

College of Engineering
Bradley Department of Electrical and Computer Engineering
Degree: Bachelor of Science in Computer Engineering
Major: Machine Learning

For Students Graduating in Calendar Year 2022 and for student date of entry under UG Catalog 2020-2021

Credits Required for graduation: 131

FALL SEMESTER FIRST YEAR		Credits	SPRING SEMESTER FIRST YEAR		Credits
CHEM 1035 General Chemistry Co: MATH 1025 or 1225	3		ENGL 1106 First-Year Writing (C-) 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-)	2		ECE 1004 ⁽¹⁾ Introduction to ECE Concepts (C) Pre: ENGE 1215 or ENGE 1414	3 ^[F, S]	
Concept 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	16		TOTAL	19	
FALL SEMESTER SECOND YEAR		Credits	SPRING SEMESTER SECOND YEAR		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 Pre: MATH 1226	3	
PHYS 2306 Foundations of Physics I Pre: (MATH 1206 or MATH 1206H or MATH 1226), PHYS 2305	4		ECE 2214 ⁽²⁾ 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 ⁽¹⁾ Embedded Systems (C) Pre: 2514, 2544	3 ^[F, S]	
ECE 2514 ⁽¹⁾ Computational Engineering (C) Pre: 1004; Co: 2024, 2544	3 ^[F, S]		ECE 2714 ⁽²⁾ Signals and Systems(C) Pre: 2024, 2514, 2544, MATH 2214; Co: 2564	3 ^[F, S]	
ECE 2544 ⁽¹⁾ Fundamentals of Digital Systems (C) Pre: 1004, ENGL 1106 or ENGL 1204H; Co: 2024, 2514	3 ^[F, S]		ECE 2804 ⁽¹⁾ Integrated Design Project (C) Pre: 2024, 2514, 2544; Co: 2214, 2564, 2714	2 ^[F, S]	
			Concept 2 or 3 or 6a	3	
TOTAL	16		TOTAL	17	
FALL SEMESTER THIRD YEAR		Credits	SPRING SEMESTER THIRD YEAR		Credits
ECE 2500 ⁽²⁾ Computer Organization and Architecture Pre: 2504 or (2544, 2804)	3 ^[F, S]		ECE 3574 ⁽¹⁾ Applied Software Design (C-) Pre: 2574 or 3514	3 ^[F, S]	
ECE 2574 ⁽¹⁾ Data Structure and Algorithms (C-) Pre:1574 or (2514, 2804)	3 ^[F, S]		STAT 4714 Probability and Statistics for Electrical Engineers (C-) Pre: MATH 2224 or MATH 2204 or MATH 2204H	3	
MATH 2534 Introduction to Discrete Math Pre: CS 1114 or ECE 1574 or ECE 1004	3		Secondary Focus Area course (see list)	3	
Secondary Focus Area course (see list)	3		Secondary Focus Area course (see list)	3	
Free Elective	3		Concept 2 or 3 or 6a	3	
			Free Elective	2	
TOTAL	15		TOTAL	17	
FALL SEMESTER FOURTH YEAR		Credits	SPRING SEMESTER FOURTH YEAR		Credits
ECE 4805 Senior Design Project (C-) See timetable for prereqs	3 ^[F, S]		ECE 4806 Senior Design Project Pre: 4805	3 ^[F, S]	
ECE 4525 ⁽²⁾ Video Game Design and Engineering Pre: 3574 or ECE 4580 Digital Image Processing	3 ^[F]		ECE 4524 ⁽²⁾ Artificial Intelligence and Engineering Applications Pre: (2574 or 3514), STAT 4714	4 ^[S]	
ECE 4424 ⁽²⁾ Machine Learning Pre: (2574 or 3514), (STAT 4714 or STAT 4704 or STAT 4705	3		Concept 2 or 3 or 6a	3	
ECE 4554 ⁽²⁾ Introduction to Computer Vision Pre: 3574, (STAT 4714 or STAT 4704 or STAT 4705)	3		Concept 7 or Free Elective (if Pathways 7 double counted)	3	
Concept 2 or 3 or 6a	3		Free Elective	3	
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.

Pathways to General Education Concepts

Consult the Pathways courses table: <https://www.pathways.prov.vt.edu/about/table.html>. Pathways courses need to be completed prior to graduation

Pathways Concept 1: Discourse (6 hrs foundational, 3 hrs advanced)	<i>Foundational: ENGL 1105</i>	(3)	<i>Foundational: ENGL 1106</i>	(3)
	<i>Advanced: ECE 4805 + ECE 4806</i>			(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)	CHEM 1035 + CHEM 1045	(4)	PHYS 2305	(4)
Pathways Concept 5: Quantitative and Computational Thinking (11 hrs)	<i>Foundational: MATH 1225</i>	(4)	<i>Foundational: MATH 1226</i>	(4)
	<i>Advanced: MATH 2214</i>			(3)
Pathways Concept 6: Critique and Practice in Design and the Arts (7 hrs)	<i>Arts (6a):</i>			(3)
	<i>Design: ENGE 1215 + ENGE 1216</i>			(4)
Pathways Concept 7: Critical Analysis of Identity & Equity in the US (3 hrs)	*Pathways 7 should be double counted with either Pathways 2, 3 or 6a to avoid taking any additional credit hours.			(3)

Electives

The Machine Learning Major requires 8 hours of free electives. Only free electives may be taken under the P/F grading option. Students are encouraged to use free elective credits to provide depth in their major or secondary focus.

Secondary Focus

The Machine Learning Major requires 9 credits from a secondary focus area. All 9 credits must be from one ECE focus area from the attached list or from an approved individualized secondary focus plan. At least 3 credits must be at the 4xxx level.

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

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

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:

- Each student must meet the minimum University-wide criteria as described in Policy 91 and summarized in the Undergraduate Catalog (under Academic Policies)
- 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. (In determining the BSCPE and BSEE in-major GPA, all ECE courses, including repeats, are used).

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 131 semester credit hours with a minimum overall GPA of 2.00 and a minimum in-major GPA of 2.00. In determining the Machine Learning in-major GPA, all ECE courses, including repeats, are used.

SECONDARY FOCUS REQUIREMENT

Machine Learning Major

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FOCUS AREAS WITHIN ECE

The courses listed below have been approved for the ECE focus areas. Students must choose 3 courses from a single focus area which **DO NOT DUPLICATE** major requirements. At least one course must be at the 4xxx level. **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 and prerequisite. Note: All ECE courses require a **C- or better** in prerequisite courses.

CHIP-SCALE INTEGRATION

- ECE3004 (3) AC CIRCUIT ANALYSIS, Pre: 2704 or (2714, 2804)
- ECE3074 (1) AC CIRCUIT ANALYSIS LAB, Pre: 2074 or 2804; Co: 3004
- ECE4514 (4) DIGITAL DESIGN II, Pre: 3544
- ECE4520 (3) DIGITAL AND MIXED SIGNAL SYSTEM TESTING AND TESTABLE DESIGN, Pre: (2574 or 3514), 3544
- ECE4530 (3) HARDWARE-SOFTWARE CO-DESIGN, Pre: (2534 or 2564), 3544
- ECE4540 (3) VLSI CIRCUIT DESIGN, Pre: (2504, 2204) or (2544, 2214, 2804)

CONTROLS, ROBOTICS, AND AUTONOMY

- ECE3714 (3) INTRODUCTION TO CONTROL SYSTEMS, Pre: 2704 or (2714, 2804)
- ECE4524 (4) ARTIFICIAL INTELLIGENCE AND ENGINEERING APPLICATIONS, Pre: (2574 or 3514), STAT 4714
- ECE4580 (3) DIGITAL IMAGE PROCESSING
- ECE4704 (3) PRINCIPLES OF ROBOTICS SYSTEMS, Pre: (2704 or (2714, 2804)) or (ME 3514, STAT 3704)

NETWORKING AND CYBERSECURITY

- ECE4560 (3) COMPUTER AND NETWORK SECURITY FUNDAMENTALS, Pre: 2504 or (2544, 2804) or CS 3214
- ECE4564 (3) NETWORK APPLICATION DESIGN, Pre: (2504 or (2544, 2804)), (2574 or 3514)
- ECE4614 (3) TELECOMMUNICATION NETWORKS, Pre: ((2504, 2704) or (2544, 2714, 2804)), STAT 4714
- CS4264 (3) PRINCIPLES OF COMPUTER SECURITY, Pre: CS 3214 or ((ECE 2500 or 3504), ECE 3574)

SOFTWARE SYSTEMS

- ECE4525 (3) VIDEO GAME DESIGN AND ENG, Pre: 3574
- ECE4550 (3) REAL-TIME SYSTEMS, Pre: 3574 or CS 3214
- ECE4574 (3) LARGE-SCALE SOFTWARE DEVELOPMENT FOR ENGINEERING SYSTEMS, Pre: 3574
- CS3214 (3) COMPUTER SYSTEMS, Pre: (CS 2506, CS 2114) or (ECE 2564, ECE 3574)

COMMUNICATIONS AND NETWORKING

- ECE3004 (3) AC CIRCUIT ANALYSIS, Pre: 2704 or (2714, 2804)
- ECE3074 (1) AC CIRCUIT ANALYSIS LAB, Pre: 2074 or 2804; Co: 3004
- ECE3105 (3) ELECTROMAGNETIC FIELDS, Pre: 2004 or (2214, 2804), MATH 2204, PHYS 2306
- ECE3614 (3) INTRODUCTION TO COMMUNICATION SYSTEMS, Pre: (2704 or (2714, 2804)), STAT 4714

ECE3704 (3)	CONTINUOUS AND DISCRETE SYSTEMS, Pre: 2704 or (2714, 2804)
ECE4614 (3)	TELECOMMUNICATION NETWORKS, Pre: ((2504, 2704) or (2544, 2714,2804)), STAT 4714
ECE4624 (3)	DIGITAL SIGNAL PROCESSING AND FILTER DESIGN, Pre: 3704
ECE4634 (3)	DIGITAL COMMUNICATIONS, Pre: 3614, STAT 4714
ECE4664 (1)	ANALOG & DIGITAL COMM LAB, Pre: 3614; Co: 4634
ECE4684 (3)	NETWORK SCIENCE, Pre: 2704 or (2714, 2804)

ENERGY AND POWER ELECTRONIC SYSTEMS

ECE3004 (3)	AC CIRCUIT ANALYSIS, Pre: 2704 or (2714, 2804)
ECE3074 (1)	AC CIRCUIT ANALYSIS LAB, Pre: 2074 or 2804; Co: 3004
ECE3105 (3)	ELECTROMAGNETIC FIELDS, Pre: 2004 or (2214, 2804), MATH 2204, PHYS 2306
ECE3204 (3)	ANALOG ELECTRONICS, Pre: (2204, 2704) or (2214, 2714, 2804)
ECE3304 (3)	INTRODUCTION TO POWER SYTEMS, Pre: 3004
ECE3354 (1)	POWER LAB, Co: 3304
ECE3704 (3)	CONTINUOUS AND DISCRETE SYSTEMS, Pre: 2704 or (2714, 2804)
ECE4224 (3)	POWER ELECTRONICS, Pre: 3204, 3304
ECE4284 (1)	POWER ELECTRONICS LAB, Co: 4224
ECE4334 (3)	POWER SYSTEM ANALYSIS AND CONTROL, Pre: 3304
ECE4354 (3)	POWER SYSTEM PROTECTION, Pre: 4334
ECE4364 (3)	ALTERNATE ENERGY SYSTEMS, Pre. STAT 4714
ECE4374 (1)	POWER SYSTEM PROTECTION LAB, Pre: 4334; Co: 4354

MICRO/NANOSYSTEMS

ECE3004 (3)	AC CIRCUIT ANALYSIS, Pre: 2704 or (2714, 2804)
ECE3074 (1)	AC CIRCUIT ANALYSIS LAB, Pre: 2074 or 2804; Co: 3004
ECE3105 (3)	ELECTROMAGNETIC FIELDS, Pre: 2004 or (2214, 2804), MATH 2204, PHYS 2306
ECE3204 (3)	ANALOG ELECTRONICS, Pre: (2204, 2704) or (2214, 2714, 2804)
ECE3274 (1)	ELECTRONIC CIRCUITS LAB II, Pre: (2274 or 2804), 3074; Co: 3204
ECE3214 (3)	SEMICONDUCTOR DEVICE FUNDAMENTALS, Pre: 2204 or (2214, 2804) or MSE 3204
ECE3614 (3)	INTRODUCTION TO COMMUNICATION SYSTEMS, Pre: (2704 or (2714, 2804)), STAT 4714
ECE4205 (3)	ELECTRONIC CIRCUIT DESIGN, Pre: 3204
ECE4220 (3)	ANALOG INTEGRATED CIRCUIT DESIGN, Pre: 3204
ECE4234 (3)	SEMICONDUCTOR PROCESSING, Pre: 2204 or (2214, 2804) or 3054
ECE4235 (3)	PRINCIPLES OF ELECTRONIC PACKAGING, Pre: 2204 or (2214, 2804) or 3054

PHOTONICS

ECE3004 (3)	AC CIRCUIT ANALYSIS, Pre: 2704 or (2714, 2804)
ECE3074 (1)	AC CIRCUIT ANALYSIS LAB, Pre: 2074 or 2804; Co: 3004
ECE3105 (3)	ELECTROMAGNETIC FIELDS, Pre: 2004 or (2214, 2804), MATH 2204, PHYS 2306
ECE3106 (3)	ELECTROMAGNETIC FIELDS, Pre: 3105
ECE3134 (3)	INTRODUCTION OPTOELECTRONICS, Pre: 2204 or (2214, 2804)
ECE3174 (1)	OPTOELECTRONICS LAB, Pre: 2274 or 2804; Co: 3134
ECE3614 (3)	INTRODUCTION TO COMMUNICATION SYSTEMS, Pre: 2704 or 2714, STAT 4714
ECE4134 (3)	PHOTONICS, Pre: 3106
ECE4144 (3)	OPTICAL SYSTEMS, Pre: 3105

