# ELECTRICAL & COMPUTER ENGINEERING - MASTER OF SCIENCE (MSECE) ONLINE

The online Master of Science in Electrical & Computer Engineering (MSEE), hosted on the internationally acclaimed Coursera (https://www.coursera.org/degrees/msee-boulder/) platform, offers stackable graduate-level courses, graduate certificates and a fully accredited master's degree in electrical engineering. The Master of Science in Electrical & Computer Engineering on Coursera students earn the same credentials as our on-campus students. There are no designations on official CU transcripts, degrees or certificates that this is an online program.

## Focus Areas

### Embedded Systems

Embedded system engineering is used in industries such as aerospace and defense, energy, industrial automation, health care, networking and communication, security, transportation and more. Embedded systems also drive the Internet of Things (IoT), enabling countless human-to-machine and machine-to-machine applications including home automation, security and more.

The embedded systems engineering curriculum covers essential embedded technologies, synthesizes foundational principles and directly applies them to current tools and trends. It is structured to provide you with a broad, versatile and highly competitive skill set. We emphasize practical, project-based learning across hardware and embedded software design that addresses numerous end markets, as well as multiple semiconductor technologies including sensors, controllers, programmable devices and development tools.

### Power Electronics

Power electronics is a key enabling technology in essentially all electronic systems and is increasingly important in the grid interface of renewable energy sources and in efficient electrical loads. The necessity for power electronics technology in these rapidly expanding areas creates an increasing need for design engineers equipped with knowledge and skills to actively participate in multidisciplinary teams.

The power electronics curriculum addresses this demand for skilled power electronics design engineers, covering switching power supplies, DC-DC converters, inverters, power factor correction converters and LED lighting drivers. The power electronics curriculum emphasizes fundamentals and application in the power electronics field. This domain competency applies to end markets such as power management, portable power, computer systems, medical applications, spacecraft power systems, the automotive industry, renewable energy and the utilities.

### Photonics & Optics

While 20th-century technology was defined by the growth of electronics, the 21st century belongs to photonics. LEDs will light households powered by photovoltaic panels and filled with displays and cameras communicating by optical fiber to distant owners wearing virtual reality glasses. Laser 3D printing will transform manufacturing. New microscopes and telescopes will peer into the depths of living cells and distant galaxies.

The photonics curriculum provides a firm theoretical foundation on the generation, modulation, radiative or guided transmission, sensing, and detection of optical signals. It also covers optical telecommunications, medical instrumentation, photovoltaic power generation, information processing, optical instruments and environmental sensing. While some of these industries are mature, photonics continues to grow into new industries such as LED lighting and on-chip silicon photonics for multi-core CPUs.

## Program Policies

This CU Boulder on Coursera program does not align with standard campus policies. Please refer to the Online Programs (https://catalog.colorado.edu/online/) section of the catalog for more information.

Up to 9 credits offered by the MS in Computer Science (https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/computer-science/computer-science-master-science-ms-online/) and/or MS in Data Science (https://catalog.colorado.edu/graduate/colleges-schools/interdisciplinary-programs/data-science-master-science-ms-online/) and/or ME in Engineering Management (https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/engineering-management/engineering-management-master-engineering-me-online/) on Coursera programs in which a student earns a grade of solid B or higher (B-minus is too low) may be applied toward the MS in Electrical Engineering degree's required 30 credits. Courses must be graduate level and meet all applicable academic standards and may not be double counted toward two credentials of the same level. Only courses offered through CU Boulder's for-credit programs on Coursera may be used.

## Admission Requirements

The MSEE program utilizes performance-based admissions for enrollment. There is no traditional application for admission to the degree. Students do not need to take the GRE or submit letters of recommendation or proof of language proficiency. Neither a prior degree nor university transcripts are required for admission. Because this is a purely online program, students do not need to complete a background check to enroll.

A student desiring admission to the MSEE program must complete four required protocols:

1. Take one pathway specialization for credit with at least a grade of C in each course.
2. Achieve a computed pathway specialization grade-point average (GPA) of at least 3.00.
3. Have a cumulative GPA of at least 3.00 for all for-credit courses taken to date.
4. Declare their intention to seek the degree, which they can do before, during, or after any work in a pathway specialization.

Upon completion of these four steps the student is admitted to the MSEE program. Students may successfully complete a designated pathway specialization and declare intent at any point in their academic journey. Completion of a pathway specialization is not required for students to begin earning academic credit, only to earn the degree. Non-degree seeking students may enroll in for-credit courses.

All courses attempted and/or completed for credit will appear on an official CU Boulder transcript (unless dropped by the drop deadline) and will count toward the cumulative GPA.

# Program Requirements

The diagram displayed on the Electrical Engineering (https://www.colorado.edu/ecee/msee/) website shows how the program's courses and certificates can be stacked into the full 30 credit hour degree.

Up to 9 credits offered by the MS-DS or ME-EM on Coursera programs may be applied toward the Electrical Engineering MS degree required 30 credits. Courses must be graduate level and meet all applicable academic standards and may not be double counted toward two credentials of the same level. Only courses offered through Coursera may be used.

