

# ELECTRICAL AND COMPUTER ENGINEERING, MASTER OF SCIENCE

Concentrations are offered in Communications and Networking as well as Photonics. A Concentration can be selected but is not required.

## Admission Requirements

Applicants (degree seeking and special student) must meet the general requirements for admission to graduate study, as outlined in the Admission Requirements (<http://e-catalog.jhu.edu/engineering/engineering-professionals/admission-requirements/>). Applicants are expected to hold a degree in electrical and/or computer engineering issued by a program accredited by the Engineering Accreditation Commission (EAC) of ABET, <http://www.abet.org>, in order to be admitted to the Master of Science in Electrical and Computer Engineering program. Those who majored in a related science or engineering field may also be accepted as candidates, provided their background is judged by the admissions committee to be equivalent to that stated above. Applicants' prior education should include the following prerequisites:

1. mathematics through vector calculus and differential equations,
2. calculus-based physics,
3. linear and non-linear circuits,
4. electromagnetics, and
5. signals and systems

Applicants whose prior education does not include the prerequisites listed above may still enroll under provisional status, followed by full admission status once they have completed the missing prerequisites. Missing prerequisites may be completed with Johns Hopkins Engineering (all prerequisites beyond calculus are available) or at another regionally accredited institution. Applicants typically have earned a grade point average of at least 3.0 on a 4.0 scale (B or above) in the latter half of their undergraduate studies. Transcripts from all college studies must be submitted. When reviewing an application, the candidate's academic and professional background will be considered.

Exceptions to these requirements can be made by the program chair or admissions committee.

## Program Requirements

Ten courses must be completed within five years. At least seven of the ten courses must be from the Electrical and Computer Engineering program (EN.525.xxx) or the Department of Electrical and Computer Engineering (EN.520.xxx) in the full-time program, and at least four of the ten required courses must be at the 700-level or above. Approved transfer courses count as 600-level courses.

At most, three of the ten courses required for the MS degree may be selected from outside the program, subject to advisor approval. Students who take an elective outside of the program typically select from the Applied and Computational Mathematics (EN.625.xxx), Applied Physics (EN.615.xxx), and Computer Science (EN.605.xxx) programs.

Limited opportunity is available for replacement of coursework by appropriate project work (EN.525.801 Special Project I and EN.525.802 Special Project II) or through a graduate thesis (EN.525.803 Electrical

and Computer Engineering Thesis and EN.525.804 Electrical and Computer Engineering Thesis). Note that EN.615.641 Mathematical Methods for Physics and Engineering, EN.615.642 Electromagnetics, EN.615.780 Optical Detectors & Applications, and EN.625.743 Stochastic Optimization & Control are counted as Electrical and Computer Engineering courses rather than electives. Only one C-range grade (C+, C, or C-) can count toward the master's degree. All course selections are subject to advisor approval.

## Concentrations

A concentration or focus area is not required for this program.

## Communications and Networking

Ten courses must be completed within five years. Of the minimum of seven Electrical and Computer Engineering courses, at least five must be Communications and Networking courses. Of the maximum of three electives, at least two must be Computer Science Communications and Networking courses. Only one C-range grade (C+, C, or C-) can count toward the master's degree. All course selections are subject to advisor approval.

Concentrations are noted on the student's transcript.

## Photonics

Ten courses must be completed within five years. The curriculum consists of four photonics core courses and three additional photonics courses, with the three remaining courses selected to fulfill the MS degree requirements. Only one C-range grade (C+, C, or C-) can count toward the master's degree. All course selections are subject to advisor approval.

Concentrations are noted on the student's transcript.

## Courses

Code	Title	Credits
<b>Prerequisite Courses</b> <sup>1</sup>		
EN.525.201	Circuits, Devices and Fields	3
EN.525.202	Signals and Systems	3
<b>Focus Areas (A Focus Area can be selected)</b>		
Communications and Networking (p. 2)		
Computer Engineering (p. 2)		
Electronics and the Solid State (p. 2)		
Optics and Photonics (p. 2)		
RF and Microwave Engineering (p. 2)		
Signal Processing (p. 3)		
Systems and Control (p. 3)		
<b>Concentrations (A Concentration can be selected)</b>		
Communications & Networking (p. 3)		
Photonics (p. 4)		

<sup>1</sup> Applicants whose prior education does not include the prerequisites listed under Admission Requirements (p. 1) may still be admitted under provisional status, followed by full admission once they have completed the missing prerequisites. All prerequisite courses beyond calculus are available at Johns Hopkins Engineering. These courses do not count toward the degree or certificate requirements.

## Focus Areas

The focus areas offered represent technology groupings that are relevant for students with interests in the selected areas. Students are not required to choose a focus area to follow. They only serve as an aid to students in planning their course schedules. They do not appear as official designations on a student's transcript or diploma.

### Communications and Networking

Code	Title	Credits
EN.525.608	Next Generation Telecommunications	3
EN.525.614	Probability & Stochastic Processes for Engineers	3
EN.525.616	Communication Systems Engineering	3
EN.525.618	Antenna Systems	3
EN.525.620	Electromagnetic Transmission Systems	3
EN.525.638	Introduction to Wireless Technology	3
EN.525.640	Satellite Communications Systems	3
EN.525.641	Computer and Data Communication Networks I	3
EN.525.654	Communications Circuits Lab	3
EN.525.678	Next Generation Mobile Networks with 5G	3
EN.525.707	Error Control Coding	3
EN.525.708	Iterative Methods in Communications Systems	3
EN.525.722	Wireless and Mobile Cellular Communications	3
EN.525.735	MIMO Wireless Communications	3
EN.525.738	Advanced Antenna Systems	3
EN.525.747	Speech Processing	3
EN.525.751	Software Radio for Wireless Communications	3
EN.525.752	Digital Receiver Synchronization Techniques	3
EN.525.754	Wireless Communication Circuits	3
EN.525.759	Image Compression, Packet Video, and Video Processing	3
EN.525.761	Wireless and Wireline Network Integration	3
EN.525.768	Wireless Networks	3
EN.525.771	Propagation of Radio Waves in the Atmosphere	3
EN.525.772	Fiber-Optic Communication Systems	3
EN.525.776	Information Theory	3
EN.525.783	Spread Spectrum Communications	3
EN.525.789	Advanced Satellite Communications	3
EN.525.791	Microwave Communications Lab	3
EN.525.793	Advanced Communication Systems	3

### Computer Engineering

Code	Title	Credits
EN.525.610	Microprocessors for Robotic Systems	3
EN.525.612	Computer Architecture	3
EN.525.615	Embedded Microprocessor Systems	3
EN.525.634	High Speed Digital Design	3
EN.525.641	Computer and Data Communication Networks I	3
EN.525.642	FPGA Design Using VHDL	3
EN.525.712	Advanced Computer Architecture	3
EN.525.742	System-on-a-Chip FPGA Design Laboratory	3
EN.525.743	Embedded Systems Development Lab	3

EN.525.778	Design for Reliability, Testability, and Quality Assurance	3
EN.525.786	Human Robotics Interaction	3

### Electronics and the Solid State

Code	Title	Credits
EN.525.606	Electronic Materials	3
EN.525.607	Intro to Electronic Packaging	3
EN.525.621	Introduction to Electronics and the Solid State	3
EN.525.624	Analog Electronic Circuit Design	3
EN.525.651	Introduction to Electric Power Systems	3
EN.525.654	Communications Circuits Lab	3
EN.525.658	Digital VLSI System Design	3
EN.525.659	Mixed-Mode VLSI Circuit Design	3
EN.525.674	Introduction to RF and Microwave Circuits	3
EN.525.725	Power Electronics	3
EN.525.732	Advanced Analog Electronic Circuit Design	3
EN.525.754	Wireless Communication Circuits	3
EN.525.774	RF & Microwave Circuits I	3
EN.525.775	RF & Microwave Circuits II	3
EN.525.779	RF Integrated Circuits	3
EN.525.787	MMIC Design	3
EN.525.788	Power Microwave Monolithic Integrated Circuit (MMIC) Design	3

### Optics and Photonics

Code	Title	Credits
EN.525.613	Fourier Techniques in Optics	3
EN.525.625	Laser Fundamentals	3
EN.525.636	Optics & Photonics Lab	3
EN.525.691	Fundamentals of Photonics	3
EN.525.753	Laser Systems and Applications	3
EN.525.756	Optical Propagation, Sensing, and Backgrounds	3
EN.525.772	Fiber-Optic Communication Systems	3
EN.525.796	Introduction to High-Speed Optoelectronics	3
EN.525.797	Advanced Fiber Optic Laboratory	3

### RF and Microwave Engineering

Code	Title	Credits
EN.525.605	Intermediate Electromagnetics	3
EN.525.618	Antenna Systems	3
EN.525.620	Electromagnetic Transmission Systems	3
EN.525.623	Principles of Microwave Circuits	3
EN.525.648	Introduction to Radar Systems	3
EN.525.654	Communications Circuits Lab	3
EN.525.674	Introduction to RF and Microwave Circuits	3
EN.525.684	Microwave Systems & Receiver Design	3
EN.525.738	Advanced Antenna Systems	3
EN.525.754	Wireless Communication Circuits	3
EN.525.771	Propagation of Radio Waves in the Atmosphere	3
EN.525.774	RF & Microwave Circuits I	3
EN.525.775	RF & Microwave Circuits II	3
EN.525.779	RF Integrated Circuits	3

EN.525.787	MMIC Design	3
EN.525.788	Power Microwave Monolithic Integrated Circuit (MMIC) Design	3
EN.525.790	RF Power Amplifier Design Techniques	3
EN.525.791	Microwave Communications Lab	3
EN.615.642	Electromagnetics	3

## Signal Processing

Code	Title	Credits
EN.525.614	Probability & Stochastic Processes for Engineers	3
EN.525.619	Introduction to Digital Image and Video Processing	3
EN.525.627	Digital Signal Processing	3
EN.525.630	Digital Signal Processing Lab	3
EN.525.631	Adaptive Signal Processing	3
EN.525.638	Introduction to Wireless Technology	3
EN.525.643	Real Time Computer Vision	3
EN.525.646	DSP Hardware Lab	3
EN.525.648	Introduction to Radar Systems	3
EN.525.670	Machine Learning for Signal Processing	3
EN.525.718	Multirate Signal Processing	3
EN.525.721	Advanced Digital Signal Processing	3
EN.525.724	Introduction to Pattern Recognition	3
EN.525.728	Detection & Estimation Theory	3
EN.525.733	Deep Learning for Computer Vision	3
EN.525.735	MIMO Wireless Communications	3
EN.525.744	Passive Emitter Geo-Location	3
EN.525.745	Applied Kalman Filtering	3
EN.525.746	Image Engineering	3
EN.525.747	Speech Processing	3
EN.525.748	Synthetic Aperture Radar	3
EN.525.751	Software Radio for Wireless Communications	3
EN.525.759	Image Compression, Packet Video, and Video Processing	3
EN.525.762	Introduction to Wavelets	3
EN.525.780	Multidimensional Digital Signal Processing	3
EN.625.603	Statistical Methods and Data Analysis	3
EN.625.609	Matrix Theory	3
EN.625.620	Mathematical Methods for Signal Processing	3
EN.625.710	Fourier Analysis with Applications to Signal Processing and Differential Equations	3

## Systems and Control

Code	Title	Credits
EN.520.633	Intro To Robust Control	3
EN.520.636	Feedback Control in Biological Signaling Pathways	3
EN.525.609	Continuous Control Systems	3
EN.525.614	Probability & Stochastic Processes for Engineers	3
EN.525.645	Modern Navigation Systems	3
EN.525.661	UAV Systems and Control	3
EN.525.666	Linear System Theory	3
EN.525.744	Passive Emitter Geo-Location	3
EN.525.745	Applied Kalman Filtering	3
EN.525.770	Intelligent Algorithms	3

EN.525.777	Control System Design Methods	3
EN.535.645	Digital Control and Systems Applications	3
EN.535.726	Robot Control	3
EN.605.613	Introduction to Robotics	3
EN.605.716	Modeling and Simulation of Complex Systems	3
EN.625.615	Introduction to Optimization	3
EN.625.695	Time Series Analysis	3
EN.625.714	Introductory Stochastic Differential Equations with Applications	3
EN.625.743	Stochastic Optimization & Control	3
EN.695.615	Cyber Physical	3

