ELECTRICAL ENGINEERING (ELG)

The following courses are offered by the Faculty of Engineering.

ELG 2136 Electronics I (3 units)
Physics of semiconductors. Diodes: operation, models. and application circuits. Bipolar Junction Transistors - operation and characteristics. DC and AC circuit models. Basic single-stage BJT amplifier configurations. Field-Effect Transistors: Structure and physical operation, bias circuits, small-signal equivalent circuits and basic amplifiers. Basic concepts of digital logic circuits. The BJT inverter. The CMOS Inverter. Propagation delay of the CMOS inverter. CMOS gates and other digital circuits. Introduction to Semiconductor Power Devices: thyristor, triac, Insulated Gate Bipolar transistor. Power Electronics Applications: The AC-DC, DC-DC, and DC-AC converters.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 2138.

ELG 2137 Circuit Theory II (3 units)
Ideal operational amplifiers - analysis and applications. Forced and natural responses of RLC circuits using the differential equation approach. Transient circuit analysis using unilateral Laplace transforms. Two-port networks and parameters. Mutual inductance and the ideal transformer. Transfer functions. Frequency response of simple filters. Fundamentals of computer-aided circuit simulation. The measurement of sinusoidal and non-sinusoidal electrical quantities in analogue and digital circuits. Introduction to sensors and instrumentation amplifiers. The measurement of non-electrical quantities.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 2138, MAT 2384.

ELG 2138 Circuit Theory I (3 units)
DC and sinusoidal steady state (AC) analysis of circuits. Basic passive circuit elements (resistors, capacitors, inductors). Voltage and current sources. Kirchoff laws. Loop and nodal analysis. Circuit theorems: Superposition, Maximum power transfer, Thevenin, Norton. Forced and natural responses of RL and RC circuits using the differential equation approach. Sinusoidal signals, complex numbers, phasors and impedance concepts. Average and RMS quantities. Steady state time-domain behaviour of inductors and capacitors. Complex, average and apparent power. Introduction to the use of electrical measurement equipment such as voltmeters, ammeters, wattmeters, function generators and oscilloscopes. Voltage, current and impedance measurement.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ITI 1100, MAT 1341, MAT 1322.

ELG 2336 Electric Circuits and Machines for Mechanical Engineering (3 units)
Network theorems. Forced and transient response to deterministic inputs. Sinusoidal steady-state response of circuits. Magnetic theory and circuits. Transformers. Electromechanical energy conversion. Introduction to AC circuits, three phase power. DC machines, AC machines, torque-speed curves and efficiency. Laboratory experiments.
Course Component: Laboratory, Lecture
Prerequisite: PHY 1122. MAT 2384 is corequisite to ELG 2336.

ELG 2536 Électronique I (3 crédits)
Physique des semi-conducteurs. Diodes : fonctionnement, modèles et circuits dapplication. Transistors Bipolaires à Jonctions - fonctionnement et caractéristiques. Circuits équivalents en cc et en ca. Configurations de base d'amplificateurs TBJ à un étage. Transistors à Effet de Champ : structure et fonctionnement physique, circuits de polarisation, circuits équivalents à faible signal et configurations de base d'amplificateurs. Concepts fondamentaux de circuits logiques. Inverseur TBJ. Inverseur CMOS. Délai de propagation de l'inverseur CMOS. Portes logiques CMOS et autres circuits numériques. Introduction aux composants semi-conducteurs de puissance : thyristor, triac, Transistor bipolaire à porte isolée. Applications en électronique de puissance : les convertisseurs ca-cc, cc-cc et cc-ca.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 2538.

ELG 2537 Théorie des circuits II (3 crédits)
Amplificateurs opérationnels idéaux-analyse et applications. Réponses naturelles et forcées de circuits RLC en utilisant l'approche par équations différentielles. Analyse transitoire de circuits par la transformée de Laplace unilatérale. Circuits à deux portes et leurs paramètres. Inductance mutuelle et transformateur idéal. Fonctions de transfert. Réponse en fréquence de filtres simples. Fondements de la simulation de circuits assistée par ordinateur. Mesures de grandeurs sinusoïdales et non sinusoïdales dans les circuits analogiques et numériques. Introduction aux capteurs et amplificateurs pour instrumentation. Mesures de grandeurs non électriques.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 2538, MAT 2784.

ELG 2538 Théorie des circuits I (3 crédits)
Analyse en régime permanent de circuits en courant continu et en courant alternatif. Éléments passifs de base des circuits (résistances, capacités, inductances). Sources de tension et courant. Lois de Kirchoff. Analyse par méthodes des mailles et des noeuds. Théorèmes pour les circuits : Superposition, transfert maximal de puissance, Thévenin, Norton. Réponses naturelles et forcées de circuits RL et RC en utilisant l'approche par équations différentielles. Signaux sinusoïdaux, nombres complexes, notions de phaseurs et impédances. Grandeurs moyennes et efficaces. Comportement des inductances et capacités en régime permanent dans le domaine temporel. Puissance complexe, moyenne et apparente. Introduction à l'utilisation d'équipement de mesures électriques tels que les voltmètres, ampèremètres, générateurs de fonctions et oscilloscopes. Mesures de courant, tension et impédance.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ITI 1500, MAT 1741, MAT 1722.

ELG 2736 Circuits et machines électriques pour ingénieurs en mécanique (3 crédits)
Théorèmes de réseaux. Réponse transitoire et réponse forcée pour excitations déterministes. Régime sinusoïdal permanent des circuits. Théorie et circuits magnétiques. Transformateurs. Conversion électromagnétique de l'énergie. Introduction aux circuits en c.a. et à la puissance triphasée. Moteurs à c.c., moteurs à c.a., courbes couple-vitesse et efficacité. Expériences au laboratoire.
Volet : Laboratoire, Cours magistral
Préalable : PHY1522. MAT2784 est concomitant à ELG 2736.

ELG 2911 Pratique professionnelle en ingénierie et technologie de l'information / Professional Practice in Information Technology and Engineering (3 crédits / 3 units)
Histoire de la profession d'ingénieur. Principes de professionnalisme dans la pratique de l'ingénieur. Obligations éthiques et légales de l'ingénieur envers la société et l'environnement. Compétences requises en communication et administration dans la pratique de l'ingénieur. Santé et sécurité au travail. / History of the profession of engineering. Principles of professional engineering practice. Ethical, societal, environmental and legal obligations of the professional engineer. Communication and management skills required by the practicing engineer. Workplace health and safety.
Volet / Course Component: Cours magistral / Lecture, Tutoriel / Tutorial

ELG 3106 Electromagnetic Engineering (3 units)
Transmission lines: time and space dependence of signals, line parameters, input impedance, use as circuit elements, reflection coefficient, standing-wave ratio, transient behaviour. Impedance matching: transformers, stubs, analysis using the Smith Chart. Maxwell's and wave equations. Electromagnetic waves: TEM, TE, TM propagation. Waveguides: basic equations, parallel plate guide, rectangular guide. Introduction to antennas. Applications to communications and radar systems.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: MAT 2322, MAT 2384, PHY 2323.

ELG 3125 Signal and System Analysis (3 units)
Continuous-time and discrete-time signals. Mathematical description of systems. Properties of systems. Convolution and impulse response of continuous and discrete time LTI systems. Fourier series of periodic continuous and discrete time signals. Decomposition and approximation of signals by orthogonal functions. The Fourier transform of continuous and discrete time signals. Frequency response of systems. Frequency selective filtering. First and second order systems. Sampling and interpolation of continuous-time signals. LTI system analysis with Laplace transforms.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 2138.

ELG 3126 Random Signals and Systems (3 units)
Probabilistic models, conditional probability and Bayes' rule; vectors of random variables, distributions and density functions, expectations and characteristic functions. Independence, Laws of Large Numbers, Central-Limit Theorem. Random process concepts. Random signal analysis concepts. Applications drawn from power systems, analog and digital circuits, communication systems and manufacturing.
Course Component: Lecture, Tutorial
Prerequisite: ELG 3125. The courses ELG 3126, MAT 2377 cannot be combined for units.

ELG 3136 Electronics II (3 units)
Differential Amplifiers: BJT, MOS. Multistage Amplifiers: Frequency Response: s-Domain analysis, amplifier transfer function, frequency response of CS, CE, CB, cascode, CC and cascaded amplifiers. Feedback: general feedback structure and basic feedback topologies. Stability, frequency compensation Output Stages and Power Amplifiers: Class A, B and AB output stages. IC and MOS power amplifiers.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 2136.

ELG 3137 Fundamentals of Semiconductor Devices (3 units)
Modern solid-state electronic devices, their principles of operation, and fabrication. Solid state physics fundamentals, free electrons, band structure, and transport properties of semiconductors. Nonequilibrium phenomena in semiconductors. p-n junctions, Schottky diodes, bipolar and field-effect transistors. Modern, high-performance devices. Ultrafast devices.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 2136, MAT 2384, (PHY 1124 or (PHY 1121, PHY 1122)).

ELG 3155 Introduction to Control Systems (3 units)
Introduction to control systems, dynamic systems modeling. Laplace transforms, partial fraction methods. Block diagram and signal flow graph models, transfer functions of linear systems. Introduction to state-space models. Feedback control system characteristics, stability and Routh-Hurwitz criteria, the root locus method, design of industrial controllers, the Nyquist stability criterion, Bode plots, design indexes, lead and lag controllers.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 3125.

ELG 3175 Introduction to Communication Systems (3 units)
Review of linear systems, the sampling theorem, and Fourier analysis. Noiseless analysis of the linear modulation schemes: double sideband, inphase-quadrature, single sideband, vestigial sideband and conventional AM. Superheterodyne receivers. Angle modulation: phase modulation, and frequency modulation. Carson's rule. Discriminator and phase-locked loop detection of FM. Basic digital modulation techniques: ASK, PSK, FSK. Bandwidth requirements of PAM (Nyquist's criterion). Pulse code modulation and companding. Introduction to error control coding and to information theory.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 3125. ELG 3126 is corequisite to ELG 3175.

ELG 3316 Electric Machines and Power Systems (3 units)
Machinery principles. Three-phase systems, transformers. AC machinery fundamentals, synchronous generators, synchronous motors, induction motors. DC machinery fundamentals, dc motors and generators, special-purpose motors, single-phase induction motors.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 2138.

ELG 3336 Electronics for Mechanical Engineers (3 units)
Semiconductor device characteristics and applications. Power supplies and regulators. Operational amplifiers and applications. Power amplifiers. Digital logic. Gates and gate circuits. Logic families. Combinational logic. Introduction to electronics for measurement and instrumentation. Introduction to power electronics. Laboratory experiments.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 2336.

ELG 3506 Électromagnétisme appliqué (3 crédits)
Lignes de transmission: variation des signaux en fonction du temps et de la position, paramètres des lignes, impédance d'entrée, emploi comme éléments de circuit, coefficient de réflexion, rapport d'ondes stationnaires, régime transitoire. Adaptation d'impédances: transformateurs, bras réactifs, analyse avec l'abaque de Smith. Équations de Maxwell et d'ondes. Ondes électromagnétiques: propagation TEM, TE, TM. Guides d'ondes: équations de base, guide à plaques parallèles, guide rectangulaire. Introduction aux antennes. Applications aux systèmes de communication et de radar.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : MAT 2722, MAT 2784, PHY 2723.

ELG 3525 Analyse des signaux et des systèmes (3 crédits)
Signaux en temps continu et en temps discret. Description mathématique des systèmes. Propriétés des systèmes. Convolution et réponse impulsionnelle des systèmes linéaires continus et discrets. Séries de Fourier des signaux périodiques en temps continu et discret. Décomposition et approximation des signaux en fonctions orthogonales. Transformée de Fourier des signaux continus et discrets. Réponse en fréquence des systèmes. Filtrage sélectif en fréquence. Systèmes du premier et du second ordre. Échantillonnage et interpolation des signaux continus dans le temps. Analyse des systèmes linéaires avec la transformée de Laplace.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 2538.

ELG 3526 Signaux et systèmes aléatoires (3 crédits)
Modèles probabilistes, probabilité conditionnelle et règle de Bayes: vecteurs de variables aléatoires, fonction de densité de probabilité et fonction de répartition, espérance mathématique et fonction caractéristique. Indépendance, lois des grands nombres, théorème de la limite centrale. Concept de processus aléatoire. Analyse de signaux aléatoires. Exemples tirés des systèmes à grande puissance, des circuits analogiques et numériques, des systèmes de télécommunication et de manufacture.
Volet : Cours magistral, Tutoriel
Préalable : ELG 3525. Les cours ELG 3526, MAT 2777 ne peuvent être combinés pour l'obtention de crédits.

ELG 3536 Électronique II (3 crédits)
Amplificateurs différentiels : TBJ, MOS. Amplificateurs à plusieurs étages. Réponse en fréquence : analyse dans le domaine, fonction de transfert d'un amplificateur, réponse en fréquence des amplificateurs SC, EC, BC, CASCODE, CC et en CASCADE. Contre-réaction : structure générale de contre-réaction et topologies de base en contre-réaction. stabilité, compensation en fréquence des étages de sortie et amplificateurs de puissance : étages de sortie en classe A, B et AB. amplificateurs de puissance MOS et EN CI.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 2536.

ELG 3537 Notions fondamentales des dispositifs à semi-conducteurs (3 crédits)
Composants électroniques semi-conducteurs modernes, leurs principes de fonctionnement et de fabrication. Fondements de la physique du solide, électrons libres, structure de bande, et propriétés de transport des semi-conducteurs. Phénomènes hors équilibre dans les semi-conducteurs. Jonctions p-n, diodes Schottky, transistors bipolaires et à effet de champ. Dispositifs modernes de haute performance. Dispositifs ultrarapides.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 2536, MAT 2784, (PHY 1524 ou (PHY 1521, PHY 1522)).

ELG 3555 Introduction aux systèmes d'asservissement (3 crédits)
Introduction aux systèmes d'asservissement, modèles des systèmes dynamiques, transformées de Laplace, méthodes de fractions partielles. Modèles de schéma-bloc et graphes de fluence, fonctions de transfert de systèmes linéaires. Introduction aux modèles d'état, caractéristiques des systèmes d'asservissement à rétroaction, stabilité et critère de Rough-Hurwitz, méthode du lieu des racines, conception des asservissements industriels. Critère de stabilité de Nyquist, tracés de Bode, indices de conception, asservissements avec avance et retard.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 3525.

ELG 3575 Introduction aux systèmes de télécommunications (3 crédits)
Revue des systèmes linéaires, théorème d'échantillonnage et analyse de Fourier. Analyse des méthodes de modulation linéaire en l'absence de bruit: bandes latérales uniques, doubles, résiduelles, en quadrature de phase et modulations AM avec porteuse. Récepteurs superhétérodynes. Modulation angulaire de phase et de fréquence. Règle de Carson. Démodulation de fréquence par discriminateur et circuit de verrouillage de phase. Techniques de base en modulation numérique: ASK, PSK, FSK. Largeur de bande requise pour PAM (critère de Nyquist). Modulation par impulsions et codage, compression-extension. Introduction au contrôle d'erreur par codage et à la théorie de l'information.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 3525. Concomitant : ELG 3526.

