College Of Engineering
Bradley Department of Electrical and Computer Engineering
Degree: Bachelor of Science in Electrical Engineering
Major: Applied Electromagnetics
For Students entering under UG Catalog 2023-2024
Credits Required for graduation: 129

FALL SEMESTER FIRST YEAR	Credits	SPRING SEMESTER FIRST YEAR	Credits
ECE 1004(1) Introduction to ECE Concepts **(C)**	3[F,S]	ENGL 1106 First-Year Writing *Pre: ENGL 1105*	3
ENGL 1105 First-Year Writing	3	MATH 1226 Calculus of a Single Variable *Pre: MATH 1225*	4
MATH 1225 Calculus of a Single Variable **(C-)** *Pre: Eligible to enroll*	4	PHYS 2305 Foundations of Physics I *See Footnote * for prerequisites*	4
ENGE 1215 Foundations of Engineering~	2	ENGE 1216 Foundations of Engineering *Pre: ENGE 1215*~	2
Pathways 2 or 3 or 6a	3	MATH 2114 Introduction to Linear Algebra **(C-)** *Pre: MATH 1226 or a grade of at least B in MATH 1225* ~	3
TOTAL	**15**	**TOTAL**	**16**
FALL SEMESTER SECOND YEAR	**Credits**	**SPRING SEMESTER SECOND YEAR**	**Credits**
MATH 2214 Introduction to Differential Equations **(C-)** *Pre: (1114 or 2114 or 2114H or 2405H or ISC 2105), 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 2214(1) Physical Electronics **(C)** *Pre: 2024*	3[F,S]
ECE 2024(1) Circuits and Devices **(C)** *Pre: 1004, (MATH 2114 or MATH 2114H or MATH 2405H) ; Co: 2514, 2544, MATH 2214, PHYS 2306*	3[F,S]	ECE 2564(2) Embedded Systems **(C)** *Pre: 2514, 2544*	3[F,S]
ECE 2514(2) Computational Engineering **(C)** *Pre: 1004; Co: 2024, 2544*	3[F,S]	ECE 2714(1) Signals and Systems**(C)** *Pre: 2024, 2514, 2544, (MATH 2214 or MATH 2214H or MATH 2406H); Co: 2564*	3[F,S]
ECE 2544(1) Fundamentals of Digital Systems **(C)** *Pre: 1004; Co: 2024, 2514*	3[F,S]	ECE 2804(1) Integrated Design Project **(C)** *Pre: 2024, 2514, 2544; Co: 2214, 2564, 2714*	2[F,S]
		Pathways 2 or 3 or 6a	3
TOTAL	**16**	**TOTAL**	**17**
FALL SEMESTER THIRD YEAR	**Credits**	**SPRING SEMESTER THIRD YEAR**	**Credits**
ECE 3004(1) AC Circuit Analysis **(C-)** *Pre: 2714, 2804*	3[F,S]	ECE 3106(2) Electromagnetic Fields *Pre: 3105*	3[F,S]
ECE 3074(1) AC Circuit Analysis Laboratory **(C-)** *Pre: 2804; Co: 3004*	1[F,S]	ECE 3104(2) Intro Space Systems *Pre: 3105* **OR** ECE 3134(2) Intro Optoelectronics *Pre: 2214, 2804* **OR** ECE 3604(2) Intro to RF & Microwave *Pre: 3105*	3
ECE 3105(1) Electromagnetic Fields **(C-)** *Pre: 2214, 2804, PHYS 2306, (MATH 2204 or MATH 2204H or MATH 2406H)*	3[F,S]	Secondary Focus Area course (see page 4)	3
MATH Elective from list (see page 6)	3	Secondary Focus Area course (see page 4)	3
STAT 4714 Probability & Statistics for Electrical Engineers *Pre: MATH 2204 or MATH 2204H or MATH 2506H or CMDA 2005*	3	Free Elective	3
Secondary Focus Area course (see page 4)	3	Pathways 2 or 3 or 6a	3
TOTAL	**16**	**TOTAL**	**18**
FALL SEMESTER FOURTH YEAR	**Credits**	**SPRING SEMESTER FOURTH YEAR**	**Credits**
ECE 4805 Senior Design Project **(C-)** *Pre: ECE 2804, (ECE 3004 or ECE 3504), (ECE 3105 or ECE 3514), (one course from list**)*~	3[F,S]	ECE 4806 Senior Design Project *Pre: 4805*~	3[F,S]
EM Elective(2) from list (see page 3)~	3	EM Elective(2) from list (see page 3)~	3
ECE 3614(2) Introduction to Communication Systems *Pre: 2714, 2804, STAT 4714*	3	Pathways 2 or 3 or 6a	3
Pathways 2 or 3 or 6a	3	Pathways 7 or Free Elective (if Pathways 7 double counted)	3
Free Elective	3	Free Elective	4
TOTAL	**15**	**TOTAL**	**16**

