ECE MS Program in Electrical and Computer Engineering
Fall 2021 EC 500 – 600 Course Offerings

ENG EC 500 Special Topics in ECE: Introduction to Online Learning **Prof. Orabona**

This course deals with the foundations and advances of online learning and online convex optimization. The main theme of the course is the design and theoretical understanding of algorithms that make sequential decisions in adversarial environments, striving to perform as close as possible to a fixed strategy that knows the future in advance. Special attention will be paid to parameter-free, efficient, and practical algorithms. The focus will be on theorems and proofs for the analysis of online learning algorithms. The class will also cover applications of online learning to stochastic optimization, boosting, portfolio selection, and statistical machine learning topics. 4cr.

ENG EC 500 Special Topics in ECE: Quantum Engineering and Technology **Prof. Dal Negro**

This course introduces graduate students to Quantum Engineering and Technology (QET) by providing a comprehensive and rigorous discussion of the basic principles and engineering design concepts of quantum coherent structures and devices for communications, computation, simulation, metrology, and sensing. The course will provide in-depth discussions of design methods, mathematical techniques, and engineering applications for the control of coherent quantum systems that drive the rapidly emerging "quantum supremacy" paradigm of computing and information processing. This course provides a broad yet rigorous foundation of quantum technology that exploits non-classical correlations and coherent superposition effects to achieve fundamentally novel optical and electronic functions on photonic and solid-state devices. A distinctive feature of this course is to present the material in strong partnership with "hands-on" computer simulations that demonstrate quantum mechanical principles and ideas "in action", leveraging the IBM Quantum Experience platform for the simulation of quantum hardware using Python. 4cr.

ENG EC 501 A1 Dynamic System Theory **Prof. Baillieul**

Introduction to analytical concepts and examples of dynamic systems and control. Mathematical description and state space formation of dynamic systems; modeling, controllability, and observability. Eigenvector and transform analysis of linear systems including canonical forms. Performance specifications. State feedback: pole placement and the linear quadratic regulator. Introduction to MIMO design and system identification using computer tools and laboratory experiments. Same as ENG ME 501 and ENG SE 501. Students may not receive credit for both. 4cr.

ENG EC 503-A1 Introduction to Learning from Data **Prof.Ishwar**

This is an introductory course in statistical learning covering the basic theory, algorithms, and applications. This course will focus on the following major classes of supervised and unsupervised learning problems: classification, regression, density estimation, clustering, and dimensionality reduction. Generative and discriminative data models and associated learning algorithms of parametric and non-parametric varieties will be studied within both frequentist and Bayesian settings in a unified way. A variety of contemporary applications will be explored through homework assignments and a project. 4 cr.

ENG EC 504-A1 Advanced Data Structures **Prof. Brower**

Review of basic data structures and Java syntax. Data abstraction and object-oriented design in the context of high-level languages and databases. Design implementation from the perspective of data structure efficiency and distributed control. Tailoring priority queues, balanced search trees, and graph algorithms to real-world problems, such as network routing, database management, and transaction processing. 4 cr.

ENG EC 505-A1 Stochastic Processes **Prof. Saligrama**

Introduction to discrete and continuous-time random processes. Correlation and power spectral density functions. Linear systems driven by random processes. Optimum detection and estimation. Bayesian, Weiner, and Kalman filtering. 4cr.

ENG EC 516-A1 Digital Signal Processing **Prof. Nawab**

Advanced structures and techniques for digital signal processing and their properties in relation to application requirements such as real-time, low-bandwidth, and low-power operation. Optimal FIR filter design; time-dependent Fourier transform and filterbanks; Hilbert transform relations; cepstral analysis and deconvolution; parametric signal modeling; multidimensional signal processing; multirate signal processing. 4cr.

ENG EC 521-A1 Cybersecurity **Prof. Stringhini**

Fundamentals of security related to computers and computer networks. Laws and ethics. Social engineering and psychology-based attacks. Information gathering, network mapping, service enumeration, and vulnerability scanning. Operating system security related to access control, exploits, and disk forensics. Shellcoding. Wired and wireless network security at the physical, network, and application layers. Theoretical lessons are augmented with case studies and demonstrative experimental labs. 4 cr.

ENG EC 524-A1 Optimization Theory and Methods **Prof. Paschalidis**

Introduction to optimization problems and algorithms emphasizing problem formulation, basic methodologies, and underlying mathematical structures. Classical optimization theory as well as recent advances in the field. Topics include modeling issues and formulations, simplex method, duality theory, sensitivity analysis, large-scale optimization, integer programming, interior-point methods, non-linear programming optimality conditions, gradient methods, and conjugate direction methods. Applications are considered; case studies included. Extensive paradigms from production planning and scheduling in manufacturing systems. Other illustrative applications include fleet management, air traffic flow management, optimal routing in communication networks, and optimal portfolio selection. Meets with ENGSE524. Students may not receive credit for both. 4 cr.

