraduate research projects are available in the design of complex electronic systems. Specifically I am interested in how these systems are validated. The large complexity of these designs makes it very easy for design bugs to creep in. In my research I am seeking for ways of proving that that designs are bug free through software proof systems, and also by making these designs more robust by building in innovative self-checking and recovery mechanisms. This research is used in the latest generation of computing systems that end up in your computers, cell phones and other electronics around you.
These projects will give you an opportunity to work with researchers in the Gigascale Systems Research Center which is a multi-university research effort, in collaboration with leading industrial researchers, towards defining design methodology and tools with a ten year vision.

M. Martonosi B215; 8-1912;
martonosi@princeton.edu

- Green Data Centers
- Mobile Computing
- Cell phone applications and programming models
- Energy-efficient computer architectures

H. V. Poor
poor@princeton.edu

- Applications involving Bluetooth piconets
- Multi-antenna communication systems
- Wireless networking protocols
- Stochastic modeling
- Underwater acoustic signal detection

P. R. Prucnal B314; 8-5549;
prucnal@princeton.edu

- Photonic switching
- Optical computer interconnect
- Biomedical imaging
- Optical signal processing
- Fiber optics lasers

P. J. Ramadge B326; 8-4645;
ramadge@princeton.edu

- Image, video processing and computer vision
- Brain Imaging, FMRI, data analysis

S.C. Schwartz B317B; 8-4618;
stuart@.princeton.edu

- Development, analysis, and simulation of image and video processing processing algorithms, for applications such as fast object tracking and recognition.
- There are a number of interesting projects in the area of terrestrial and satellite digital communications and mobile telephony. Some projects involve simulation and others would have an analytical component. Students should have had, or be taking, ELE485
- Application of sequential Markov decision models to econometric problems (i.e., the stock market), and various investment strategies

M. Shayegan B408; 8-4639;
shayegan@ princeton.edu

- Fabrication of high-quality GaAs/AlGaAs hetero-structures and nanostructures by molecular beam epitaxy and electron beam lithography
- Physics and electronic properties of heterostructures and nanostructures

J. Sturm B404; 8-5610;
sturm@princeton.edu

- Fabrication, characterization, and modeling of semiconductor materials, devices and circuits for microelectronics (VLSI) and for large area electronics (e.g. flat panel displays).

D.Tsui B426; 8-4621;
tsui@.princeton.edu

- Transport of super-mobile 2D electrons in Si
- Two-dimensional metal-insulator transition

S. Verdú B308; 8-5315;
verdu@ princeton.edu

- Simulation studies in wireless multiuser communications subject to fading.
- Speech Coding

N. Verma B226; 8-1424
nverma@princeton.edu

- Memories using hybrid technologies (i.e. flash, DRAM, SRAM, FeRAM, MRAM)
- Sensor instrumentation for biomedical/neural applications
- Hardware architectures and implementations incorporating machine-learning (for biomedical and neural applications)
- *Adaptive mixed-signal circuits for dynamic performance and energy scaling
- Energy-harvesting circuits for self-powered electronics

S. Wagner B422; 8-4631;
wagner@ princeton.edu

- Break in and calibrate new equipment in the micro/nanofabrication clean room
- Test the electrical performance of thin film transistors made on plastic.
- Test the stretchability of elastic electrodes for brain trauma research.
- Evaluate mechanical properties of thin-film multilayers

G. Wysocki B324; 8-8187;
gwysocki@princeton.edu

- Broadly tunable external cavity quantum cascade lasers
- Mid-IR laser molecular spectroscopy and trace-gas detection – systems and applications
- Laser-spectroscopic distributed sensor networks

6. Electrical Engineering Degree Requirements Checklist

Name:	Class:	Advisor:

Certificates (student is responsible for checking that the certificate requirements are met)

Applied and Computational Math		Materials Science and Engineering	
Engineering Physics		Engineering and Management Syst.	
Engineering Biology		Woodrow Wilson School	

Engineering School Requirements (Indicate semester or course and semester)

Math 103		Physics 103/105	
Math 104		Physics 104/106	
Math 201/203/217		Chemistry 201/203	
Math 202/204/218		COS 126/ELE101/ORF 201/other	
Writing Requirement			

Liberal Arts Courses and Distribution Requirements
(At least 7 courses total and at least 1 course from 4 of 6 areas. Indicate course and semester.)

Epistemology Cognition (EC)	Ethical/Moral Values (EM)	Historical Analysis (HA)	Literature and Arts (LA)	Social Analysis (SA)	Foreign Language (FL)	Other

ABET H/SS depth and breadth requirement (Satisfy one of the following 4 items. No AP allowed)

Three nonlanguage courses in one dept/area			
Two nonlanguage courses in one dept/area, one beyond intro level			
One 300-400 course in a distribution area			
Completion of AB foreign language requirement			

Electrical Engineering Requirements (Indicate course and semester)

ELE 201		Upper Class Math (1)			Cannot be a departmental
ELE 203		Engineering Science (1)			Not ELE & not a departmental
ELE 206		Oral Presentation (1)			course/date/faculty
ELE 208		Design (2) see note 1	ELE 302 / S _ _		
ELE 301		Breadth (2)			NO ELE380
ELE 302		Concentration (3)			

Eight Departmentals (300-400 level technical. Minimum of 5 from ELE. GPA>2. Indicate course and grade)

1.	3.	5.	7.
2.	4.	6.	8.

Other Departmental Courses | **Course count**

	Year	Fall	Spring	Add
	Freshman			
	Sophomore			
Notes	Junior			
1. Independent work must be certified to meet the design requirement.	Senior			
	TOTAL	must be ≥ 36		

Comments: