# Computer Engineering (BS): Artificial Intelligence and Machine Learning Concentration

The CPE core courses provide a foundation for all CPE students in electric circuits, digital logic, computer systems, programming, signals, linear systems, embedded systems, discrete math, data structures, teaming and communication, and the social and ethical dimensions of the practice of electrical and computer engineering.

Students will select a concentration for their CPE degree. CPE offers a robust set of concentrations to guide students in their studies. All concentrations within CPE share the core courses required by the major. Concentrations are offered in the following areas: Artificial Intelligence and Machine Learning, Computer Architecture and Emerging Systems, Computer Systems Software, Embedded Systems, Networking Hardware, and Networking Software.

Each CPE concentration contains 22 hours of work. Students will take 12 hours from a prescribed list of courses that provide the necessary depth and background to pursue a career in the area. An additional 10 hours from a broader list of “open” electives are also required as part of the concentration, and these are meant to reinforce and add breadth to that area. There are many connections between areas and too many to explicitly list, and therefore, the open category gives students the freedom to choose courses that either broaden or deepen their expertise as they determine appropriate in consultation with their advisor. Furthermore, the open elective list intentionally allows students to take courses outside of ECE, such as other engineering, math, or science courses.

In their final year, all Computer Engineering majors participate in a two-semester senior design course sequence. Students work in teams to solve an engineering problem identified by faculty or industrial sponsors. Over the course of two semesters, students gain experience designing, documenting, and communicating about their project to various audiences.

This curriculum leads to a Bachelor of Science in Computer Engineering and is nationally accredited by ABET, http://www.abet.org.

## Plan Requirements

| Code | Title | Hours |
|---|---|---|
| **Major Field of Study Requirements** | | |
| **Math** | | |
| MA 141 | Calculus I [1,2] | 4 |
| MA 241 | Calculus II [1,2] | 4 |
| MA 242 | Calculus III | 4 |
| ST 371 | Introduction to Probability and Distribution Theory | 3 |
| **Science** | | |
| CH 101 & CH 102 | Chemistry - A Molecular Science and General Chemistry Laboratory [1,2] | 4 |
| PY 205 & PY 206 | Physics for Engineers and Scientists I and Physics for Engineers and Scientists I Laboratory [1,2] | 4 |
| PY 208 & PY 209 | Physics for Engineers and Scientists II and Physics for Engineers and Scientists II Laboratory | 4 |
| **Computer Engineering Core Courses** | | |
| ECE 109 | Introduction to Computer Systems [3] | 3 |
| ECE 200 | Introduction to Signals, Circuits and Systems [3] | 4 |
| ECE 209 | Computer Systems Programming [3] | 3 |
| ECE 211 | Electric Circuits [3] | 4 |
| ECE 212 | Fundamentals of Logic Design [3] | 3 |
| ECE 220 | Analytical Foundations of Electrical and Computer Engineering [3] | 3 |
| CSC 226 | Discrete Mathematics [3] | 3 |
| ECE 301 | Linear Systems | 3 |
| ECE 306 | Introduction to Embedded Systems | 3 |
| ECE 309 | Data Structures and Object-Oriented Programming for Electrical and Computer Engineers | 3 |
| ECE 381 | Engineering Profession for Computer Engineers | 1 |
| or ECE 380 | Engineering Profession for Electrical Engineers | |
| or ECE 383 | Introduction to Entrepreneurship and New Product Development | |
| ECE 484 | Electrical and Computer Engineering Senior Design I | 3 |
| or ECE 482 | Engineering Entrepreneurship Senior Design I | |
| ECE 485 | Electrical and Computer Engineering Senior Design II | 3 |
| or ECE 483 | Engineering Entrepreneurship Senior Design II | |
| **AI/ML Concentration** | | |
| MA 305 | Introductory Linear Algebra and Matrices [7] | 3 |
| or MA 405 | Introduction to Linear Algebra | |
| ECE 411 | Introduction to Machine Learning | 3 |
| AI/ML Electives (p. 2) | | 6 |
| Open Electives (p. ) [6] | | 10 |
| **Other Major Requirements** | | |
| COM 110 | Public Speaking | 3 |
| ENG 331 | Communication for Engineering and Technology | 3 |
| **College Requirements** | | |
| E 101 | Introduction to Engineering & Problem Solving [3] | 1 |
| E 102 | Engineering in the 21st Century [3] | 2 |
| E 115 | Introduction to Computing Environments [3] | 1 |
| EC 205 | Fundamentals of Economics | 3 |
| or EC 201 | Principles of Microeconomics | |
| or ARE 201 | Introduction to Agricultural & Resource Economics | |
| or ARE 201A | Introduction to Agricultural & Resource Economics | |
| **Total Hours** | | **101** |

| Code | Title | Hours |
|---|---|---|
| **GEP Courses** | | |
| ENG 101 | Academic Writing and Research [3] | 4 |
| GEP Humanities (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-humanities/) | | 6 |
| GEP Social Sciences (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-social-sciences/) | | 3 |

| | |
|---|---|
| GEP Health and Exercise Studies (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/) | 2 |
| GEP Interdisciplinary Perspectives (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-interdisciplinary-perspectives/) | 3 |
| GEP Elective (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/) | 3 |
| GEP Global Knowledge (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-global-knowledge/) (verify requirement) | |
| GEP Foundations of American Democracy (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-fad/) (verify requirement) | |
| World Language Proficiency (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/world-language-proficiency/) (verify requirement) | |
| **Total Hours** | **21** |

## AI/ML Electives

| Code | Title | Hours |
|---|---|---|
| ECE 410 | Introduction to Signal Processing [4] | 3 |
| or ECE 510 | Introduction to Signal Processing | |
| ECE 425 | Neural Networks and Deep Learning [4] | 3 |
| or ECE 525 | Neural Networks and Deep Learning | |
| ECE 512 | Data Science from a Signal Processing Perspective [4] | 3 |
| ECE 558 | Digital Imaging Systems [4] | 3 |
| DSA 201 | Introduction to R/Python for Data Science [5] | 1 |
| DSA 202 | Introduction to Data Visualization [5] | 1 |
| DSA 205 | Data Communication [5] | 1 |
| DSA 225 | Data Science for Social Good [5] | 1 |
| DSA 235 | Introduction to Data Science for Cybersecurity [5] | 1 |
| DSA 405 | Data Wrangling and Web Scraping [5] | 1 |
| DSA 406 | Exploratory Data Analysis for Big Data [5] | 1 |
| DSA 412 | Exploring Machine Learning [5] | 1 |

## Open Electives

## Open Electives

Choose from the ECE Elective List or the other Open Electives listed below.

**ECE Elective**

| Code | Title | Hours |
|---|---|---|
| ECE 402 | Communications Engineering | 3 |
| ECE 403 | Electronics Engineering | 3 |
| ECE 404 | Introduction to Solid-State Devices | 3 |
| ECE 406/506 | Architecture Of Parallel Computers | 3 |
| ECE 407 | Introduction to Computer Networking | 3 |
| ECE 410/510 | Introduction to Signal Processing | 3 |
| ECE 411 | Introduction to Machine Learning | 3 |
| ECE 418/518 | Wearable Biosensors and Microsystems | 3 |
| ECE 420 | Wireless Communication Systems | 3 |
| ECE 422 | Transmission Lines and Antennas for Wireless | 3 |
| ECE 423 | Introduction to Photonics and Optical Communications | 3 |
| ECE 424/524 | Radio System Design | 3 |
| ECE 426 | Analog Electronics Laboratory | 3 |
| ECE 434 | Fundamentals of Power Electronics | 3 |
| ECE 436 | Digital Control Systems | 3 |
| ECE 442 | Introduction to Integrated Circuit Technology and Fabrication | 3 |
| ECE 451 | Power System Analysis | 3 |
| ECE 452/552 | Renewable Electric Energy Systems | 3 |
| ECE 453 | Electric Motor Drives | 3 |
| ECE 455 | Industrial Robot Systems | 3 |
| ECE 456/556 | Mechatronics | 3 |
| ECE 460/560 | Course ECE 460 Not Found | 3 |
| ECE 461/561 | Embedded System Analysis and Optimization | 3 |
| ECE 463/563 | Microprocessor Architecture | 3 |
| ECE 464/564 | ASIC and FPGA Design with Verilog | 3 |
| ECE 465/565 | Operating Systems Design | 3 |
| ECE 466/566 | Compiler Optimization and Scheduling | 3 |
| ECE 468/568 | Conventional and Emerging Nanomanufacturing Techniques and Their Applications in Nanosystems | 3 |
| ECE 470 | Internetworking | 3 |
| ECE 488/588 | Systems Biology Modeling of Plant Regulation | 3 |
| ECE 489/589 | Solid State Solar and Thermal Energy Harvesting | 3 |
| ECE 492 | Special Topics in Electrical and Computer Engineering | 1-4 |
| ECE 505 | Neural Interface Engineering | 3 |
| ECE 511 | Analog Electronics | 3 |
| ECE 512 | Data Science from a Signal Processing Perspective | 3 |
| ECE 514 | Random Processes | 3 |
| ECE 515 | Digital Communications | 3 |
| ECE 516 | System Control Engineering | 3 |
| ECE 517 | Object-Oriented Design and Development | 3 |
| ECE 522 | Medical Instrumentation | 3 |
| ECE 523 | Photonics and Optical Communications | 3 |
| ECE 530 | Physics of Semiconductors | 3 |
| ECE 531 | Course ECE 531 Not Found | 3 |
| ECE 532 | Course ECE 532 Not Found | 3 |
| ECE 533 | Power Electronics Design & Packaging | 3 |
| ECE 534 | Power Electronics | 3 |
| ECE 535 | Design of Electromechanical Systems | 3 |
| ECE 536 | Digital Control System Projects | 3 |
| ECE 538 | Integrated Circuits Technology and Fabrication | 3 |
| ECE 540 | Electromagnetic Fields | 3 |
| ECE 541 | Antennas and Arrays | 3 |
| ECE 542 | Neural Networks and Deep Learning | 3 |
| ECE 544 | Design Of Electronic Packaging and Interconnects | 3 |
| ECE 546 | VLSI Systems Design | 3 |
| ECE 547 | Cloud Computing Technology | 3 |
| ECE 549 | RF Design for Wireless | 3 |
| ECE 550 | Power System Operation and Control | 3 |