ENG EC 528-A1 Cloud Computing **Prof. Krieger**

Prerequisites: Graduate students must have taken a rigorous programming class recently, such as EC504 or equivalent (or have major software design experience in industry).
Fundamentals of cloud computing covering IaaS platforms, OpenStack, key Big Data platforms, and data center scale systems. Examines influential publications in cloud computing. Culminates in a group project supervised by a mentor from industry or academia. 4 cr.

ENG EC 533-A1 Advanced Discrete Mathematics **Prof. Levitin**

Selected topics in discrete mathematics. Formal systems. Mathematical deduction. Logical concepts. Theorem proving. Sets, relations on sets, operations on sets. Functions, graphs, mathematical structures, morphisms, algebraic structures, semigroups, quotient groups, finite-state machines, their homomorphism, and simulation. Machines as recognizers, regular sets. Kleene theorem. 4 cr.

ENG EC 541-A1 Computer Communication Networks **Prof. Starobinski**

Basic delay and blocking models for computer communications: M/M/1 queue; Jackson networks and loss networks; analysis of MAC protocols; flow control for data traffic; TCP and active queueing mechanisms for congestion control; traffic shaping and network calculus; packet switch architectures and scheduling algorithms; routing algorithms; flow assignment and fairness. 4 cr.

ENG EC 545-A1 Cyber-Physical Systems **Prof. Li**

This course introduces students to the principles underlying the design and analysis of cyber-physical systems – computational systems that interact with the physical world. We will study a wide range of applications of such systems ranging from robotics, through medical devices, to smart manufacturing plants. A strong emphasis will be put on building high-assurance systems with real-time and concurrent behaviors. The students will gain both in-depth knowledge and hands-on experience on the specification, modeling, design, and analysis of representative cyber-physical systems. 4 cr.

ENG EC 555-A1 Introduction to Biomedical Optics **Prof. Bigio**

This course surveys the applications of optical science and engineering to a variety of biomedical problems, with emphasis on optical and photonics technologies that enable real, minimally-invasive clinical and laboratory applications. The course teaches only those aspects of the biology itself that are necessary to understand the purpose of the applications. The first weeks introduce the optical properties of tissue, and following lectures cover a range of topics in three general areas: 1) Optical spectroscopy applied to diagnosis of cancer and other tissue diseases; 2) Photon migration and diffuse optical imagine of subsurface structures in tissue; and 3) laser-tissue interactions and other applications of light for therapeutic purposes. Some classes will invoke traditional lectures, and others will be "inverted," devoted to discussing and understanding application problems, with students having read textbook sections or online material prior to class. 4cr.

ENG EC 565-A1 Electromagnetic Fundamentals **Prof. Ramachandran**

Fundamentals of electromagnetic theory as deduced from Maxwell's equations and material modeling; electromagnetic radiation and quasistatic limits in electromagnetic modeling. Radio frequency coaxial cables; VLSI interconnects, transmission lines. Waveguides and resonators; both dielectric and hollow. Particle tracking, plasmas, microwave sources, with applications. Depending on time and interest: numerical methods (variational formulations will be emphasized whenever practical), inverse problems; applications of magnetics and superconductivity. 4 cr.

ENG EC 571-A1 Ditigal VL SI Circuit Design **Prof. Yazicigil**

Very-large-scale integrated circuit design. Review of FET basics. Functional module design, including BiCMOS, combinational and sequential logic, programmable logic arrays, finite-state machines, ROM, and RAM. Fabrication techniques, layout strategies, scalable design rules, design-rule checking, and guidelines for testing and testability. Analysis of factors affecting speed of charge transfer, power requirements, control and minimization of parasitic effects, survey of VLSI applications. Extensive CAD laboratory accompanies course. 4 cr.

ENG EC 573-A1 Solar Energy Systems **Prof. Mazumder**

This course is designed for first year graduate and senior undergraduate students from engineering disciplines. It is intended to educate students in the design and applications of solar energy technology. It will focus on fundamentals of solar energy conversion, solar cells, optical engineering, photoelectrochemical cells, thermoelectric generators, and energy storage and distribution systems. The course covers solar energy insolation and global energy needs, current trends in photovoltaic energy engineering, solar cell materials science, design and installation of solar panels for residential and industrial applications and connections to the national grid and cost analysis of the overall system. In addition, basic manufacturing processes for the production of solar panels, environmental impacts, and the related system engineering aspects will be included to provide a comprehensive state-of-the-art approach to solar energy utilization. Meets with ENG MS573; students may not take credit for both. 4 cr.

ENG EC 574-A1 Physics of Semiconductor Materials **Prof. Bellotti**

This course teaches the relevant notions of quantum mechanics and solid state physics necessary to understand the operation and the design of modern semiconductor devices. Specifically, this course focuses on the engineering aspects of solid state physics that are important to study the electrical and optical properties of semiconductor materials and devices. Particular emphasis is placed on the analysis of the electronic structure of semiconductor bulk systems and low-dimensional structures, the study of the carrier transport properties and the calculation of the optical response that are relevant to the design and optimization of electronics and photonics semiconductor devices. The students will learn to apply the quantum mechanical formalism to the solution of basic engineering device problems (quantum wells, wires, and dots, 2D electron gas) and to perform numerical calculation on more complex systems (band structure calculation of bulk and low dimensional systems). 4 cr.

ENG EC 577 A1 Electrical, Optical and Magnetic Properties of Materials **Prof. Swan**

This course in intended to develop an in depth knowledge of solid state concepts that are important for students in the areas of material science and electrical engineering. Specifically, this course focuses on the study of

different aspect of solid state physics necessary to study technologically relevant crystalline and amorphous systems. Particular emphasis is placed on the study of the crystal structure, crystal diffraction and the related techniques used as diagnostic tools; the electronic, thermal, optical and magnetic properties of material systems important for electronics and photonics device applications. Furthermore the course will also consider the theory of superconductivity, the chemistry aspects of solid state materials and will provide an introduction to solid state biophysics. This course complements EC 574 (Physics of semiconductor material) and EC575 (semiconductor devices) with its focus on technologically relevant structural, optical, thermal and magnetic material properties. Meets with ENG MS 577. Students may not receive credit for both. 4 cr.

ENG EC 578 Fabrication Technology for Integrated Circuits **Prof. Kleptsyn**

Presentation of fabrication procedures for silicon-integrated circuits: physical properties of bulk and epitaxially grown silicon; silicon processing, such as oxidation, diffusion, epitaxy, deposition, and ion implantation; silicon crystallography, anisotropic etching, photolithography, piezorestivity, and chemical and plasma techniques. The limitations these processes impose on the design of bipolar and MOS devices and integrated circuits are discussed. Design of an integrated circuit and the required processing. Includes lab. 4 cr.

ENG EC 591 A1 Photonics Lab I **Prof. Paiella**

Introduction to optical measurements. Laser safety issues. Laboratory experiments: introduction to lasers and optical alignment; interference; diffraction and Fourier optics; polarization components; fiber optics; optical communications; beam optics; longitudinal laser modes. Optical simulation software tools. 4cr.

ENG EC 601 A1 Product Design in Electrical and Computer Engineering **Prof. Alshaykh**

Engineers influence their community, society and the world. Engineers build products and services that can enhance people's lives. The product starts with an idea and is delivered through research (technical and societal), design, implementation, testing and support. During this class, students will experience all of this. The course provides design and practical insights into building products that involve WEB and mobile app development, data simulation, analysis and modeling, cloud computing, signal processing and/or computer vision. In the class, we work on how to take an idea and concept and translate it into product requirements. Afterwards, we translate the product requirements into system and engineering requirements. We also discuss solution selection techniques. We then work on implementing our ideas into systems and verify that they address the product requirements and fulfill the concept we started with. During the class, we go over how to choose solutions to build our products. We also discuss real product realization, implementations and tradeoffs. The class is taught via an example product and the class sessions are interactive. Students are divided into groups where they work in parallel on their projects during class sessions and hackathons. Teams define their target audience, product mission, requirements and features. The class adopts agile software development based on a two-week sprint. Students present their sprint results to the class. 4cr.

ENG EC 602 A1 Design by Software **Prof. Carruthers**

Software plays a central role in all aspects of electrical and computer engineering. This course will provide the foundation for effectively using software as a key part of a career as a professional electrical or computer engineer. Fundamentals of software development systems: system languages, high-level object-oriented languages, and computational languages. Data structures and algorithms in problem analysis and design. Strategies for designing software and designing with software. Software design and development: methodologies, principles and practice. Formalizing software: management, requirements, specifications, testing. Survey of software applications in ECE, including real-time systems, the web, networked systems, audio, graphics, and video systems, research and engineering analysis, consumer electronics and computing, instrumentation and measurement, design, modeling, prototyping, simulation, optimization and information analysis. Students can choose projects and assignments with application to/inspired by/drawn from a broad array of ECE fields including the traditional areas of electro-physics/photonics, computer engineering, and information and data science. 4cr.

ENG EC 605 A1 Computer Engineering Fundamentals **Prof. Moreshet**

This is an introductory course to computer engineering, focusing on the hardware/software interface, and

presenting a bottom-up view of a computer system. Topics include logic design: binary arithmetic, combinational and sequential logic. Computer organization: assembly language programming, CPU design, and memory systems. Introduction to compilers, operating systems, and computer networks. 4 cr.