

# ELECTRICAL AND COMPUTER ENGINEERING

## Courses

All courses except ELEC 898, ELEC 899 and ELEC 999 are 3.0 credit units. Not all courses are offered every year.

### **APSC 801 Master of Engineering Foundations**

An introduction to the Master of Engineering (MEng) graduate studies program at Queen's University. The course provides students with essential administrative information, an introduction to information literacy within Smith Engineering, as well as an overview of the various support services on campus. Additionally, the course contains several modules on professional and career skills. This non-credit course is comprised of a number of individual modules, and its completion may be a requirement to graduate from the MEng program. Graded on a Pass/Fail basis.  
Prerequisite: Enrolment in the MEng program.  
Exclusion: Students not enrolled in the MEng program.

### **APSC 810 Teaching and Learning in Engineering**

This course is an introduction to learning principles and effective teaching in engineering, intended to prepare for roles like teaching assistant, university course instruction, or training in engineering industry. The course includes relevant theories of teaching and learning with practical elements like classroom management, designing sessions and assessments, signature engineering teaching approaches, and using digital pedagogies. In Electrical and Computer Engineering, this course can be taken as a secondary (additional) course, or as an audited course, but will not count towards the coursework requirement of any graduate degree.

### **APSC 812 AI Ethics and Society**

This course investigates the ethical implications of Artificial Intelligence (AI) as a social, technological and cultural phenomenon. Given the increasing use of intelligent systems for decision-making and autonomous control, it is essential that designers and developers are aware of the ethical and social implications that AI can have. The course materials will examine fundamental ethical principles related to the application of AI and investigate its influence in a number of industries including self-driving vehicles, healthcare, law and defense. The course will also examine the delicate balance between innovations in AI versus regulation, privacy, and individual rights. This course is graded on a Pass/Fail basis. This is a required course for Master of Applied Science students in the field of study in Artificial Intelligence in the Department of Electrical and Computer Engineering. Students in other graduate programs in the Department of Electrical and Computer Engineering must consult with the

Department to confirm if this course will count towards the coursework requirement of their graduate degree.

### **APSC 877 Engineering Project Management**

The course will examine the essential skills and knowledge required for effective engineering project management. The foundational principles of project management including integration, scope, cost, time, human resources, stakeholders and procurement are examined. The course will be delivered online. In Electrical and Computer Engineering, this course can be taken as a secondary (additional) course, or as an audited course, but will not count towards the coursework requirement of any graduate degree.  
Exclusions: MECH 896, APSC 223

### **APSC 888 Engineering Innovation and Entrepreneurship**

This course will help learners from across engineering develop an entrepreneurial mindset capable of turning problems into opportunities. Learners will investigate the relationships between innovation and industrial dynamics, and seek to understand the fundamental forces that drive the science and technology industries' evolution and industry life cycles. In Electrical and Computer Engineering, this course can be taken as a secondary (additional) course, or as an audited course, but will not count towards the coursework requirement of any graduate degree.  
Exclusions: CHEE 410

### **APSC 896 Engineering Leadership**

The course is designed to develop a range of leadership skills essential for engineering professional practice. Students will explore their own leadership abilities and develop their competencies in areas such as managing conflict, team dynamics and developing others. The course content will be presented through lectures, case studies, panel discussions and other active learning activities. In Electrical and Computer Engineering, students in the M.Eng. program can take APSC-896 as a primary course toward their program requirements.

For students in the M.A.Sc. or Ph.D. program in Electrical and Computer Engineering, APSC 896 can be taken as a secondary (additional) course, but the course will not count towards the coursework requirement of the M.A.Sc. or Ph.D.

### **ELEC 823 Signal Processing**

This course covers basic topics in statistical signal processing and machine learning with applications in speech, communication, and biomedical signal processing. The student is assumed to be familiar with digital signal processing rudiments such as discrete Fourier transforms and design and analysis of digital filters. Topics covered include: spectral modeling, linear prediction, optimal filtering,



adaptive filters, Bayesian inference, linear models, support vector machines, neural networks, and hidden Markov models.

### **ELEC 825 Machine Learning and deep learning**

Basic machine learning concepts in supervised and unsupervised learning; discriminative and generative models; backpropagation, FFN, CNN, RNN, autoencoders; regularization technologies; attention-based models, Transformer, Capsule Networks; pretraining and self-supervised models; Generative Adversarial Networks (GANs), variational autoencoders; applications. Three term hours. Lectures.

PREREQUISITE: ELEC 326 or equivalent, or permission of the instructor.

### **ELEC 827 Multimedia Signal Processing**

Study of multimedia signal processing for network mediated human-human communication and human machine interaction (HMI). Topics covered include: overview of multimedia applications and processing functions; speech production; human auditory and speech perception; image formation; human visual perception; perceptual quality and user experience modeling; speech and image analysis and synthesis methods; lossless and lossy compression techniques; coding for communication and storage; sensing modalities for HMI; machine learning algorithms for information extraction and understanding. Three-term-hours; lectures. Permission of instructor.

### **ELEC 829 Optimization for Machine Learning**

This course provides students with an in-depth understanding of optimization methods specifically tailored for machine learning. It covers the foundations of convex analysis and widely used optimization algorithms in machine learning such as gradient descent, subgradient, and projected gradient methods. Proximal methods and regularized optimization will be covered for handling optimization problems with non-smooth objectives or constraints. Stochastic gradient methods, including stochastic (sub)gradient descent and variance-reduced stochastic gradient, will be discussed for handling large datasets. The course will conclude by exploring non-convex optimization using coordinate descent, Newton's and Quasi-Newton Methods, and adaptive methods. The course emphasizes both the theoretical foundations and practical applications of these optimization techniques within the context of machine learning algorithms. By the end of the course, students will be well-versed in advanced optimization methods and equipped to apply them effectively in machine learning scenarios, enhancing model performance, convergence rates, and robustness. (3.0 credit units).

PREREQUISITES: Working knowledge of linear algebra and probability. Prior exposure to optimization is a plus but not necessary.

### **ELEC 830 Emerging Technologies in power grid**

Renewable energy generation; wind and Photovoltaic energy conversion; energy storage; distributed energy generation; hybrid systems; Power electronics interfaces and control. Grid-connected distributed sources. Stand-alone operation of distributed sources and micro-grid systems. System protection. Economical dispatch. Centralized and decentralized control. Smart grid.

### **ELEC 831 Power Electronics**

Fundamentals of loss-less switching techniques: zero-voltage switching, zero-current switching. Resonant converters: series, parallel and series-parallel topologies; Soft-switching converters: natural and auxiliary commutation converter topologies; Control techniques: variable frequency, phase-shift and hybrid control. Applications to single-phase three-phase and multi-level converters. Special emphasis will be placed on the design techniques using practical examples. PREREQUISITE: ELEC 431 or permission of instructor.

### **ELEC 832 Modeling and Control of Switching Power Converters**

This course covers the modeling and control techniques for switching power converters. Small signal models and large signal models will be presented. Peak current mode control and average current mode control for switching power converters will be investigated. System stability issues when several power supplies are connected together are investigated and solutions are presented and analyzed. Digital control techniques, using FPGA or DSP, will be investigated and analyzed. Conventional fuzzy logic control and improved version of fuzzy logic control will be analyzed in detail. Sliding mode control and sliding mode like control will be analyzed. Digital control techniques for AC-DC converter with power factor correction will be analyzed. It is expected the students will do a project based one or more of the above mentioned techniques. Three term-hours, lectures, fall.

### **ELEC 834 Micro-Grid Technology**

This course covers various power electronics technologies for micro-grids, nano-grids and energy harvesting systems. In this course various types of micro-grids will be covered (e.g., AC microgrids, hybrid micro-grids, and DC micro-grids), along with their respective architectures and control systems. PREREQUISITES: ELEC 431 and ELEC 443, or equivalent, or permission of the instructor.

### **ELEC 835 Nonlinear Control for Power Electronics**

This course provides an overview of advanced nonlinear control and its application in power electronics. It covers

mathematical background and major topics in this area. Students will be introduced to the rigorous mathematical background for nonlinear systems particularly differential geometry. Then, the design of nonlinear control systems will be covered for power electronics applications.  
**PREREQUISITES:** ELEC 431 (Power Electronics) or equivalent or permission of the instructor, and ELEC 443 (Linear Control Systems) or equivalent.

### **ELEC 837 High Power Electronics**

Introduction. Power semiconductor devices. Line- and force-commutated converters. High power ac/dc and dc/ac converter structures and switching techniques. Principles of HVDC and HVAC systems. Large and small scale stabilities, sub-synchronous resonances, inter-area oscillations, voltage sags, and harmonic instability. Voltage, power angle, and impedance control, phase balancing, and power factor correction by means of solid-state power converters. Flexible AC Transmission Systems (FACTS). Three term hours; lectures, Winter.

### **ELEC 841 Nonlinear Systems: Analysis and Identification**

Analytical methods for nonlinear systems; nonlinear difference equation models: functional expansions and Volterra, Wiener and Fourier-Hermite kernels; kernel estimation techniques; identification of cascades of linear and static nonlinear systems; use of Volterra series to find region of stability of nonlinear differential equations; applications to pattern recognition, communications, physiological systems, and non-destructive testing. Three term-hours; lectures, Fall.

### **ELEC 842 Safe Learning-Based Control for Robotics**

This graduate course aims to introduce students to the emerging field of learning for robot control. The course focuses on studying and designing safe decision-making algorithms for robotic systems under uncertainties using machine learning. The topics covered include selected fundamental concepts in robust and adaptive control, learning uncertain dynamics to improve performance safely, encouraging safety and robustness in reinforcement learning (RL), and safety certificates for learning-based controllers. (3.0 credit units)  
**PREREQUISITE:** ELEC 443 (Linear Control Systems) or equivalent.

### **ELEC 843 Control of Discrete-Event Systems**

Study of discrete-event processes that require control to induce desirable behaviour. Topics include: basic automata and language theory; modeling of processes using automata (finite-state machines, directed graphs); centralized and decentralized problems; nonblocking supervisors; partial observation; and computational complexity. Connections with

manufacturing systems and communication protocols are emphasized. Three term-hours; lectures, Fall.

### **ELEC 844 Search and Planning Algorithms for Robotics**

This graduate course will introduce students to search and planning algorithms through autonomous and mobile robots. Topics will span foundational works in dynamic programming, graph search, sampling-based planning, and local optimization. The course will cover both the formal properties and practical considerations of these widely used algorithms. (3.0 credit units)

### **ELEC 845 Vehicle Control and Navigation**

The objective of this course is to introduce graduate-level engineering students to the fundamentals of autonomous vehicles engineering. The course focuses on those tasks usually carried out by autonomy engineers, including sensor selection, applied control (e.g., trajectory and path following) and navigation techniques for autonomous vehicles that operate in real environments (e.g., mining, construction, warehouses, roadways, etc.). Although the focus in this course is on ground vehicles, the presented methods are also applicable more broadly. The audience is engineers from all relevant engineering and applied science disciplines who have an interest in mobile robotics, applied control and estimation, and robotic vehicle applications. Three term hours, Lectures.

**PREREQUISITES:** ELEC 443, MECH-350 or equivalent undergraduate level course in control systems.

**EXCLUSION:** MINE-855

### **ELEC 846 Runtime Verification**

This course introduces students to background, fundamentals, and emerging themes in the area of Runtime Verification (RV). RV is a branch of formal verification primarily focused on monitoring the correctness of executing systems. The course covers general concepts in formal methods, such as formal languages and automata theory, as well as topics specific to RV, such as monitor construction, verdict domains, program instrumentation, and monitorability. Students will also explore current subjects in RV and experiment with tools. (3.0 credit units).

**Prerequisites:** Working knowledge of combinatorics, set theory, graph theory, and propositional logic, as would be taught in an undergraduate discrete mathematics course, as well as computer programming and data structures. Prior exposure to predicate (first-order) logic and finite-state automata is beneficial but not required.

### **ELEC 848 Control Systems Design for Robots and Telerobots**

This course provides an overview of manipulator modeling, and presents and analyzes many different control architectures designed for robots and telerobots. Topics



include introduction to robotics and telerobotics; serial manipulator forward and inverse kinematics, Jacobian, singularities and dynamics; robot position and force control methodologies and their stability analyses; bilateral teleoperation control architectures, stability and performance issues due to communication delays and environment uncertainties. Three term hours, Lectures, Winter.

#### **ELEC 852 Broadband Integrated Circuits**

Topics covered include broadband and ultra-wide band circuit design techniques with applications to wireless and lightwave systems. Broadband amplifiers, mixers and active filters are discussed using radio frequency, microwave and millimeter-wave methods. Three term hours; lectures.

#### **ELEC 853 Silicon RF and Microwave Circuits**

This course presents an introduction to the design of RF and microwave circuits using silicon technologies. Topics include: an overview of silicon technologies; the design of passive structures including transmission lines, inductors, and couplers; considerations in the layout of active devices; examples of the design of circuit components on silicon; system design including integrated system-on-chip designs; and a look at the future of silicon high-speed circuits. Three term-hours, lectures; Winter.

PREREQUISITE: ELEC 483 or equivalent

#### **ELEC 854 Microwave Circuits and Systems**

Investigation of the design and performance of wireless circuits and systems at microwave and millimeter-wave frequencies. Topics include: communications transceivers, millimeter-wave imaging systems, RFID, radar systems, transmission lines and passive circuits, resonators, microstrip and lumped element low-pass and bandpass filters, amplifier noise and linearity, diode and transistor mixers, LC and relaxation oscillators, frequency multipliers and dividers, phase shifters, FSK QPSK and GMSK modulators and demodulators. Three term hours; lectures.

#### **ELEC 855 Nanoelectronics and Nano-Devices**

This course teaches the fundamentals of electron devices in nanometer regime. The course will cover introduction to the nanoelectronics, basics of quantum mechanics and band theory of solids. The concept of Coulomb blockade, many electrons phenomenon, ballistic and spin transport will be discussed and single electron transistor, quantum dots, nanowire and quantum wells based devices will be taught. PREREQUISITES: ELEC 252, ENPH 336 or equivalent courses.

#### **ELEC 856 Introduction to Nanophotonics**

The course will provide an overview of the principles of operation of current nanophotonic devices, and recent advances in nanophotonics. Topics covered will include: light-matter interaction, optical waveguides, modeling of

nanophotonic devices, light propagation in periodic and anisotropic media, coupled mode devices, plasmonics, metamaterial and metasurface. Emphasis of the course will be on the underlying physics behind the operation and design of nanophotonic devices.

PREREQUISITES: ELEC 381 or PHYS 239 or their equivalents.

#### **ELEC 857 Selected Topics in RF Engineering**

This course will cover advanced techniques in high-frequency electronics. Possible topics include ultra-low power circuits, wireless sensors, integrated antennas, microwave photonic circuits, RF technology for high-performance instrumentation.

PREREQUISITES: ELEC 353 and ELEC 381 (or their equivalents).

#### **ELEC 859 Unconventional Computing**

This course gives an overview of computing hardware from classic conventions to emerging frontiers: machine learning accelerators, quantum circuits, and others. It covers unconventional information representations, architectures, and programming. Assignments measuring cloud-based CPU, GPU, FPGA, neuromorphic, and quantum computers will give hands-on exposure to the physicality – the time, energy, and matter – of information processing. (3.0 credit units)

#### **ELEC 860 Communication Network Analysis**

This course provides an analytical study of communication networks that covers many of the major advances made in this area. Students will be introduced to the mathematical preliminaries in queueing theory, optimization and control, followed by a rigorous treatment of network architectures, protocols and algorithms, including resource allocation, congestion control, routing, and scheduling that are essential to existing and future communication networks and the Internet. Three term-hours; lectures.

PREREQUISITE: ELEC 326 (Probability and Random Processes) or equivalent.

#### **ELEC 861 Probability, Random Variables and Stochastic Processes**

The review of probability theory including probability spaces, random variables, probability distribution and density functions, characteristic functions, convergence of random sequences, and laws of large numbers. Fundamental concepts of random processes including stationarity, ergodicity, autocorrelation function and power spectral density, and transmission of random processes through linear systems. Special random processes, including Gaussian processes, with applications to electrical and computer engineering at a rigorous level. Three term-hours; lectures.

#### **ELEC 863 Topics in Optical Communications**



Selected topics in optical communications will be studied. Possible topics include semiconductor lasers, optical modulators, modulation formats, multiplexing and demultiplexing techniques, optical fibers, dispersion compensation, optical amplifiers, optical receivers, system performance, optical time division multiplexing, optical signal processing (e.g., wavelength conversion, optical regeneration, clock recovery), passive components, optical networks, and applications (e.g., access, metro, long-haul, ultra-long haul). Three term-hours, lectures, Fall.

#### **ELEC 864 WDM Fiber Optic Communication Systems**

This course presents the fundamentals of fiber optic communications, with focus on dense wavelength division multiplexed (DWDM) systems. Topics: components (lasers, modulators, receivers, and optical fibers) and detailed study of system issues in DWDM transmission (interplay between fiber dispersion and non-linearities, transmitter chirp, optical amplification, and polarization mode dispersion). Three term hours, lectures.

#### **ELEC 865 Coding Theory**

The problem of reliable data transmission; communication and coding; error-detecting and error-correcting codes; classification of codes; introduction to algebra; linear block codes; cyclic codes; algebraic decoding, shift register encoding and decoding of cyclic codes; convolutional codes; Viterbi decoder; trellis codes; trellis decoding, trellis structure of codes; graphical representation of codes, block- and trellis-coded modulation, codes defined on graphs, turbo codes, iterative decoding, low-density parity-check codes. Three term-hours, lectures.

#### **ELEC 866 Signal Detection and Estimation**

Vector space concepts. Hypothesis testing. Signal detection in discrete time including performance evaluation methods and sequential detection. Parameter estimation, including Bayesian, maximum-likelihood and minimum-variance unbiased estimation. Signal estimation in discrete time, including Kalman filtering, linear estimation, and Wiener filtering. Applications include communications, sensor array, image processing, and target tracking. Three term-hours; lectures.

#### **ELEC 867 Data Communication**

Channel characterization and transmission impairments, performance evaluation, baseband pulse transmission, linear modulation, frequency and phase modulation, detection theory and system optimization, equalization, coded modulation.

#### **ELEC 869 MIMO Communications Systems**

This course introduces fundamental theories of multiple-input multiple-output (MIMO) communications systems and

design of space-time codes. Topic includes: MIMO channel models; capacity of MIMO systems; transmit and receive diversity; design criteria for space-time codes; space-time block codes; space-time trellis codes; layered space-time codes; differential space-time block codes; combined space-time codes and interference suppression; super-orthogonal space-time codes; variable rate space-time block codes. Three term-hours, lectures.

#### **ELEC 870 Human-Robot Interaction**

This course focuses on the study and design of human-robot interactions (HRIs). Students will gain exposure to a broad cross-section of HRI research, exploring topics such as sensors and actuators, software architectures and design and evaluation tools. Selected HRI subdomains will be examined, including nonverbal communication, trust, and ethics. (3.0 credit units)

PREREQUISITE: ELEC 344 or similar course.

CO-REQUISITES: ELEC 448 or MECH 456 or MREN 348 or similar from another university, OR permission of the instructor.

#### **ELEC 871 Shared-Memory Multiprocessor Systems**

This course provides a comprehensive overview of shared-memory multiprocessing. Topics include: shared-memory programming, system and application software considerations, cache coherence protocols, memory consistency models, small-scale and large-scale shared-memory architectures, and case studies to explore practical considerations in multiprocessor systems ranging from single-chip implementations to scalable high-performance platforms. Three term hours; lectures. Winter.

#### **ELEC 872 Artificial Intelligence and Interactive Systems**

Fundamental concepts and applications of intelligent and interactive system design and implementation. Topics include: (1) Sensors and Signals in Interactive Systems (2) Data Preprocessing: data acquisition, filtering, missing data, source separation, feature extraction, feature selection, dimensionality reduction; (3) Machine Learning: supervised learning, ensemble learning, multi-task learning, unsupervised learning; (4) Identity Recognition; (5) Activity Recognition and Analysis; (6) Affective Computing. Three term hours. Lectures.

PREREQUISITE: ELEC 326 or equivalent, or permission of the instructor.

#### **ELEC 873 Cluster Computing**

This course covers topics related to network-based parallel computing systems. Issues related to clusters and computational "grid" such as interprocessor communications, message-passing and mixed mode paradigms and programming techniques, high performance interconnects, efficient host-network interface for fast



messaging, lightweight user-level messaging layers and protocols, (network interface-assisted based) collective communications, communication latency tolerance techniques, power-aware high-performance computing, high performance file systems and I/O, benchmarking and performance evaluation, scheduling and load balancing, system-level middleware and computational grid applications and services will be discussed, Research papers from literature, a term paper and hands-on programming and experiments on a network of workstations will supplement the course. Three term-hours; lectures.

#### **ELEC 874 Deep Learning in Computer Vision**

This course will study advances in Deep Learning as applied to the field of Computer Vision. The course will start with the introduction of AlexNet in 2012, and will advance chronologically, exploring the innovations that led to the significant improvements in performance. Topics covered will include object detection and recognition, region proposal networks, instance and semantic segmentation, depth and video processing. Three term hours, lectures.

PREREQUISITES: ELEC 474, ELEC 425 or equivalent, or permission of instructor.

#### **ELEC 875 Software Design Recovery and Automated Evolution**

Design recovery is the extraction of a design model from the artifacts of an existing software system. This design model is used to continue the evolution of the system. The model can be used in the planning and impact analysis stage, while making the changes and to test the result. The extracted design model can also be used to automate each of these tasks to varying degrees. Topics include design models, design recovery techniques, software evolution tasks, the semantics of programming languages and execution environments, and source code transformation. Three term-hours, lectures, Winter.

#### **ELEC 876 Software Reengineering**

This course covers software reengineering techniques and tools that facilitate the evolution of legacy systems. This course is broken into three major parts. In the first part, the course discusses the terminology and the processes pertaining to software evolution. In the second part, the course provides the fundamental reengineering techniques to modernize legacy systems. These techniques include source code analysis, architecture recovery, and code restructuring. The last part of the course focuses on specific topics in software reengineering research. The topics include software refactoring strategies, migration to Object Oriented platforms, quality issues in reengineering processes, migration to network-centric environments, and software integration. Three term-hours, lectures, Fall.

#### **ELEC 877 AI for Cybersecurity**

This course covers the fundamentals of cybersecurity and machine learning, selected topics in machine learning for cybersecurity, including anomaly detection, malware analysis, network traffic analysis, and fake news defense, and the advanced topics in artificial intelligence (AI) security, including privacy-preserving AI, fairness in AI, and adversarial machine learning. Three term hours, Lectures.

PREREQUISITE: ELEC 425 or equivalent, or permission of the instructor

#### **ELEC 878 Extreme Scale Networking**

This course will provide students with understanding of the field of Extreme-scale Systems with an emphasis on Extreme-Scale networks. Students will learn the fundamentals of Extreme-scale systems networks and an ability to read, understand, discuss and critique research. Use cases like Scientific computing, AI/ML, big data and commercial applications will be discussed. (3.0 credit units).

PREREQUISITE: ELEC 373 (networks) or equivalent. Pre-requisites may be waived with permission of the instructor.

#### **ELEC 879 Wearable and IoT Computing**

This course focuses on recent advances and computing trends in wearable technologies, mobile devices, the Internet of Things (IoT), smart homes, and smart vehicles. The history, background, and applications of these systems are reviewed, followed by the description of common sensing technologies often utilized in these devices. Signal/time-series analysis techniques, machine learning algorithms, and computing methods that are often utilized in such applications will be covered in detail. The course is highly applied and students will complete a project and present their results.

#### **ELEC 880 Machine Learning for Natural Language Processing**

Human (or natural) language data permeate almost all aspects of our daily life. This course covers basic machine learning approaches to modelling natural language, including fundamental supervised and unsupervised methods for modelling sequences and structures in the data. Based on this, students learn how to develop various applications such as chatbots and information extraction systems. The course will also include state-of-the-art artificial intelligence and deep learning approaches to natural language processing.

#### **ELEC 881 Empirical Methods in Software Engineering**

This course delves into advanced concepts and methodologies in empirical software engineering. In this class, you will learn about the different qualitative and quantitative empirical research methods and how they can be used for a particular software development process or tool. The course will focus on the following topics: measurement types, qualitative and statistical methods, systematic

literature reviews, survey studies, and mining of software repositories. (3.0 credit units)

Prerequisites: Familiarity with python. A basic understanding of GitHub and familiarity with reading/ writing research papers is beneficial but not necessary.

### **ELEC 888 Probabilistic Machine Learning**

This graduate course will look at machine learning from probability perspective, which provides a framework to explain graphical models and use it to address three machine learning tasks, including inference, prediction and decision-making. Using probabilistic approach, this course navigates from statistical analyses to probabilistic models and deeper networks. This course provides in-depth analytic knowledge for discovering/customizing machine learning techniques with applications in biological data science and digital health. (3.0 credit units). Prerequisites: ELEC 326 (Probability and Random Processes) (or equivalent); STAT 351 (Probability 1) (or equivalent)

### **ELEC 891 Seminar**

ECE graduate students must register in this non-credit course for the duration of their degree program. The student is given a Pass grade for this course upon attending a majority of seminars designated by ECE.

### **ELEC 895 Industrial Internship I**

The industrial internship involves spending a minimum of 4 months and a maximum of 8 months in a paid internship position in industry, government, or other suitable employment opportunities. Students in the 4 month internship must register in ELEC 895. Students in the 8 month internship must register in ELEC 895 and ELEC 896. Successful completion of the course requires submission of a report on the industrial project within thirty days of completion of the work period. Each project must be approved by the academic supervisor. Career Services manages the non-academic aspects of the course.

### **ELEC 896 Industrial Internship II**

See ELEC 895.

### **ELEC 898 M.Eng. Project**

### **ELEC 899 M.Sc. Thesis Research**

### **ELEC 999 Ph.D. Thesis Research**

### **ADVANCED UNDERGRADUATE ELECTIVE COURSES**

Courses listed below may be taken for credit, subject to the regulations set forth in the departmental prescription above and those of the School of Graduate Studies and Postdoctoral Affairs.

ELEC 421, 431, 436, 443, 448, 451, 454, 461, 464, 470, 471, 476, 478, 483, 486, 487, SOFT 423, 426, 437.