ELECTRICAL & COMPUTER ENGINEERING -PROFESSIONAL MASTER OF SCIENCE (MSECE)

The professional Master of Science degree in electrical & computer engineering is a professional degree composed of advanced courses relevant to working engineers.

The department offers many professional degree tracks, each of which result in a professional Master of Science degree in electrical engineering (MSEE).

Program Tracks Embedded Systems Engineering (ESE) Track

The Embedded Systems Engineering (http://www.colorado.edu/ecee/ graduate-program/degrees/embedded-systems/) (ESE) track provides comprehensive coverage of essential embedded technologies, current tools and trends. It is structured to provide students with a broad, versatile skill set and is coupled with industry input for continuous curriculum updates.

Through flexible core course options and electives, students enrolled in the ESE program pursue a 30-credit-hour MSEE degree. Many courses offer distance learning options through CU Boulder Distance Education.

High-Speed Digital Engineering (HSDE) Track

The High-Speed Digital Engineering (https://www.colorado.edu/ecee/ academics/graduate-programs/professional-masters/high-speeddigital-engineering/)(HSDE) track is an innovative practical degree plan that prepares students for a career in industry with the specialized knowledge required to be a successful high-speed design engineering team member and to be able to solve complex signal integrity, power integrity and electromagnetic compatibility design problems quickly and efficiently. Simulation and measurement tools used in industry are leveraged to develop and enhance high-speed digital engineering design intuition at the same time fundamental principles are studied through best practices from industry in design, measurement, simulation and analysis. The program facilitates lifelong learning capabilities and is continuously updated with industry input.

Through five core courses and five elective options, students enrolled in this program pursue a ten course, 30-credit-hour degree. Most courses emphasize practical, hands-on experience, understanding and solving real world problems faced by the electronics industry today. Students with a background in electrical engineering fundamentals will be wellprepared for this program. It is intended for students and engineers with a background in basic electromagnetics. Students with other relevant engineering or scientific backgrounds may still be admitted to the program with a personalized study program to address foundational knowledge gaps.

Next-Generation Power and Energy Systems (PPS) Track

The Next-Generation Power and Energy Systems (https:// www.colorado.edu/ecee/graduate-program/degrees-programs/nextgeneration-power-and-energy-systems/) (PPS) track offers five core courses and numerous electives for the 30-credit hour program to prepare students with the specialized knowledge required to practice grid integration of renewable energy into integrated energy systems, taught by instructors from CU Boulder's faculty and National Renewable Energy Laboratory (NREL) research programs

Through flexible core course options and electives, students enrolled in the PPS program pursue a 30-credit-hour MSEE degree. Many courses also offer distance learning options.

Power Electronics (PPE) Track

Power Electronics (http://www.colorado.edu/ecee/graduate-program/ degrees/power-electronics-certificate/) 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.

Through flexible core course options and electives, students enrolled in this program pursue a 30-credit-hour MSEE degree. The program is intended for students and engineers with a BS degree in electrical engineering or the equivalent. Entering students must have adequate knowledge of circuits and electronics, as taught in undergraduate courses intended for EE majors.

Quantum Engineering (QE) Track

Inspired by the promise of more powerful computers and better sensors the global rise in funding for quantum technology has skyrocketed. This can be evidenced by the investment in several large companies (Google, IBM, Intel and Amazon). The quantum engineering track provides a unique overview of one of the fastest-growing technological fields and will help to prepare students for the quantum workforce of today and tomorrow.

The QE track provides students with a working knowledge of the principles of quantum mechanics and how they can be implemented in technological areas such as quantum computing, communications and sensing. Through core course options and electives, students enrolled in this program pursue a 30-credit-hour professional MSEE degree. The program is intended for students and engineers with a BS degree in STEM with solid knowledge in calculus, linear algebra and probability.

Distance Education Option

Students can take individual courses toward a master's degree or graduate certificate through distance education (online). For more information, connect with the individual graduate program directly.

Requirements Admission

A minimum undergraduate GPA of 3.00 is required for application to the master's program. Students who are interested in the PhD degree and have strong academics (including 3.50 or higher GPA) should apply directly to the PhD program (https://catalog.colorado.edu/graduate/

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colleges-schools/engineering-applied-science/programs-study/electrical-engineering/electrical-engineering-doctor-philosophy-phd/).

Course Requirements

The following course requirements are subject to change; for the most current information, visit the ECEE department's Professional Master's Program webpage (https://www.colorado.edu/ecee/academics/graduate-programs/professional-masters/).

Students must complete a total of 30 course credit hours with a grade of C or better and a cumulative GPA of at least 3.00. At least 24 credit hours must be completed at the 5000-level or above, and at least 18 of those credits must be in sufficiently technical ECEN 5000+ level courses.

Time Limit

All degree requirements must be completed within four years of the date of commencing coursework. Most students complete the degree in oneand-a-half to two years.

Program Tracks

Embedded System	s Engineering (ESE) Track
Code	Title

A minimum of 5 ESE core courses (15 credit hours) and 2 ESE elective courses (6 credit hours) from the ESE course list are required.

ESE Core Courses

Choose five of the following:		15
ECEN 5613	Embedded System Design	
ECEN 5623	Real-Time Embedded Systems	
ECEN 5803	Mastering Embedded Systems Architecture	
ECEN 5813	Principles of Embedded Software	
ECEN 5823	Internet of Things Embedded Firmware	
ECEN 5833	Low Power Embedded Design Techniques	
ECEN 5853	Embedding Sensors and Motors	
ECEN 5863	Programmable Logic Embedded System Design	
ESE Program Electives		
Choose two of the following (or additional ESE core courses):		
ECEN 5133	Fundamentals of Computer Security	
ECEN 5224	High Speed Digital Design	
ECEN 5593	Advanced Computer Architecture	
ECEN 5713	Advanced Embedded Software Development	
ECEN 5763	Embedded Computer Vision	
ECEN 5730	Practical Printed Circuit Board Design and Manufacture	
ECEN 5773	Developing the Industrial Internet of Things	
ECEN 5783	Embedded Interface Design	
ECEN 5313	Concurrent Programming	
ECEN 5139	Computer-Aided Verification ¹	
Open 5000 Level Electives		9

Choose three 5000-level electives from the ESE core, ESE electives, other ECEE courses, or courses in other departments, with approval of academic advisor.

Total Credit Hours

Credit

Hours

¹ Can also optionally take ECEN 5525 Compiler Construction and/ or ECEN 5033 Special Topics: Datacenter Scale Computing, when available.

For more information, visit the department's Embedded Systems Engineering (http://www.colorado.edu/ecee/graduate-program/ degrees/embedded-systems/) webpage. (At that page, please click on the "Courses (https://www.colorado.edu/ecee/academics/graduateprograms/professional-masters/embedded-systems/embedded-systemsiot-courses/)" button to see particular semesters of course availability).

High-Speed Digital Engineering (HSDE) Track

This program track consists of 10 courses totaling 30 credits. Five of the courses (15 credits) must be the core courses of the curriculum. A minimum of two additional courses (6 credits) must be chosen from the HSDE PMP elective courses list. The remaining three courses (9 credits) may be chosen from the HSDE PMP elective courses list OR from the courses that fulfill general ECEE Master's degree requirements.

A grade of C or better is required for each course applied towards the HSDE PMP track for degree-seeking students.

For HSDE courses taken non-degreed, and subsequently wanting to transfer maximally 9 credit hours toward a degree, the minimal grade in each course must be a solid B or better.

Code	Title	Credit Hours
HSDE Core Courses		
All five required:		
ECEN 5224	High Speed Digital Design (spring)	3
ECEN 5514	Principles of Electromagnetics for High- Speed Digital Engineering (spring)	3
ECEN 5524	Principles of Computational Electromagnetics for Signal and Power Integrity (spring)	3
ECEN 5534	Signal Integrity Measurements for High Speed Digital Engineering (fall)	3
ECEN 5730	Practical Printed Circuit Board Design and Manufacture (fall, spring)	3
HSDE Program Electiv	ves	
Choose two:		6
ECEN 5013	Special Topics (Advanced PCB Design for high-speed serial links (fall))	
ECEN 5414	Essential Principles of Signal Integrity (spring)	
ECEN 5424	High Speed Channel Design for Signal Integrity (spring 2024)	
ECEN 5434	S-Parameters for Signal Integrity in High Speed Digital Engineering (fall)	
ECEN 5444	Electromagnetic Compatibility (EMC) for High-Speed Digital Engineering (fall)	
ECEN 5544	EM Signal Modeling for HSDE using Ansys HFSS and Q3D (spring)	

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ECEN 5554	Designing PCB Memory Systems using Keysight ADS (fall)	
Choose three more a other STEM elective	from the above HSDE electives list, or from es	9
Total Credit Hours		30
 For more inform Engineering (h graduate-prograduate-p	nation, visit the department's High-Speed Digita ttps://www.colorado.edu/ecee/academics/ ams/professional-masters/high-speed-digital- ebpage.	al
Next-Generation	Power and Energy Systems (PPS) Track	Cradit
Code	nue	Hours
Core Courses		
ECEN 5797	Introduction to Power Electronics	3
ECEN 5407	Renewable Energy and the Future Power Grid (Renewable Energy and the Future Power Grid)	3
ECEN 5417	Power System Analysis (Power Systems Analysis)	3
ECEN 5427	Power System Planning & Operations (Power System Operations & Planning)	3
ECEN 5437	Distribution System Analysis (Distribution System Analysis)	3
Elective Courses		
At least 3 credit ho above.	urs of ECEN courses at the 5000 level or	3
AREN 5010	Energy System Modeling and Control	
AREN 5570	Building Electrical Systems Design 1 (Building Electrical Systems)	
AREN 5060		
AREN 5830	Architectural Engineering Special Topic (Grid-Connected Systems)	
ECEN 5007	Special Topics (Electrified Transportation)	
ECEN 5007	Special Topics (Power System Protection)	
ECEN 5007	Special Topics (High Voltage AC and DC Transmission)	
ECEN 5447	Power System Dynamics with Renewable Energy	
ECEN 5457	Energy Systems Optimization	
ECEN 5467	Data Analytics and Data-Driven Decision Making for Modern Power and Energy Systems	
ECEN 5517	Power Electronics and Photovoltaic Power Systems Laboratory	
ECEN 5807	Modeling and Control of Power Electronic Systems	
ENVM 5005	The Business of Renewable and Sustainable Energy	
ENVM 5006	Sustainable Energy Policy	

Power Electronics (PPE) Track

This curriculum is built around a core of three theory courses and two laboratory courses that provide practical laboratory and design experience of specific relevance to the practice of power electronics.

Code	Title	Credit Hours	
Required Theory Cour	rses		
ECEN 5797	Introduction to Power Electronics (fall)	3	
ECEN 5807	Modeling and Control of Power Electronic Systems (alternate spring)	3	
ECEN 5817	Resonant and Soft-Switching Techniques in Power Electronics (alternate spring)	3	
Required Laboratory	Courses		
The degree also requi course in power elect	res completion of the following laboratory ronics.		
ECEN 5527	Power Electronics Design Laboratory (fall)	3	
ECEN 5517	Power Electronics and Photovoltaic Power Systems Laboratory (spring)	3	
Electives			
Select at least one of	the following power electronics electives:	3	
Digital Control for Pow	er Electronics		
ECEN 5857	Digital Control for Power Electronics (fall)		
Electric Vehicles			
ECEN 5607	Power Electronics for Electrified Transportation (alternate fall)		
ECEN 5737	Adjustable-Speed AC Drives (alternate spring)		
Power Management In	tegrated Circuits		
ECEN 5827 Analog IC Design (alternate fall)			
Grid Integration of Ren	ewables (variable semesters)		
ECEN 5407	Renewable Energy and the Future Power Grid		
ECEN 5417	Power System Analysis		
ECEN 5427	Power System Planning & Operations		
ECEN 5437	Distribution System Analysis		
ECEN 5447	Power System Dynamics with Renewable Energy		
ECEN 5457	Energy Systems Optimization		
ECEN 5467	Data Analytics and Data-Driven Decision Making for Modern Power and Energy Systems		
Technical Electives	Technical Electives		
Choose up to three te	chnical electives with advisor approval.	9	
Open Elective			
Choose an additional elective course with advisor approval.		3	
Total Credit Hours		30	

For more information, visit the department's Power Electronics (http:// www.colorado.edu/ecee/graduate-program/degrees/power-electronicscertificate/) webpage.

Quantum Engineering Track

Quantum engineering has a wide variety of hardware platforms to choose from and quantum engineers need a broad range of skills that are more traditional EE topics. To address this diversity and help quantum engineers make informed choices, the program offers a wide range of options, allowing students to tailor their education to their interests and to the specific demands of the quantum industry.

1-Both of the two core courses below are required.

2-Two **quantum electives** are also required (of the four listed below, with the offerings changing semester to semester).

3-Additionally, students may request specific 5000-level (graduate) courses be counted on a case-by-case basis.

Code	Title	Credit
		Hours

Required Core courses

	ECEN 5915	Foundations of Quantum Engineering			
	ECEN 5925	Foundations of Quantum Hardware			
Re	equired Quantum El	ective Courses			
	PHYS 7570	Quantum Information and Computing Must have UG Quantum pre-reqs			
	Quantum Metrology & Sensing. (Currently ECEN 5005 Special Topics: Optical & Quantum Metrology) ^{Must have} _{Quantum pre-regs}				
	CSCI 7000 Special	Topics: Intro Quantum Comp Arch/Sys			
	CSCS 7000 Specia	l Topics: Quantum Complexity and Beyond			
01	ther Electives				
El	ectromagnetics / RF	Electives			
	ECEN 5114	Electromagnetic Theory			
	ECEN 5154	Computational Electromagnetics			
	ECEN 5634	Microwave and RF Laboratory			
	ECEN 5104	Passive Microwave Circuits			
	ECEN 5014	Special Topics (Active Microwave Circuits)			
Оļ	otics Electives				
EC	CEN 5156	Physical Optics	3		
EC	CEN 5696	Fourier Optics	3		
EC	CEN 5645	Introduction to Optical Electronics	3		
EC	CEN 5126	Computational Optical Imaging	3		
EC	CEN 6006	Special Topics (Crystal & Nonlinear Optics)	3		
Er	nbedded Systems En	ngineering Electives			
EC	CEN 5623	Real-Time Embedded Systems	3		
EC	CEN 5803	Mastering Embedded Systems Architecture	3		
EC	CEN 5593	Advanced Computer Architecture	3		
EC	CEN 5783	Embedded Interface Design	3		
EC	CEN 5863	Programmable Logic Embedded System Design	3		
Τŀ	neory Electives				
EC	CEN 5712	Machine Learning for Engineers	3		
Pł	HYS 5250	Introduction to Quantum Mechanics 1	3		
Pł	HYS 5260	Introduction to Quantum Mechanics 2	3		
EC	CEN 5345	Introduction to Solid State Physics	3		
Pł	HYS 7560	Quantum Optics	3		

By petition, other STEM (Science, Technology, Engineering, Math) courses will be considered if not explicitly listed.

Learning Outcomes

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

- Demonstrate the necessary understanding and skillsets with specific kinds of software and hardware in order to perform at a relatively strong level in industry jobs, both for optional industry internships and in post-graduation employment.
- Practice the necessary technical and interpersonal skills to gain meaningful employment within their chosen field of study through university relations with local and national companies and laboratories in addition to career events.
- Demonstrate a deeper, specialized set of technical skills through successful completion of additional, concentrated coursework in a chosen specialty within the field of study.
- Demonstrate the experimental and/or analytical skills essential to a career in their chosen field of study.