College of Engineering
Bradley Department of Electrical and Computer Engineering
Degree: Bachelor of Science in Electrical Engineering
Major: Communications & Networking
For Students Graduating in Calendar Year 2022 and for student date of entry under UG Catalog 2020-2021
Credits Required for graduation: 132

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 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 (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; 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]
		Concept 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: 2704 or(2714, 2804)	3[F,S]	ECE 3614[2] Introduction to Communication Systems (C-) Pre: (2704 or (2714, 2804)), STAT 4714	3[F,S]
ECE 3074[1] AC Circuit Analysis Laboratory (C-) Pre: 2074 or 2804; Co: 3004	1[F,S]	ECE 4614[2] Telecommunication Networks Pre: ((2504, 2704) or (2544, 2714, 2804)), STAT 4714	3
ECE 3105[1] Electromagnetic Fields Pre: (2004 or (2214, 2804)), PHYS 2306, (MATH 2204 or MATH 2204H or MATH 2406H)	3[F,S]	Secondary Focus Area course (see list)	3
ECE 3704[2] Continuous & Discrete System Theory Pre: 2704 or (2714, 2804)	3[F,S]	Secondary Focus Area course (see list)	3
STAT 4714 Probability & Statistics for Electrical Engineers (C-) Pre: (MATH 2204 or MATH 2224)	3	Concept 2 or 3 or 6a	3
Secondary Focus Area course (see list)	3		
TOTAL	**16**	**TOTAL**	**15**

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 4624[2] Digital Signal Processing and Filter Design Pre: 3704	3[F]	MATH Elective from list	3[S]
ECE 4634[2] Digital Communications Pre: 3614, STAT 4714	3[F]	Concept 7 or Free Elective (if Pathways 7 double counted)	3
ECE 4664[2] Analog & Digital Communications Lab Pre: 3614, Co: 4634	1[F]	Concept 2 or 3 or 6a	3
Concept 2 or 3 or 6a	3	Free Elective	3
Free Elective	3	Free Elective	2
TOTAL	**16**	**TOTAL**	**17**

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)	*Foundational:* **ENGL 1105**	**(3)**	*Foundational:* **ENGL 1106**	**(3)**
	Advanced: **ECE 4805 + ECE 4806**			**(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)	*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)	*Pathways 7 should be double counted with either Pathways 2, 3 or 6a to avoid taking any additional credit hours.			**(3)**

Electives

The Communications & Networking major requires 3 hours of math electives from list and 8 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 Communications & Networking 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 132 semester credit hours with a minimum overall GPA of 2.00 and a minimum in-major GPA of 2.00. In determining the Communications & Networking in-major GPA, all ECE courses, including repeats, are used.

SECONDARY FOCUS REQUIREMENT
Communications and Networking Major
For Students Graduating in Calendar Year 2022 and for student date of entry under UG Catalog 2020-2021

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

ECE2500 (3)   COMPUTER ORGANIZATION AND ARCHITECTURE, Pre: 2504 or (2544, 2804)

ECE2574 (3)   DATA STRUCTURES AND ALGORITHMS, Pre: 1574 or (2514, 2804)

ECE3574 (3)   APPLIED SOFTWARE DESIGN, Pre: 2574 or 3514

ECE3544 (4)   DIGITAL DESIGN, Pre: 2504 or (2544, 2804)

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

ECE2500 (3)   COMPUTER ORGANIZATION AND ARCHITECTURE, Pre: 2504 or (2544, 2804)

ECE2574 (3)   DATA STRUCTURES AND ALGORITHMS, Pre: 1574 or (2514, 2804)

ECE3574 (3)   APPLIED SOFTWARE DESIGN, Pre: 2574 or 3514

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)

MACHINE LEARNING

ECE2500 (3)   COMPUTER ORGANIZATION AND ARCHITECTURE, Pre: 2504 or (2544, 2804)

ECE2574 (3)   DATA STRUCTURES AND ALGORITHMS, Pre: 1574 or (2514, 2804)

ECE3574 (3)   APPLIED SOFTWARE DESIGN, Pre: 2574 or 3514

ECE4424 (3)   MACHING LEARNING (CS 4824), Pre: (2574 or 3514), (STAT 4604 or STAT 4705 or STAT 4714)

ECE4524 (4)   ARTIFICIAL INTELLIGENCE AND ENGINEERING APPLICATIONS, Pre: (2574 or 3514), STAT 4714

ECE4525 (3)   VIDEO GAME DESIGN AND ENG, Pre: 3574

ECE4526 (3)   VIDEO GAME DESIGN AND ENG, Pre: 4525

ECE4554 (3)   INTRODUCTION TO COMPUTER VISION, Pre: 3574, (STAT 4705 or STAT 4714)

ECE4580 (3)   DIGITAL IMAGE PROCESSING

NETWORKING AND CYBERSECURITY

ECE2500 (3)   COMPUTER ORGANIZATION AND ARCHITECTURE, Pre: 2504 or (2544, 2804)

ECE2574 (3)   DATA STRUCTURES AND ALGORITHMS, Pre: 1574 or (2514, 2804)

ECE3574 (3)   APPLIED SOFTWARE DESIGN, Pre: 2574 or 3514

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)

CS4264 (3)   PRINCIPLES OF COMPUTER SECURITY, Pre: CS 3214 or ((ECE 2500 or 3504), ECE 3574)

SOFTWARE SYSTEMS

ECE2500 (3)   COMPUTER ORGANIZATION AND ARCHITECTURE, Pre: 2504 or (2544, 2804)

ECE2574 (3)   DATA STRUCTURES AND ALGORITHMS, Pre: 1574 or (2514, 2804)

ECE3574 (3)   APPLIED SOFTWARE DESIGN, Pre: 2574 or 3514

ECE4524 (4)   ARTIFICIAL INTELLIGENCE AND ENGINEERING APPLICATIONS, Pre: (2574 or 3514), STAT 4714

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)

ENERGY AND POWER ELECTRONIC SYSTEMS

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

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

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

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

ECE3106 (3)   ELECTROMAGNETIC FIELDS, Pre: 3105

ECE3134 (3)   INTRODUCTION OPTOELCTRONICS, Pre: 2204 or (2214, 2804)

ECE3174 (1)   OPTOELECTRONICS LAB, Pre: 2274 or 2804; Co: 3134

ECE4134 (3)   PHOTONICS, Pre: 3106

ECE4144 (3)   OPTICAL SYSTEMS, Pre: 3105

RADIO FREQUENCY AND MICROWAVE

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

ECE3106 (3)   ELECTROMAGNETIC FIELDS, Pre: 3105

ECE3104 (3)   INTRO SPACE SYSTEMS, Pre: 3105

ECE3154 (2)   SPACE SYSTEMS – DESIGN, Pre: 3105; Co: 3104

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 Communications & Networking 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.

MATH ELECTIVE REQUIREMENT
Communications & Networking Major
For Students Graduating in Calendar Year 2022 and for student date of entry under UG Catalog 2020-2021

Communications & Networking majors are required to take one math elective course from the following list. Some courses may include prerequisite courses not required for the EE 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

MATH 3034 (3)   INTRODUCTION TO PROOFS, 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]