



## Recommended Courses by ECE Topic Area

### Graduate Students

The course recommendations below do not represent full plans of study. The courses listed under each heading represent appropriate courses to take if you are seeking content within a topic area. Graduate students must meet the graduation requirements for their degree. Please see the *ECE Graduate Handbook* for degree requirement information:

[http://www.engr.colostate.edu/ece/pdfs/current\\_students/graduate\\_student\\_handbook.pdf](http://www.engr.colostate.edu/ece/pdfs/current_students/graduate_student_handbook.pdf)

A maximum of **6 credits** of 400-level coursework is allowed for Master of Science (M.S.) and Master of Engineering (M.E.) programs. Up to 8 credit hours at the 400-level are permitted when at least one course is a 4 credit course. M.S. students may count a maximum of **12 credits** outside of the ECE Department. M.E. students may count a maximum of **15 credits** outside of the ECE Department.

Course descriptions and additional course information can be found at:

[http://www.engr.colostate.edu/ece/current\\_students/courses.php](http://www.engr.colostate.edu/ece/current_students/courses.php)

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## Aerospace – Electrical Engineering

Course Number	Course Name	Semester Offered*	Credits	Online
ECE 404	Experiments in Optical Electronics	F	2	
ECE 411	Control Systems	F	3	X
ECE 412	Digital Control and Digital Filters	S	3	X
ECE 421	Telecommunications I	F	3	X
ECE 441	Optical Electronics	F	3	
ECE 444	Antennas & Radiation	F	3	
ECE 452	Computer Organization and Architecture	S, Even years	3	X
ECE 455	Intro to Robot Programming/Simulation	F	3	X
ECE 456	Computer Networks	S	4	X
ECE 461/462	Power Systems I	F, Odd years	4	
ECE 512	Digital Signal Processing	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 516	Information Theory	F	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 521	Satellite Communication	S	3	X
ECE/CS 528	Embedded Systems and Machine Learning	F	4	X
ECE 536	RF Integrated Circuit Design	F, Even years	3	
ECE 540	Computational Electromagnetics	F, Odd years	3	
ECE 541	Applied Electromagnetics	F, Even years	3	
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 548	Microwave Theory & Component Design	S, Odd years	3	
ECE 549	Radar Systems and Design	S, Odd years	3	X
ECE 555	Advanced Robotics: Redundancy & Optimization	S, Even years	3	
ECE 556	AI for Radar and Remote Sensing	S	3	X
ECE/CS 561	Hardware/Software Design of Embedded Systems	S, Odd years	4	X
ECE 562	Power Electronics I	S, Even years	3	X
ECE/ENGR 565	Electrical Power Engineering	F, Odd years	3	X
ENGR 570	Coupled Electromechanical Systems	F, Even years	3	X
ECE 611	Nonlinear Control Systems	F, Even years	3	X
ECE 612	Robust Control Systems	S, Even years	3	X
ECE 614	Principles of Digital Communications	S, Even years	3	X
ECE 652	Estimation and Filtering Theory	S, Odd years	3	X

## Avionics and Power Systems

Course Number	Course Name
ECE 404	Experiments in Optical Electronics
ECE 441	Optical Electronics
ECE 461/462	Power Systems I
ECE 562	Power Electronics I
ECE/ENGR 565	Electrical Power Engineering
ENGR 570	Coupled Electromechanical Systems

## Communications and Sensing

Course Number	Course Name
ECE 421	Telecommunications I
ECE 444	Antennas & Radiation
ECE 512	Digital Signal Processing
ECE 514	Applications of Random Processes
ECE 516	Information Theory
ECE 521	Satellite Communication
ECE 536	RF Integrated Circuit Design
ECE 540	Computational Electromagnetics
ECE 541	Applied Electromagnetics
ECE 545	FPGA Signal Processing/Software-Defined Radio
ECE 548	Microwave Theory & Component Design
ECE 549	Radar Systems and Design
ECE 556	AI for Radar and Remote Sensing
ECE 614	Principles of Digital Communications
ECE 652	Estimation and Filtering Theory

## Robotics and Controls

Course Number	Course Name
ECE 411	Control Systems
ECE 412	Digital Control and Digital Filters
ECE 452	Computer Organization and Architecture
ECE 455	Intro to Robot Programming/Simulation
ECE 456	Computer Networks
ECE 520	Optimization Methods for Control & Communications
ECE/CS 528	Embedded Systems and Machine Learning
ECE 555	Advanced Robotics: Redundancy & Optimization
ECE/CS 561	Hardware/Software Design of Embedded Systems
ECE 611	Nonlinear Control Systems
ECE 612	Robust Control Systems

## Aerospace - Computer Engineering

Course Number	Course Name	Semester Offered*	Credits	Online
CS 415	Software Testing	S	4	X
CS 420	Introduction to Analysis of Algorithms	F	4	X
CS 430	Database Systems	S	4	X
CS 435	Introduction to Big Data	F	4	X
CS 440	Introduction to Artificial Intelligence	F	4	X
CS 445	Introduction to Machine Learning	S	4	X
CS 455	Introduction to Distributed Systems	S	4	X
CS 456	Modern Cybersecurity	F	4	X
CS 464	Principles of Human-Computer Interaction	S	4	X
CS 475	Parallel Programming	F	4	X

## Aerospace - Computer Engineering, continued

Course Number	Course Name	Semester Offered*	Credits	Online
CS 545	Machine Learning	F	4	X
CS 553	Algorithmic Language Compilers	As needed	4	
CS 559	Quantitative Security	F	4	X
CS 575	Parallel Processing	As needed	4	X
ECE 411	Control Systems	F	3	X
ECE 412	Digital Control and Digital Filters	S	3	X
ECE 421	Telecommunications I	F	3	X
ECE 444	Antennas & Radiation	F	3	
ECE 455	Intro to Robot Programming/Simulation	F	3	X
ECE 456	Computer Networks	S	4	X
ECE 512	Digital Signal Processing	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 516	Information Theory	F	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 521	Satellite Communication	S	3	X
ECE/CS 528	Embedded Systems and Machine Learning	F	4	X
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 549	Radar Systems and Design	S, Odd years	3	X
ECE 554	Computer Architecture	S, Even years	3	X
ECE 556	AI for Radar and Remote Sensing	S	3	X
ECE 558	Manycore System Design Using Machine Learning	F	3	X
ECE/CS 561	Hardware/Software Design of Embedded Systems	S, Odd years	4	X
ECE 571/575	VLSI System Design/Lab	S	4	
ECE 611	Nonlinear Control Systems	F, Even years	3	X
ECE 612	Robust Control Systems	S, Even years	3	X
ECE 656	Machine Learning and Adaptive Systems	S, Even years	3	X
ECE 661	Advanced Topics in Embedded	As needed	4	X

## Biomedical Devices

Course Number	Course Name	Semester Offered*	Credits	Online
ECE/BIOM 403	Intro to Optical Techniques in Biomedical Engineering	S, Odd years	3	X
ECE 404	Experiments in Optical Electronics	F	2	
ECE/BIOM 431	Biomedical Signal and Image Processing	S	3	X
ECE 441	Optical Electronics	F	3	
ECE 471A	Semiconductor Physics	S	1	
ECE 471B	Semiconductor Junction	S	1	
ECE 504	Physical Optics	F, Odd years	3	X
ECE 505	Nanostructures: Fundamentals and Applications	F, Odd years	3	X
ECE/BIOM 517	Advanced Optical Imaging	F, Even years	3	X
ECE/BIOM 518	Biophotonics	F, Odd years	3	X
ECE/MATH 522	Random Walks	F, Even years	3	X
ECE/BIOM 526	Biosensors: Biological Physics	F, Odd years	3	X
ECE/BIOM 527A	Biosensors: Cells as Circuits	F, Odd years	1	

## **Biomedical Devices, continued**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
ECE/BIOM 527B	Biosensors: Signal and Noise in Biosensors	S, Even years	1	
ECE/BIOM 527C	Biosensors: Sensor Circuit Fundamentals	F, Odd years	1	
ECE/BIOM 527D	Biosensors: Electrochemical Sensors	F, Odd years	1	
ECE/BIOM 527E	Biosensors: Affinity Sensors	S, Even years	1	
ECE/BIOM 527F	Biosensors: Biophotonic Sensors Using Refractive Index	S, Even years	1	
ECE 541	Applied Electromagnetics	F, Even years	3	
ECE 546	Laser Fundamentals and Devices	S, Odd years	3	
ECE 572	Semiconductor Transistors	S	1	
ECE 574	Optical Materials and Devices	S, Even years	3	X
ECE 641	Electromagnetics	As needed	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 560	Linear Algebra	F	3	X

## **Biomedical Signals and Systems**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
ECE/BIOM 403	Intro to Optical Techniques in Biomedical Engineering	S, Odd years	3	X
ECE/BIOM 431	Biomedical Signal and Image Processing	S	3	X
ECE 457 <sup>a</sup>	Fourier Optics	S	3	X
ECE 502 <sup>a</sup>	Advanced Fourier Optics	S	4	X
ECE 503	Ultrafast Optics	As needed	3	
ECE 504	Physical Optics	F, Odd years	3	X
ECE 512	Digital Signal Processing	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE/BIOM 518	Biophotonics	F, Odd Years	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE/MATH 522	Random Walks	F, Even years	3	X
ECE/BIOM 526	Biological Physics	F, Odd years	3	X
ECE/BIOM 527A	Biosensors: Biological Physics	F, Odd years	1	
ECE/BIOM 527B	Biosensors: Cells as Circuits	S, Even years	1	
ECE/BIOM 527C	Biosensors: Signal and Noise in Biosensors	F, Odd years	1	
ECE/BIOM 527D	Biosensors: Sensor Circuit Fundamentals	F, Odd years	1	
ECE/BIOM 527E	Biosensors: Affinity Sensors	S, Even years	1	
ECE/BIOM 527F	Biosensors: Biophotonic Sensors Using Refractive Index	S, Even years	1	
ECE/BIOM 537	Biomedical Signal Processing	S, Even years	3	X
ECE 541	Applied Electromagnetics	F, Even years	3	
ECE 604	Nonlinear Optics	F, Odd years	3	X
ECE 652	Estimation and Filtering Theory	S, Odd years	3	X
MATH 419	Introduction to Complex Variables	F	3	
MATH 450	Introduction to Numerical Analysis I	F	3	

## **Biomedical Signals and Systems, continued**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
MATH 560	Linear Algebra	F	3	X
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MATH 569B	Linear Algebra for Data Science: Geometric Data Reduction	F, S	1	X
MATH 569C	Linear Algebra for Data Science: Matrix Factorizations and Transformations	F, S	1	X

\*Students cannot get credit for both ECE457 and ECE502

## **Communications**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
ECE 421	Telecommunications I	F	3	X
ECE/MATH 430	Fourier and Wavelet Analysis with Apps.	S	3	
ECE 444	Antennas & Radiation	F	3	
ECE 456	Computer Networks	S	4	X
ECE 512	Digital Signal Processing	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 516	Information Theory	F	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 521	Satellite Communication	S	3	
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 549	Radar Systems and Design	F, Odd years	3	X
ECE 614	Principles of Digital Communications	S, Even years	3	X
ECE 652	Estimation and Filtering Theory	S, Odd years	3	X
ECE 653	Detection Theory	F, Odd years	3	
MATH 417	Advanced Calculus I	F	3	
MATH 466	Abstract Algebra I	F	3	
MATH 469	Linear Algebra II	S	3	
MATH 474	Introduction to Differential Geometry	F, Odd years	3	
MATH 517	Introduction to Real Analysis	F	3	
MATH 519	Complex Variables I	S	3	
MATH 560	Linear Algebra	F	3	X
MATH 566	Introduction to Abstract Algebra I	F	3	
MATH 570	Topology I	F, Odd years	3	
MATH 617	Integration and Measure Theory	S	4	
MATH 618	Advanced Real Analysis	F	3	
MATH 670	Introduction to Differential Manifolds	As needed	3	
STAT 525	Time Series Analysis I	F	3	
STAT 620	Introduction to Measure Theoretic Probability	S	3	
STAT 720 <sup>b</sup>	Probability Theory	As needed	3	

<sup>b</sup>Course recommended for PhD level students only

## Computer Architecture

Course Number	Course Name	Semester Offered*	Credits	Online
CS 414	Object Oriented Design	F	4	X
CS 415	Software Testing	S	4	X
CS 420	Introduction to Analysis of Algorithms	F	4	X
CS 422	Automata, Logic, and Computation	F	4	X
CS 425	Intro to Bioinformatics Algorithms	F	4	
CS 435	Introduction to Big Data	F	4	X
CS 440	Introduction to Artificial Intelligence	F	4	X
CS 445	Introduction to Machine Learning	S	4	X
CS 453	Introduction to Compiler Construction	S	4	X
CS 455	Introduction to Distributed Systems	S	4	X
CS 456	Modern Cybersecurity	F	4	X
CS 458	Blockchain Principles and Applications	S	4	X
CS 464	Principles of Human-Computer Interaction	S	4	X
CS 475	Parallel Programming	F	4	X
CS 480A5	Cyber Security Accelerators	F	4	X
CS 481A4	Introduction to Digital Forensics	As needed	4	X
CS 530	Fault-Tolerant Computing	S	4	X
CS 535	Big Data	F	4	X
CS 540	Artificial Intelligence	S	4	X
CS 542	Natural Language Processing	F	4	X
CS 545	Machine Learning	F	4	X
CS 553	Algorithmic Language Compilers	As needed	4	
CS 556	Computer Security	S	4	X
CS 557	Advanced Networking and the Internet	S	4	X
CS 559	Quantitative Security	F	4	X
CS 567	3D User Interfaces	F	4	X
CS 575	Parallel Processing	As needed	4	X
ECE 450/451	Digital System Design and Laboratory	F	4	
ECE 452	Computer Organization and Architecture	S	4	X
ECE 480A4	Digital Logic Synthesis	S	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 519	Network Centric Systems	S, Even years	3	X
ECE/CS 528	Embedded Systems and Machine Learning	F	4	X
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 554	Computer Architecture	S, Even years	3	X
ECE 558	Manycore System Design Using Machine Learning	F	3	X
ECE/CS 560	Foundations of Fine-Grain Parallelism	As needed	4	
ECE/CS 561	Hardware/Software Design of Embedded Systems	S, Odd years	4	X
ECE 571/575	VLSI System Design/Lab	S	4	
ECE 661	Advanced Topics in Embedded Systems	As needed	4	X
ECE/CS 670	Topics in Architecture/Systems	As needed	1-4	
GRAD 510	Fundamentals of High Performance Computing	F	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 460	Information and Coding Theory	S	3	
MATH 480A1	Post-Quantum Cryptography	S	3	
MATH 510	Linear Programming and Network Flows	F	3	

## Computer Architecture, continued

Course Number	Course Name	Semester Offered*	Credits	Online
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MATH 569C	Linear Algebra for Data Science: Matrix Factorizations and Transformations	F, S	1	X
STAT 421	Introduction to Stochastic Processes	S	3	

## Computer Engineering

Course Number	Course Name	Semester Offered*	Credits	Online
CS 414	Object Oriented Design	F	4	X
CS 415	Software Testing	S	4	X
CS 420	Introduction to Analysis of Algorithms	F	4	X
CS 422	Automata, Logic, and Computation	F	4	X
CS 425	Intro to Bioinformatics Algorithms	F	4	
CS 435	Introduction to Big Data	S	4	X
CS 440	Introduction to Artificial Intelligence	F	4	X
CS 445	Introduction to Machine Learning	S	4	X
CS 453	Introduction to Compiler Construction	S	4	X
CS 455	Introduction to Distributed Systems	S	4	X
CS 456	Modern Cybersecurity	F	4	X
CS 458	Blockchain Principles and Applications	S	4	X
CS 464	Principles of Human-Computer Interaction	S	4	X
CS 475	Parallel Programming	F	4	X
CS 480A5	Cyber Security Accelerators	F	4	X
CS 481A4	Introduction to Digital Forensics	As needed	4	X
CS 530	Fault-Tolerant Computing	S	4	X
CS 535	Big Data	F	4	X
CS 540	Artificial Intelligence	S	4	X
CS 542	Natural Language Processing	F	4	X
CS 545	Machine Learning	F	4	X
CS 553	Algorithmic Language Compilers	As needed	4	
CS 556	Computer Security	S	4	X
CS 557	Advanced Networking and the Internet	S	4	X
CS 559	Quantitative Security	F	4	X
CS 567	3D User Interfaces	F	4	X
CS 575	Parallel Processing	As needed	4	X
ECE 450/451	Digital System Design and Laboratory	F	4	
ECE 452	Computer Organization and Architecture	S	3	X
ECE 456	Computer Networks	S	4	X
ECE 480A4	Digital Logic Synthesis	S	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE/CS 528	Embedded Systems and Machine Learning	F	4	X
ECE 544	Silicon Photonics for Computing Systems	F	3	X
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 554	Computer Architecture	S, Even years	3	X

\*Subject to change. Please see the course schedule regarding semester course offerings



## **Computer Engineering, continued**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
ECE 555	Advanced Robotics: Redundancy & Optimization	S, Even years	3	
ECE 558	Manycore System Design Using Machine Learning	F	3	X
ECE/CS 560	Foundations of Fine-Grain Parallelism	As needed	4	
ECE/CS 561	Hardware/Software Design of Embedded Systems	S, Odd years	4	X
ECE 571/575	VLSI System Design/Lab	S	4	
ECE 556	AI for Radar and Remote Sensing	S	3	X
ECE 519	Network Centric Systems	S, Even years	3	X
ECE 656	Machine Learning and Adaptive Systems	S, Even years	3	X
ECE/CS 658	Internet Engineering	F, Even years	4	X
ECE 661	Advanced Topics in Embedded	As needed	4	X
ECE/CS 670	Topics in Architecture/Systems	As needed	1-4	
GRAD 510	Fundamentals of High Performance Computing	F	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 460	Information and Coding Theory	S	3	
MATH 480A1	Post-Quantum Cryptography	S	3	
MATH 510	Linear Programming and Network Flows	F	3	
MATH 532	Mathematical Modeling of Large Data Sets	S, Even years	3	
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MATH 569C	Linear Algebra for Data Science: Matrix Factorizations and Transformations	F, S	1	X
MECH 564	Fundamentals of Robot Mechanics and Controls	S	3	X
STAT 421	Introduction to Stochastic Processes	S	3	
STAT 520	Introduction to Probability Theory	F	4	

## **Computer Networking**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
CS 422	Automata, Logic, and Computation	F	4	X
CS 425	Intro to Bioinformatics Algorithms	F	4	
CS 435	Introduction to Big Data	S	4	X
CS 445	Introduction to Machine Learning	S	4	X
CS 456	Modern Cybersecurity	F	4	X
CS 458	Blockchain Principles and Applications	S	4	X
CS 464	Principles of Human-Computer Interaction	S	4	X
CS 480A5	Cyber Security Accelerators	F	4	X
CS 481A4	Introduction to Digital Forensics	As needed	4	X
CS 530	Fault Tolerant Systems	S	4	X
CS 535	Big Data	F	4	X
CS 540	Artificial Intelligence	S	4	X
CS 542	Natural Language Processing	F	4	X
CS 545	Machine Learning	F	4	X
CS 556	Computer Security	S	4	X
CS 557	Advanced Networking and the Internet	S	4	X

## Computer Networking, continued

Course Number	Course Name	Semester Offered*	Credits	Online
CS 559	Quantitative Security	F	4	X
CS 567	3D User Interfaces	F	4	X
ECE 456	Computer Networks	S	4	X
ECE 514	Applications of Random Processes	F	3	X
ECE 516	Information Theory	F	3	X
ECE 519	Network Centric Systems	S, Even years	3	X
ECE 521	Satellite Communication	S	3	X
ECE/CS 528	Embedded Systems and Machine Learning	F	4	X
ECE/MATH 522	Random Walks	F, Even years	3	X
ECE 554	Computer Architecture	S, Even years	3	X
ECE/CS 560	Reconfigurable Computing	As needed	4	
ECE/CS 658	Internet Engineering	F, Even years	4	X
MATH 460	Information and Coding Theory	S	3	
MATH 480A1	Post-Quantum Cryptography	S	3	
MATH 532	Mathematical Modeling of Large Data Sets	S, Even years	3	
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MATH 569C	Linear Algebra for Data Science: Matrix Factorizations and Transformations	F, S	1	X
STAT 421	Introduction to Stochastic Processes	S	3	
STAT 520	Introduction to Probability Theory	F	4	

## Controls

Course Number	Course Name	Semester Offered*	Credits	Online
ECE 411	Control Systems	F	3	X
ECE 412	Digital Control and Digital Filters	S	3	X
ECE 455	Intro to Robot Programming/Simulation	F	3	X
ECE 480A5	Distributed Nonlinear Control/AI Systems	S	3	X
ECE 481A4	Real-Time Applied Non-Linear Control Systems	F	3	X
ECE 512	Digital Signal Processing	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 555	Advanced Robotics: Redundancy & Optimization	S, Even years	3	
ECE 611	Nonlinear Control Systems	F, Even years	3	X
ECE 612	Robust Control Systems	S, Even years	3	X
ECE 652	Estimation and Filtering Theory	S, Odd years	3	X
ECE 656	Machine Learning and Adaptive Systems	S, Even years	3	X
ECE 666	Topics in Robotics	S, Odd years	3	
MATH 417	Advanced Calculus I	F	3	
MATH 418	Advanced Calculus II	S, Even years	3	
MATH 466	Abstract Algebra I	F	3	
MATH 469	Linear Algebra II	S	3	
MATH 474	Introduction to Differential Geometry	F, Odd years	3	

\*Subject to change. Please see the course schedule regarding semester course offerings

## Controls, continued

Course Number	Course Name	Semester Offered*	Credits	Online
MATH 517	Introduction to Real Analysis	F	3	
MATH 519	Complex Variables I	S	3	
MATH 560	Linear Algebra	F	3	X
MATH 561	Numerical Analysis I	S	4	
MATH 566	Introduction to Abstract Algebra I	F	3	
MATH 570	Topology I	F, Odd years	3	
MATH 617	Integration and Measure Theory	S	4	
MATH 618	Advanced Real Analysis	F	3	
MATH 670	Introduction to Differential Manifolds	As needed	3	
STAT 525	Time Series Analysis I	F	3	
STAT 620	Introduction to Measure Theoretic Probability	S	3	

## Digital Signal and Imaging Processing

Course Number	Course Name	Semester Offered*	Credits	Online
ECE 512	Digital Signal Processing	F	3	X
ECE 513	Digital Image Processing	S	3	X
ECE 514	Applications of Random Processes	F	4	X
ECE 516	Information Theory	F	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 521	Satellite Communication	S	3	X
ECE/MATH 522	Random Walks	F, Even years	3	X
ECE/BIOM 537	Biomedical Signal Processing	S, Even years	3	X
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 556	AI for Radar and Remote Sensing	S	3	X
ECE 652	Estimation and Filtering Theory	S, Odd years	3	X
ECE 653	Detection Theory	F, Odd years	3	
ECE 656	Machine Learning and Adaptive Systems	F, Odd years	3	X
ECE 752	Topics in Signal Processing	As needed	3	
MATH 417	Advanced Calculus I	F	3	
MATH 418	Advanced Calculus II	S, Even years	3	
MATH 466	Abstract Algebra I	F	3	
MATH 469	Linear Algebra II	S	3	
MATH 474	Introduction to Differential Geometry	F, Odd years	3	
MATH 517	Introduction to Real Analysis	F	3	
MATH 519	Complex Variables I	S	3	
MATH 532	Mathematical Modeling of Large Data Sets	S, Even years	3	
MATH 560	Linear Algebra	F	3	X
MATH 566	Introduction to Abstract Algebra I	F	3	
MATH 570	Topology I	F, Odd years	3	
MATH 617	Integration and Measure Theory	S	4	
MATH 618	Advanced Real Analysis	F	3	
MATH 670	Introduction to Differential Manifolds	As needed	3	
STAT 525	Time Series Analysis I	F	3	

\*Subject to change. Please see the course schedule regarding semester course offerings

## **Electric Power and Energy (See also Systems Engineering – Energy Systems)**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
ECE 411	Control Systems	F	3	X
ECE 461/462	Power Systems I	F, Odd years	4	
ECE 520 <sup>b</sup>	Optimization Methods for Control & Communications	S	3	X
ECE 562	Power Electronics I	S, Even years	3	X
ECE/ENGR 565	Electrical Power Engineering	F, Odd years	3	X
ECE/ENGR 566	Grid Integration of Wind Energy Systems	S, Odd years	3	X
ENGR 510 <sup>b</sup>	Engineering Optimization: Method/Application	F	3	X
MATH 417	Advanced Calculus I	F	3	
MATH 418	Advanced Calculus II	S	3	
MATH 419	Introduction to Complex Variables	F	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 451	Introduction to Numerical Analysis II	S	3	
MATH 519	Complex Variables	S	3	
MATH 560	Linear Algebra	F	3	X
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MECH 421	Fundamentals of Wind Energy	F	3	X
MECH 575	Solar and Alternative Energies	S	3	X

<sup>b</sup> ECE520 is the preferred and recommended course. Students may take only one of the optimization courses to count toward their degree.

## **Electromagnetics and Remote Sensing**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
ECE 444	Antennas & Radiation	F	3	
ECE 512	Digital Signal Processing	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 521	Satellite Communication	S	3	X
ECE 536	RF Integrated Circuit Design	F, Even years	3	
ECE 540	Computational Electromagnetics	F, Odd years	3	
ECE 541	Applied Electromagnetics	F, Even years	3	
ECE 548	Microwave Theory & Component Design	S, Odd years	3	
ECE 549	Radar Systems and Design	F, Odd years	3	X
ECE 556	AI for Radar and Remote Sensing	S	3	X
ECE 641	Electromagnetics	As needed	3	
ECE 642	Time-Harmonic Electromagnetics	As needed	3	
ECE 742	Topics in Electromagnetics	As needed	3	

## Embedded Systems

Course Number	Course Name	Semester Offered*	Credits	Online
CS 414	Object Oriented Design	F	4	X
CS 415	Software Testing	S	4	X
CS 420	Introduction to Analysis of Algorithms	F	4	X
CS 422	Automata, Logic, and Computation	F	4	X
CS 425	Intro to Bioinformatics Algorithms	F	4	
CS 435	Introduction to Big Data	S	4	X
CS 440	Introduction to Artificial Intelligence	F	4	X
CS 445	Introduction to Machine Learning	S	4	X
CS 453	Introduction to Compiler Construction	S	4	X
CS 455	Introduction to Distributed Systems	S	4	X
CS 456	Modern Cybersecurity	F	4	X
CS 458	Blockchain Principles and Applications	S	4	X
CS 464	Principles of Human-Computer Interaction	S	4	X
CS 475	Parallel Programming	F	4	X
CS 480A5	Cyber Security Accelerators	F	4	X
CS 481A4	Introduction to Digital Forensics	As needed	4	X
CS 530	Fault-Tolerant Computing	S	4	X
CS 540	Artificial Intelligence	S	4	X
CS 542	Natural Language Processing	F	4	X
CS 545	Machine Learning	F	4	X
CS 557	Advanced Networking and the Internet	S	4	X
CS 559	Quantitative Security	F	4	X
CS 567	3D User Interfaces	F	4	X
CS 575	Parallel Processing	As needed	4	X
ECE 450/451	Digital System Design and Laboratory	F	4	
ECE 452	Computer Organization and Architecture	S	3	X
ECE 455	Intro to Robot Programming/Simulation	F	3	X
ECE 456	Computer Networks	S	4	X
ECE 480A4	Digital Logic Synthesis	S	3	X
ECE 480A5	Distributed Nonlinear Control/AI Systems	S	3	X
ECE 481A4	Real-Time Applied Non-Linear Control Systems	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 519	Network Centric Systems	S, Even years	3	X
ECE/CS 528	Embedded Systems and Machine Learning	F	4	X
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 554	Computer Architecture	S, Even years	3	X
ECE 555	Advanced Robotics: Redundancy & Optimization	S, Even years	3	
ECE/CS 560	Foundations of Fine-Grain Parallelism	As needed	4	
ECE/CS 561	Hardware/Software Design of Embedded Systems	S, Odd years	4	X
ECE 571/575	VLSI System Design/Lab	S	4	
ECE 661	Advanced Topics in Embedded Systems	As needed	4	X
GRAD 510	Fundamentals of High Performance Computing	F	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 460	Information and Coding Theory	S	3	
MATH 480A1	Post-Quantum Cryptography	S	3	
MATH 510	Linear Programming and Network Flows	F	3	

\*Subject to change. Please see the course schedule regarding semester course offerings

## Embedded Systems, continued

Course Number	Course Name	Semester Offered*	Credits	Online
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MECH 564	Fundamentals of Robot Mechanics and Controls	S	3	X
STAT 421	Introduction to Stochastic Processes	S	3	

## High Performance Computing

Course Number	Course Name	Semester Offered*	Credits	Online
CS 414	Object Oriented Design	F	4	X
CS 415	Software Testing	S	4	X
CS 420	Introduction to Analysis of Algorithms	F	4	X
CS 422	Automata, Logic, and Computation	F	4	X
CS 425	Intro to Bioinformatics Algorithms	F	4	
CS 435	Introduction to Big Data	S	4	X
CS 440	Introduction to Artificial Intelligence	F	4	X
CS 445	Introduction to Machine Learning	S	4	X
CS 453	Introduction to Compiler Construction	S	4	X
CS 455	Introduction to Distributed Systems	S	4	X
CS 456	Modern Cybersecurity	F	4	X
CS 458	Blockchain Principles and Applications	S	4	X
CS 464	Principles of Human-Computer Interaction	S	4	X
CS 475	Parallel Programming	F	4	X
CS 480A5	Cyber Security Accelerators	F	4	X
CS 481A4	Introduction to Digital Forensics	As needed	4	X
CS 530	Fault-Tolerant Computing	S	4	X
CS 540	Artificial Intelligence	S	4	X
CS 542	Natural Language Processing	F	4	X
CS 545	Machine Learning	F	4	X
CS 556	Computer Security	S	4	X
CS 557	Advanced Networking and the Internet	S	4	X
CS 559	Quantitative Security	F	4	X
CS 567	3D User Interfaces	F	4	X
CS 575	Parallel Processing	As needed	4	X
ECE 450/451	Digital System Design and Laboratory	F	4	
ECE 452	Computer Organization and Architecture	S	4	X
ECE 456	Computer Networks	S	4	X
ECE 480A4	Digital Logic Synthesis	S	3	X
ECE 480A5	Distributed Nonlinear Control/AI Systems	S	3	X
ECE 481A4	Real-Time Applied Non-Linear Control Systems	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 519	Network Centric Systems	S, Even years	3	X
ECE/CS 528	Embedded Systems and Machine Learning	F	4	X
ECE 544	Silicon Photonics for Computing Systems	F	3	X

## High Performance Computing, continued

Course Number	Course Name	Semester Offered*	Credits	Online
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 554	Computer Architecture	S, Even years	3	X
ECE 555	Advanced Robotics: Redundancy & Optimization	S, Even years	3	
ECE 558	Manycore System Design Using Machine Learning	F	3	X
ECE/CS 560	Foundations of Fine-Grain Parallelism	As needed	4	
ECE/CS 561	Hardware/Software Design of Embedded Systems	S, Odd years	4	X
ECE 556	AI for Radar and Remote Sensing	S	3	X
ECE 661	Advanced Topics in Embedded Systems	As needed	4	X
GRAD 510	Fundamentals of High Performance Computing	F	3	
GRAD 511	High Performance Computing and Visualization	S	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 451	Introduction to Numerical Analysis II	S	3	
MATH 460	Information and Coding Theory	S	3	
MATH 469	Linear Algebra I	S	3	
MATH 480A1	Post-Quantum Cryptography	S	3	
MATH 510	Linear Programming and Network Flows	F	3	
MATH 560	Linear Algebra	F	3	X
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MATH 569C	Linear Algebra for Data Science: Matrix Factorizations and Transformations	F, S	1	X
MATH 676	Topics in Mathematics	F, S	3	
STAT 421	Introduction to Stochastic Processes	S	3	

## Lasers and Optics

Course Number	Course Name	Semester Offered*	Credits	Online
ECE 404	Experiments in Optical Electronics	F	2	
ECE/MATH 430	Fourier & Wavelet Analysis with Applications	S	3	
ECE 441	Optical Electronics	F	3	
ECE 457 <sup>a</sup>	Fourier Optics	S	3	X
ECE 471A	Semiconductor Physics	S	1	
ECE 471B	Semiconductor Junction	S	1	
ECE 502 <sup>a</sup>	Advanced Fourier Optics	S	4	X
ECE 503	Ultrafast Optics	As needed	3	
ECE 504	Physical Optics	F, Odd years	3	X
ECE 505	Nanostructures: Fundamentals and Applications	F, Odd years	3	X
ECE 506	Optical Interferometry and Laser Metrology	F, Odd years	3	X
ECE 507	Plasma Physics and Applications	S, Even years	3	
ECE 513	Digital Image Processing	S	3	X
ECE/BIOM 517	Advanced Optical Imaging	F, Even years	3	X
ECE/BIOM 518	Biophotonics	F, Odd years	3	X
ECE/BIOM 526	Biological Physics	F, Odd years	3	X
ECE/BIOM 527B	Biosensing: Signal and Noise in Biosensors	S, Even years	1	

\*Subject to change. Please see the course schedule regarding semester course offerings

## Lasers and Optics, continued

Course Number	Course Name	Semester Offered*	Credits	Online
ECE/BIOM 527F	Biophotonic Sensors Using Refractive Index	S, Even years	1	
ECE 546	Laser Fundamentals and Devices	S, Odd years	3	
ECE 572	Semiconductor Transistors	S	1	
ECE 573	Semiconductor Optoelectronics Laboratory	S, Even years	3	
ECE 574	Optical Materials and Devices	S, Even years	3	X
ECE 604	Nonlinear Optics	F, Odd years	3	X
ECE 641	Electromagnetics	As needed	3	
ECE 650	Extreme Ultraviolet and Soft X-Ray Radiation	As needed	3	
ECE 673	Thin Film Growth	F	3	X
PH 451	Introductory Quantum Mechanics I	F	3	
PH 452	Introductory Quantum Mechanics II	S	3	

<sup>a</sup> Students cannot get credit for both ECE457 and ECE502

## Robotic Control

Course Number	Course Name	Semester Offered*	Credits	Online
CS 445	Introduction to Machine Learning	S	4	X
ECE 411	Control Systems	F	3	X
ECE 412	Digital Control and Digital Filters	S	3	X
ECE 455	Intro to Robot Programming/Simulation	F	3	X
ECE 480A5	Distributed Nonlinear Control/AI Systems	S	3	X
ECE 481A4	Real-Time Applied Non-Linear Control Systems	F	3	X
ECE 514	Applications of Random Processes	F	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 555	Advanced Robotics: Redundancy & Optimization	S, Even years	3	
ECE/CS 561	Hardware/Software Design of Embedded Systems	S, Odd years	4	X
ECE 611	Nonlinear Control Systems	F, Even years	3	X
ECE 612	Robust Control Systems	S, Even years	3	X
ECE 656	Machine Learning and Adaptive Systems	S, Even years	3	X
ECE 666	Topics in Robotics	S, Odd years	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 469	Linear Algebra II	S	3	
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MATH 569B	Linear Algebra for Data Science: Geometric Data Reduction	F, S	1	X
MATH 569C	Linear Algebra for Data Science: Matrix Factorizations and Transformations	F, S	1	X
MATH 569D	Linear Algebra for Data Science: Theoretical Foundations	F, S	1	X
MECH 564	Fundamentals of Robot Mechanics and Controls	S	3	X
MECH 630	Biologically Inspired Robotics	F, Odd years	3	

\*Subject to change. Please see the course schedule regarding semester course offerings



## **Robotics Vision**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
CS 410	Introduction to Computer Graphics	F	3	X
CS 445	Introduction to Machine Learning	S	4	X
CS 612	Topics in Computer Graphics	S, Even years	4	
DSCI 475	Topological Data Analysis	S	2	
ECE 455	Intro to Robot Programming/Simulation	F	3	X
ECE 512	Digital Signal Processing	F	3	X
ECE 513	Digital Image Processing	S	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 555	Advanced Robotics: Redundancy & Optimization	S, Even years	3	
ECE 656	Machine Learning and Adaptive Systems	S, Even years	3	X
ECE 666	Topics in Robotics	S, Odd years	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 469	Linear Algebra II	S	3	
MATH 474	Introduction to Differential Geometry	F, Odd years	3	
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
MATH 569B	Linear Algebra for Data Science: Geometric Data Reduction	F, S	1	X
MATH 569C	Linear Algebra for Data Science: Matrix Factorizations and Transformations	F, S	1	X
MATH 569D	Linear Algebra for Data Science: Theoretical Foundations	F, S	1	X
MECH 564	Fundamentals of Robot Mechanics and Controls	S	3	X
MECH 630	Biologically Inspired Robotics	F, Odd years	3	

## **Semi-Conductor Devices and Processing**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
ECE 404	Experiments in Optical Electronics	F	2	
ECE 441	Optical Electronics	F	3	
ECE 471A	Semiconductor Physics	S	1	
ECE 471B	Semiconductor Junction	S	1	
ECE 504	Physical Optics	F, Odd years	3	X
ECE 505	Nanostructures	F, Odd years	3	X
ECE 536	RF Integrated Circuit Design	F, Even years	3	
ECE 541	Applied Electromagnetics	F, Even years	3	
ECE 546	Laser Fundamentals and Device	S, Odd years	3	
ECE 571/575	VLSI System Design/Lab	S	4	
ECE 572	Semiconductor Transistors	S	1	
ECE 573	Semiconductor Optoelectronics Laboratory	S, Even years	3	
ECE 574	Optical Materials and Devices	S, Even years	3	X
ECE 641	Electromagnetics	As needed	3	
PH 531	Introductory Solid State Physics	S	3	

## Systems Engineering – Energy Systems (See also Electric Power and Energy)

Course Number	Course Name	Semester Offered*	Credits	Online
CIVE 546	Water Resource Systems Analysis	S	3	X
ECE 520 <sup>c</sup>	Optimization Methods for Control & Communications	S	3	X
ECE/SYSE 532	Dynamics of Complex Engineering Systems	F	3	X
ECE/ENGR 565	Electrical Power Engineering	F, Odd years	3	X
ECE/ENGR 566	Grid Integration of Wind Energy Systems	S, Odd years	3	X
ECE 612	Robust Control Systems	S, Even years	3	X
ENGR 510 <sup>c</sup>	Engineering Optimization: Method/Application	F	3	X
ENGR 531	Engineering Risk Analysis	S	3	X
MATH 417	Advanced Calculus I	F	3	
MATH 418	Advanced Calculus II	S	3	
MATH 419	Introduction to Complex Variables	F	3	
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 451	Introduction to Numerical Analysis II	S	3	
MATH 519	Complex Variables	S	3	
MATH 560	Linear Algebra	F	3	X
MECH 421	Fundamentals of Wind Energy	F	3	X
MECH 513	Simulation Modeling & Experimentation	As needed	3	X
MECH 575	Solar and Alternative Energies	S	3	X
SYSE 530	Overview of Systems Engineering Processes	S	3	X
SYSE 567	Systems Engineering Architecture	S	3	X

<sup>c</sup>ECE520 is the preferred and recommended course. Students may take only one of the optimization courses to count toward their degree.

## VLSI

Course Number	Course Name	Semester Offered*	Credits	Online
ECE 450/451	Digital System Design and Laboratory	F	4	
ECE 452	Computer Organization and Architecture	S	3	X
ECE 520	Optimization Methods for Control & Communications	S	3	X
ECE 534/535	Analog Integrated Circuit Design	As needed	4	
ECE 536	RF Integrated Circuit Design	F, Even years	3	
ECE 538	Design Analysis of Analog Digital Interface	As needed	4	
ECE 541	Applied Electromagnetics	F, Even years	3	
ECE 544	Silicon Photonics for Computing Systems	F	3	X
ECE 545	FPGA Signal Processing/Software-Defined Radio	S, Odd years	3	X
ECE 554	Computer Architecture	S, Even years	3	X
ECE 558	Manycore System Design Using Machine Learning	F	3	X
ECE/CS 561	Hardware/Software Design of Embedded Systems	S, Odd years	4	X
ECE 571/575	VLSI System Design/Lab	S	4	
ECE 661	Advanced Topics in Embedded Systems – Lab	As needed	4	X
MATH 450	Introduction to Numerical Analysis I	F	3	
MATH 451	Introduction to Numerical Analysis II	S	3	
MATH 517	Introduction to Real Analysis	F	3	
MATH 560	Linear Algebra	F	3	X

\*Subject to change. Please see the course schedule regarding semester course offerings

## **VLSI, continued**

<b>Course Number</b>	<b>Course Name</b>	<b>Semester Offered*</b>	<b>Credits</b>	<b>Online</b>
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	F, S	1	X
STAT 421	Introduction to Stochastic Processes	S	3	
STAT 511	Design and Data Analysis for Researchers I	F	4	
STAT 512	Design Data Analysis for Researchers II	S	4	
STAT 520	Introduction to Probability Theory	F	4	