

COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
**BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING –
CONTROLS, ROBOTICS & AUTONOMY MAJOR**
FOR STUDENTS GRADUATING IN CALENDAR YEAR 2020
132 CREDITS REQUIRED FOR GRADUATION

APPROVED
COMMITTEE OF UNDERGRADUATE
STUDENTS AND FACULTY

FALL SEMESTER FRESHMAN 2016		Credits	SPRING SEMESTER FRESHMAN 2017		Credits
CHEM 1035 General Chemistry Co: MATH 1025 or 1225		3	ENGL 1106 First-Year Writing Pre: ENGL 1105		3
CHEM 1045 General Chemistry Lab Co: CHEM 1035		1	MATH 1226 Calculus of a Single Variable Pre: MATH 1225		4
ENGL 1105 First-Year Writing		3	PHYS 2305 Foundations of Physics I Co: PHYS 2325 or MATH 1206 or MATH 1206H or MATH 1226 Pre: MATH 1205 or MATH 1205H or MATH 1225 or MATH 1206 or MATH 1206H or MATH 1226		4
MATH 1225 Calculus of a Single Variable (C-) Pre: Math Ready		4	ENGE 1216 Foundations of Engineering (C-) Pre: ENGE 1215		2
ENGE 1215 Foundations of Engineering (C-) Co: MATH 1225		2	ECE 1574 ⁽¹⁾ Engineering Problem Solving w/C++ (C-) Pre: ENGE 1024 or ENGE 1215, (MATH 1205 or MATH 1205H or MATH 1225)		3 ^[F,S]
CLE (Area 2, 3, or 7)		3	MATH 1114 Elementary Linear Algebra OR MATH 2114 Introduction to Linear Algebra Pre: MATH 1226 or a grade of at least B in MATH 1225		2-3
TOTAL		16	TOTAL		18-19
FALL SEMESTER SOPHOMORE 2017		Credits	SPRING SEMESTER SOPHOMORE 2018		Credits
MATH 2214 Introduction to Differential Equations (C-) Pre: 1114 or 1114H or 2114 or 2114H, (1206 or 1226)		3	MATH 2204 Introduction to Multivariable Calculus (C-) Pre: MATH 1226		3
PHYS 2306 Foundations of Physics I (C-) Pre: (MATH 1206 or MATH 1206H or MATH 1226), PHYS 2305		4	ECE 2204 ⁽¹⁾ Electronics (C-) Pre: 2004		3 ^[F,S,SI]
ECE 2004 ⁽¹⁾ Electric Circuit Analysis (C-) Pre: ENGE 1216; Co: MATH 2214		3 ^[F,S,SI]	ECE 2274 ⁽¹⁾ Electronic Networks Laboratory I (C-) Pre: 2074; Co: 2204		1 ^[F,S,SI]
ECE 2014 ⁽¹⁾ Engineering Professionalism in ECE (C-) Pre: Sophomore standing, Co: 2004 or 2504		2 ^[F,S]	ECE 2534 ⁽¹⁾ Microcontroller Programming and Interfacing (C-) Pre: 2504		4 ^[F,S]
ECE 2074 ⁽¹⁾ Electric Circuit Analysis Laboratory (C-) Pre: ENGE 1104 or ENGE 1204 or ENGE 1216. Co: 2004, MATH 2214		1 ^[F,S,SI]	ECE 2704 ⁽¹⁾ Signals and Systems (C-) Pre: (2004 or 2004H), 2074, (MATH 2214 or MATH 2214H)		3 ^[F,S]
ECE 2504 ⁽¹⁾ Introduction to Computer Engineering (C-) Pre: 1574		3 ^[F,S,SI]	CLE (Areas 2, 3, or 7)		3
TOTAL		16	TOTAL		17
FALL SEMESTER JUNIOR 2018		Credits	SPRING SEMESTER JUNIOR 2019		Credits
ECE 3004 ⁽²⁾ AC Circuit Analysis (C-) Pre: 2704		3 ^[F,S]	ECE 3714 ⁽²⁾ Introduction to Controls Systems I Pre: 2704		3 ^[S]
STAT 4714 Probability & Statistics for EE (C-) Pre: (MATH 2204 or MATH 2224)		3	ECE 2574 ⁽²⁾ Data Structures and Algorithms Pre: 1574		3 ^[F,S]
ENGL 3764 Technical Writing Pre: Junior standing		3	Free Elective		2-4
ECE 3074 ⁽²⁾ AC Circuit Analysis Laboratory (C-) Pre: 2074; Co: 3004		1 ^[F,S]	Controls, Robotics & Autonomy Technical Elective from list		3 ^[F,S]
ECE 3105 ⁽²⁾ Electromagnetic Fields Pre: PHYS 2306, (MATH 2204 or MATH 2204H or MATH 2224 or MATH 2224H), (ECE 2004 or ECE 2004H)		3 ^[F,S,SI]	MATH 3144 Linear Algebra I or MATH 4144 ⁽²⁾ Linear Algebra II Pre: (3034 or 2534), (2114 or 2114H or 2405H) for 3144; 3144 for 4144.		3 ^[F,S]
ECE 3704 ⁽²⁾ Continuous & Discrete System Theory Pre: 2704		3 ^[F,S,SI]	CLE (Area 6)		1
TOTAL		16	TOTAL		15-17
FALL SEMESTER SENIOR 2019		Credits	SPRING SEMESTER SENIOR 2020		Credits
ISE 2014 Engineering Economy Pre: ENGE 1024 or ENGE 1215 or BC 1224		2	ECE 4806 ⁽¹⁾ Senior Design Project Pre: 4805		3 ^[F,S]
Controls, Robotics & Autonomy Elective Choose from: (4704, 4524, or 4580) ⁽²⁾		3-4	Controls, Robotics & Autonomy Technical Elective from list		3
Controls, Robotics & Autonomy Technical Elective from list		3	Controls, Robotics & Autonomy Technical Elective from list		3
ECE 4805 ⁽¹⁾ Senior Design Project (C-) See timetable for prereqs		3 ^[F,S]	CLE (Areas 2, 3, or 7)		3
Engineering and Science Elective from list		3	CLE (Areas 2, 3, or 7)		3