| | | |
|---|---|---|
| ECE 551 | Smart Electric Power Distribution Systems | 3 |
| ECE 553 | Semiconductor Power Devices | 3 |
| ECE 554 | Electric Motor Drives | 3 |
| ECE 555 | Autonomous Robot Systems | 3 |
| ECE 557 | Principles Of MOS Transistors | 3 |
| ECE 558 | Digital Imaging Systems | 3 |
| ECE 570 | Computer Networks | 3 |
| ECE 573 | Internet Protocols | 3 |
| ECE 574 | Computer and Network Security | 3 |
| ECE 575 | Introduction to Wireless Networking | 3 |
| ECE 576 | Networking Services: QoS, Signaling, Processes | 3 |
| ECE 577 | Switched Network Management | 3 |
| ECE 578 | LTE and 5G Communications | 3 |
| ECE 579 | Introduction to Computer Performance Modeling | 3 |
| ECE 581 | Electric Power System Protection | 3 |
| ECE 582 | Course ECE 582 Not Found | 3 |
| ECE 583 | Electric Power Engineering Practicum I | 3 |
| ECE 584 | Electric Power Engineering Practicum II | 3 |
| ECE 585 | The Business of the Electric Utility Industry | 3 |
| ECE 586 | Communication and SCADA Systems for Smart Grid | 3 |
| ECE 587 | Power System Transients Analysis | 3 |
| ECE 591 | Special Topics In Electrical Engineering | 1-6 |
| ECE 592 | Special Topics In Electrical Engineering | 1-6 |

| Code | Title | Hours |
|---|---|---|
| ECE 303 | Electromagnetic Fields | 3 |
| E 304 | Introduction to Nano Science and Technology | 3 |
| ECE 305 | Principles of Electromechanical Energy Conversion | 3 |
| ECE 306 | Introduction to Embedded Systems | 3 |
| ECE 308 | Elements of Control Systems | 3 |
| ECE 309 | Data Structures and Object-Oriented Programming for Electrical and Computer Engineers | 3 |
| ECE 310 | Design of Complex Digital Systems | 3 |
| ECE 384 | Practical Engineering Prototyping | 3 |
| ECE 425 | Neural Networks and Deep Learning | 3 |
| or ECE 525 | Neural Networks and Deep Learning | |
| ECE 469 | Quantum Programming | 3 |
| CE 214 | Engineering Mechanics-Statics | 3 |
| or MAE 206 | Engineering Statics | |
| MSE 200 | Mechanical Properties of Structural Materials | 3 |
| or MSE 201 | Structure and Properties of Engineering Materials | |
| ISE 311 | Engineering Economic Analysis | 3 |
| MAE 208 | Engineering Dynamics | 3 |
| MAE 201 | Thermal-Fluid Sciences | 3 |
| MAE 302/ BME 525 | Engineering Thermodynamics II | 3 |
| DSA 200 or higher level courses, up to 3 credit hours | | 3 |
| College of Science courses 400-level or higher with permission of advisor | | |
| College of Engineering Courses 400-level or higher with permission of advisor | | |

1 Course required for Change of Degree Audit (CODA).
2 A grade of C or higher is required.
3 A grade of C- or higher is required.
4 Minimum 3.5 GPA required to enroll in graduate classes.
5 A maximum of 3 credit hours of DSA courses can count toward the AI/ML Electives requirement.
6 Suggested open electives, depending on interests of the student, include digital circuits (ECE 310, ECE 464), controls (ECE 308, ECE 436, ECE 455, ECE 456), communications and signal processing (ECE 402, 410/510, 411, 420, 425, 512), networking (ECE 407, 470), embedded systems (ECE 460/560, ECE 461/561), and systems software (ECE 448/548, 465/565).
7 MA 405 is recommended for students persuing graduate studies.

**First Year**

| **Fall Semester** | | **Hours** |
|---|---|---|
| CH 101 | Chemistry - A Molecular Science [1,2] | 3 |
| CH 102 | General Chemistry Laboratory [1,2] | 1 |
| E 101 | Introduction to Engineering & Problem Solving [3] | 1 |
| E 115 | Introduction to Computing Environments [3] | 1 |
| ENG 101 | Academic Writing and Research [3] | 4 |
| MA 141 | Calculus I [1,2] | 4 |
| GEP Health and Exercise Studies (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/) | | 1 |
| | **Hours** | **15** |
| **Spring Semester** | | |
| ECE 109 | Introduction to Computer Systems [3] | 3 |
| MA 241 | Calculus II [1,2] | 4 |
| PY 205 | Physics for Engineers and Scientists I [1,2] | 3 |
| PY 206 | Physics for Engineers and Scientists I Laboratory [1,2] | 1 |
| E 102 | Engineering in the 21st Century [3] | 2 |
| EC 205<br>or EC 201<br>or ARE 201<br>or ARE 201A | Fundamentals of Economics<br>or Principles of Microeconomics<br>or Introduction to Agricultural & Resource Economics<br>or Introduction to Agricultural & Resource Economics | 3 |
| | **Hours** | **16** |

**Second Year**

| **Fall Semester** | | |
|---|---|---|
| ECE 200 | Introduction to Signals, Circuits and Systems [3] | 4 |
| ECE 209 | Computer Systems Programming [3] | 3 |
| MA 242 | Calculus III | 4 |
| PY 208<br>& PY 209 | Physics for Engineers and Scientists II and Physics for Engineers and Scientists II Laboratory [1] | 4 |
| | **Hours** | **15** |
| **Spring Semester** | | |
| COM 110 | Public Speaking | 3 |
| CSC 226 | Discrete Mathematics [3] | 3 |
| ECE 211 | Electric Circuits [3] | 4 |

| | | |
|---|---|---|
| ECE 212 | Fundamentals of Logic Design [3] | 3 |
| ECE 220 | Analytical Foundations of Electrical and Computer Engineering [3] | 3 |
| | **Hours** | **16** |
| **Third Year** | | |
| **Fall Semester** | | |
| ECE 301 | Linear Systems | 3 |
| ECE 309 | Data Structures and Object-Oriented Programming for Electrical and Computer Engineers | 3 |
| ST 371 | Introduction to Probability and Distribution Theory | 3 |
| MA 305<br>or MA 405 | Introductory Linear Algebra and Matrices [7]<br>or Introduction to Linear Algebra | 3 |
| GEP Requirement (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/) | | 3 |
| | **Hours** | **15** |
| **Spring Semester** | | |
| ECE 306 | Introduction to Embedded Systems | 3 |
| ECE 411 | Introduction to Machine Learning | 3 |
| Select one of the following: | | 1 |
| ECE 381 | Engineering Profession for Computer Engineers | |
| ECE 380 | Engineering Profession for Electrical Engineers | |
| ECE 383 | Introduction to Entrepreneurship and New Product Development | |
| Open Electives (p. 2) [6] | | 4 |
| ENG 331 | Communication for Engineering and Technology | 3 |
| GEP Health and Exercise Studies (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/gep-health-exercise-studies/) | | 1 |
| | **Hours** | **15** |
| **Fourth Year** | | |
| **Fall Semester** | | |
| ECE 484 | Electrical and Computer Engineering Senior Design I | 3 |
| AI/ML Elective (p. 2) [5] | | 3 |
| Open Electives (p. ) [6] | | 3 |
| GEP Requirement (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/) | | 3 |
| GEP Requirement (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/) | | 3 |
| | **Hours** | **15** |
| **Spring Semester** | | |
| ECE 485 | Electrical and Computer Engineering Senior Design II | 3 |
| AI/ML Elective (p. 2) [5] | | 3 |
| Open Electives (p. ) [6] | | 3 |
| GEP Requirement (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/) | | 3 |
| GEP Requirement (http://catalog.ncsu.edu/undergraduate/gep-category-requirements/) | | 3 |
| | **Hours** | **15** |
| | **Total Hours** | **122** |

