



ELECTRICAL & COMPUTER
ENGINEERING

ECE Undergraduate Program Handbook

2014-2015 Academic Year

The handbook is updated every year.
Students and faculty should always use the latest version of the handbook.

Table of Contents

Introduction	3
Mission	3
Program Educational Objectives	4
Student Outcomes and Program Criteria	4
Pratt School of Engineering and ECE Major Requirements	5
One Biology Course	5
One Chemistry Course	5
Two Physics Courses	5
One Statistics Course	5
Five Mathematics Courses	5
Engineering Computation and Computer Programming	6
Five Social Sciences and Humanities (SSH) Courses	6
One Undergraduate Writing Course	6
ECE Required Courses (Core)	6
ECE Required Courses (Concentration Electives)	7
ECE Required Courses (Approved Design Elective)	7
ECE Required Courses (Free ECE Electives)	8
Unrestricted Electives	8
Requirements for a Minor in Electrical and Computer Engineering	8
Second Major, Minor, and Certificate Programs	9
Independent Study and Research Opportunities	9
Graduation with Distinction	10
Preparation for Medical School	11
Planning for Study Abroad	11
4 + 1 BSE/MS Program (Five-Year Combined Bachelor/Master Degree Program)	11
Advising	12
Information on Internships and Employment	13
Appendix A: Sample Programs of Study for the ECE Major	14
Table A.1 Electrical and Computer Engineering (ECE) Major	14
Table A.2 ECE with Computer Science (COMPSCI) Second Major	15
Table A.3a ECE with BME Second Major (matriculating classes \leq 2010)	16
Table A.3b ECE with BME Second Major (matriculating classes \geq 2011)	17
Table A.4 Electrical and Computer Engineering (ECE) with Physics Second Major	18
Table A.5 Electrical and Computer Engineering (ECE) Major (Focus program)	19
Table A.6 Electrical and Computer Engineering (ECE) Major (Marine Lab)	20
Appendix B: Check sheets for the ECE Major and Select Second Majors	21
Appendix C: Major-specific Requirements for the Minor in ECE	27
Appendix D: Approved ECE Concentration Elective Areas and Courses	30
Appendix E: Approved ECE Design, Biology, and Statistics Electives	33
Table E.1 Approved ECE Design Electives	33
Table E.2 Approved ECE Biology Courses	33
Table E.3 Approved ECE Statistics Courses	33

Introduction

This handbook provides an overview of the undergraduate program in Electrical and Computer Engineering (ECE) at Duke University. It covers the program, mission, educational objectives, major requirements, second major options, minor requirements, and research opportunities.

Duke's Department of Electrical and Computer engineering offers an ABET accredited Bachelor of Science in engineering emphasizing analytical thinking, problem solving, and technology, and each fosters the development of ethical leadership, communication, and teamwork skills. The Duke program provides more opportunities and is less restrictive than many other ECE programs in the United States. Students use this flexibility to expand their personal horizons or to explore a personal interest more deeply. The student population is diverse both geographically and culturally, and is a cross-section of the very best students in the nation and from around the world.

For more information about the ECE undergraduate program contact:

Director of Undergraduate Studies

Professor Lisa G. Huettel
112 Hudson Hall
Tel: 660-5237
Email: lisa.huettel@duke.edu

Director of Undergraduate Studies Assistant

Ellen Currin
129 Hudson Hall
Tel: 660-5252
Email: ecurrin@ee.duke.edu

Mission

Electrical and computer engineering is a broadly based engineering discipline dealing with the processing, control, and transmission of information and energy by making extensive use of electrical and electromagnetic phenomena, systems theory, and computational hardware and software. The Department also encourages students and faculty to develop synergies with disciplines outside of engineering, such as medicine and the life sciences. Electrical and computer engineers can complete a second major or a minor in many fields such as biomedical engineering, computer science, physics, mathematics, economics, and public policy studies. Additional interests such as pre-medicine, pre-law, business, other engineering disciplines, art, music, psychology, and social sciences can be accommodated.

The mission of the Department of Electrical and Computer Engineering is to facilitate the development of well rounded, educated, productive, and ethical individuals who are well versed in technology and in social, political, and environmental issues. Our goals are to develop within each student a robust repertoire of professional skills, to provide each with avenues for exploring diverse interests, and to launch each successfully into one of a variety of careers offering lifelong learning, service, and leadership within their own local, national and global

communities. To achieve our mission, the department puts forth the following educational objectives for the extremely capable students entering the ECE program.

Program Educational Objectives

Our goal is to graduate electrical and computer engineers who embody excellence in a broad sense. We expect our graduates to advance within industry positions or in graduate study, or to carry the attributes of an engineering education into other disciplines. The electrical and computer engineering program of study must include mathematics and basic sciences, fundamentals and applications in several engineering sciences, and team-based experience in the process of design, where theory is applied in the context of real needs and limitations, and where judgment must be exercised. Our electrical and computer engineering graduates should be able to think critically when solving problems and managing tasks and communicate effectively in multidisciplinary professional environments. To be a responsible member of the engineering profession, each graduate must be aware of social, ethical, environmental and economic factors and constraints on engineering activity, and must understand the importance of these matters in a global context. We aspire to have our graduates exhibit intellectual depth and creativity, uphold high ethical standards, and show a commitment to the betterment of society through service and professional work.

The specific Program Educational Objectives that we look for in our graduates are that they:

- **Advance professionally** in their chosen field
- **Contribute to their professional community and to society**
- Engage in **lifelong learning** in professional and personal endeavors

Student Outcomes and Program Criteria

Our students will have the following capabilities upon completion of their degrees:

- 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 within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability,
- d. an ability to function on multidisciplinary 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, economic, environmental, 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.

Pratt School of Engineering and ECE Major Requirements

As a program accredited by the Engineering Accreditation Commission of ABET (www.abet.org), the ECE curricula must satisfy minimum requirements in mathematics, sciences, and engineering. In addition, the Pratt School of Engineering has requirements for all engineering students. To meet these constraints, the Department of Electrical and Computer Engineering has developed specific requirements for undergraduate students. Samples of curricula for students with different ECE-related major choices are provided in [Appendix A: Sample Programs of Study for the ECE Major](#). In summary, ECE students need to take the following courses:

One Biology Course

This requirement may be satisfied by taking an approved course in Biology. The list of approved Biology options can be found in [Table D.2](#) Approved ECE Biology Courses. AP credit in Biology [Biology 20 (19)] may be used to satisfy this requirement.

One Chemistry Course

This requirement may be satisfied by taking Chemistry 101DL (31L). AP credit in Chemistry [20 (18) or 21 (19)] may be used to satisfy this requirement.

Two Physics Courses

Engineering students must take at least one Physics course at Duke. Students with no AP credit will take the following:

- Physics 151L (61L) + Physics 152L (62L)

Students with a 4 or 5 on the AP Physics C exam(s) earn Physics 25(61)-*Mechanics*; and/or Physics 26 (62)-*Electricity & Magnetism*. The following options are available:

- Physics 25 (61) + Physics 26 (62) + any one of the following courses: Physics 153L (63L), 264 (143), 361 (181), or 362 (182)
- Physics 25 (61) + Physics 152L (62)

Students may not take Physics 151L (61L) at Duke and use AP credit for Physics 152L (62L).

One Statistics Course

All ECE majors must take a course on Statistics/Probability. The approved options can be found in [Table D.3](#) Approved ECE Statistics Courses.

Five Mathematics Courses

All ECE majors must take Math 111L(31L), 112L(32L), 212(103), 216(107) and 353(108). AP credit [Math 21(31)] is accepted in place of Math 111L(31L) and AP credit [Math 22(32)] is accepted in place of 112L(32L). Common questions about mathematics placement are answered at the website: http://www.math.duke.edu/first_year/placement.html. Transfer credits are examined on an individual basis.

Math options for the first two courses:

No AP: Math 111L(31L) **and** 112L(32L)

Math 21(31) AP: Math 122L(41L) in the Fall **or** Math 112L(32L) in the Spring

Math 21(31) AP **and** Math 22(32) AP: proceed to Math 212(103)

If students are advised by the Math department to skip any courses in the Math sequence listed above, *they must replace those courses with additional Math courses approved by the ECE DUS. The total number of Math courses (including the required Probability/Statistics course listed above) taken at Duke plus the number of AP or transfer credits must equal five or more.*

Special Note for students with a second major in Math: Students wishing to complete a second major in Math will need to take Math 111L(31L), 112L(32L), 212(103), 221(104), 356(131), and 453(133) [i.e., 221(104) + 356(131) + 453(133) substituting for 216(107) + 353(108)]. *Once a student starts the Math major sequence by taking Math 221(104), they must complete it. They cannot switch to the regular ECE sequence.*

Engineering Computation and Computer Programming

All ECE students must take EGR 103L(53L) and Computer Science 201(100).

Five Social Sciences and Humanities (SSH) Courses

All majors in Pratt must take five (5) humanities and social science courses from approved departments and programs (see <http://www.pratt.duke.edu/undergrad/policies/3505#humanities> for complete list) subject to the following requirements:

- **Social Science:** At least one course must be a Social Science (SS).
- **Breadth:** At least two of the following three areas of knowledge must be covered: Arts, Literature, and Performance (ALP), Civilizations (CZ), and Foreign Language (FL).
- **Depth:** At least two courses must be taken from the same approved department or program with at least one of the two courses at 200-level or higher.

and subject to the following restrictions:

- Courses utilized to meet the social science and breadth components can contribute only a single area of knowledge code even if the course possesses multiple codes, thus, a total of three unique courses will be required.
- A maximum of two AP credits can be used
- AP credit cannot be used to meet the “200-level or higher”-component of the depth requirement
- Skill courses cannot be used
- Courses must be from, or cross-listed with, an approved department or program. See <http://www.pratt.duke.edu/undergrad/policies/3505#humanities> for brief list of exceptions to this restriction.

One Undergraduate Writing Course

Writing 101(20) is required.

ECE Required Courses (Core)

The following five core courses are required for all ECE majors: ECE 110L(27L), ECE 230L(51L), ECE 250L(52L), ECE 270L(53L), ECE 280L(54L).

ECE Required Courses (Concentration Electives)

ECE majors must select a minimum of four upper-level courses in at least two departmental areas of concentration, with no less than two courses in one of the elected areas. For students expecting to enter the engineering profession after graduation, a two- or three-course sequence prepares the student for professional work in that area of concentration. For all students, including those expecting to enter fields such as medicine, law, or business, these upper-level courses reinforce the broad relevance of the powerful problem-solving methodologies of engineering and illuminate enabling technologies for breathtaking applications of technology.

Some concentration areas have a foundation course. If two or more courses are taken in such a Concentration Area, the Foundation Course for that area must be taken. The Solid State Devices and Integrated Circuits area has two foundation courses, either one of which will satisfy this requirement.

The four ECE Concentration Courses are chosen from the following five areas:

- Computer Engineering and Digital Systems
- Signal Processing, Communications, and Control Systems
- Solid-State Devices and Integrated Circuits
- Electromagnetic Fields
- Photonics

A complete list of approved Concentration Electives in each area can be found in [Appendix D: Approved ECE Concentration Elective Areas and Courses](#).

ECE Required Courses (Approved Design Elective)

The undergraduate ECE Program includes an Approved ECE Design Elective. This course is normally taken during Senior year, after a student has completed the core courses in Math and Science, and core and some advanced courses in ECE. This "capstone design course" involves multidisciplinary teams of students who build and test custom designed systems, components or engineering processes. Students gain experience in the design/building/testing/demonstration processes intrinsic to engineering design as practiced by engineering graduates.

Requirements for the team project include:

- a design plan incorporating engineering standards and realistic constraints
- a timeline indicating project milestones
- a written project report including an assessment of the results
- oral presentations to the class

The completed project assessment must include most of the following elements:

- cost
- environmental impact
- manufacturability
- ethics
- health and safety
- social and political impacts

The list of approved ECE design courses can be found in [Table D.1](#) Approved ECE Design Electives.

ECE Required Courses (Free ECE Electives)

Students take elective courses to learn advanced knowledge in specific areas of electrical and computer engineering. In addition to the four ECE Concentration Electives and approved ECE Design course, students are required to take at least two elective ECE courses at the 300-level or above. An ECE Free Elective can be any ECE course for which you have the prerequisites and which is not a required course for your major. Up to two independent study courses can be counted as ECE Free Electives.

NOTE: For students with a second major, the total number of ECE Concentration and ECE Free Electives required depends on the second major (see [Appendix A: Sample Programs of Study for the ECE Major](#)).

Unrestricted Electives

The standard ECE curriculum (assuming no AP credit) includes four unrestricted elective courses. Only unrestricted electives can be taken on the Satisfactory/Unsatisfactory basis.

Requirements for a Minor in Electrical and Computer Engineering

A Minor in Electrical and Computer Engineering provides Duke undergraduates with a creditable exposure to ECE that complements the program of study in their first major. It is designed to provide students with a broad, fundamental foundation in ECE, coupled with the opportunity to explore advanced topics tailored to a student's specific interests.

The minor in ECE requires a minimum of five technical courses. Three courses must be drawn from the set of "core courses" required of all ECE majors and two must be upper-level ECE courses.

Core courses (3): Choose 3 from the following 5 core ECE courses¹:

- *ECE 110L(27L) Fundamentals of ECE²*
- *ECE 230L(51L) Microelectronic Devices & Circuits*
- *ECE 250L Computer Architecture*
- *ECE 270L(53L) Electromagnetic Fields*
- *ECE 280L(54L) Signals & Systems*

¹ Students with credit for any of these courses (e.g., exact or equivalent course taken to satisfy a requirement of the primary major) may substitute additional upper-level ECE courses. The DUS in ECE must approve such exceptions.

² Note that ECE 110L(27L) is a prerequisite for the other core courses.

Upper-level courses (2): Two ECE courses at or above the 300(100)-level

- At most, one ECE Independent Study (supervised by an ECE faculty member) can be used toward satisfying this requirement.
- At most, one 300(100)-level (or above) course cross-listed between ECE and the major department can be used toward satisfying this requirement. This course may not be double-counted toward the primary major.

Courses that are used to fulfill the student's primary major may not be double-counted toward the minor. In addition, ECE courses with content substantially equivalent to courses in the student's primary major may not be counted toward the minor

It is expected that a student pursuing a minor in ECE will satisfy all pre-requisites for each course selected for their minor program. This will typically involve completion of courses in Math, Physics and/or Computer Science, which are pre-requisites for many of the core ECE courses. See [Appendix C](#): Major-specific Requirements for the Minor in ECE for major-specific course and pre-requisite equivalents.

Students interested in pursuing a Minor in ECE are advised to discuss their plan of study with the Director of Undergraduate Studies in ECE (Dr. Lisa Huettel, lisa.huettel@duke.edu).

Second Major, Minor, and Certificate Programs

Students can declare a second major within the Pratt School of Engineering. Opportunities also exist for students with AP credits to combine the ECE major with a second major, minor, or certificate from the Trinity College. (A certificate is similar to a minor but offered for interdisciplinary study.) To do so, the students must meet the same requirements as those for the ECE major plus the specific requirements from other departments/programs outlined in the Bulletin of Undergraduate Instruction (<http://registrar.duke.edu/university-bulletins/undergraduate-instruction>). The additional requirements usually consist of ≥ 10 courses for a second major, 5 courses for a minor, and ≥ 6 courses for a certificate. Some of these courses can be double-counted towards both the ECE degree and the second major, minor or certificate in the Trinity College. For example, two courses required for the second major in economics may be counted as two of the five SSH courses required for the ECE degree. To reduce the work load for obtaining the second major, minor, or certificate in the Trinity College during the regular academic semesters, students can either take the required Trinity courses as unrestricted electives in the ECE curriculum or take them in the summer.

[Appendix A](#) provides samples of curricula for the most popular combinations of the ECE major with a second major.

Independent Study and Research Opportunities

Independent study courses are designed to allow Juniors and Seniors to work individually with a faculty member on a project or topic of mutual interest. Courses are arranged on an individual basis at the instigation of the student or faculty member. Most students who undertake Independent Study do so in their Senior year, but qualified students can undertake Independent Study after Sophomore year.

Many students find that Independent Study is a rewarding educational experience. Students who anticipate Independent Study are encouraged to complete their foundation courses in mathematics, chemistry, physics, and engineering as early as possible, so that they will have the background to address challenging engineering problems in collaboration with their faculty study mentor.

Up to two Independent Study courses may be counted as ECE Free Electives [ECE 391(191), ECE 392(192), ECE 493(193) and 494(194)]. Students may take Independent Study courses as

Free Electives, and all successfully completed Independent Study courses count toward the total of 34 courses required for a Duke degree.

A research experience can be achieved in a number of ways.

- Perform directed ECE research with an ECE faculty member.
- Take independent study courses with a non-ECE faculty member. In such cases, the project must be sponsored by an ECE faculty member. The sponsor is responsible for evaluating the quality of the project and ensuring ECE content as appropriate for ECE course credit.
- Apply for a Pratt Research Fellow position during your Junior year (to learn more, check the website at <http://www.pratt.duke.edu/undergrad/students/research-fellows>). Pratt Research Fellows perform research in an ECE faculty member's lab for three academic semesters plus a full summer term and receive two ECE Free Elective credits.

All students taking the ECE independent-study courses, *including Pratt Fellows and Graduation with Departmental Distinction candidates*, must participate in ECE Independent Study Poster Session to present their research results and to answer questions from faculty and other students. Poster sessions are scheduled by the ECE Department late in each semester for the independent study done during that semester.

Other opportunities for integrating research into the plan of study include the [Duke Smart Home Fellows](#) program, the [Grand Challenge Scholars](#) program, and [Bass Connections](#).

Graduation with Distinction

Students who aspire to Graduate with Departmental Distinction (GWDD) within the Department of Electrical and Computer Engineering conduct supervised research through independent study courses and present the results of individual research and study in both written and oral forms to the department's faculty. Those candidates who are judged by the department's faculty to have distinguished themselves through their paper and presentation earn Graduation with Departmental Distinction honors.

To be considered for Graduation with Departmental Distinction a student must have a 3.5 Cumulative GPA and must successfully complete in his or her Senior year an ECE faculty supervised Independent Study project with significant Electrical and Computer Engineering accomplishment. The significance of this project must be demonstrated in a formal written report and defended in an oral presentation before a committee of faculty members.

Candidates must submit a 10-20 page written report (single spaced, 12-point Times New Roman, single column) including figures and references. The entire report must be submitted electronically to the Director of Undergraduate Studies Assistant, Ms. Ellen Currin, at ecurrin@ee.duke.edu no later than one week **before** the oral presentation begins. The project report essentially constitutes a Senior thesis.

This accomplishment is recognized when the BSE degree is awarded. If that time is different from the principal Spring commencement exercises, the student work remains in contention for the Charles Seager prize for that academic year awarded each Spring Commencement.

Preparation for Medical School

Students planning to attend medical and dental schools should consult with the Office of Health Professions Advising (HPA) about course planning. HPA is located at 011 Allen Building (the website is <http://prehealth.duke.edu>). The Office provides advice to students planning careers in health professions and also information on the application process, degree requirements, research and volunteer opportunities.

Planning for Study Abroad

Students interested in participating in the Global Education program need to develop an academic plan with their advisors several semesters in advance. This plan includes the courses to be taken in foreign countries and the remaining courses to be taken at Duke before and after the semester abroad. In the semester *prior* to study abroad, students submit requests for course approvals (if courses are not already in the GEO database) to the ECE DUS. The process for approval of courses in the study abroad program is the same as that used for all transfer courses. For details, see <http://gloaled.duke.edu/>.

The most common courses for students to receive credit for taking abroad (i.e., the courses for which it is easiest to find an equivalent) include ECE 270L(53L), ECE 280L(54L), some ECE Concentration Electives (particularly ECE 356(156), 381(180), 382(141), 383(142), and 488(189)), ECE Free Electives, and/or Social Studies or Humanities electives.

4 + 1 BSE/Master's Program (Five-Year Combined Bachelor/Master's Degree Program)

Completing both a Bachelor of Science in Engineering (BSE) and a Master's degree in five years is a great opportunity to advance your training. If you plan accordingly, you can complete all requirements for your BSE degree without carrying a full undergraduate course load in your senior spring. By taking two or more graduate courses in your senior spring (which are not being used to satisfy any BSE requirements), you can complete the remaining graduate courses in one year beyond your BSE.

At Duke there are three engineering master's degrees options to consider:

- 4+1: BSE + Master of Engineering
- 4+1: BSE + Master of Science
- 4+1: BSE + Master of Engineering Management

More information about all three 4+1 programs is provided at the 4+1 webpage (<http://www.pratt.duke.edu/undergrad/degree-programs/bse-masters>) and a comparison of the graduate degrees can be found here at <http://www.pratt.duke.edu/grad>. In all cases, you want to work with your Director of Undergraduate Studies and the Director of Graduate Studies to develop your academic plan. The main steps are:

- Develop course plans for your senior year and for one graduate year with your academic adviser and obtain Director of Graduate Studies (DGS) approval.
- Take the GRE exam in the senior fall or earlier

- Apply for admission to Duke's Graduate School (for a Master of Science) or Pratt's Master's Program Office (for a Master of Engineering or Master of Engineering Management program) during senior fall.

Advising

Assignment of ECE advisors: Students are assigned an ECE faculty advisor upon arrival at Duke (if they expressed an interest in majoring in ECE in their pre-matriculation forms) or at the time they declare their major (for those initially assigned to a non-ECE faculty advisor). Students can declare majors or change them at any time after their first year. To do this, the students complete an online form (<http://www.pratt.duke.edu/forms/declaration-of-major>).

The assignment of faculty advisors is based upon the major interests (e.g., computer engineering, integrated circuits, CompSci second major) expressed by the students and the need to balance the number of advisees per faculty.

First-year advising: In order to provide program information to first-year students interested in ECE, all students are invited to an orientation presented by the ECE Director of Undergraduate Studies (DUS) at the end of August, prior to the start of classes. The presentation covers the degree requirements and commonly asked questions. Incoming students will also meet with their assigned academic advisor during the first few weeks of the semester. Students will again meet with their academic advisor in October/November and March/April, during the pre-registration periods.

To assist undecided students choosing a major in engineering, an elective course, EGR 90L(10), Introduction to Engineering, is offered to first year students in the Fall term. This course surveys the fields of engineering offered by the Pratt School of Engineering.

Pre-registration advising of ECE students: Students meet with their advisors during the pre-registration period in March/April for the Fall semester and in October/November for the Spring semester. The advisor reviews the student's academic report, discusses with the student the courses that he or she will take in the following semester, and makes the student 'eligible to enroll' in classes for the following semester. Should you make any changes to your course plan after meeting with your advisor it is your responsibility to inform your advisor of those changes. Your advisor is likely to keep notes on your meetings and this will keep his or her notes accurate and, more importantly, your change in plan may trigger a comment from your advisor that could be beneficial to you.

During the advising meeting you should discuss any concerns or problems that you might be having academically, and you are encouraged to initiate conversations about the field of electrical and computer engineering that you may be interested in exploring further, and/or career options within the discipline.

Career advising: Students can discuss their career plans with their advisors. In addition, Duke's Career Center is available for career advising, support for career exploration, and assistance with job search skills such as networking, writing professional documents, and interviewing in preparation for securing summer internships, full-time employment, and other professional opportunities.

Information on Internships and Employment

Information on internship and employment opportunities is posted on the website of the Duke University Career Center: <http://www.studentaffairs.duke.edu/career>. In addition to maintaining the websites mentioned above, the Career Center organizes various career-related activities. These include (a) career advice sessions, (b) career skills workshops, (c) providing information about specific industries and opportunities, (d) alumni connections, and (d) workshops and seminars on internship and employment that are specific for engineering or ECE students. The workshops and seminars are announced via emails and posted on the plasma screens in the engineering buildings. The Career Center is located in Smith Warehouse at 114 S. Buchanan Blvd, Bay 5, 2nd floor, and may be reached at 919-660-1050.

In addition to the Career Center, Russell Holloway (russell.holloway@duke.edu), Associate Dean of Corporate and Industry Relations in the Pratt School of Engineering and Kirsten Shaw (Kirsten.shaw@duke.edu), Associate Director of Corporate and Industry Relations, help Pratt students connect with corporations for internship opportunities. For more information, see <http://www.pratt.duke.edu/undergraduate-internship>.

Information on internships and employment is sometimes sent directly to the ECE faculty or the department. When this happens, the information will be distributed to ECE students via emails from the DUS Assistant, Ms. Ellen Currin.

Appendix A: Sample Programs of Study for the ECE Major and Select Second Majors, Minors, and Special Programs

Table A.1
Electrical and Computer Engineering (ECE) Major

First Year	
Fall Semester	Spring Semester
EGR 103L (53L) Computational Methods in Engineering	ECE 110L (27L) Fundamentals of ECE
Math 111L (31L) Introductory Calculus I	Math 112L (32L) Introductory Calculus II
Chem 101DL (31L) Core Concepts in Chemistry ¹	Physics 151L (61L) Introductory Mechanics ²
Writing 101(20) / Social Science or Humanities Elective 1	Social Science or Humanities Elective 1 / Writing 101(20)
Sophomore Year	
Fall Semester	Spring Semester
ECE 280L (54L) Signals and Systems	ECE 230L (51L) Microelectronic Devices and Circuits
COMPSCI 201 (100) Data Structures and Algorithms	ECE 250L Computer Architecture
Math 212 (103) Multivariable Calculus	Math 216 (107) Linear Algebra & Differential Equations
Physics 152L (62L) Intro Electricity, Magnetism, Optics ²	Biology Elective ³
Social Science or Humanities Elective 2	Social Science or Humanities Elective 3
Junior Year	
Fall Semester	Spring Semester
ECE 270L (53L) Electromagnetic Fields	ECE Elective 1 ⁵
ECE Concentration Elective 1 ⁴	ECE Concentration Elective 2
Math 353 (108) Ordinary & Partial Differential Equations	Statistics Elective ⁶
Social Science or Humanities Elective 4	Social Science or Humanities Elective 5
Senior Year	
Fall Semester	Spring Semester
ECE Elective 2 or Approved ECE Design Elective ⁷	Approved ECE Design Elective or ECE Elective 2
ECE Concentration Elective 3	ECE Concentration Elective 4
Free Elective	Free Elective
Free Elective	Free Elective

1. AP credit for Chem 20(18) or 21(19) is also acceptable.
2. See also the Physics requirements on [p.5](#).
3. Biology Elective selected from the list of approved Biology electives, found in [Appendix E](#).
4. ECE Concentration Electives: Four courses selected from the set approved for the ECE program. Courses must be selected from at least two areas, and at least two courses must be from the same area. See [Appendix D](#) for a complete course listing.
5. ECE Elective: Any ECE course at the 300(100) level or above.
6. Statistics Elective selected from the list of approved Statistics electives, found in [Appendix E](#).
7. Approved ECE Design Elective: Approved Electrical & Computer Engineering Design Elective taken after meeting all Math, Science, and ECE Core curriculum requirements. In addition, each approved design elective has one or more pre-requisite upper-level ECE courses. The elected design course may not simultaneously also count as an ECE Concentration Elective or ECE Elective. See [Appendix E](#) for a list of all currently approved Design courses.

Table A.2
ECE with Computer Science (COMPSCI) Second Major

First Year	
Fall Semester	Spring Semester
EGR 103L (53L) Computational Methods in Engineering	ECE 110L (27L) Fundamentals of ECE
Math 111L (31L) Introductory Calculus I	Math 112L (32L) Introductory Calculus II
Chem 101DL (31L) Core Concepts in Chemistry ¹	Physics 151L (61L) Introductory Mechanics ²
Writing 101(20) / Social Science or Humanities Elective 1	Social Science or Humanities Elective 1 / Writing 101(20)
Sophomore Year	
Fall Semester	Spring Semester
ECE 280L (54L) Signals and Systems	ECE 230L (51L) Microelectronic Devices and Circuits
COMPSCI 201 (100) Data Structures and Algorithms	ECE 250L Computer Architecture
Math 212 (103) Multivariable Calculus	Math 216 (107) Linear Algebra & Differential Equations
Physics 152L (62L) Intro Electricity, Magnetism, Optics ²	Biology Elective ³
Social Science or Humanities Elective 2	Social Science or Humanities Elective 3
Junior Year	
Fall Semester	Spring Semester
ECE 270L (53L) Electromagnetic Fields	ECE 350L Digital Systems
COMPSCI 310 (110) Operating Systems	COMPSCI 308 (108) Software Design & Implementation
Math 353 (108) Ordinary & Partial Differential Equations	Statistics Elective ⁴
Social Science or Humanities Elective 4	ECE Concentration Elective ⁵
Senior Year	
Fall Semester	Spring Semester
ECE Elective 1 ⁶ or ECE Digital Systems Elective ⁷	ECE Elective 1 or ECE Digital Systems Elective
ECE Elective 2 or ECE/COMPSCI Design Elective ⁸	ECE Elective 2 or ECE/COMPSCI Design Elective
COMPSCI 330 (130) Design & Analysis of Algorithms ⁹	COMPSCI Elective ¹⁰
Social Science or Humanities Elective 5	Free Elective

1. AP credit for Chem 20(18) or 21(19) is also acceptable.
2. See also the Physics requirements on [p.5](#).
3. Biology Elective selected from the list of approved Biology electives, found in [Appendix E](#).
4. Statistics Elective selected from the list of approved Statistics electives, found in [Appendix E](#).
5. ECE Concentration Elective: One course selected from the set of approved ECE Concentration Electives *from outside the Computer Engineering and Digital Systems area*. See [Appendix D](#) for a complete course listing. For the ECE with COMPSCI second major, the four-course ECE Concentration requirement is satisfied by taking this one non-Digital Systems ECE Concentration elective in addition to three other courses built into the ECE with COMPSCI second major curriculum: ECE 350L, COMPSCI 310 (110), and an ECE Digital Systems Elective.
6. ECE Elective: Any ECE course at the 300(100) level or above.
7. ECE Digital Systems Elective: One course from the Digital Systems area in the list of Approved ECE Concentration Area electives (see [Appendix D](#)).
8. Approved ECE/COMPSCI Design Elective: Approved ECE/COMPSCI Design Elective taken after meeting all Math, Science, and ECE Core curriculum requirements. In addition, each approved design elective has one or more pre-requisite upper-level ECE courses. The elected design course may not simultaneously also count as an ECE Concentration Elective or ECE Elective. See [Appendix E](#) for a list of all currently approved Design courses.
9. Students who matriculated prior to Fall 2013 may substitute COMPSCI 334(140) or 220(150) for 330(130)
10. COMPSCI Elective: Any COMPSCI elective at the 200 level or above.

Table A.3a
ECE with BME Second Major (matriculating classes ≤ 2010)

Freshman Year	
Fall Semester	Spring Semester
EGR 103L (53L) Computational Methods in Engineering	Chem 210DL (32L) Mod Apps Chem Principles or Chem 201DL (151L) Organic Chemistry
Math 111L (31L) Introductory Calculus I	Math 112L (32L) Introductory Calculus II
Chem 101DL (31L) Core Concepts in Chemistry ¹	Physics 151L (61L) Introductory Mechanics ²
Writing 101(20) / Social Science or Humanities Elective 1	Social Science or Humanities Elective 1 / Writing 101(20)
Sophomore Year	
Fall Semester	Spring Semester
ECE 110L (27L) Fundamentals of ECE	ECE 230L (51L) Microelectronic Devices and Circuits
COMPSCI 201 (100) Data Structures and Algorithms	ECE 280L (54L) Signals and Systems
Math 212 (103) Multivariable Calculus	Math 216 (107) Linear Algebra & Differential Equations
Physics 152L (62L) Intro Electricity, Magnetism, Optics ²	BME 260L (100L) Modeling Cell & Molecular Systems
Biology 201L (101L) Molecular Biology	EGR 201L (75L) Mechanics of Solids
Junior Year	
Fall Semester	Spring Semester
ECE 270L (53L) Electromagnetic Fields	ECE Concentration Elective 1 ³
ECE 250L Computer Architecture	BME 354L (154L) Biomed Electronics and Measurement II
Math 353 (108) Ordinary & Partial Differential Equations	BME 301L (201L) Bioelectricity or BME 303 (233) Modern Diagnostic Imaging Systems ^{5,6}
ME 221L (83L) Structure and Properties of Solids	Statistics Elective ⁷
Social Science or Humanities Elective 2	Social Science or Humanities Elective 3
Senior Year	
Fall Semester	Spring Semester
ECE Elective ⁴ or ECE Concentration Elective 2	ECE Elective or ECE Concentration Elective 2
BME design: BME 436L (236L) or 464L (264L)	Physiology or Life Science Elective ⁶
BME Area Elective ⁵	BME General Elective
Social Science or Humanities Elective 4	Social Science or Humanities Elective 5

1. Students are required to have Chem 21 (19) or take Chem 101DL (31L) or Chem 110DL (43L).
2. See also the Physics requirements on [p.5](#).
3. ECE Concentration Electives: Two courses selected from the set approved for the ECE program. Both courses must be selected from the same area. See [Appendix D](#) for a complete course listing.
4. ECE Elective: Any ECE course at the 300 (100) level or above.
5. If BME 301L (201L) is taken, the Area Elective must be from the Bioelectricity Area
If BME 303 (233) is taken, the Area Elective must be from the Imaging and Sensors Area
See the BME Undergraduate Program Handbook for details.
6. If BME 303 (233) is taken, choose from approved list of Physiology Electives
If BME 301L (201L) is taken, choose from the approved list of Life Science Electives
See the BME Undergraduate Program Handbook for details.
7. Statistics Elective selected from the list of approved Statistics electives, found in [Appendix E](#).

Table A.3b
ECE with BME Second Major (matriculating classes ≥ 2011)

Freshman Year	
Fall Semester	Spring Semester
EGR 103L (53L) Computational Methods in Engineering	Biology 201L (101L) Molecular Biology <i>[alt; Chem 210DL (32L) or Chem 201DL (151L)]</i>
Math 111L (31L) Introductory Calculus I	Math 112L (32L) Introductory Calculus II
Chem 101DL (31L) Core Concepts in Chemistry ¹	Physics 151L (61L) Introductory Mechanics ²
Writing 101(20) / Social Science or Humanities Elective 1	Social Science or Humanities Elective 1 / Writing 101(20)
Sophomore Year	
Fall Semester	Spring Semester
ECE 110L (27L) Fundamentals of ECE	ECE 230L (51L) Microelectronic Devices and Circuits
EGR 201L (75L) Mechanics of Solids	ECE 280L (54L) Signals and Systems
Math 212 (103) Multivariable Calculus	Math 216 (107) Linear Algebra & Differential Equations
Physics 152L (62L) Intro Electricity, Magnetism, Optics ²	COMPSCI 201 (100) Data Structures and Algorithms
BME 244L (144L) Quantitative Physiology <i>[alt: Bio 201L(Bio 101L)]</i>	Chem 210DL (32L) Apps Chem Principles or Chem 201DL (151L) Organic Chemistry <i>[alt: BME 244L (BME 144L)]</i>
Junior Year	
Fall Semester	Spring Semester
ECE 270L (53L) Electromagnetic Fields	ECE Concentration Elective 1 ³
ECE 250L Computer Architecture	BME 354L (154L) Biomed Electronics and Measurement II
Math 353 (108) Ordinary & Partial Differential Equations	BME 301L (201L) Bioelectricity or BME 303 (233) Modern Diagnostic Imaging Systems ⁵
ME 221L (83L) Structure and Properties of Solids	Statistics Elective ⁶
BME 260L (100L) Modeling Cell & Molecular Systems	Social Science or Humanities Elective 2
Senior Year	
Fall Semester	Spring Semester
ECE Elective ⁴ or ECE Concentration Elective 2	ECE Elective or ECE Concentration Elective 2
BME design: BME 436L (236L) or 464L (264L)	BME General Elective
BME Area Elective ⁵	Social Science or Humanities Elective 4
Life Science Elective ⁷	Social Science or Humanities Elective 5
Social Science or Humanities Elective 3	

- Students are required to have Chem 21 (19) or take Chem 101DL (31L) or Chem 110DL (43L).
- See also the Physics requirements on [p.5](#).
- ECE Concentration Electives: Two courses selected from the set approved for the ECE program. Both courses must be selected from the same area. See [Appendix D](#) for a complete course listing.
- ECE Elective: Any ECE course at the 300 (100) level or above.
- If BME 301L (201L) is taken, the Area Elective must be from the Bioelectricity Area
If BME 303 (233) is taken, the Area Elective must be from the Imaging and Sensors Area
See the BME Undergraduate Program Handbook for details.
- Statistics Elective selected from the list of approved Statistics electives, found in [Appendix E](#).
- See the BME Undergraduate Program Handbook for a list of approved Life Science Electives.

Table A.4
Electrical and Computer Engineering (ECE) with Physics Second Major
(with one Math AP credit)

First Year	
Fall Semester	Spring Semester
EGR 103L (53L) Computational Methods in Engineering	ECE 110L (27L) Fundamentals of ECE
Math 122L (41L) Calculus II	Math 212 (103) Multivariable Calculus
Chem 101DL (31L) Core Concepts in Chemistry ¹	Physics 151L (61L) Introductory Mechanics
Writing 101(20) / Social Science or Humanities Elective 1	Social Science or Humanities Elective 1 / Writing 101(20)
Sophomore Year	
Fall Semester	Spring Semester
ECE 280L (54L) Signals and Systems	ECE 230L (51L) Microelectronic Devices and Circuits
COMPSCI 201 (100) Data Structures and Algorithms	ECE 250L Computer Architecture
Math 216 (107) Linear Algebra & Differential Equations	Math 353 (108) Ordinary & Partial Differential Equations
Physics 152L (62L) Intro Electricity, Magnetism, Optic	Physics 361 (181) Intermediate Mechanics
Social Science or Humanities Elective 2	Social Science or Humanities Elective 3
Junior Year	
Fall Semester	Spring Semester
ECE 270L (53L) Electromagnetic Fields	Physics Elective (200-level or above)
ECE Concentration Elective 1 ²	ECE Concentration Elective 2
Physics 264L (143L) Optics and Modern Physics	Statistics Elective ³
Physics 362 (182) Electricity & Magnetism	Biology Elective ⁴
Social Science or Humanities Elective 4	
Senior Year	
Fall Semester	Spring Semester
ECE Elective ⁵ or Approved ECE Design Elective ⁶	ECE Elective or Approved ECE Design Elective
ECE Concentration Elective 3	ECE Concentration Elective 4
Physics 464 (211) Quantum Mechanics I	Physics Elective (300-level or above)
Physics 417S(217S) Advanced Physics Lab & Seminar	ECE 311 (176) Thermal Physics (crosslisted as Physics 363)
Social Science or Humanities Elective 5	

1. AP credit for Chem 20 (18) or 21 (19) is also acceptable.
2. ECE Concentration Electives: Four courses selected from the set approved for the ECE program. Courses must be selected from at least two areas, and at least two courses must be from the same area. See [Appendix D](#) for a complete course listing.
3. Statistics Elective selected from the list of approved Statistics electives, found in [Appendix E](#).
4. Biology Elective selected from the list of approved Biology electives, found in [Appendix E](#).
5. ECE Elective: Any ECE course at the 300 (100) level or above. Note that ECE 311 (176), which is required for the Physics major, counts as a second ECE elective.
6. Approved ECE Design Elective: Approved Electrical & Computer Engineering Design Elective taken after meeting all Math, Science, and ECE Core curriculum requirements. In addition, each approved design elective has one or more pre-requisite upper-level ECE courses. The elected design course may not simultaneously also count as an ECE Concentration Elective or ECE Elective. See [Appendix E](#) for a list of all currently approved Design courses.

Table A.5
Electrical and Computer Engineering (ECE) Major
 Course plan for students in the Focus program

The Focus program is an opportunity for first year students to study topics in depth. For more information about the program, please visit the [Focus Program website](#).

These sample programs below illustrate two possible courses of study for Focus participation in the fall semester of the freshman year depending upon the number and distribution of AP credits. Students with different AP credits may have different options.

First Year Schedule for Matriculants with AP Credit in Math or Chemistry

Students can follow the [standard ECE major program of study](#) beginning in the sophomore year. The two Focus Seminars take the place of two Free Electives, and the fifth Social Science or Humanities elective takes the place of one Free Elective.

First Year	
Fall Semester	Spring Semester
EGR 103L (53L) Computational Methods in Engineering	ECE 110L (27L) Fundamentals of ECE
Math 111L (31L) Introductory Calculus I or Chem 101DL (31L) Core Concepts in Chemistry	Math 112L (32L) Introductory Calculus II
Focus Seminar 1	Physics 151L (61L) Introductory Mechanics ¹
Focus Seminar 2	Writing 101(20)
Focus Interdisciplinary Discussion Course (0.5 credit)	

1. See also the Physics requirements on [p.5](#).

First Year Schedule for Matriculants with AP Credit in Math and Chemistry

Students can follow the [standard ECE major program of study](#) beginning in the sophomore year. The two Focus Seminars take the place of two Free Electives, and the fifth Social Science or Humanities elective takes the place of one additional Free Elective. In addition, the courses in the Math sequence can be taken one semester earlier than in the ECE sample program.

First Year	
Fall Semester	Spring Semester
EGR 103L (53L) Computational Methods in Engineering	ECE 110L (27L) Fundamentals of ECE
Math 122L (41L) Calculus II	Math 212 (103) Multivariable Calculus
Focus Seminar 1	Physics 151L (61L) Introductory Mechanics ¹
Focus Seminar 2	Writing 101(20)
Focus Interdisciplinary Discussion Course (0.5 credit)	

1. See also the Physics requirements on [p.5](#).

Table A.6
Electrical and Computer Engineering (ECE) Major
(with Junior Fall semester at the Marine Lab)

First Year	
Fall Semester	Spring Semester
EGR 103L (53L) Computational Methods in Engineering	ECE 110L (27L) Fundamentals of ECE
Math 111L (31L) Introductory Calculus I	Math 112L (32L) Introductory Calculus II
Chem 101DL (31L) Core Concepts in Chemistry ¹	Physics 151L (61L) Introductory Mechanics ²
Writing 101(20) / Social Science or Humanities Elective 1	Social Science or Humanities Elective 1 / Writing 101(20)
Sophomore Year	
Fall Semester	Spring Semester
ECE 280L (54L) Signals and Systems	ECE 230L (51L) Microelectronic Devices and Circuits
COMPSCI 201 (100) Data Structures and Algorithms	ECE 250L Computer Architecture
Math 212 (103) Multivariable Calculus	Math 216 (107) Linear Algebra & Differential Equations
Physics 152L (62L) Intro Electricity, Magnetism, Optics ²	Social Science or Humanities Elective 3
Social Science or Humanities Elective 2	
Junior Year	
Fall Semester (at the Marine Lab)	Spring Semester
ECE Elective 1 ³ [ECE 493 Independent Study]	ECE 270L (53L) Electromagnetic Fields
Biology Elective ⁴	ECE Concentration Elective 1 ⁵
Math 353 (108) Ordinary & Partial Differential Equations	Statistics Elective ⁶
Social Science or Humanities Elective 4	Social Science or Humanities Elective 5
Senior Year	
Fall Semester	Spring Semester
ECE Elective 2 or Approved ECE Design Elective ⁷	ECE Elective 2 or Approved ECE Design Elective
ECE Concentration Elective 2	ECE Concentration Elective 4
ECE Concentration Elective 3	Free Elective
Free Elective	Free Elective
Free Elective	

1. AP credit for Chem 20 (18) or 21 (19) is also acceptable.
2. See also the Physics requirements on [p.5](#).
3. ECE Elective: Any ECE course at the 300 (100) level or above.
4. Biology Elective selected from the list of approved Biology electives, found in [Appendix E](#). Note that Biology 275A (144) is taught at the Marine Lab; other Biology courses taught on the main campus may be available via distance learning classrooms.
5. ECE Concentration Electives: Four courses selected from the set approved for the ECE program. Courses must be selected from at least two areas, and at least two courses must be from the same area. See [Appendix D](#) for a complete course listing.
6. Statistics Elective selected from the list of approved Statistics electives, found in [Appendix E](#).
7. Approved ECE Design Elective: Approved Electrical & Computer Engineering Design Elective taken after meeting all Math, Science, and ECE Core curriculum requirements. In addition, each approved design elective has one or more pre-requisite upper-level ECE courses. The elected design course may not simultaneously also count as an ECE Concentration Elective or ECE Elective. See [Appendix E](#) for a list of all currently approved Design courses.

Appendix B:
Check Sheets for the ECE Major and Select Second Majors

Electrical & Computer Engineering

ECE Major Requirements

Name _____

	Semester Taken	Grade	Notes
Writing			
1. Writing 101(20)			
Mathematics and Natural Science			
2. MATH 111L (31L) [or AP credit for Math 21 (31)]			
3. MATH 112L (32L) [or AP credit for Math 22 (32)]			
4. MATH 212 (103)			
5. MATH 216 (107)			
6. MATH 353 (108)			
7. Statistics elective _____			Approved options: STA 130 (113) or Math 230 (135) or ECE 380 or ECE 555 (255)
8. CHEM 101DL (31L) [or AP credit for Chem 20 (18) or 21(19)]			
9. PHY 151L (61L) [or AP credit for Physics 25 (61)] *			
10. PHY 152L (62L) [or AP credit for Physics 26 (62)] *			
11. Biology elective [or AP credit for Biology 20 (19)] _____			Approved options: Bio 201L (101L), 202L (102L), 275LA (144), or 311 (147)
ECE Foundation Courses			
12. EGR 103L (53L)			
13. CompSci 201 (100)			
14. ECE 110L (27L)			
15. ECE 230L (51L)			
16. ECE 250L			
17. ECE 270L (53L)			
18. ECE 280L (54L)			
ECE Concentration & Application Electives			
19. ECE Concentration Elective 1 ** _____			
20. ECE Concentration Elective 2 ** _____			
21. ECE Concentration Elective 3 ** _____			
22. ECE Concentration Elective 4 ** _____			
23. ECE Elective _____			Any ECE course at the 300(100)-level or above Any ECE course at the 300(100)-level or above Approved options: ECE 449 (135), 458, 459 (154), 539 (261), or 559 (251)
24. ECE Elective _____			
25. ECE Design Elective _____			
Humanities and Social Sciences ***			
26. _____			
27. _____			
28. _____			
29. _____			
30. _____			
Electives			
31. _____			
32. _____			
33. _____			
34. _____			

* To satisfy the Physics Requirement, students must take (or have AP credit for) PHYSICS 151L(61L) and 152L(62L), and at least one physics course must be taken at Duke. If a student has AP credit for both 25 (61) & 26 (62), then one of PHYSICS 153L (63L), 264 (143), 361 (181), 362 (182), or 363 (176)) must be taken. Alternatively, AP credit for 26 (62) can be waived by taking 152L (62L). You do not have the option of taking PHY 151 (61) and then using AP for PHY 26 (62)--unless the *only* Physics AP credit you have is for PHY 26 (62).

** Courses must be selected from at least two areas, and at least two courses must be from the same area. The same course may not be used as a Concentration Elective and count as a required Design Elective or ECE Elective.

*** Five required. At least one SS and 2 from remaining areas of knowledge (FL, CZ, ALP). For depth, two must be from the same approved department or program --and one course must be at the 200-level, or above. See Pratt Policies & Procedures for detailed list of approved departments and programs (<http://www.pratt.duke.edu/undergrad/policies/3505#humanities>).

Electrical & Computer Engineering
ECE with BME Second Major (matric \geq 2011)

Name _____

Semester Taken Grade Notes

Writing

1. Writing 101(20)		
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Mathematics and Natural Science

2. MATH 111L (31L) [or AP credit for Math 21 (31)]		
3. MATH 112L (32L) [or AP credit for Math 22 (32)]		
4. MATH 212 (103)		
5. MATH 216 (107)		
6. MATH 353 (108)		
7. Statistics elective _____		
8. CHEM 101DL (31L) [AP credit for Chem 21(19)]		
9. CHEM 201DL (151L) or CHEM 210DL(32L)		
10. PHY 151L (61L) [or AP credit for Physics 25 (61)] *		
11. PHY 152L (62L) [or AP credit for Physics 26 (62)] *		
12. Biology 201L (101L) [cannot use AP credit]		
13. Life Science Elective ** _____		

Approved options: STA 130 (113) or Math 230 (135)
 or ECE 380 or ECE 555 (255)
 Alternate option : CHEM 110DL (43L)

ECE and BME Courses

14. EGR 103L (53L)		
15. CompSci 201 (100)		
16. ECE 110L (27L)		
17. ECE 230L (51L)		
18. ECE 250L		
19. ECE 270L (53L)		
20. ECE 280L (54L)		
21. ECE Concentration Elective 1 *** _____		
22. ECE Concentration Elective 2 *** _____		
23. ECE Elective _____		
24. BME 244L (144L)		
25. EGR 201L (75L)		
26. ME 221L (83L)		
27. BME 260L (100L)		
28. BME 354L (154L)		
29. BME 301L (201L) or BME 303 (233) ****		
30. BME Area Elective ***** _____		
31. BME General Elective _____		
32. BME Design Elective _____		

Any ECE course at the 300(100)-level or above

Approved options: BME 436L (236L) or 464L (264L)

Humanities and Social Sciences *****

Area

33. _____		
34. _____		
35. _____		
36. _____		
37. _____		

* To satisfy the Physics Requirement, students must take (or have AP credit for) PHYSICS 151L(61L) and 152L(62L), and at least one physics course must be taken at Duke. If a student has AP credit for both 25 (61) & 26 (62), then one of PHYSICS 153L (63L), 264 (143), 361 (181), 362 (182), or 363 (176)) must be taken. Alternatively, AP credit for 26 (62) can be waived by taking 152L (62L). You do not have the option of taking PHY 151 (61) and then using AP for PHY 26 (62)--unless the *only* Physics AP credit you have is for PHY 26 (62).

** If BME 303 (233) is taken, choose from approved list of Physiology Electives (see BME Handbook Table 7a)
 If BME 301L (201L) is taken, choose from the approved list of Life Science Electives (see BME Handbook Table 7)

*** Courses must be selected from the same concentration area.

**** If BME 301L (201L) is taken the Area Elective must be from the Bioelectricity Area
 If BME 303 (233) is taken the Area Elective must be from the Imaging and Sensors Area

***** Five required. At least one SS and 2 from remaining areas of knowledge (FL, CZ, ALP). For depth, two must be from the same approved department or program --and one course must be at the 200-level, or above. See Pratt Policies & Procedures for detailed list of approved departments and programs (<http://www.pratt.duke.edu/undergrad/policies/3505#humanities>).

Appendix C: Major-specific Requirements for the Minor in ECE

The basic requirements for a minor in ECE (described in detail on [p.8](#)) include three courses at the foundational/core level and two upper-level courses. Below are major-specific modifications (e.g., courses that are disallowed for the Minor in ECE because students are required to take essentially equivalent courses for their primary major).

Majors in Pratt

ME Major/ECE Minor: Path #1

If an ME major has taken EGR224L(119L), then

- **Core courses (choose at least one, and up to three)¹:**
 - *ECE 230L(51L) Microelectronic Devices & Circuits,*
 - *ECE 250L Computer Architecture,*
 - *ECE 270L(53L) Electromagnetic Fields.*
- **Upper-level courses:** Take a minimum of two upper-level courses². Student may choose to replace up to two (of three) ECE core courses with additional upper-level ECE courses to meet the minimum requirement of 5 ECE courses.

¹ An ME major cannot take ECE 110L(27L) or ECE 280L(54L), however, EGR 224L(119L) will satisfy prerequisites in lieu of ECE 110L(27L) and ECE 280L(54L).

² Because the ME major requires courses essentially equivalent to ECE 110L(27L) and ECE 280L(54L), a student majoring in ME can choose to reduce the number of ECE core courses taken to fulfill Minor requirements to as few as one, and take additional upper-level courses to meet the minimum requirement of 5 ECE courses.

ME Major/ECE Minor: Path #2

If an ME major has taken ECE 110L(27L), then

- Student should take ECE 280L in lieu of EGR 224L(119L) to satisfy ME major requirement, but ECE 280L will not count toward the ECE minor.
- **Core courses (choose at least two, and up to three):**
 - *ECE 110L(27L) Fundamentals of ECE*
 - *ECE 230L(51L) Microelectronic Devices & Circuits,*
 - *ECE 250L Computer Architecture,*
 - *ECE 270L(53L) Electromagnetic Fields.*
- **Upper-level courses:** Take a minimum of two upper-level courses¹. Student may choose to replace one (of three) ECE core courses with an additional upper-level ECE course to meet the minimum requirement of 5 ECE courses.

¹ Because the ME major requires course essentially equivalent to ECE 280L(54L), a student majoring in ME can choose to reduce the number of ECE core courses taken to fulfill Minor requirements to as few as two, and take additional upper-level courses to meet the minimum requirement of 5 ECE courses.

BME Major/ECE Minor

- **Core courses (choose at least one, and up to three)^{1,2}:**
 - *ECE 230L(51L) Microelectronic Devices & Circuits,*
 - *ECE 250L Computer Architecture,*
 - *ECE 270L(53L) Electromagnetic Fields.*
- **Upper-level courses:** Take a minimum of two upper-level courses³. Student may choose to replace up to two (of three) ECE core courses with additional upper-level ECE courses to meet the minimum requirement of 5 ECE courses.

¹ ECE 110L(27L) cannot count toward the ECE Minor (ECE 110L(27L) is required for BME major)

² ECE 280L(54L) cannot count toward the ECE Minor (ECE 280L(54L) is required for BME major)

³ Because the BME major requires ECE 110L(27L) and ECE 280L(54L) or their equivalents, a student majoring in BME can choose to reduce the number of ECE core courses taken to fulfill Minor requirements to as few as one, and take additional upper-level courses to meet the minimum requirement of 5 ECE courses.

Majors in Trinity

- EGR 103L(53L) pre-requisite for ECE 110L(27L) waived for students who have already taken COMPSCI 201.
- Physics 142L or Physics 162L are considered equivalent to Physics 152L for purposes of meeting ECE course prerequisites.

COMPSCI Major/ECE Minor

- **Core courses (choose at least two, and up to three)¹:**
 - *ECE 110L(27L) Fundamentals of ECE,*
 - *ECE 230L(51L) Microelectronic Devices & Circuits,*
 - *ECE 270L(53L) Electromagnetic Fields,*
 - *ECE 280L(54L) Signals & Systems*
- **Upper-level courses:** Take a minimum of two upper-level courses². Student may choose to replace up to one (of three) ECE core courses with additional upper-level ECE courses.

¹ ECE 250L cannot count toward the ECE Minor (COMPSCI 250(104) is equivalent)

² Because the COMPSCI major requires COMPSCI 250 (equivalent to ECE 250L), a student majoring in COMPSCI can choose to reduce the number of ECE core courses taken to fulfill Minor requirements to as few as two, and take additional upper-level courses to meet the minimum requirement of 5 ECE courses.

PHYSICS Major/ECE Minor

- **Core courses (choose at least two, and up to three)¹:**
 - *ECE 110L (27L) Fundamentals of ECE,*
 - *ECE 230L (51L) Microelectronic Devices & Circuits,*
 - *ECE 250L Computer Architecture,*
 - *ECE 280L (54L) Signals & Systems*
- **Upper-level courses:** Take a minimum of two upper-level courses². Student may choose to replace up to one (of three) ECE core courses with additional upper-level ECE courses.

¹ ECE 270L(53L) cannot count toward the ECE Minor due to a substantially equivalent requirement for the Physics major.

² Because the PHYSICS major requires courses with significant overlap with ECE 270L(53L), a student majoring in PHYSICS can choose to reduce the number of ECE core courses taken to fulfill Minor requirements to as few as two, and take additional upper-level courses to meet the minimum requirement of 5 ECE courses.

Appendix D: Approved ECE Concentration Elective Areas and Courses

Computer Engineering and Digital Systems

The discipline concerned with the operation and design of computers and computer-based systems. Although analog computers, in which electrical signals directly represent physical quantities, were historically important in the development of modern computers (and continue to be used in some systems), digital computers are predominant and are the primary focus of the computer engineering in the ECE department in the Pratt School. The Computer Engineering and Digital Systems curriculum begins with a core course in computer architecture (ECE 250L). Students can then study logic design (ECE 350I – the foundation course), computer networking, VLSI chip design, and other advanced topics. Computer engineering interfaces strongly with many other areas of electrical engineering (electronics, electromagnetics, signal processing, and control theory) as well as with computer science.