CLE (Areas 2, 3, or 7)	3		
TOTAL	17-18	TOTAL	15

General Information about Checksheet: Superscripted annotation after the course number (1) indicates core course of the degree while (2) indicates courses associated with the major. Additionally (F, S, SI, SII) in credits column indicates terms when a course is expected to be offered. Course offerings are subject to change and the availability of sufficient resources. Students should confirm course offerings in advance with their department.

Curriculum for Liberal Education (CLE)

Consult the CLE Alphabetical Listing at: <http://www.cle.prov.vt.edu/guides/alpha.html>, CLE courses need to be completed prior to graduation.

CLE Area 1: Writing and Discourse (6 hrs)	ENGL 1105	(3)	ENGL 1106	(3)
CLE Area 2: Ideas, Cultural Traditions, Values Electives (6 hrs)		(3)		(3)
CLE Area 3: Society & Human Behavior electives (6 hrs)		(3)		(3)
CLE Area 4: Scientific Reasoning and Discovery (8 hrs)	PHYS 2305	(4)	PHYS 2306	(4)
CLE Area 5: Quantitative and Symbolic Reasoning (8 hrs)	MATH 1225	(4)	MATH 1226	(4)
CLE Area 6: Creativity & Aesthetic Experience elective (1 hr)	(1)			
CLE Area 7: Global Issues Elective (3 hrs)		(3)		

If a CLE course is double-counted to satisfy two different CLE areas, a free elective(s) must be taken to maintain a minimum of 132 credits.

Electives

The EE degree with a Major in Controls, Robotics & Autonomy requires 3 hours of Controls, Robotics & Autonomy electives, 12 hours of Controls, Robotics & Autonomy technical electives from list, 3 hours of engineering and science electives from list, and 2-4 hours of free electives. Free electives or Area 6 courses offered only on a P/F basis may be taken under the P/F grading option.

Change of Major Requirements: For Change of Major requirement, please see:

<http://www.enge.vt.edu/undergraduate/undergraduate-changing-majors>

Foreign Language Requirements: Students must have had 2 years of a foreign language in high school or one year at the college level (6 credit hours) of the same language. College-level credits used to meet this requirement do not count towards the degree.