1 Course required for Change of Degree Audit (CODA).
2 A grade of C or higher is required.
3 A grade of C- or higher is required.
4 A minimum GPA of 3.5 is required to enroll in graduate-level courses.
5 A maximum of 3 credit hours of DSA courses can count toward the AI/ML Electives requirement.
6 Suggested open electives, depending on interests of the student, include digital circuits (ECE 310, ECE 464), controls (ECE 308, ECE 436, ECE 455, ECE 456), communications and signal processing (ECE 402, 410/510, 411, 420, 425, 512), networking (ECE 407, 470), embedded systems (ECE 460/560, ECE 461/561), and systems software (ECE 448/548, 465/565).
7 MA 405 is recommended for students pursuing graduate studies.

A computer engineering degree unlocks a vast array of exciting career opportunities at the forefront of technology. Graduates can delve into roles such as hardware engineers—designing and optimizing the next generation of computing devices—or software engineers who crafting innovative applications and systems that drive technological progress. You have career opportunities in fields like cybersecurity or you can delve into artificial intelligence and machine learning, developing algorithms that power intelligent systems.

Additionally, opportunities abound in areas such as embedded systems, where engineers create the brains behind smart devices, and in networking, where they build the backbone of our connected world. Moreover, with the rapid expansion of fields like the Internet of Things, augmented reality, and quantum computing, the possibilities for computer engineering professionals are continually expanding, offering avenues for creative problem-solving and impactful innovation across industries.

Whether in established tech giants like Apple, Samsung, or Analog Devices, cutting-edge startups, research institutions, or entrepreneurial ventures, computer engineering graduates are poised to shape the future of technology and drive meaningful change in society.

You can see some currently-hiring positions in ePack (https://my.ece.ncsu.edu/careers/jobs/) for examples of career paths.

## Career Titles

- Architectural Drafters
- Automotive Engineering Technicians
- Computer and Information Scientists
- Computer and Information Systems Managers
- Computer Hardware Engineers
- Computer Network Architects
- Computer Programmer
- Computer Systems Analyst
- Computer Systems Engineer
- Database Administrator
- Database Architects
- Electrical and Electronic Engineering Technologists and Technicians
- Engineering Professor
- Information Security Analysts

- Sales Representative (Computers)
- Software Developers - Applications
- Telecommunications Engineering Specialists

## Learn More About Careers

NCcareers.org (https://nccareers.org/)
Explore North Carolina's central online resource for students, parents, educators, job seekers and career counselors looking for high quality job and career information.

Occupational Outlook Handbook (https://www.bls.gov/ooh/)
Browse the Occupational Outlook Handbook published by the Bureau of Labor Statistics to view state and area employment and wage statistics. You can also identify and compare similar occupations based on your interests.

Career One Stop Videos (https://www.careeronestop.org/)
View videos that provide career details and information on wages, employment trends, skills needed, and more for any occupation. Sponsored by the U.S. Department of Labor.

Focus 2 Career Assessment (https://careers.dasa.ncsu.edu/explore-careers/career-assessments/) (NC State student email address required)
This career, major and education planning system is available to current NC State students to learn about how your values, interests, competencies, and personality fit into the NC State majors and your future career. An NC State email address is required to create an account. Make an appointment with your career counselor (https://careers.dasa.ncsu.edu/about/hours-appointments/) to discuss the results.

Focus 2 Apply Assessment (https://www.focus2career.com/Portal/Register.cfm?SID=1929) (Available to prospective students)
A career assessment tool designed to support prospective students in exploring and choosing the right major and career path based on your unique personality, interests, skills and values. Get started with Focus 2 Apply and see how it can guide your journey at NC State.

Institute of Electrical and Electronics Engineers (http://www.ieee.org/)
National Association of Professional Engineers (https://www.nspe.org/)