## Embedded Systems Track

### Computer Engineering / Embedded Systems Engineering

**Computer engineering** encompasses a wide range of topics surrounding this interaction between hardware and software. Computer engineers of the future will be versatile full-stack developers, comfortable with understanding the technical depths of software development while also possessing a wide knowledge of the underlying hardware implementations. The MSEE on Coursera curriculum in computer engineering emphasizes computer-aided verification and synthesis.

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The MSEE on Coursera's Embedded Systems Engineering curriculum covers essential embedded technologies, synthesizes foundational principles, and directly applies them to current tools and trends. It is structured to provide you with a broad, versatile and highly competitive skill set. We emphasize practical, project-based learning across hardware and embedded software design that addresses numerous end markets, as well as multiple semiconductor technologies including sensors, controllers, programmable devices and development tools.

#### Industrial Internet of Things - Graduate Certificate

To earn a graduate certificate (9 credits), students must complete the required specializations.

Required specializations:

- Embedded Sensors and Motors Specialization
- Embedded Interface Design Specialization
- Developing Industrial Internet of Things Specialization

**Advanced Embedded Linux Development Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5305 | Linux System Programming and Introduction to Buildroot | |
| ECEA 5306 | Linux Kernel Programming and Introduction to Yocto | |
| ECEA 5307 | Embedded System Topics and Project | |

**Embedding Sensors and Motors Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5340 | Embedding Sensors and Motors: Sensors, Sensor Circuit Design | |
| ECEA 5341 | Embedding Sensors and Motors: Motors, Motor Control Circuits | |
| ECEA 5342 | Embedding Sensors and Motors: Pressure and Motion Sensors | |
| ECEA 5343 | Embedding Sensors and Motors: Sensor Manufact, Process Ctrl | |

**FPGA Design for Embedded Systems Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5360 | FPGA Design for Embedded Systems: Intro to FPGA Dsgn for ES | |
| ECEA 5361 | FPGA Design for Embedded Systems: Hardwr Desc Lang FPGA Dsgn | |
| ECEA 5362 | FPGA Design for Embedded Systems: FPGA Softcore Proc, IP Acq | |
| ECEA 5363 | FPGA Design for Embedded Systems: Building FPGA Projects | |

**Developing Industrial Internet of Things Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5385 | Industrial IoT Markets and Security | |
| ECEA 5386 | Developing Industrial IoT: Proj Planning, Machine Learning | |
| ECEA 5387 | Developing Industrial IoT: Modeling and Debugging Embed Sys | |

**Real-time Embedded Systems Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5315 | Real-Time Embedded Systems: Concepts and Practices | |
| ECEA 5316 | Real-Time Embedded Systems: Theory and Analysis | |
| ECEA 5317 | Real-Time Embedded Systems: Mission-Critical, SW Application | |
| ECEA 5318 | Real-Time Embedded Systems: Project | |

**Embedded Interface Design Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5346 | Embedded Interface Design: User Exp I/F Design for Emb Sys | |
| ECEA 5347 | Embedded Interface Design: Rapid Prototyping Emb I/F Designs | |

| | |
|---|---|
| ECEA 5348 | Embedded Interface Design: M2M, IoT I/F Design & Protocols |

**Network Systems: Principles and Practice (Linux and Cloud Networking)**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5370 | Network Systems Foundation | |
| ECEA 5371 | Network Principles in Practice: Linux Networking | |
| ECEA 5372 | Network Principles in Practice: Cloud Networking | |

**Sensors for a Carbon Free World Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5349 | Sensors for a Carbon Free World: Electric Vehicle Sensors | |
| ECEA 5350 | Sensors for a Carbon Free World: Wind Turbine Sensors | |
| ECEA 5351 | Sensors for a Carbon Free World: Solar Power Sensors | |

**Engineering Genetic Circuits Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5934 | Engineering Genetic Circuits: Design | |
| ECEA 5935 | Engineering Genetic Circuits: Modeling and Analysis | |
| ECEA 5936 | Engineering Genetic Circuits: Abstraction Methods | |

## Spectrum Engineering - Graduate Certificate

The spectrum engineering graduate certificate requires 12 credit hours of coursework. Three hours of coursework is recommended, though not required.

| Code | Title | Credit Hours |
|---|---|---|
| **Recommended Specialization** | | **3** |
| ECEA 5453 | The Electromagnetic Spectrum | |
| ECEA 5454 | Signal Fundamentals | |
| ECEA 5455 | Economics, Management and Policy | |
| **Required Specializations** | | **12** |
| ECEA 5450 | The Science of Spectrum Access | |
| ECEA 5451 | Radio Frequency Engineering | |
| ECEA 5452 | Signals and Propagation | |
| ECEA 5456 | Radio Services and Broadcast Applications | |
| ECEA 5457 | Mobile Communication: Cellular and Wi-Fi | |
| ECEA 5458 | Radio Determination and Space Applications | |
| ECEA 5459 | The Electromagnetic Spectrum | |
| ECEA 5460 | History of Spectrum Management | |
| ECEA 5461 | Spectrum Sharing | |
| ECEA 5462 | Consumer Demand and Valuation | |
| ECEA 5463 | Firm Supply and the Structure of the Market | |
| ECEA 5464 | Optimal Pricing with Market Power | |

# Power Electronics Track

### Power Electronics - Graduate Certificate

To earn a graduate certificate (9 credits), students must complete the required specializations/courses.