RADIO FREQUENCY AND MICROWAVE

ECE3004 (3)	AC CIRCUIT ANALYSIS, Pre: 2704 or (2714, 2804)
ECE3074 (1)	AC CIRCUIT ANALYSIS LAB, Pre: 2074 or 2804; Co: 3004
ECE3105 (3)	ELECTROMAGNETIC FIELDS, Pre: 2004 or (2214, 2804), MATH 2204, PHYS 2306
ECE3106 (3)	ELECTROMAGNETIC FIELDS, Pre: 3105
ECE3204 (3)	ANALOG ELECTRONICS, Pre: (2204, 2704) or (2214, 2714, 2804)
ECE3274 (1)	ELECTRONIC CIRCUITS LAB II, Pre: (2274 or 2804), 3074; Co: 3204
ECE3604 (3)	INTRODUCTION TO RF & MICROWAVE ENGINEERING, Pre: 3105
ECE4104 (3)	MICROWAVE AND RF ENGINEERING, Pre: 3106, 3204
ECE4114 (3)	ANTENNAS, Pre: 3106
ECE4124 (3)	RADIO WAVE PROPOGATION, Pre: 3106
ECE4220 (3)	ANALOG INTEGRATED CIRCUIT DESIGN, Pre: 3204
ECE4605 (3)	RADIO ENGINEERING, Pre: 3105, 3204, 3614

SPACE SYSTEMS

ECE3004 (3)	AC CIRCUIT ANALYSIS, Pre: 2704 or (2714, 2804)
ECE3074 (1)	AC CIRCUIT ANALYSIS LAB, Pre: 2074 or 2804; Co: 3004
ECE3105 (3)	ELECTROMAGNETIC FIELDS, Pre: 2004 or (2214, 2804), MATH 2204, PHYS 2306
ECE3106 (3)	ELECTROMAGNETIC FIELDS, Pre: 3105
ECE3104 (3)	INTRO SPACE SYSTEMS, Pre: 3105
ECE3154 (2)	SPACE SYSTEMS – DESIGN, Pre: 3105; Co: 3104
ECE3614 (3)	INTRODUCTION TO COMMUNICATION SYSTEMS, Pre: (2704 or (2714, 2804)), STAT 4714
ECE4154 (3)	INTRODUCTION TO SPACE WEATHER, Pre: 3106
ECE4164 (4)	INTRODUCTION TO FLOBAL POSITIONING SYSTEMS (GPS) THEORY AND DESIGN, Pre: 3106 or AOE 4134
ECE4194 (3)	ENGINEERING PRINCIPLES OF REMOTE SENSING, Pre: 3106
ECE4644 (4)	SATELLITE COMMUNICATIONS, Pre: 3614

INDEPENDENT STUDIES AND UNDERGRADUATE RESEARCH

ECE 4974 Independent Study and ECE 4994 Undergraduate Research listed below can *generally* be used as part of the Secondary Focus Area if the topic of the course fits with student's stated career goals and the student has a faculty for supervising the course. Please discuss Secondary Focus Area options for ECE 4974/ECE 4994 with your advisor prior to completing the required paperwork to add these courses. For purposes of satisfying the Secondary Focus requirements, the sum of the number of hours taken from ECE 4974 and 4994 cannot exceed 6 credits.

4974 (ARR) Independent Study
 4994 (ARR) Undergraduate Research

Students must complete the College of Engineering Undergraduate Research/Independent Study Form, the ECE Undergraduate Research/Independent Study Secondary Focus Proposal Form, and the ABET Breakdown prior to registration. To be considered for inclusion in the Secondary Focus, all forms are due to the ECE Student Services office no later than 2 weeks before classes begin for the requested semester – no exceptions. Forms are available online at www.ece.vt.edu/undergrad/policies.

INDIVIDUALIZED SECONDARY FOCUS (Must be preapproved by ECE Department)

The Machine Learning Major requires 9 credits from a secondary focus area. All 9 credits must be from one ECE focus area from the attached list or from an approved individualized secondary focus plan. At least 3 credits must be at the 4xxx level. The individualized secondary focus helps students pursue their interests. This option can be used in place of a pre-defined, in-department secondary focus.

The individualized secondary focus is pursued via a university-approved program taken from a single degree, major, minor, or certificate. Students can 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 outside of ECE, the student should attach documentation from the course catalog to the proposal form.
- 5) Exception: 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 single 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.