ELG 3716 Machines électriques et systèmes d'alimentation électrique (3 crédits)
Principes des machines électriques. Systèmes triphasés, transformateurs. Fondements des équipements à courant alternatif, générateurs synchrones, moteurs synchrones, moteurs à induction. Fondements des équipements à courant continu, générateurs et moteurs à courant continu, moteurs pour applications spéciales, moteurs à induction monophasés.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 2538.

ELG 3736 Électronique pour ingénieurs en mécanique (3 crédits)
Caractéristiques des dispositifs à semi-conducteurs et leurs applications. Blocs d'alimentation et régularisateurs de tension. Amplificateurs opérationnels et leurs applications. Amplificateurs de puissance. Circuits logiques. Portes et circuits de porte. Familles de dispositifs logiques. Logique combinatoire. Introduction à l'électronique en mesure et en instrumentation. Introduction à l'électronique de puissance. Expériences de laboratoire.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 2736.

ELG 4115 Microwave Circuits (3 units)
Review of transmission line theory and the Smith Chart. Microstrip transmission lines. Network parameter description of microwave circuits (S, Z,Y, ABCD parameters). Impedance transformation and matching networks. Stability, gain and noise considerations. Microwave amplifier and oscillator design. Passive 2, 3, and 4 port microwave networks. Attenuators, couplers, power dividers, circulators, isolators. Computer-aided design of microwave circuits.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 3106, ELG 3136.

ELG 4117 Optoelectronics and Optical Components (3 units)
Wave-Particle duality of light. Interaction of light with matter. Review of semiconductor physics and introduction to optoelectronics. Gener ation of optical energy: light emitting diodes and lasers. Detection of optical energy: photoconductors, PIN and avalanche photodiodes. Introduction to electro-optics. Control of optical radiation: modulation and switching of light.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 3106, ELG 3136.

ELG 4118 Wave Propagation and Antennas (3 units)
Review of Maxwell's equations, Poynting's theorem and boundary conditions. Plane waves at an interface. Rectangular and circular metallic waveguides. Resonant cavities. The equivalent circuit description of discontinuities and junctions in waveguiding structures. Antenna fundamentals. Radiation integrals. Dipole and loop antennas. Microstrip antennas. Source equivalence principles. Aperture antennas. Reflector antennas. Array antennas. Antenna measurements. Use of computational electromagnetics in antenna analysis & design.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 3106.

ELG 4121 Topics in Electrical Engineering II (3 units)
Topics in Electrical Engineering II
Course Component: Laboratory, Lecture, Tutorial
Permission of the Department is required.

ELG 4122 Topics in Electrical Engineering I (3 units)
Topics in Electrical Engineering I
Course Component: Laboratory, Lecture, Tutorial
Permission of the Department is required.

ELG 4125 Electric Power Transmission, Distribution and Utilization (3 units)
Energy resources and electric power generation, transmission and distribution; simple generator models, transformers, transmission lines. Power system analysis: per unit representation, real and reactive power flow, VAR compensation, fault analysis and protection. Power system control. Power system stability. Load representation, power quality. Computational modelling of typical power system problems.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 2137, ELG 3316.

ELG 4126 Sustainable Electrical Power Systems (3 units)
Introduction to electrical power generation and conditioning. Emerging requirements. Emerging renewable energy technologies. Fundamentals of electrical power systems. Emerging renewable electrical power systems (wind power, solar power). Network integration issues. Impact of distributed generation on network operation. "Smart Grid" implementation and control.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 2137, ELG 3316, ELG 3136, ELG 3155.

ELG 4137 Principles and Applications of VLSI Design (3 units)
Introduction to VLSI technology. Electrical properties of NMOS and CMOS transistors. NMOS subsystem design and layout. Subsystem design and layout using simple static, complex static, and dynamic domino CMOS lo gic circuits. Designs of NMOS and CMOS PLA, finite state machines and memory systems. System designs using BiCMOS technology, GaAs technology, gate arrays and Field-Programmable Gate Arrays.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 2136.

ELG 4139 Electronics III (3 units)
Design, applications, and physical limitations of operational amplifiers: filters, amplifiers, oscillators, comparators, timing circuits, and ADC/DAC circuits. Application of electronics to energy conversion and control: analysis, performance, characterization, and design of power electronic devices including power amplifiers, transistor switches, and converters using diodes, thyristors, and controllable semiconductor switches. MEMS/NEMS-based sensors and actuators: design, analysis, modeling, fabrication, and applications
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 3136, ELG 3155.

ELG 4156 Linear Systems (3 units)
Classification of finite dimensional systems, system and model properties, linearized small-signal models. Solution of state space equations, free and forced responses, weighting sequences, convolutions, system response from transfer matrix. Writing state space equations. Review of matrix algebra, the normal form, the Cayley-Hamilton theorem. Similarity transformation, invariance of the external behaviour, diagonalization. Stability of LTI systems, the Lyapunov second method. Controllability, observability, the Kalman canonical decomposition. The Smith-McMillan form, computation of poles and zeroes.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 3125, ELG 3155.

ELG 4157 Modern Control Engineering (3 units)
Review of State space modeling concepts, controllability, observability, poles and zeros. Minimal realizations. State and output feedback, spectral assignability, pole placement techniques, full and reduced order observers, separation principle, compensator design using observers. Introduction to optimal control, linear quadratic problem, algebraic Riccati equations, Kalman filtering. Introduction to nonlinear control. Applications to fuzzy systems, neural networks, genetic algorithms, and chaotic systems.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 3155.

ELG 4159 Integrated Control Systems (3 units)
Microcontroller technologies. Interfacing techniques. Analog-to-digital and digital-to-analog conversions. Sensor and actuator modeling. Dynamic systems modeling and simulation. Electric drives. Design of integrated control systems. Discrete system control and stability. Z-domain.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: CEG 3136, ELG 3125, ELG 3155, ELG 3316.

ELG 4176 Communication Systems (3 units)
Review of random signals and system concepts, and modulation and detection. Basic antenna equations. SNR link calculations. Analysis of linear modulation in the presence of noise. Analysis of angle modulation in the presence of noise. The threshold effect, threshold extension, and preemphasis and deemphasis in angle modulation. Digital modulation techniques. Detection principles for digital communication signals in noise: matched filter receivers, signal space concepts, maximum a posteriori receivers, maximum likelihood receivers. Partial response signalling. Channel coding. Coherent and noncoherent detection. Maximum likelihood sequence estimation receivers for modulation with memory and the Viterbi algorithm. Channel capacity.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 3175, ELG 3126.

ELG 4177 Digital Signal Processing (3 units)
Review of discrete-time signals and systems, the sampling theorem, and Fourier series/transforms. Sampling rate conversions. A/D and D/A conversions. Z-transform and LTI system analysis. Minimal, maximal and mixed phase systems. Discrete Fourier Transform and Fast Fourier Transform (FFT). Windowing effects. Finite Impulse Response (FIR) filter design (linear phase, windowing, frequency sampling, Remez). Infinite Impulse Response (IIR) filter design from analog prototypes. Frequency transformations. Structures for implementation: direct, cascade, lattice, lattice-ladder, parallel. Finite word length effects. Introduction to spectral analysis. Real time implementation.
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 3125.

ELG 4178 Optical Communications and Networking (3 units)
Optics review. Dielectric slab waveguides and introduction to integrated optics. Optical fibers and fiber devices (bandgap structures, Bragg reflectors). Theory of optical fiber communications. Signal degradation in optical fibers. Optical sources. Photo detectors. Optical transmitters. Optical receivers. Optical amplifiers. WDM Systems.
Course Component: Laboratory, Lecture, Tutorial
Prerequisites: ELG 3106 or PHY 3320

ELG 4179 Wireless Communication Fundamentals (3 units)
Overview of wireless communications. Cellular system principles. Wireless propagation channel: average path loss, multipath and shadowing; large and small scale fading; delay and Doppler spread. Digital modulation techniques. Performance in fading channels. Spectral and power efficiency; fundamental limits. Adaptive modulation and coding. Diversity combining and MIMO systems. Multiple access methods: fixed (FDMA, TDMA, CDMA) and random (ALOHA, CSMA). Modern industrial standards (cellular and WiFi).
Course Component: Laboratory, Lecture, Tutorial
Prerequisite: ELG 3175. The courses ELG 4179, CEG 4186 cannot be combined for units.

ELG 4515 Circuits micro-ondes (3 crédits)
Revue de la théorie des lignes de transmission et de l'abaque de Smith. Lignes de transmission micro-ruban. Représentation de circuits micro-ondes à l'aide de paramètres de réseaux (S, Z, Y, ABCD). Transformation d'impédances et réseaux d'adaptation. Stabilité, gain et bruit. Conception d'amplificateurs et d'oscillateurs micro-ondes. Circuits micro-ondes passifs à 2, 3 et 4 accès. Atténuateurs, coupleurs, diviseurs de puissance, circulateurs, isolateurs. Conception de circuits micro-ondes assistée par ordinateur.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 3506, ELG 3536.

ELG 4517 Optoélectronique et composantes optiques (3 crédits)
Dualité onde-particule de la lumière. Interaction de la lumière avec la matière. Revue de la physique des semiconducteurs et introduction à l'optoélectronique. Génération de l'énergie optique: diodes électroluminescentes et lasers. Détection de l'énergie optique: photoconducteurs, photodiodes PIN et avalanche. Introduction à l'électro-optique. Commande de la radiation optique: modulation et commutation de la lumière.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 3506, ELG 3536.

ELG 4518 Propagation d'ondes et antennes (3 crédits)
Revue des équations de Maxwell, du théorème de Poynting et des conditions aux frontières. Ondes planes incidentes à une interface. Guides d'ondes métalliques rectangulaires et circulaires. Cavités résonantes. Circuits équivalents de discontinuités et jonctions en guides d ondes. Fondements des antennes. Intégrales de rayonnement. Antennes dipôle et boucle. Antennes microruban. Principes des sources équivalentes. Antennes à ouvertures. Antennes à réflecteur. Réseaux d antennes. Mesures d antennes. Utilisation de la modélisation électromagnétique dans l analyse et la conception d antennes.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 3506.

ELG 4521 Sujets spéciaux en génie électrique II (3 crédits)
Volet : Laboratoire, Cours magistral, Tutoriel
Permission du Département est requise.

ELG 4522 Sujets spéciaux en génie électrique I (3 crédits)
Volet : Laboratoire, Cours magistral, Tutoriel
Permission du Département est requise.

ELG 4525 Transmission, distribution et utilisation de l'énergie électrique (3 crédits)
Ressources énergétiques, production, transmission et distribution de l énergie électrique; modèles de générateurs, transformateurs et lignes de transmission. Analyse des systèmes de puissance: représentation unitaire, puissance active et réactive, compensation des charges réactives, analyse de défauts et protection. Contrôle et stabilité des systèmes de puissance. Représentation des charges, critères de qualité de l énergie. Simulation des problèmes typiques des réseaux d énergie.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 2537, ELG 3716.

ELG 4526 Systèmes d'énergie électrique renouvelable (3 crédits)
Introduction à la production et au conditionnement de l énergie électrique. Nouvelles exigences. Technologies émergentes en énergie renouvelable. Fondements des systèmes électriques de puissance. Systèmes d énergie électrique renouvelable (énergie éolienne, énergie solaire). Intégration des réseaux. Impact de la distribution des points de production sur l opération d un réseau. Implantation et contrôle d un réseau intelligent.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 2537, ELG 3716, ELG 3536, ELG 3555.

ELG 4537 Principes et applications de la conception de circuits intégrés à très grande échelle (3 crédits)
Introduction à la technologie des circuits intégrés à très grande éche lle (VLSI). Propriétés électriques des transistors NMOS et CMOS. Conception d'un sous-système NMOS et disposition des composantes. Conception de sous-systèmes et disposition des composantes en utilisant des circuits logiques CMOS statiques simples et complexes ainsi que dynamiques. Conception de réseaux logiques programmables et de machines à états finis NMOS et CMOS. Conception de sous-systèmes utilisant la technologie BiCMOS, la technologie GaAs, les réseaux logiques et les réseaux logiques programmables par l'utilisateur (FPGA).
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 2536.

ELG 4539 Électronique III (3 crédits)
Conception, applications et limitations physiques des amplificateurs opérationnels : filtres, amplificateurs, oscillateurs, comparateurs, circuits de synchronisation et circuits CAN/CNA. Applications de l électronique à la conversion et au contrôle de l énergie : analyse, performance, caractérisation et conception de dispositifs d électronique de puissance incluant amplificateurs de puissances, interrupteurs à transistors, convertisseurs à diodes, thyristors, et interrupteurs contrôlables à semi-conducteurs. Capteurs et actionneurs à MEMS/NEMS : conception, analyse, modélisation, fabrication et applications.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 3536, ELG 3555.

ELG 4559 Systèmes de contrôle intégrés (3 crédits)
Technologies des microcontrôleurs. Techniques d'interface. Conversions analogue-digitale et digitale-analogue. Modélisation des capteurs et actionneurs. Modélisation et simulation des systèmes dynamiques. Moteurs électriques. Conception de systèmes de contrôle intégrés. Système de contrôle discret et stabilité. Transformée en Z.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : CEG 3536, ELG 3525, ELG 3555, ELG 3716.

ELG 4576 Systèmes de télécommunications (3 crédits)
Revue des concepts des signaux et systèmes aléatoires et de modulation et démodulation. Équations d'antennes de base. Calcul du budget de liaison. Analyse de la modulation linéaire en présence de bruit. Analyse de la modulation d'angle en présence de bruit. Effet de seuil, extension de seuil, préaccentuation et désaccentuation en modulation d'angle. Principes de détection des signaux numériques dans le bruit: filtres adaptés, concept d'espace de signaux, récepteurs à maximum de vraisemblance et à maximum de probabilité à posteriori. Transmission à réponse partielle. Codage de canal. Détection cohérente et non cohérente. Récepteur à estimation de séquence à vraisemblance maximale et algorithme de Viterbi. Capacité d'un canal.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 3575, ELG 3526.

ELG 4577 Traitement numérique du signal (3 crédits)
Revue des signaux et systèmes en temps discret, du théorème d'échantillonnage et des séries/transformées de Fourier. Conversions de fréquence d'échantillonnage. Conversions A/N et N/A. Transformée en Z et analyse de systèmes LTI. Systèmes à phase minimale, maximale et mixe. Transformée de Fourier discrète (DFT) et transformée de Fourier rapide (FFT). Effets de fenêtrage. Design de filtre à réponse impulsionnelle finie (FIR): phase linéaire, fenêtrage, échantillonnage en fréquence, Remez. Design de filtres à réponse impulsionnelle infinie (IIR) à partir de prototypes analogiques. Transformations en fréquence. Structures pour mise en oeuvre: directe, cascade, treillis, treillis-échelle, parallèle. Effets de précision numérique finie. Introduction à l'analyse spectrale. Mise en oeuvre en temps réel.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 3525.

ELG 4578 Communications optiques et réseautage (3 crédits)
Revue d optique. Guides d'ondes diélectriques planaires et introduction à l optique intégrée. Fibres optiques et dispositifs à fibres (structures à bande interdite, réflecteurs Bragg). Théorie des communications par fibres optiques. Dégradation du signal dans les fibres optiques. Sources optiques. Photo-détecteurs. Émetteurs optiques. Amplificateurs optiques. Systèmes MRL.
Volet : Laboratoire, Cours magistral, Tutoriel
Préalables : ELG 3506 ou PHY 3720.

ELG 4579 Introduction aux télécommunications sans fil (3 crédits)
Introduction aux communications sans fil. Principes du système cellulaire. Propagation des signaux dans le canal sans fil: attenuation moyenne, trajets multiples et ombrage; évanouissement à grande et petite échelle; retard et l'effet Doppler. Techniques de modulation numérique. Performances dans les canaux d'évanouissement. Efficacité spectrale et de puissance; limites fondamentales. Modulation et codage adaptatifs. La combinaison de la diversité et systèmes MIMO. Méthodes d'accès multiples : fixe (FDMA, TDMA, CDMA) et aléatoire (ALOHA, CSMA). Normes industrielles modernes (cellulaire et WiFi).
Volet : Laboratoire, Cours magistral, Tutoriel
Préalable : ELG 3575. Les cours ELG 4579, CEG 4186 ne peuvent être combinés pour l'obtention de crédits.

ELG 4912 Projet de design en génie électrique : Partie I / Electrical Engineering Design Project: Part I (3 crédits / 3 units)
Cours et exercices sur la méthodologie du design et du développement de produits, et le rôle de l'ingénieur professionnel à cet égard. Sélection d'un projet qui pourra développer les habiletés de design, du travail d'équipe et d'entrepreneuriat. Formation des équipes. documentation et présentation de la première itération du projet de design. / Lectures and tutorials on product design and development methodology, and the role of the professional engineer in this regard. Selection of a project that will build, team work and entrepreneurial skills. Formation of teams. Documentation and presentation of first iteration of design project.
Volet / Course Component: Laboratoire / Laboratory, Cours magistral / Lecture
Préalables : ELG 3106, ELG 3136, ELG 3175, ELG 3155.

ELG 4913 Projet de design en génie électrique : Partie II / Electrical Engineering Design Project: Part II (3 crédits / 3 units)
Lectures and tutorials on product design and development methodology, and the role of the professional engineer in this regard. Completion of work started in ELG 4912. Deliverables include written documentationand presentations in class.
Volet / Course Component: Laboratoire / Laboratory, Cours magistral / Lecture
Préalable : ELG 4912.

ELG 5100 Software Engineering Project Management (3 units)
Software system engineering and organization methods; work breakdown structure and task determination; effort, duration and cost estimation; scheduling and planning. Monitoring and control; analysis of options; management of risks, change, and expectations. Process and product metrics, post-performance analysis, process improvement and maturity. Management of Agile Programming methodologies such as Extreme Programming. Case studies. This course is equivalent to EACJ 5211 at Carleton University.
Course Component: Lecture

ELG 5103 Optical Communications Systems (3 units)
Optical communication system concepts and basic characteristics. Optical Transmitters. Optical detection. Optical noise sources and their mathematical models. Non-coherent (direct) detection: system model, direct detection of intensity modulation, application of photo-multiplication, optimal post-detection processing, and subcarrier systems. Coherent detection: heterodyne receivers, the field matching problem and receiver performance. Optical binary digital system, single-mode binary and heterodyne binary systems. Block coded digital optical communication systems: PPM, PAM, PSK, and FSK signalling. Integration of device technology and system architecture. Selected topics in optical communications and networking. This course is equivalent to EACJ 5201 at Carleton University.
Course Component: Lecture

ELG 5104 Electromagnetic Waves Theory and Applications (3 units)
The homogeneous wave equation. Uniform and nonuniform plane waves. Inhomogeneous wave equations. Green's functions. Theory of potentials. Scattering problems. Numerical methods. Boundary value problems. Perturbation and variational techniques. This course is equivalent to EACJ 5401 at Carleton University.
Course Component: Lecture

ELG 5106 Fourier Optics (3 units)
Diffraction: Plane waves expansions, angular spectra, 2D Fourier transform, scalar and vector diffraction theory, Fresnel and Fraunhofer diffraction, coherence. Linear optical systems: Thin lenses, Gaussian beam optics, transmission functions, linear systems theory, imaging, transfer functions, aberration. Applications: Holography, diffractive optics, gratings, optical correlation. This course is equivalent to EACJ 5003 at Carleton University.
Course Component: Lecture

ELG 5119 Stochastic Processes (3 units)
Probability. Random variables. Distribution and density functions. Expectation. Functions of random variables. Moments and characteristic functions. Random vectors. Sequences of random variables and convergence. Limit theorems. Stochastic processes: basic notions. Stationarity. Ergodicity. Poisson and Gaussian processes. Second order processes. Representation theorems. Markov processes and chains. Courses ELG 5119, ELG 6153 (SYSC 5503) cannot be combined for units. This course is equivalent to EACJ 5109 at Carleton University.
Course Component: Lecture

ELG 5121 Multimedia Communications (3 units)
Introduction, applications, standards. Networking technologies. Image, video and audio compression. Quality of Service and resource management. Scheduling issues for real-time MM transport. Multimedia synchronization. Multimedia and the Internet. Multimedia conferencing. Multimedia to the home. Satellites and multimedia. Multimedia applications. This course is equivalent to EACJ 5201 at Carleton University.
Course Component: Lecture

ELG 5124 Virtual Environments (3 units)
Basic concepts. Virtual worlds. Hardware and software support. World modeling. Geometric modeling. Light modeling. Kinematic and dynamic models. Other physical modeling modalities. Multisensor data fusion, anthropomorphic avatars. Animation: modeling languages, scripts, real-time computer architectures. VE interfaces. Case studies. This course is equivalent to EACJ 5204 at Carleton University.
Course Component: Lecture

ELG 5126 Source Coding and Data Compression (3 units)
Lossless coding: discrete sources, entropy rate, Huffman coding, arithmetic coding, dictionary methods. Lossy coding: continuous sources, rate-distortion functions. Waveform coding methods: scalar and vector quantization, predictive coding, transform coding, subband and wavelet coding. Applications to telecommunications and storage: text, speech, audio, facsimile, image, video.
Course Component: Lecture
Courses ELG 5126 and ELG 6167 cannot be combined for units.

ELG 5127 Medical Image Processing (3 units)
Mathematical models of image formation based on the image modality and tissue properties. Linear models of image degradation and reconstruction. Inverse problems and regularization for image reconstruction. Image formation in Radiology, Computed Tomography, Magnetic Resonance Imaging, Nuclear Medicine, Ultrasound, Positron Emission Tomography, Electrical Impedance Tomography.
Course Component: Lecture
Courses ELG 5127, ELG 7173 (EACJ 5601) cannot be combined for units if taken as a topic in ELG 7173.

ELG 5128 Wireless Ad Hoc Networking (3 units)
Self-organized, mobile, and hybrid ad hoc networks. Physical, medium access, networks, transport and application layers, and cross-layering issues. Power management. Security in ad hoc networks. Topology control and maintenance. Date communication protocols, routing and broadcasting. Location service for efficient routing. Courses CSI 5148 (COMP 5103), ELG 5128 cannot be combined for units.
Course Component: Lecture
Exclusion: CSI 5148 (COMP 5103)

ELG 5131 Graphical Models (3 units)
Bayesian networks, factor graphs, Markov random fields, maximum a posteriori probability (MAP) and maximum likelihood (ML) principles, elimination algorithm, sum-product algorithm, decomposable and non-decomposable models, junction tree algorithm, completely observed models, iterative proportional fitting algorithm, expectation-maximization (EM) algorithm, iterative conditional modes algorithm, variational methods, applications. Courses ELG 5131, ELG 7177 (EACJ 5605) cannot be combined for units. This course is equivalent to EACJ 5131 at Carleton University.
Course Component: Lecture

ELG 5132 Smart Antennas (3 units)
Wireless systems and their imitations. Introduction to propagation and antenna arrays. Concept of smart antenna; spatial processing; space-division multiple access. Types of smart antennas. Range and capacity improvement. Beamforming networks and algorithms. Direction-of-arrival estimation. Multiple-input multiple- output (MIMO) architecture: basic principles; capacity issues; performance analysis. Bell Lab Layered Space-Time (BLAST) algorithm. Space-time coding. Alamouti scheme. Spatio-temporal radio channels. Impact of correlation. Courses ELG 5132, ELG 7178 (EACJ 5606) cannot be combined for units.
Course Component: Lecture

ELG 5133 Introduction to Mobile Communications (3 units)
Introduction to mobile and cellular systems. Radio channel characterization: signal strength prediction techniques and coverage; indoor/outdoor models; fading; delay spread; interference models and outage probabilities. Digital modulation and transmission system performance. Signal processing techniques, diversity and beamforming.Multiple-input multiple-output (MIMO) systems. New directions and recent results.
Course Component: Lecture

ELG 5137 Planning and Design of Computer Networks (3 units)
Planning process of computer networks; needs and technical requirements; modeling of different network planning problems; exact and approximate algorithms; topological planning and expansion problems; equipment (switch, router) location problem; approximate and optimal routing algorithms; presentation of various case studies.
Course Component: Lecture

ELG 5142 Ubiquitous Sensing for Smart Cities (3 units)
This course is an introduction to ubiquitous sensing systems for intelligently coordinated and efficient cities and spaces. Three primary foci will be on smart cities sensing, reliable sensory data acquisition, and security and privacy in smart city sensing systems. Topics will include: a thorough presentation of sensor and actuator networks for smart cities, software-defined Internet of Things, vehicular sensing, social sensing, detailed investigation of opportunistic and participatory sensing solutions, sensing as a service, and security and privacy assurance in smart city services by using artificial intelligence methods. An emphasis will be given on the design and analysis of multi-purposed, non-dedicated and large-scale sensing systems along with the trustworthiness, reliability, security and efficiency requirements of smart city services.
Course Component: Lecture

ELG 5143 AI-Enabled Wireless Networks (3 units)
Communication fundamentals. Wireless communications. Device-to-device communications. Cyber physical systems (CPS). Self-organization. Supervised and unsupervised learning. Reinforcement learning. Deep learning.
Course Component: Lecture

ELG 5161 Robotics: Control, Sensing and Intelligence (3 units)
Robotics as the intelligent connection of perception to action. Advanced robotics technologies. Robot arm kinematics and dynamics. Planning of manipulator trajectories. Control of robot manipulators. Robot-level programming. Sensors and sensory perception. Control problems for sensory controlled robotic-based flexible manufacturing systems. Task-level programming. Knowledge-based control for mobile robots. This course is equivalent to EACJ 5207 at Carleton University.
Course Component: Lecture

ELG 5163 Machine Vision (3 units)
Image acquisition. Structured light and stereo ranging. Grey-scale and binary images: geometric and topological properties. Image segmentation, preprocessing, edge finding, processing. Image recognition. Mathematical models for image representation. Morphology. Representation of 3-D objects, scene understanding, motion detection. Massively parallel computers architectures. Machine vision for manufacturing. This course is equivalent to EACJ 5100 at Carleton University.
Course Component: Lecture

ELG 5164 Cloud Infrastructure and Technologies (3 units)
Theory and hands-on experience of virtualization technology and infrastructure to support cloud computing systems and services starting from Metal-As-A-Service and building up to a full, open, standards compliant Software-As-A-Service stack. Full explanation of the processes, methodologies, and tools needed for DevOps support. Topics covered include: Linux Fundamentals, Container Orchestration with Docker and Kubernetics, Networking Fundamentals, Cloud Computing using OpenStack, Network Functions Virtualization as well as special topics related to emerging applications and research.
Course Component: Lecture

ELG 5166 Cloud Analytics (3 units)
Fundamentals of complex and large-scale data processing in the cloud (evolution, characteristics, application). Distributed data processing approaches: master/slave, vertical vs. horizontal scalability, batch and streaming, transactions management, CAP Theorem. Batch processing. In-memory processing. Data processing clusters and pipelines. Hands-on experience developing and managing complex and large-scale data pipeline applications in a cloud. NoSQL databases (characteristics, types, architectures). Data lakes and cloud computing infrastructure.
Course Component: Lecture

ELG 5170 Information Theory (3 units)
Measure of information: entropy, relative entropy, mutual information, asymptotic equipartition property, entropy rates for stochastic processes; Data compression: Huffman code, arithmetic coding; Channel capacity: random coding bound, reliability function, Blahut-Arimoto algorithm, Gaussian channels, colored Gaussian noise and "water-filling"; Rate distortion theory; Network information theory. This course is equivalent to EACJ 5501 at Carleton University.
Course Component: Lecture

ELG 5179 Detection and Estimation (3 units)
Binary, M-ary and composite hypothesis testing. Bayes risk and Neyman-Pearson criteria. Parameter estimation: Cramer-Rao bounds; maximum-likelihood estimation. Detection in additive white Gaussian noise and coloured noise. Noise in noise problems. Classical estimation problems. The linear filtering problem. Wiener/Kalman filtering. Sequential and non-parametric detection. This course is equivalent to EACJ 5503 at Carleton University.
Course Component: Lecture

ELG 5180 Advanced Digital Communication (3 units)
Techniques and performance of digital signalling and equalization over linear bandlimited channels with additive Gaussian noise. Fading multipath channels: diversity concepts, modelling and error probability performance evaluation. Synchronization in digital communications. Spread spectrum in digital transmission over multipath fading channels. Courses ELG 5180, ELG 6165 (SYSC 5605) cannot be combined for units. This course is equivalent to EACJ 5704 at Carleton University.
Course Component: Lecture
Prerequisite: SYSC 5504 or ELG 5375 or the equivalent.