Required specializations:

- Power Electronics Specialization
- Modeling and Control of Power Electronics Specialization
- Power Electronics Project Course: ECEA 5715

**Power Electronics Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5700 | Power Electronics: Introduction to Power Electronics | 0.8 |
| ECEA 5701 | Power Electronics: Converter Circuits | 1.0 |
| ECEA 5702 | Power Electronics: Converter Control | 1.2 |
| ECEA 5703 | Power Electronics: Magnetics Design | 1.0 |

**Modeling and Control of Power Electronics Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5705 | Modeling, Control of Power Elec: Avged-Sw Modeling and Sim | 0.8 |
| ECEA 5706 | Modeling, Control of Power Elec: Tech Dsgn-Oriented Analysis | 0.6 |
| ECEA 5707 | Modeling, Control of Power Elec: Input Filter Design | 0.6 |
| ECEA 5708 | Modeling, Control of Power Elec: Current-mode Control | 1.2 |
| ECEA 5709 | Modeling, Control of Power Elec: Mod/Ctrl 1-Phase Rect/Inv | 0.6 |

**Power Electronics Project Course**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5715 | Power Electronics Capstone Project | 1.2 |

**Algorithms for Battery Management Systems Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5730 | Introduction to Battery-Management Systems | 0.8 |
| ECEA 5731 | Equivalent-Circuit Cell-Model Simulation | 0.8 |
| ECEA 5732 | Battery State-of-Charge (SOC) Estimation | 1.0 |
| ECEA 5733 | Battery State-of-Health (SOH) Estimation | 0.8 |
| ECEA 5734 | Battery-Pack Balancing and Power Estimation | 0.8 |

**Photovoltaic Power Electronics Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5716 | Open-Loop Photovoltaic Power Electronics Laboratory | 1.0 |
| ECEA 5717 | Closed-Loop Photovoltaic Power Electronics Laboratory | 1.0 |
| ECEA 5718 | Photovoltaic Power Electronics Battery Management Laboratory | 1.0 |

**Power Semiconductor Devices Specialization (3.6 credits)**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5721 | Introduction to Power Switches | 0.6 |
| ECEA 5722 | High-Voltage p-n and Schottky Diodes | 1.2 |
| ECEA 5723 | MOSFETs, IGBTs and more | 1.2 |
| ECEA 5724 | Power Device Fabrication | 0.6 |

**Control Systems Analysis Specialization is part of the Systems and Controls Track**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5800 | Control Systems Analysis: Modeling of Dynamic Systems | |
| ECEA 5801 | Feedback Control and Root Locus Design | |
| ECEA 5802 | Frequency-Domain and State-Space Design | |

## Photonics and Optics Track

**Semiconductor Photonics - Graduate Certificate**

Admission to a graduate degree-seeking program in the ECEE department is not required for students pursuing the certificate. Certificate credit hours may be applied towards a full master's degree, provided the student is admitted to the electrical engineering graduate program as a degree-seeking student.

The semiconductor photonics certificate is comprised of 3 specializations, each of which is comprised of 3–4 individual online courses (MOOCs), which deliver about one month of content:

To complete a certificate, you must complete the following required specializations/courses.

**Semiconductor Photonics Graduate Certificate (9 credits)**

Required specializations:

- Optical Engineering Specialization
- Semiconductor Specialization
- Active Optical Devices Specialization

**Optical Engineering Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5600 | Optical Engineering: First Order Optical System Design | 1.0 |
| ECEA 5601 | Optical Engineering: Optical Efficiency and Resolution | 1.0 |
| ECEA 5602 | Optical Engineering: Design High-Performance Optical Systems | 1.0 |

**Semiconductor Devices Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5630 | Semiconductor Devices: Semiconductor Physics | 1.0 |
| ECEA 5631 | Semiconductor Devices: Diode: pn junction and metal semiconductor contact | 1.0 |
| ECEA 5632 | Semiconductor Devices: Transistor: Field Effect Transistor and Bipolar Junction Transistor | 1.0 |

**Active Optical Devices Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5605 | Active Optical Devices: LEDs and Semiconductor Lasers | 1.2 |
| ECEA 5606 | Active Optical Devices: Nanophotonics and Detectors | 1.2 |
| ECEA 5607 | Active Optical Devices: Displays | 0.6 |

**Quantum Mechanics for Engineers Specialization**

| Code | Title | Credit Hours |
|---|---|---|
| ECEA 5610 | Foundations of Quantum Mechanics | 1.4 |
| ECEA 5611 | Theory of Angular Momentum | 0.8 |
| ECEA 5612 | Approximation Methods | 0.8 |

For further details regarding Photonics content under our online MSEE degree through Coursera, see Photonics and Optics (https://www.colorado.edu/ecee/academics/online-programs/ms-ee-coursera/curriculum/photonics-and-optics/).

# Learning Outcomes

By the completion of the program, students will be able to: