ECE MS Program in Electrical and Computer Engineering

Spring 2025 EC 500 – 700 Level Course Offerings

ENG EC 500 A1 Advanced Topics in Software Design: Database Design **Prof Solovey**

Monday/Wednesday 12:20 PM – 2:05 PM

This class will start by building up students' foundational knowledge and appreciation for traditional relational database systems and their architecture. Relational models, algebra, and schema design will be covered in detail. Basic and advanced (aggregation and analytics) SQL operations will similarly be covered in detail and will build on top of the relational foundation. With this fundamental, practical usage of relational databases in place, we will look under the hood and cover core properties of relational database implementation: storage techniques, indexing (binary trees and heaps), query planning, execution, and optimization. As we get into the internals, the homework assignments will have students implement their own, small but basic SQL functional databases from scratch. Building on the students' appreciation for the core aspects of building a database, the class will move onto more advanced topics such as data normalization theory, ACID transaction guarantees, concurrency and data recovery. Finally, we will cover the limitations that internet scale has exposed in traditional, relational databases, the CAP theorem, and some of the database evolution that resulted. We will look at columnar databases, NoSQL databases, and cloud databases. Students will gain an appreciation of the pros and cons of relational, columnar, NoSQL, hybrid databases and be able to make an argument of using each given particular application requirements. 4cr.

ENG EC 500 A2 Control of Sustainable Power Systems **Prof Dall'anese**

Monday/Wednesday 10:10 AM – 11:55 AM

This course focuses on computational methods for control of modern power systems, with particular emphasis on renewable generation and system sustainability. To build background, the course covers basics of linear systems, feedback control, and convex optimization. With this groundwork, the course explores methods that are currently utilized to optimize generation in today's operation of power grids; these methods include the economic dispatch, unit commitment, DC optimal power flow (OPF), and AC OPF at the power transmission level. The course then covers primary frequency control methods, secondary control methods, and automatic generation control, along with an analysis of system stability. The contribution of inverter-based resources to stability and grid-forming setups under massive renewable generation integration is discussed. At the power distribution level, the course addresses formulations and solution methods for demand response problems and the AC OPF, with an emphasis on modern distribution grids with distributed energy resources (DERs). The course emphasizes the understanding of the convergence and optimality properties of optimization algorithms used to solve demand response and OPF tasks. Finally, the course introduces advanced algorithms for real-time demand response and AC OPF, focusing on computational methods for the reliable integration of DERs and decarbonization of the power grid. 4cr.

ENG EC 503 A1 Introduction to Learning from Data **Prof Saligrama**

Tuesday/Thursday 1:30 PM – 3:15 PM
Discussion: Wednesday 6:30 PM – 8:15 PM

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 Castanon**
Monday/Wednesday 2:30 PM – 4:15 PM

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 512 A1 Enterprise Client-Server Software Systems Design **Prof Skinner**
Monday/Wednesday 12:20 PM – 2:05 PM

Examination of past, current, and emerging technologies. Client side technologies including DHTML, CSS, scripting, and proprietary applications. Legacy server side technologies including CGI, HTTP protocol, and active server pages. Current server technologies including ASP.NET, XM, web services, SQL databases, streaming media, and middleware. Design and implementation of solutions involving database connectivity, session state, security requirements, SSL, and authentication of clients. Assignments involving design through implementation. Students must be fully competent in an object oriented programming language (C++, C#, or Java preferred). Familiarity with web technologies such as HTML, scripting, XML, etc. is helpful. Programming experience with a graphical user environment is also very desirable. 4 cr.

ENG EC 513 A1 Computer Architecture **Prof Joshi**
Tuesday/Thursday 1:30 PM – 3:15 PM
Recitation/Lab: Friday (time to be determined)

Computer architecture and design. Topics include computer arithmetic and ALU design; performance evaluation; instruction set design; CPU design, including pipelining, branch prediction, and speculative execution; memory hierarchy, including cache basics, cache design for performance, and virtual memory support; I/O, including devices, interfaces, specification, and modeling. Examples from high-end microprocessors and embedded systems. 4 cr.

ENG EC 520 A1 Digital Image Processing and Communication **Prof Konrad**
Monday/Wednesday 12:20 PM – 2:05 PM

Review of signals and systems in multiple dimensions. Sampling of still images. Quantization of image intensities. Human visual system. Image color spaces. Image models and transformations. Image enhancement and restoration. Image analysis. Image compression fundamentals. Image compression standards (JPEG, JPEG-2000). Homework will include MATLAB assignments. 4 cr.

ENG EC 521 A1 Cybersecurity **Prof Stringhini**
Monday/Wednesday 10:10 AM – 11:55 AM

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 522 A1 Computational Optical Imaging **Prof Tian**
Monday/Wednesday 2:30 PM – 4:15 PM

Recent years have seen the growth of computational optical imaging - optical imaging systems that tightly integrate hardware and computation. The results are the emergence of many new imaging capabilities, such as 3D, super resolution, and extended depth of field. Computational optical imaging systems have a wide range of applications in consumer photography, scientific and biomedical imaging, microscopy, defense, security and remote sensing. This course looks at this new design approach as it is applied to modern optical imaging, with a focus on the tools and techniques at the convergence of physical optical modeling, and signal processing. 4 cr.

ENG EC 523 A1 Deep Learning **Prof Kulis**
Tuesday/Thursday 1:30 PM – 3:15 PM

Mathematical and machine learning background for deep learning. Feed-forward networks., Backpropagation. Training strategies for deep networks. Convolutional networks. Recurrent neural networks. Deep reinforcement learning. Deep unsupervised learning. Exposure to Pytorch and other modern programming tools. Other recent topics, time permitting. Same as CAS CS 523. Students may not receive credit for both. 4 cr.

ENG EC 527 A1 High Performance Programming with Multicore and GPUs **Prof Herbordt**
Monday/Wednesday 4:30 PM – 6:15 PM

Considers theory and practice of hardware-aware programming. Key theme is obtaining a significant fraction of potential performance through knowledge of the underlying computing platform and how the platform interacts with programs. Studies architecture of, and programming methods for, contemporary high-performance processors. These include complex processor cores, multicore processors, and graphics processors. Laboratory component includes use and evaluation of programming methods on these processors through applications such as matrix operations and the Fast Fourier Transform. 4 cr.

ENG EC 528 A1 Cloud Computing **Prof Turk**
Monday/Wednesday 6:30 PM – 8:15 PM

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. Same as CAS CS 528. Students may not receive credits for both. 4 cr.

ENG EC 530 A1 Software Engineering Principles **Prof Alshaykh**
Tuesday/Thursday 5:30 PM – 7:15 PM

This class was designed to bring the basic concepts of software engineering together and practice them in real life examples. We will focus on studying different concepts that the students have taken in different classes or were not exposed to that are necessary for their careers. Examples include continuous build and integration, Modular Design, API Design, Rest APIs, Application frameworks, Containers, and Multi-. The class follows a flipped classroom model. Outside of the classroom, the students: study concepts, read assigned papers and tutorials; work on homeworks, which is equivalent to what other classes consider projects. 4 cr.

ENG EC 531 A1 Full-Stack Software at Scale **Prof Trachtenberg**
Tuesday/Thursday 1:30 PM – 3:15 PM

Scaling software to many developers, modules, or machines requires a fundamentally different skill-set than writing short prototype code. Large groups of software engineers developing web or mobile applications, financial or healthcare systems, and even multiplayer games must synthesize a wide variety of elements at all layers of the software stack. This course addresses fundamental skills and experience needed for such software development within a modern multi-developer software development infrastructure. Through a variety of intensive programming projects in various languages and group sizes, students will learn about four core elements of software development at scale: design (writing future-oriented code for modularity, extensibility, interoperability), distribution (managing code across multiple processors), optimization (understanding the long-term effects of design and distribution on performance), and security (how all the previous elements influence the security and privacy of the overall system). 4 cr.

ENG EC 534 A1 Discrete Stochastic Models **Prof Levitin**
Monday/Wednesday 2:30 PM – 4:15 PM

Markov chains, Chapman-Kolmogorov equation. Classification of states, limiting probabilities, Poisson process and its generalization, continuous-time Markov chains, queuing theory, reliability theory. 4 cr.

ENG EC 535 A1 Introduction to Embedded Systems **Prof Ohn-Bar**
Tuesday/Thursday 9:00 AM – 10:45 AM
Lab: Friday 10:10 AM – 11:00 AM

This course introduces students to a unified view of hardware and software in embedded systems. The lectures will survey a comprehensive array of techniques including system specification languages, embedded computer architecture, real-time operating systems, hardware-software codesign, and co-verification techniques. The lectures will be complemented by assignments and projects that involve system design, analysis, optimization, and verification. 4 cr.

ENG EC 541 A1 Computer Communication Networks **Prof Staorbinski**
Monday/Wednesday 2:30 PM – 4:15 PM

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 556 A1 Optical Spectroscopic Imaging **Prof Cheng**
Tuesday/Thursday 3:30 PM – 6:15 PM

This introductory graduate-level course aims to teach students how electromagnetic waves and various forms of molecular spectroscopy can be used to study a complex biological system by pushing the physical limits on engineering system design.The course will cover fundamental concepts of optical spectroscopy and microscopy, followed by specific topics covering fluorescence-based , absorption-based, and scattering-based spectroscopic imaging. In addition, this course will provide in-depth discussions of linear and nonlinear spectroscopic imaging in the aspects of theory, instrumentation, image data analysis and enabling applications. Students will learn how to give a concise and informative presentation of a recent literature to the class. Students will be able to challenge their creativity in designing advanced imaging instrument of data analysis methods as part of their course assignments. The students will learn how to write and present a convincing proposal for the required final project to be designed by interdisciplinary teams formed among the students. Same as ENG BE 556. Students may not receive credit for both. 4cr.