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 indication 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.
*Prerequisites for PHYS 2305: Pre: (MATH 1205 or MATH 1205H or MATH1225) or (MATH 1206 or MATH 1206H or MATH 1226); Co: 2325 or (MATH 1206 or MATH 1206H or MATH 1226)
**Prerequisites for ECE 4805: Pre: 2804, (3004 or 3504), (3105 or 3514) (3106 or 3134 or 3204 or 3214 or 3304 or 3544 or 3564 or 3574 or 3614 or 3704 or 4205 or 4234 or 4254 or 4424 or 4524 or 4540 or 4580 or 4704)

Pathways General Education (Pathways)
Consult the pathways courses table https://www.pathways.prov.vt.edu/students-and-advisors/pathways-guides.html. Pathways courses need to be completed prior to graduation

Pathways Concept 1: Discourse (6 hrs foundational, 3 hrs advanced)	*Foundational:* **ENGL 1105**	**(3)**	*Foundational:* **ENGL 1106**	**(3)**
	Advanced: **ECE 4805 + ECE 4806 or ENGE 4735 + ENGE 4736**			**(6)**
Pathways Concept 2: Critical Thinking in the Humanities (6 hrs)		**(3)**		**(3)**
Pathways Concept 3: Reasoning in the Social Sciences (6 hrs)		**(3)**		**(3)**
Pathways Concept 4: Reasoning in the Natural Sciences (8 hrs)	**PHYS 2305**	**(4)**	**PHYS 2306**	**(4)**
Pathways Concept 5: Quantitative and Computational Thinking (11 hrs)	*Foundational:* **MATH 1225**	**(4)**	*Foundational:* **MATH 1226**	**(4)**
	Advanced: **MATH 2214**			**(3)**
Pathways Concept 6: Critique and Practice in Design and the Arts (7 hrs)	*Arts (6a):*			**(3)**
	Design: **ENGE 1215 + ENGE 1216**			**(4)**
Pathways Concept 7: Critical Analysis of Identity & Equity in the US (3 hrs)	*If Pathways 7 is double counted with another course, these credits will be free elective credits.			**(3)**

Electives: The Applied Electromagnetics major requires 3 hours of math electives from list (see page 6), 6 hours of EM electives from list (see page 3) and 7 hours of free electives. Only free electives may be taken under the P/F grading option. Students are encouraged to use free electives to provide depth in their major or secondary focus.

Secondary Focus: The Applied Electromagnetics Major requires 9 credits for a secondary focus area. Students have the flexibility to choose any 3 ECE courses (9 credits) at the 3xxx level, 4xxx level or 5xxx level to meet the secondary focus requirements as long as at least one course (3 credits) is at the 4xxx or 5xxx level and the courses do not duplicate major courses. Alternatively, students may seek an approved individualized secondary focus. See the requirements below (page 4) for more information.

Change of Major Requirements: Please see: https://eng.vt.edu/em

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 BSCPE and BSEE majors are as follows:

- Upon completing 2 semesters in ECE, students must have satisfactorily completed ECE 2024, ECE 2514, ECE 2544, MATH 2214, and PHYS 2306
- Upon completing 3 semesters in ECE, students must have satisfactorily completed ECE 2804.
- Upon attempting 90 credits, BSCPE and BSEE students must have successfully completed 33 credits of in-major courses and have 2.0 overall and in-major GPAs. (The BSCPE and BSEE in-major GPA includes all ECE courses, including repeats).

Grade Requirement: Students must earn a C or higher in the following ECE courses: ECE 1004, ECE 2024, ECE 2214, ECE 2514, ECE 2544, ECE 2564, ECE 2714, ECE 2804.

Statement of Prerequisites: Pre-requisites for each course are listed after the course title. In general, all ECE courses require a C- or better in prerequisite courses. Students must earn a C or higher in the ECE courses listed above. There are no hidden prerequisites in this program of study. Prerequisites may change from what is indicated. Be sure to consult the Timetable of Classes or check with your advisor for the most current requirements.