Satisfactory Progress Towards Degree: University Policy 91 outlines university-wide minimum criteria to determine if students are making satisfactory progress towards the completion of their degrees. The ECE Department fully supports this policy. Specific expectations for satisfactory progress for Electrical Engineering majors are as follows:

- Each student must meet the minimum University-wide criteria as described in Policy 91 and summarized in the Undergraduate Catalog (under Academic Policies)
- Additionally, upon attempting 60 credits, EE students must have satisfactorily completed ECE 2014, ECE 2004, MATH 2214 and 2204, and PHYS 2306
- Upon attempting 90 credits, EE students must have successfully completed 33 credits of in-major courses (including ECE 2534) and have 2.0 overall and in-major GPAs. (In determining the EE in-major GPA, all ECE courses, including repeats, are used).

Statement of Hidden Prerequisites: Pre-requisites for each course are listed after the course title. All ECE courses required a C- or better in prerequisite courses. There are no hidden pre-requisites in this program of study. Prerequisites may change from what is indicated. Be sure to consult the University Catalog or check with your advisor for the most current requirements.

Graduation Requirements: Each student must complete at least 132 semester credit hours with a minimum overall GPA of 2.00 and a minimum in-major GPA of 2.00.

**TECHNICAL ELECTIVES FOR
ELECTRICAL ENGINEERING UNDERGRADUATES
CONTROLS, ROBOTICS & AUTONOMY
Graduating 2020**

APPROVED
COMMITTEE ON UNDERGRADUATE
STUDIES AND POLICIES

The courses listed below are approved for EE in-major and non-major technical elective credit. **Actual course offerings will be based on sufficient resources, including faculty availability and student demand.** Refer to the University's on-line timetable of classes for specific course availability information.

In-Major Technical Electives

Courses are grouped according to their inter-relatedness, but students are free to choose from multiple groups. If you are unsure of an academic focus, you are encouraged to take courses from several groups, giving you a broader background.

ELECTROMAGNETICS

- ECE3104 (3) INTRODUCTION TO SPACE SYSTEMS AND TECHNOLOGIES, Pre: 2204, 3105.
- ECE3106 (3) ELECTROMAGNETIC FIELDS, Pre: 3105.
- ECE3134 (3) INTRODUCTION TO OPTOELECTRONICS, Pre: 3105.
- ECE3154 (1) SPACE SYSTEMS LAB, Pre: 3105. Co: 3104.
- ECE3174 (1) OPTOELECTRONICS LAB, Pre: 2274. Co: 3134.
- ECE4104 (4) MICROWAVE AND RF ENGINEERING, Pre: 3106, 3204, 2014.
- ECE4114 (3) ANTENNAS, Pre: 3106, 2014.
- ECE4124 (3) RADIO WAVE PROPAGATION, Pre: 3106.
- ECE4134 (3) PHOTONICS, Pre: 3106.
- ECE4144 (3) OPTICAL SYSTEMS, Pre: 3106.
- ECE4154 (3) INTRODUCTION TO SPACE WEATHER, Pre: 3106.
- ECE4164 (3) INTRODUCTION TO GLOBAL POSITIONING SYSTEM (GPS) THEORY AND DESIGN, Pre: 2014, (3106 or AOE 4134).
- ECE4194 (3) ENGINEERING PRINCIPLES OF REMOTE SENSING, Pre: 3106.

CIRCUITS/ELECTRONICS

- ECE3204 (3) ANALOG ELECTRONICS, Pre: 2204, 2704. Co: 3274.
- ECE3214 (3) SEMICONDUCTOR DEVICE FUNDAMENTALS
- ECE3274 (1) ELECTRONIC CIRCUITS LABORATORY II, Pre: 2274, 3074. Co: 3204.
- ECE4205 (3) ELECTRONIC CIRCUIT DESIGN, Pre: 3204.
- ECE4206 (3) ELECTRONIC CIRCUIT DESIGN, Pre: 2014, 4205.
- ECE4220 (3) ANALOG INTEGRATED CIRCUIT DESIGN, Pre: 3204.
- ECE4224 (3) POWER ELECTRONICS, Pre: 3204, 2014.
- ECE4234 (3) SEMICONDUCTOR PROCESSING, Pre: 2204 or 3054.
- ECE4244 (3) INTERMEDIATE SEMICONDUCTOR PROCESSING LABORATORY, Pre: 2014, (4234 or MSE 4234).
- ECE4284 (1) POWER ELECTRONICS LABORATORY, Co: 4224.