ENG EC 570 A1 Lasers and Applications **Prof Sander**
Monday/Wednesday 10:10 AM – 11:55 AM

Review of wave optics. Gaussian, Hermite-Gaussian, Laguerre-Gaussian, and Bessel optical beams. Planar- and spherical-mirror resonators; microresonators. Photons and photon streams. Energy levels; absorption, spontaneous emission, and simulated emission. Thermal and scattered light. Laser amplification and gain saturation. Laser oscillation. Common lasers and introduction to pulsed lasers. Photon interactions in semiconductors. LEDs, laser diodes, quantum-confined lasers, and microcavity lasers. Introductoin to photon detectors. Laboratory experiments: beam optics; longitudinal laser modes; laser-diode output characteristics. 4 cr.

ENG EC 571 A1 Digital VLSI Circuit Design **Prof Yazicigil**
Monday/Wednesday 12:20 PM – 2:05 PM
Lab: Friday (time to be determined)

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 575 A1 Semiconductor Devices **Prof Bellotti**
Monday/Wednesday 10:10 AM – 11:55 AM

Fundamentals of carrier generation, transport, recombination, and storage in semiconductors. Physical principles of operation of the PN junction, metal-semiconductor contact, bipolar junction transistor, MOS capacitor, MOSFET (Metal Oxide Semiconductor Field Effect Transistor), JFET (Junction Field Effect Transistor), and bipolar junction transistor. Develops physical principles and models that are useful in the analysis and design of integrated circuits. 4 cr.

ENG EC 583 A1 Power Electronics for Energy systems **Prof Lee**
Tuesday/Thursday 1:30 PM – 3:15 PM
Lab: Thursday 9:00 AM – 10:45 AM or Wednesday 10:10 AM – 11:55 AM

Introduction to power electronics with emphasis on conversion circuits for energy systems. DC to DC conversion using buck, boost, and buck-boost converters. DC to AC inverters. Connection to power grid. Properties of MOS transistors used for high power conversion applications. Properties of magnetic elements and interactions with power circuits. Applications of power electronic circuits to energy systems, including solar cell installations, wave and wind power, and electric vehicles. High frequency inductors and transformers. 4 cr.

ENG EC 585 A1 Quantum Engineering Technology **Prof Dal Negro**
Monday/Wednesday 4:30 PM – 6:15 PM

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. this course will provide in-depth discussion 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". 4 cr.

ENG EC 700 A1 Contemporary Stochastic Optimization **Prof Cutkosy**
Tuesday/Thursday 3:30 PM – 5:15 PM

This course will explore recent advancements in optimization theory, with a particular focus on "gradient-based" optimization techniques that are prevalent in stochastic and online optimization problems arising in machine learning as well as techniques for tuning hyperparameters and dataset properties for improved convergence. The class will emphasize connections between optimization algorithms and disparate areas such as statistics and high-dimensional probability and architecture choices in deep learning. Students will read contemporary literature throughout the class. This course will focus on mathematical fundamentals rather than implementation details. 4 cr.

ENG EC 710 A1 Dynamic Programming and Stochastic Control **Prof Caramanis**
Monday/Wednesday 10:10 AM – 11:55 AM

Introduction to sequential decision making via dynamic programming. The principle of optimality as a unified approach to optimal control of dynamic systems and Markovian decision problems. Applications from control theory and operations research include linear-quadratic problems, the discrete Kalman Filter, inventory control, network, investment, and resource allocation models. Adaptive control and numerical solutions through successive approximation and policy iteration, suboptimal control, and neural network applications involving functional approximations and learning. Same as ENG EC 710 and ENG ME 710. Students may not receive credits for both. 4 cr.

ENG EC 716 A1 Advanced Digital Signal Processing **Prof Nawab**
Monday/Wednesday 10:10 AM – 11:55 AM

Classical and contemporary theories of machine learning. Topics/emphasis may change based on instructor preference in different years. A project involving computer implementation of a learning or inference algorithm accompanied by or in support of theoretical analysis is required. 4 cr.

ENG EC 774 A1 Semiconductor Quantum Structures and Photonic Devices **Prof Paiella**
Tuesday/Thursday 1:30 PM – 3:15 PM

Optical properties of semiconductors: interband optical transitions; excitons. Low-dimensional structures: quantum wells, superlattices, quantum wires, quantum dots, and their optical properties; intersubband transitions. Lasers: double-heterojunction, quantum-well, quantum-dot, and quantum-cascade lasers; high-speed laser dynamics. Electro-optical properties of bulk and low-dimensional semiconductors; electroabsorption modulators. Detectors: photoconductors and photodiodes; quantum-well infrared photodetectors. Same as ENG MS 774. Students may not receive credit for both. 4 cr.