Graduation Requirements: Each student must complete at least 129 semester credit hours with a minimum overall GPA of 2.00 and a minimum in-major GPA of 2.00. In determining the Applied Electromagnetics in-major GPA, all ECE courses plus ENGE 4735 plus ENGE 4736, including repeats, are used.

~Additional Checksheet Comments:

- ENGE 1414 (4c) may be substituted for ENGE 1215 (2c) + ENGE 1216 (2c)
- MATH 2405H (5c) may be substituted for MATH 2114 (3c)
- MATH 2405H (5c) + MATH 2406H (5c) may be substituted for MATH 2114 (3c) + MATH 2204 (3c) + MATH 2214 (3c)
- AOE 4654 (3c) may be substituted for ECE 4154 (3c)
- AOE 4674 (3c) may be substituted for ECE 4174 (3c)
- ENGE 4735 (3c) + ENGE 4736 (3c) may be substituted for ECE 4805 (3c) + ECE 4806 (3c). Note: Students who wish to enroll in ENGE 4735/ENGE 4736 must successfully complete all prerequisites for ECE 4805 and must be approved by the Director of the ECE Major Design Experience prior to enrolling in ENGE 4735/ENGE 4736. These courses will also count in the in-major GPA

ELECTROMAGNETICS ELECTIVES
APPLIED ELECTROMAGNETICS MAJOR
For students entering under UG Catalog 2023-2024

The courses listed below are approved for Applied Electromagnetics elective credit. Students must choose 2 courses to complete the Applied Electromagnetic Major requirements. **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. Note: All ECE courses require a **C- or better** in prerequisite courses. Courses used toward the 6c elective requirement cannot be used as part of the secondary focus.

ECE 3104 (3) INTRO SPACE SYSTEMS, Pre: 3105

ECE 3134 (3) INTRODUCTION OPTOELECTRONICS, Pre: 2214, 2804

ECE 3204 (3) ANALOG ELECTRONICS, Pre: 2214, 2704, 2804

ECE 3604 (3) INTRODUCTION TO RF & MICROWAVE ENGINEERING, Pre: 3105

ECE 4104 (3) MICROWAVE & RF ENGINEERING, Pre: 3106, 3204

ECE 4114 (3) ANTENNAS, Pre: 3106

ECE 4124 (3) RADIO WAVE PROPOGATION, Pre: 3106

ECE 4134 (3) PHOTONICS, Pre: 3105

ECE 4144 (3) OPTICAL SYSTEMS, Pre: 3106

ECE 4154 (AOE 4654) (3) INTRODUCTION TO SPACE WEATHER, Pre: 3105 or AOE 3014

ECE 4164 (4) INTRODUCTION TO GLOBAL POSITIONING SYSTEMS (GPS) THEORY & DESIGN, Pre: 3106 or AOE 3154

ECE 4174 (3) UPPER ATMOSPHERE/IONOSPHERE SPACE WEATHER, Pre: 3105 or AOE 3104

ECE 4194 (3) ENGINEERING PRINCIPLES OF REMOTE SENSING, Pre: 3106

ECE 4205 (3) ELECTRONIC CIRCUIT DESIGN, Pre: 2214, 2804

ECE 4220 (3) ANALOG INTEGRATED CIRCUIT DESIGN, Pre: 3204

ECE 4605 (3) RADIO ENGINEERING, Pre: 3105, 3204, 3614

ECE 4644 (3) SATELLITE COMMUNICATIONS, Pre: 3614

ECE 4974/4994 (ARR) INDEPENDENT STUDY/UNDERGRADUATE RESEARCH (requires departmental and college approval) [No more than 3 hours total of either ECE 4974 or ECE 4994 can be counted toward the Applied Electromagnetic Major]

SECONDARY FOCUS REQUIREMENT
Applied Electromagnetics
For Students entering under UG Catalog 2023-2024

The ECE Secondary Focus Requirement can be completed in one of two ways: Within ECE or as an Individualized Secondary Focus.

WITHIN ECE

The ECE Secondary Focus Requirement consists of 3 ECE courses (9 credits) at the 3xxx level, 4xxx level, or 5xxx level where at least one course (3 credits) is at the 4xxx or 5xxx level. **None of the 3 courses can duplicate a course from the student's major.** For a list of recommended courses grouped by major/research area, please refer to https://ece.vt.edu/undergrad/curriculum.html.