- **FOUNDATION COURSE - ECE 350L Digital Systems [ECE 250L & COMPSCI 201(100)] - Note: for those who took ECE 52L Digital Systems, the Foundation Course is ECE 152 Intro to Computer Architecture (taught as ECE 496.04 in Sp13)**
- ECE 253(153) Intro to Operating Systems (C/L COMPSCI 310(110)) [COMPSCI 250(104) or ECE 250L or (ECE 152)^D]
- ECE 358(150)^D Introduction to Computer Networks (C/L COMPSCI 310(114))[COMPSCI 308(108) and COMPSCI 310(110) or equivalent]
- ECE 356(156) Computer Network Architecture [{ECE 250L or (52L)^D} and COMPSCI 308(108) and COMPSCI 310(110) or equivalent]
- ECE 459(154) Introduction to Embedded System [ECE 331L (163L) and {ECE 350L or (152)^D}]
- ECE 534(264) CAD for Mixed-Signal Circuits [ECE 331L(163L)]
- ECE 536(266) Synthesis & Verification of VLSI Systems [ECE 350L or (52L)^D]
- ECE 538(269) VLSI System Testing [ECE 350L or (52L)^D]
- ECE 539(261) Full Custom VLSI Design [{ECE 350L or (52L)^D}and ECE 331L(163L)]
- ECE 552(252) Advanced Computer Architecture I [COMPSCI 250(104) or {ECE 250L or (152)^D}]
- ECE 554(254) Fault-Tolerant and Testable Computer Systems[{ECE 250L or (152)^D} or COMPSCI 250(104)]
- ECE 555(255) Probability for Electrical and Computer Engineers [MATH 216(107)]
- ECE 556(256) Wireless Networking and Mobile Computing [ECE 356(156) or COMPSCI 310(114)]
- ECE 557(257) Performance and Reliability of Computer Networks [ECE 356(156) and ECE 555(255)]
- ECE 558(250) Computer Networks and Distributed Systems (C/L COMPSCI 514(214))
- ECE 559(251) Advanced Digital System Design [ECE 331L(163L) and {350L or (52L)^D}]
- ECE 590(299.03) Nanocomputing (Sp07, Sp12) [{ECE 250L or (152)^D} or COMPSCI 250(104)]
- ECE 652(259) Advanced Computer Architecture II [COMPSCI 550(220) or ECE 552(252)]

^DNo longer offered

Signal Processing, Communications, and Control Systems

The disciplines concerned with representing, storing, interpreting, and transmitting information in systems of finite capacity in the presence of interference and noise; with extracting information from speech, image, video, radar, sonar, and medical data signals; and with using information, including feedback information comparing actual and desired system states, for controlling, shaping and stabilizing system performance in the presence of noise, delay, and inertia. Applications include telecommunications, intra- and inter-system communications, remote sensing, imaging, robotics, feed-back stabilized electronics, and the remote control of electro-mechanical systems, both large and small.

- ECE 381(180) Fundamentals of Digital Signal Processing [ECE 280L(54L) and one of STA 130(113), MATH 230(135), ECE 380, or ECE 555(255)]
- ECE 382(141) Linear Control Systems [ECE 280L(54L)]
- ECE 483(184) Introduction to Digital Communication Systems [ECE 280L(54L) and one of STA 130(113), MATH 230(135) or ECE 555(255)]
- ECE 485 Digital Audio and Acoustic Signal Processing [ECE 280L(54L)]
- ECE 486(186) Wireless Communications Systems[ECE 280L(54L) and one of STA 130(113), MATH 230(135) or ECE 555(255)]
- ECE 488(189) Digital Image and Multidimensional Signal Processing [ECE 280L(54L) and one of STA 130(113), MATH 230(135) or ECE 555(255) or permission of instructor]
- ECE 495(195) Biological Signal Processing (F09) [ECE 280L(54L); one of STA 130(113), MATH 230(135) or ECE 555(255); and BIOLOGY 201L(25L) or 147; or permission of the instructor]
- ECE 590 (Sp14 and Sp15) Image and Video Processing

Solid-State Devices and Integrated Circuits

This area is concerned with the properties and manufacture of building-block devices (diodes, transistors, lasers) used in integrated circuits (IC's) to build electronic and photonic systems, and with their integration into circuits. Example applications include: digital computer components (CPUs, RAM, CDROM), telecommunications equipment components (parts essential for cell phones, digital switches, modems), and displays, which underlie a large array of consumer products (televisions, CD players, VCR's, etc.). It also encompasses the burgeoning field of microelectromechanical, micromechanical and microfluidic devices made possible by the fabrication techniques underlying integrated circuit manufacture.

- **FOUNDATION COURSE - ECE 330(162) Microelectronic Devices [ECE 230L(51L)] or ECE 331L(163) Integrated Circuits [ECE 230L(51L)] Note: Either may be taken as the Foundation Course; if both courses are taken, they both count as Concentration Courses.**
- ECE 526(216) Devices for Integrated Circuit [ECE 330(162)]
- ECE 527(217) Analog Integrated Circuits [ECE 526(216)]
- ECE 528(218) Integrated Circuit Engineering [ECE 330(162) or ECE 331L(163L)]
- ECE 529(219) Digital Integrated Circuits [ECE 330(162) and ECE 331L(163L)]
- ECE 539(261) Full Custom VLSI Design [ECE 250L(52L) and ECE 331L(163L)]
- ECE 532(262) Analog Integrated Circuit Design [ECE 330(162) or ECE 331L(163L)]
- ECE 534(264) CAD for Mixed-Signal Circuits [ECE 331L(163L)]

Electromagnetic Fields

The discipline concerned with the interaction of electromagnetic waves with materials. Applications of electromagnetics include microwave circuits (used in satellite communication systems, mobile/cellular radios, and aeronautical navigation instruments), optical fiber communication systems, radar (tracking, imaging, and guidance), radio astronomy, antennas (single and phased arrays), transmission lines and waveguides. Also, radio frequency (RF) signals and microwaves are used in numerous industrial, scientific and medical applications. These include: RF and microwave induced hyperthermia for cancer therapy, drying, sterilization, thawing and curing of materials (including the cooking of food!).

- ECE 571(271) Electromagnetic Theory [ECE 270L(53L)]
- ECE 572(272) Electromagnetic Communication Systems [ECE 270L(53L)]
- ECE 573(273) Optical Communication Systems [ECE 270L(53L) & 280L(54L)]
- ECE 575(275) Microwave Electronic Circuits [ECE 270L(53L)]
- ECE 577(277) Computational Electromagnetics [ECE 270(53L)]
- ECE 574(279) Waves in Matter [ECE 270(53L)]

Photonics

The discipline concerned with the application of optical and optoelectronic technologies in information science. Photonic applications include information transmission on fiber and free space networks, data storage on disks and volume media, visible and infrared imaging systems, and displays. The Duke photonics program emphasizes hands-on experience with optical systems in communications, sensing, and display applications. Photonic engineering at Duke spans experiences as diverse as logical layer analysis of network protocols over fiber systems, analysis and testing of fiber dispersion, materials studies for optical memory, design of 3D microscopes for biomedical imaging, testing of liquid crystal materials and interfaces, analysis and construction of quantum dynamic systems, and explorations of laser-material and laser-tissue interactions.

- **FOUNDATION COURSE - ECE 340L(122L) Optics & Photonics (F) [ECE 270L(53L)]**
- ECE 449(135) Opto-Electronic Design Projects [ECE core courses and at least one 300-level ECE courses]
- ECE 496(196) Applications of Photonic Devices (Sp09)
- ECE 545(225) Nanophotonics [ECE 270L(53L)]
- ECE 546(226) Optoelectronic Devices for Optical Fiber Network [ECE 526(216)]
- ECE 523(227)/PHYSICS 627(272) Quantum Information Science [ECE 521(211) or PHYSICS 464(211), or equivalent] (Note the similar but different ECE and PHYSICS course numbers!)
- ECE 573(273) Optical Communication Systems [ECE 270L(53L) & 280L(54L)]

Appendix E: Approved ECE Design, Biology, and Statistics Electives

Table E.1 Approved ECE Design Electives

#ECE 449 (135)	Opto-Electronic Design Projects (<i>typically offered in the Spring</i>)
#ECE 458	Engineering Software for Maintainability (<i>typically offered in the Spring</i>)
#ECE 459 (154)	Embedded Systems Design (<i>typically offered in the Fall</i>)
#ECE 539 (261)	CMOS VLSI Design Methodologies (<i>typically offered in the Fall</i>)
#ECE 559 (251)	Advanced Digital System Design (<i>typically offered every term</i>)
#ECE 495 (F12, F13)	Signal Processing System Design ^D

indicates courses that are approved as ECE/COMPSCI Design Electives

^DNo longer offered

Table E.2 Approved ECE Biology Courses

Biology 201L(101L)	Gateway to Biology: Molecular Biology
Biology 202L(102L)	Gateway to Biology: Genetics and Evolution
Biology 275A(144)	Biology for Engineers: Informing Engineering Decisions
Biology 311(147)	Systems Biology: An Introduction for the Quantitative Sciences

AP credit for Biology 20 (19) is also acceptable.

Table E.3 Approved ECE Statistics Courses

Statistics 130(113)	Probability and Statistics for Engineers
Math 230(135)	Probability
ECE 380	Introduction to Random Signals and Noise
ECE 555(255)	Probability for Electrical and Computer Engineers

If ECE 555(255) is elected, it may not be double-counted as an ECE Concentration Elective or ECE Elective. If ECE 380 is elected, it may not be double-counted as an ECE Elective.