## Special Project/Thesis Courses

Code	Title	Credits
EN.525.801	Special Project I	3
EN.525.802	Special Project II	3
EN.525.803	Electrical and Computer Engineering Thesis	3
EN.525.804	Electrical and Computer Engineering Thesis	3

## Courses by Concentration

### Communications and Networking

Code	Title	Credits
Select five of the following:		
EN.525.608	Next Generation Telecommunications	3
EN.525.614	Probability & Stochastic Processes for Engineers	3
EN.525.616	Communication Systems Engineering	3
EN.525.618	Antenna Systems	3
EN.525.620	Electromagnetic Transmission Systems	3
EN.525.638	Introduction to Wireless Technology	3
EN.525.640	Satellite Communications Systems	3
EN.525.641	Computer and Data Communication Networks I	3
EN.525.654	Communications Circuits Lab	3
EN.525.678	Next Generation Mobile Networks with 5G	3
EN.525.707	Error Control Coding	3
EN.525.708	Iterative Methods in Communications Systems	3
EN.525.722	Wireless and Mobile Cellular Communications	3
EN.525.735	MIMO Wireless Communications	3
EN.525.738	Advanced Antenna Systems	3
EN.525.747	Speech Processing	3
EN.525.751	Software Radio for Wireless Communications	3
EN.525.754	Wireless Communication Circuits	3
EN.525.759	Image Compression, Packet Video, and Video Processing	3
EN.525.761	Wireless and Wireline Network Integration	3
EN.525.768	Wireless Networks	3
EN.525.771	Propagation of Radio Waves in the Atmosphere	3
EN.525.772	Fiber-Optic Communication Systems	3
EN.525.776	Information Theory	3
EN.525.783	Spread Spectrum Communications	3
EN.525.789	Advanced Satellite Communications	3
EN.525.791	Microwave Communications Lab	3
EN.525.793	Advanced Communication Systems	3

Select two of the following:

EN.605.671	Principles of Data Communications Networks	3
EN.605.672	Computer Network Architectures and Protocols	3
EN.605.674	Network Programming	3
EN.605.675	Protocol Design	3
EN.605.677	Internetworking with TCP/IP I	3
EN.605.678	Next Generation Mobile Networks with 5G	3
EN.605.771	Wired and Wireless Local and Metropolitan Area Networks	3
EN.605.772	Network Security Management	3
EN.605.775	Optical Networking Technology	3
EN.605.776	Fourth Generation Wireless Communications: WiMAX and LTE	3
EN.605.777	Internetworking with TCP/IP II	3
EN.605.778	Voice Over IP	3
EN.695.622	Web Security	3
EN.695.641	Cryptology	3
EN.695.721	Network Security	3

## Photonics

Code	Title	Credits
<b>Core Courses</b> <sup>1</sup>		
EN.525.613	Fourier Techniques in Optics	3
EN.525.625	Laser Fundamentals	3
EN.525.691	Fundamentals of Photonics	3
EN.615.641	Mathematical Methods for Physics and Engineering	3
EN.615.654	Quantum Mechanics	3
EN.615.671	Principles Of Optics	3
<b>Electives</b>		
Select three of the following: <sup>2</sup>		
EN.525.636	Optics & Photonics Lab	3
EN.525.753	Laser Systems and Applications	3
EN.525.756	Optical Propagation, Sensing, and Backgrounds	3
EN.525.772	Fiber-Optic Communication Systems	3
EN.525.796	Introduction to High-Speed Optoelectronics	3
EN.525.797	Advanced Fiber Optic Laboratory	3
EN.585.734	Biophotonics	3
EN.615.751	Modern Optics	3
EN.615.758	Modern Topics in Applied Optics	3
EN.615.778	Computer Optical Design	3
EN.615.780	Optical Detectors & Applications	3
EN.615.781	Quantum Information Processing	3
EN.615.782	Optics and Matlab	3

<sup>1</sup> Only one 615.XXX course is required.

<sup>2</sup> EN.525.801 Special Project I and EN.525.802 Special Project II courses can also be used to allow students to pursue specialized interests in optics.

Please refer to the course schedule ([ep.jhu.edu/schedule](https://apps.ep.jhu.edu/schedule) (<https://apps.ep.jhu.edu/schedule/search/>)) published each term for exact dates, times, locations, fees, and instructors.