- The following courses are also included in the secondary focus:
  - AOE 4654 (ECE 4154) Space Weather, Pre: AOE 3104 or ECE 3105
  - AOE 4674 (ECE 4174) Upper Atmosphere Space Weather, Pre: AOE 3104 or ECE 3105
  - CS 3214 Computer Systems, Pre: (CS 2506, CS 2114) or (ECE 2564, ECE 3574)
  - CS 4224 (ECE 4414) Linux Kernel Programming, Pre: CS 3114 or ECE 3574
  - CS 4264 Principles Computer Security, Pre: CS 3214 or (ECE 3504, ECE 3574)
  - CS 4504 (ECE 4504) Computer Organization, Pre: CS 3214 or ECE 2500 or ECE 3504
  - CS 4824 (ECE 4424) Machine Learning, Pre: (ECE 2574 or CS 2114), (STAT 4604 or STAT 4705 or STAT 4714)
- All courses used for secondary focus must be taken on an A-F basis.
- The following courses **cannot** be used toward secondary focus:
  - ECE 3054 Electrical Theory, Pre: PHYS 2305; Co: MATH 2214
  - ECE 3074 AC Circuits Lab, Pre: 2804; Co: 3004
  - ECE 3254 Industrial Electronics, Pre: 2054
  - ECE 3274 Electronic Circuits Lab II, Pre: 2804, 3074; Co: 3204
  - ECE 3354 Power Lab
  - ECE 3524 Introduction to Unix for ECE, Pre: 2804
  - ECE 4944 Cybersecurity Seminar, Pre: 2804 or CS 2505
- For purposes of satisfying the Secondary Focus requirements, the sum of the number of hours taken from ECE 4974 Independent Study and ECE 4994 Undergraduate Research cannot exceed 6 credits.

INDIVIDUALIZED SECONDARY FOCUS (Must be preapproved by ECE Department)

Electrical and computer engineering has applications across a wide variety of fields, such as medicine, human-computer interaction, finance, and entertainment. People with ECE degrees can be entrepreneurs, patent lawyers, policy makers, and business executives. The individualized secondary focus helps students pursue these interests. This option can be used in place of a pre-defined, in-department secondary focus.

The individualized secondary focus typically is pursued via an already defined university-approved program such as a degree, major, minor, or certificate that the student has declared. Students are encouraged to select courses from these programs, subject to the guidelines below.

1) To begin this process, students must first meet with their academic advisor.
2) The student must complete a brief proposal form describing the expected added value to their major. This includes a narrative about how these courses support the student's career goals and ability to achieve their professional aspirations. This proposal must be approved by the Director of Undergrad Program or designee.
3) Individualized secondary focus plans must include 3 courses within the following parameters:
   a. None of the courses may duplicate the student's ECE major requirements.
   b. None of the courses can be at the 1xxx level (1xxx courses required for university-approved programs, e.g. minors, can be used for a student's free electives).
   c. A maximum of one course can be at the 2xxx level, and only if it is a requirement of a university approved program, or if the course is a prerequisite to one or more of the other two courses in the individualized secondary focus.
   d. A minimum of one course must be at the 4xxx level.

4) If the set of courses is part of an already defined university program, the student should attach documentation to the proposal form.
5) If the set of three courses are *not* part of an already defined university-approved program, the student must also obtain written approval from the department that houses the courses.
6) It is the student's responsibility to ensure that the set of courses is available to be taken in a timely manner. The ECE department is not responsible for changes of programs elsewhere in the university.

MATH ELECTIVE REQUIREMENT
Applied Electromagnetics Major
For Students entering under UG Catalog 2023-2024

Electrical Engineering majors are required to take one math elective course from the following list. Some courses may include prerequisite courses not required for the BSEE 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. Note that courses may be restricted to specific majors during certain semesters.

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

MATH 2534 (3) INTRO DISCRETE MATH, Pre: CS 1114 or ECE 1574 or ECE 1004 or CS 2064

MATH 3034 (3) INTRODUCTION TO PROOFS, Pre: MATH 2114 or MATH 2114H or MATH 2405H

MATH 3214 (3) CALCULUS OF SEVERAL VARIABLES, Pre: MATH 2204 or MATH 2204H or MATH 2406H or CMDA 2005

MATH 3414/CS 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 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), 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), 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 2204 or MATH 2204H