POWER SYSTEMS

ECE3304 (3)	INTRODUCTION TO POWER SYSTEMS, Pre: 3004.
ECE3354 (1)	ELECTRIC POWER ENGINEERING LABORATORY, Co: 3304.
ECE4304 (3)	DESIGN IN POWER ENGINEERING, Pre: 2014, 3304.
ECE4334 (3)	POWER SYSTEM ANALYSIS AND CONTROL, Pre: 3304.
ECE4344 (3)	ELECTRIC POWER QUALITY FOR THE DIGITAL ECONOMY, Pre: 3304.
ECE4354 (3)	POWER SYSTEM PROTECTION, Pre: 4334.
ECE4364 (3)	ALTERNATE ENERGY SYSTEMS, Pre: STAT 4714.
ECE4374 (1)	POWER SYSTEM PROTECTION LABORATORY, Pre: 4334. Co: 4354.

SYSTEMS/CONTROLS

ECE4704 (3)	PRINCIPLES OF ROBOTICS SYSTEMS, Pre: (2574, STAT 4714) or (ME 3514, STAT 3704).
ME 4735 (3)	MECHATRONICS, Pre: (ECE2204, ECE2704) or (ECE 3254, ME 3514).
ME 4736 (3)	MECHATRONICS, Pre: ME 4735.

(ME courses are typically restricted to ME students and will need to be force-added through the ME Advising office.)

COMPUTERS

ECE2500 (3)	COMPUTER ORGANIZATION AND ARCHITECTURE, Pre: 2504.
ECE3544 (4)	DIGITAL DESIGN I, Pre: 2504, C- or better, Pre: 2204 or MSE 3204.
ECE3574 (3)	APPLIED SOFTWARE DESIGN, Pre: 2574.
ECE4424 (3)	MACHINE LEARNING (CS 4824), Pre: 2574, (STAT 4604 or STAT 4705 or STAT 4714).
ECE4504 (3)	COMPUTER ORGANIZATION (CS 4504), Pre: 2504 or CS 3214.
ECE4514 (4)	DIGITAL DESIGN II, Pre: 3544. DTE
ECE4520 (3)	DIGITAL AND MIXED-SIGNAL SYSTEM TESTING AND TESTABLE DESIGN, Pre: 2574, (3504 or 3544).
ECE4524 (4)	ARTIFICIAL INTELLIGENCE AND ENGINEERING APPLICATIONS, Pre: 2574, STAT 4714. DTE
ECE4525 (3)	VIDEO GAME DESIGN AND ENG, Pre: 3574. DTE
ECE4526 (3)	VIDEO GAME DESIGN AND ENG, Pre: 4525. DTE
ECE4530 (3)	HARDWARE-SOFTWARE CODESIGN, Pre: 2534, (3504 or 3544). DTE
ECE4534 (4)	EMBEDDED SYSTEM DESIGN, Pre: 2014, 2534, 3574.
ECE4540 (3)	VLSI CIRCUIT DESIGN, Pre: 2204, 2504. DTE
ECE4550 (3)	REAL-TIME SYSTEMS, Pre: 4534 or CS 3214. DTE
ECE4554 (3)	INTRODUCTION TO COMPUTER VISION, Pre: 3574, (STAT 4705 or STAT 4714).
ECE4560 (3)	COMPUTER AND NETWORK SECURITY FUNDAMENTALS, Pre: 4564 or CS 3214. DTE
ECE4564 (3)	NETWORK APPLICATION DESIGN, Pre: 2504, 2574. DTE
ECE4570 (3)	WIRELESS NETWORKS AND MOBILE SYSTEMS (CS 4570), Pre: 4564. DTE
ECE4574 (3)	LARGE-SCALE SOFTWARE DEVELOPMENT FOR ENGINEERING SYSTEMS, Pre: 3574. DTE
ECE4580 (3)	DIGITAL IMAGE PROCESSING.

COMMUNICATIONS

APPROVED
COMMISSION ON UNDERGRADUATE
STUDIES AND POLICIES

ECE3604 (3)	INTRODUCTION TO RF & MICROWAVE ENGINEERING, Pre: 2004, 3105.
ECE3614 (3)	INTRODUCTION TO COMMUNICATION SYSTEMS, Pre: 2704, STAT 4714.
ECE4605 (3)	RADIO ENGINEERING, Pre: 2014, 3105, 3204, 3614.
ECE4606 (3)	RADIO ENGINEERING, Pre: 4605.
ECE4614 (3)	TELECOMMUNICATION NETWORKS, Pre: 2504, 2704, STAT 4714.
ECE4624 (3)	DIGITAL SIGNAL PROCESSING AND FILTER DESIGN, Pre: 2014, 3704.
ECE4634 (3)	DIGITAL COMMUNICATIONS, Pre: 3614, STAT 4714.
ECE4644 (3)	SATELLITE COMMUNICATIONS, Pre: 3614.
ECE4664 (1)	ANALOG & DIGITAL COMMUNICATIONS LABORATORY, Pre: 3614. Co: 4634
ECE4675 (1)	RADIO ENGINEERING LABORATORY, Pre: 3106, 3204. Co: 4605.
ECE4676 (1)	RADIO ENGINEERING LABORATORY, Pre: 4675. Co: 4606.

MECHANICAL ENGINEERING SENIOR ENGINEERING DESIGN AND PROJECT

ECE graduating seniors, with the permission of the ME department, can enroll in the ME senior engineering design and project courses. **Note: both semesters must be completed to earn credit.**

ME 4015 (3) Engineering Design and Project [Permission of ME Department]

ME 4016 (3) Engineering Design and Project [Permission of ME Department]

INDEPENDENT STUDY AND UNDERGRADUATE RESEARCH

The courses listed below can *generally* be used for technical elective credit or design technical elective credit, based on the particular content of each course as it is taught in a given semester. Please discuss technical elective credit options for these courses with your advisor prior to registering for the courses.

ECE 4974 (ARR) Independent Study

ECE 4994 (ARR) Undergraduate Research

Notes:

Students must complete the College of Engineering Undergraduate Research/Independent Study Form, the ECE Undergraduate Research/Independent Study Proposal Form, and the ABET Breakdown prior to registration. The forms are due in 340 Whittemore by 2:00 PM on the 3rd day of the first week of class for the requested semester – no exceptions. Forms are available online at www.ece.vt.edu/ugrad/policies.php.

For purposes of satisfying the major technical elective requirements, the sum of the number of hours taken from ECE 4974 and 4994 cannot exceed 6 in any one project, without prior approval.

Non-Major Technical Electives

ECE students may take up to 3 credit hours of non-major technical electives. Students are reminded that they DO NOT have to take a non-major technical elective. *All* technical electives can come from the in-major list.

- 1) Any 3000 or 4000 level course, *except those listed in Items 2 and 3 below*, in Engineering, Engineering non-degree (ENGR), Biology, Biomedical Engineering and Sciences, Chemistry, Computer Science, Mathematics, Nuclear Engineering, Physics, and Statistics **NOT REQUIRED FOR GRADUATION, THAT DOES NOT DUPLICATE** any course in the program of study, and for which you have the appropriate prerequisite, may be used as a non-major technical elective.
- 2) Non-major 4974, 4984, 4994 courses and study abroad courses must be approved for non-major technical elective credit in advance. See your advisor for guidance.
- 3) REMINDER: ESM 4404 – Fundamentals of Professional Engineering – **CANNOT** be used as a non-major technical elective and **DOES NOT COUNT TOWARDS GRADUATION.**

Graduate Courses Used as Technical Electives

ECE students who meet the University requirements to enroll in graduate courses may use graduate level ECE courses as technical elective credit.

- 1) Per University policy, undergraduate students must have earned a 3.0 cumulative GPA to be eligible to enroll in graduate level courses.
- 2) Note that graduate courses taken as an undergraduate **cannot** be used toward a graduate degree in ECE at VT. Exceptions to this policy: a) students enrolled in the Accelerated UG/G program; b) students who are dual enrolled in the ECE graduate program. Please see your advisor if you have questions regarding this policy.
- 3) To enroll in graduate level courses, undergraduates will need to complete an online ECE force add request. If prerequisites are met and space permits, students will be force-added to the graduate course(s).

**Bradley Department of Electrical and Computer Engineering
Virginia Polytechnic Institute and State University
Math Elective List for Electrical Engineering
Graduating in 2020**

APPROVED
COLLECTION OF UNDERGRADUATE
STUDIES AND POLICIES

Electrical Engineering majors are required to take one math elective course from the following list. There are no hidden prerequisites for these courses for EE majors: prerequisite courses, if any, are also required courses within the EE curriculum.

Enrollment into courses will be based on sufficient resources, including faculty availability and student demand.

- MATH 3034 (3) INTRODUCTION TO PROOFS, (limited availability due to course restrictions), Pre: MATH 2114 or MATH 2114H or MATH 2405H.
- MATH 3214 (3) CALCULUS OF SEVERAL VARIABLES , Pre: MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H or MATH 2406H or CMDA 2005.
- MATH 3414 (3) NUMERICAL METHODS (CS 3414), Pre: (CS 1044 or CS 1705 or CS 1114 or CS 1124), MATH 2406H or (CMDA 2005, CMDA 2006) or (MATH 2214 or MATH 2214H), (MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H).
- MATH 4445 (3) INTRODUCTION TO NUMERICAL ANALYSIS, Pre: MATH 2406H or (CMDA 2005, CMDA 2006) or (MATH 2214 or MATH 2214H), (MATH 2224 or MATH 2224H) or (MATH 2204 or MATH 2204H).
- MATH 4446 (3) INTRODUCTION TO NUMERICAL ANALYSIS, Pre: MATH 2406H or (CMDA 2005, CMDA 2006) or (MATH 2214 or MATH 2214H), (MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H).
- MATH 4564 (3) OPERATIONAL METHODS FOR ENGINEERS, Pre: (MATH 2214 or MATH 2214H) or MATH 2406H or CMDA 2006.
- MATH 4574 (3) VECTOR AND COMPLEX ANALYSIS FOR ENGINEERS, Pre: MATH 2224 or MATH 2204 or MATH 2204H]

Bradley Department of Electrical and Computer Engineering
Virginia Polytechnic Institute and State University
Engineering and Science Elective List
For Electrical Engineering and Computer Engineering majors
Graduating in 2020

APPROVED
COMMISSION ON UNDERGRADUATE
STUDIES AND POLICIES

EE and CPE majors are required to take one non-major engineering or science course from the following list. Some courses may include prerequisite courses not required for the EE or CpE curriculum. It is the student's responsibility to be aware of prerequisites and to ensure that all prerequisites are completed prior to enrolling in the chosen course.

Enrollment into courses will be based on sufficient resources, including faculty availability and student demand.

Within the College of Engineering:

BSE	3154	Thermodynamics of Biological Systems
CHE	2114	Mass and Energy Balances
ECE	3105	Electromagnetic Fields (CpE majors only)
ESM	2104	Statics
ESM	4084	(AOE 4084) Engineering Design Optimization
ISE	2404	Deterministic Operations Research I
ISE	3414	Probabilistic Operations Research
ME	3134	Fundamentals of Thermodynamics
MSE	2034	Elements of Materials Engineering
MSE	3204	Fundamentals of Electronic Materials
NSEG	3145	Fundamentals of Nuclear Engr

Outside of the College of Engineering:

BIOL	1005	General Biology
BIOL	1006	General Biology
BMVS	4064	(BMES 4064) Introduction to Medical Physiology
CHEM	1036	General Chemistry
PHYS	3324	Modern Physics
PHYS	3355	Intermediate Mechanics
PHYS	3405	Intermediate Electricity and Magnetism (CpE Majors only)
PHYS	3655	Introduction to Astrophysics
PHYS	3656	Introduction to Astrophysics
PHYS	3704	Thermal Physics
PHYS	4574	Nanotechnology
PHYS	4614	Optics
PHYS	4714	Introduction to Biophysics