ELG 5191 Design of Distributed System Software (3 units)
Distributed systems design and programming issues; distributed computing. Basics of object oriented technology for distributed computing. Distributed objects technologies. Object oriented models for distributed programming. Distributed computing architecture design. Component based distributed software design. Scalability, interoperability, portability and distributed services. Distributed applications design. This course is equivalent to EACJ 5203 at Carleton University.
Course Component: Lecture

ELG 5195 Digital Logic Design: Principles and Practices (3 units)
Switching algebra. Combinational circuit design including PLA and MSI techniques. Special properties-symmetric functions, unate functions, threshold functions, functional decomposition. Sequential circuits-state reduction, incompletely specified machines, state assignments and series-parallel decomposition. Fundamental mode sequential circuits-race, hazards, and state assignment. Semicustom and MSI design. Special sequential circuits. This course is equivalent to EACJ 5705 at Carleton University.
Course Component: Lecture

ELG 5199 Design of Multimedia Distributed Database Systems (3 units)
Database concepts and architectures. Data modelling. Relational technology and distributed databases. Examples of the new generation of databases for advanced multimedia applications such as multimedia information retrieval, VOD and the limitations of the conventional models for managing multimedia information (graphics, text, image, audio and video). This course is equivalent to EACJ 5104 at Carleton University.
Course Component: Lecture

ELG 5214 Deep Learning and Reinforcement Learning (3 units)
Advanced course in the theory, techniques, tools and applications of deep learning and reinforcement learning to Applied Machine Learning.
Course Component: Lecture

ELG 5218 Uncertainty Evaluation in Engineering Measurements and Machine Learning (3 units)
Bayesian analysis, Uncertainty quantification, Probabilistic programming, Data analysis, Modeling, Monte Carlo simulations, Bayesian machine learning, Measurement, Errors, Time series analysis.
Course Component: Lecture

ELG 5228 Mobile Robotics (3 units)
Locomotion and kinematics, wheeled and mobile robotics. Robot autonomy and perception. Localization: simultaneous localization and mapping (SLAM), map-based localization, Markov-based localization, Kalman filter-based localization. Path planning: configuration space, cell decomposition, artificial potential fields, collision avoidance. Motion control: trajectory tracking, regulation. Robotic Operating System (ROS).
Course Component: Lecture

ELG 5255 Applied Machine Learning (3 units)
Machine learning is an effective tool to design systems that learn from experience and adapt to an environment. Theory and applications of machine learning to the design of electrical and computer systems, devices and networks by using techniques that utilize statistics, neural computation and information theory. Fundamentals of supervised learning, Bayesian estimation, clustering and unsupervised learning, multivariate, parametric and non-parametric methods, kernel machines, hidden Markov models, multilayer perceptron networks and deep neural networks, ensemble learning and reinforcement learning. Design and testing of machine learning techniques integrated into real-world systems, devices and networks. Guidelines for machine learning experiments, methods for cross-validation and resampling, classifier performance analysis and tools for comparing classification algorithms and analysis of variance to compare multiple algorithms.
Course Component: Lecture
Courses ELG 5255, CSI 5155, DTO 5100, DTO 5101, IAI 5100, IAI 5101, MIA 5100, SYS 5185 cannot be combined for units.

ELG 5271 Topics in Applied Artificial Intelligence (3 units)
Recent and advanced topics in the field of Applied Artificial Intelligence. Topics vary from year to year.
Course Component: Lecture

ELG 5295 Ethics for Design, AI, and Robotics (3 units)
Artificial Intelligence technologies are becoming ever more present in applications like: automated vehicles and mobility-as-a-service (e.g. driving and system-level control algorithms); consumer electronics (e.g. social robots and smart speakers); healthcare (e.g. image classification in medical imaging); and weapons systems (e.g. targeting and kill decision-making). Many of these applications are raising significant ethical concerns. A range of topics in applied technology ethics are examined through the lens of contemporary philosophy and applied ethics texts and popular media articles. Practical frameworks, methodologies and tools for anticipating, and addressing, ethical issues are introduced through hands-on, group-based design thinking workshops and projects.
Course Component: Lecture
Courses CSI 5195 and DTI 5310, ELG 5295, SYS 5185 cannot be combined for units.

ELG 5301 Professional Skills and Responsibility (3 units)
Students work in teams (peer groups) to complete hands-on projects and online learning modules to build their professional network and develop their careers; understand their responsibilities as professionals; and develop professional skills with a focus on communication, team leadership, and project management. Fundamentals of technical team-based projects including problem definition, research, planning and how to write a technical project proposal. Required modules on academic writing, plagiarism and conducting a literature review.
Course Component: Lecture, Tutorial

ELG 5360 Digital Watermarking (3 units)
Overview of recent advances in watermarking of image, video, audio, and other media. Spatial, spectral, and temporal watermarking algorithms. Perceptual models. Use of cryptography in steganography and watermarking. Robustness, security, imperceptibility, and capacity of watermarking. Content authentication, copy control, intellectual property, and other applications. This course is equivalent to EACJ 5360 at Carleton University.
Course Component: Lecture

ELG 5369 Internetworking Technologies (3 units)
IP Based Internet Technologies: Internet architecture and its protocols. Software/hardware requirements for quality of service (QoS), Integrated services. Scheduling. Fair queueing. Traffic and admission control algorithms. Differentiated services. Multiprotocol label switching (MPLS) and associated software/hardware design issues. Fast internet protocol (IP), asynchronous transfer mode (ATM), internet protocol (IP) over synchronous optical network (SONET), wavelength division multiplexing (WDM), satellite implementations. This course is equivalent to EACJ 5369 at Carleton University.
Course Component: Lecture
Courses ELG 5369, ELG 7187 (EACJ 5808) cannot be combined for units.

ELG 5372 Error Control Coding (3 units)
General introduction. Algebraic concepts. Linear block codes. Cyclic codes, BCH and Reed-Solomon codes. Convolutional codes. Maximum likelihood decoding, and sequential decoding of convolutional codes. Burst-error correcting convolutional and block codes. Automatic repeat request. Trellis Coded Modulation. Turbo codes and iterative decoding. This course is equivalent to EACJ 5504 at Carleton University.
Course Component: Lecture

ELG 5373 Data Encryption (3 units)
Secure communications: encryption and decryption. Entropy, equivocation and unicity distance. Cryptanalysis and computational complexity. Substitution, transposition and product ciphers. Data Encryption Standard (DES): block and stream cipher modes. Modular arithmetics. Public key cryptosystems: RSA, knapsack. Factorization methods. Elliptic curve cryptography. Authentication methods and cryptographic protocols. This course is equivalent to EACJ 5105 at Carleton University.
Course Component: Lecture

ELG 5374 Computer Communication Network (3 units)
Network applications, structures and their design issues. Resource sharing/access methods. Network transmission and switching techniques. OSI model. Error control, flow control and various issues related to the physical, data link and network layers. Local area networks. Performance issues of delay-throughput in various protocols. Courses ELG 5374, ELG 6121 (SYSC 5201) cannot be combined for units. This course is equivalent to EACJ 5607 at Carleton University.
Course Component: Lecture

ELG 5375 Digital Communications (3 units)
Elements of communication theory and information theory applied to digital communications systems. Characterization of noise and channel models. Analysis of digital data transmission techniques for additive Gaussian noise channels. Efficient modulation and coding for relable transmission. Spread spectrum and line coding techniques. This course is equivalent to EACJ 5506 at Carleton University.
Course Component: Lecture

ELG 5376 Digital Signal Processing (3 units)
Review of discrete time signals and systems, A/D and D/A conversions, representation in time, frequency, and Z domain, DFT/FFT transforms, FIR/IIR filter design, quantization effects. Correlation functions. Cepstrum analysis. Multi-rate signal processing. Power spectrum estimation. Introduction to joint time-frequency analysis. DSP architecture: implementation approaches. Applications. Courses ELG 5376, ELG 6162 (SYSC 5602) cannot be combined for units. This course is equivalent to EACJ 5507 at Carleton University.
Course Component: Lecture

ELG 5377 Adaptive Signal Processing (3 units)
Theory and techniques of adaptive filtering, including Wiener filters, gradient and LMS methods; adaptive transversal and lattice filters; recursive and fast recursive least squares; convergence and tracking performance; implementation. Applications, such as adaptive prediction; channel equalization; echo cancellation; source coding; antenna beamforming; spectral estimation. This course is equivalent to EACJ 5800 at Carleton University.
Course Component: Lecture

ELG 5378 Image Processing and Image Communications (3 units)
Image acquisition, display and perception: sampling and reconstruction, quantization, human vision. Discrete image representations: color spaces, block, subband and wavelet representations. Image transformations, enhancement and restoration. Image analysis: edge detection, motion estimation. Image and video compression: lossless coding, predictive and transform coding, motion compensation.
Course Component: Lecture

ELG 5379 Numerical Methods in Electromagnetic Engineering (3 units)
Review of electromagnetic and potential theory. Formulation of static and electrodynamic problems. Introduction to numerical and field-theoretical modelling techniques. Numerical methods considered: FD, MoL, SDA, TLM and BPM. Examples of commonly encountered electromagnetic problems at microwave, millimeterwave and optical frequencies. This course is equivalent to EACJ 5402 at Carleton University.
Course Component: Lecture

ELG 5381 Photonics Networks (3 units)
Optical communication networks. Network layers. Optical signal formats. Clients to the optical layer (SONET, Optical Transport Network, IP). Optical fiber. Transmitter and receiver components. Multilevel modulation of optical signals. Coherent detection. Optical bypass technology. Routing. Wavelength assignment. Grooming. Optical protection schemes. Dynamic networking. Flexible optical networks. Gridless network architecture. This course is equivalent to EACJ 5004 at Carleton University.
Course Component: Lecture

ELG 5383 Survivable Optical Networks (3 units)
Optical networks design with emphasis on network survivability. Wavelength division multiplexing (WDM), wavelength conversion, optical switch architectures, routing and wavelength assignment algorithms, IP over WDM, optical network protocols, optical network control architectures, protection and restoration, spare capacity allocation, survivable routing, design and performance evaluation.
Course Component: Lecture

ELG 5385 Matrix Methods and Algorithms for Signal Processing (3 units)
Representation and approximation in vector spaces, matrix factorization, pseudoinverses, application of eigen decomposition methods, Singular Values Decomposition, least squares problems, applications of special matrices, iterative algorithms, expectation maximization algorithm. This course is equivalent to EACJ 5385 at Carleton University.
Course Component: Lecture

ELG 5386 Neural Networks and Fuzzy Systems (3 units)
Neuro-fuzzy and soft computing. Fuzzy set theory: rules, reasoning and inference systems. Regression and optimization; derivative-based optimization - genetic algorithms, simulated annealing, downhill simplex search. Neural Networks: adaptive networks; bidirectional associative memories; supervised and unsupervised learning; learning from enforcement. Applications: neuro-fuzzy modelling and control, pattern recognition. Courses ELG 5386, MCG 5356 (MECH 5506) cannot be combined for units. This course is equivalent to EACJ 5386 at Carleton University.
Course Component: Lecture
Exclusion: MCG 5356 (MECH5506).

ELG 5901 Projet en génie électrique / Electrical Engineering Project (6 crédits / 6 units)
Projet en génie électrique. Nécessite un rapport écrit approfondi et une présentation orale. Classé S (satisfaisant) ou NS (non satisfaisant). / Project in electrical engineering. Requires an in-depth written report and an oral presentation. Graded S (Satisfactory) or NS (Not satisfactory).
Volet / Course Component: Recherche / Research
Préalable : ELG 5301. Les cours ELG 5901, ELG 5902, GNG 5902 ne peuvent être combinés pour l'obtention de crédits. / Prerequisite: ELG 5301. The courses ELG 5901, ELG 5902 and GNG 5902 cannot be combined for units.

ELG 5902 Projet de stage en entreprise / Industry Internship Project (6 crédits / 6 units)
Réalisation d'un projet d'ingénierie électrique encadré par un expert de l'industrie et un professeur qui supervise le projet. Le projet sera évalué par un rapport de projet final soumis au professeur, ainsi que par une évaluation formelle de l'étudiant par l'expert de l'industrie. Les projets internationaux (emplacement ou expert du secteur) sont autorisés. / Completion of an electrical engineering project mentored by an industry expert and a professor who co-supervise the project. Project will be evaluated by a final project report submitted to the professor, as well as a formal assessment of the student by the industry expert. International projects (location or industry expert) are permitted.
Volet / Course Component: Recherche / Research
Préalable : ELG 5301. Les cours ELG 5901, ELG 5902, GNG 5902 ne peuvent être combinés pour l'obtention de crédits. / Prerequisite: ELG 5301. The courses ELG 5901, ELG 5902 and GNG 5902 cannot be combined for units.

ELG 6101 Simulation and Modelling (3 units)
Simulation as a problem solving tool. Random variable generation, general discrete simulation procedure: event table and statistical gathering. Analyses of simulation data: point and interval estimation. Confidence intervals. Overview of modelling, simulation and problem solving using simscript, modism and other languages. This course is equivalent to SYSC 5001 at Carleton University.
Course Component: Lecture

ELG 6102 Pattern Classification and Experiment Design (3 units)
This course covers media compression, in-depth issues of scalability in the compression domain (including audio, images, video, 2D and 3D graphics), and adaptation towards various contexts; as well is covering various popular media encoding standards (including JPEG and MPEG). This course is equivalent to SYSC 5405 at Carleton University.
Course Component: Lecture

ELG 6104 Optimization for Engineering Applications (3 units)
Introduction to algorithms and computer methods for optimizing complex engineering systems. Includes linear programming, networks, nonlinear programming, integer and mixed-integer programming, genetic algorithms and search methods, and dynamic programming. Emphasizes practical algorithms and computer methods for engineering applications. This course is equivalent to SYSC 5004 at Carleton University.
Course Component: Lecture

ELG 6108 Introduction to Convex Optimization (3 units)
Mathematics of optimization: linear, nonlinear and convex problems. Convex and affine sets. Convex, quasiconvex and log-convex functions. Operations preserving convexity. Recognizing and formulating convex optimization problems. The Lagrange function, optimality conditions, duality, geometric and saddle-point interpretations. Least-norm, regularized and robust approximations. Statistical estimation, detector design. Adaptive antennas. Geometric problems (networks). Algorithms.
Course Component: Lecture

ELG 6110 Information Theory (3 units)
Measure of information: entropy, relative entropy, mutual information, asymptotic equipartition property, entropy rates for stochastic processes; Data compression: Huffman code, arithmetic coding; Channel capacity: random coding bound, reliability function, Blahut-Arimoto algorithm, Gaussian channels, coloured Gaussian noise and "water-filling"; Rate distortion theory; Network information theory. This course is equivalent to SYSC 5506 at Carleton University.
Course Component: Lecture

ELG 6111 Design of High Performance Software (3 units)
Designing software to demanding performance specifications. Design analysis using models of computation, workload, and performance. Principles to govern design improvement for sequential, concurrent and parallel execution, based on resource architecteure and quantitative analysis. This course is equivalent to SYSC 5101 at Carleton University.
Course Component: Lecture

ELG 6113 Software Agents (3 units)
Agent-based programming; elements of distributed artificial intelligence; beliefs, desires and intentions; component-based technology; languages for agent implementations; ontologies; KQML; autonomy; adaptability; security issues; mobility; standards; agent design issues and frameworks; applications in telecommunications. This course is equivalent to SYSC 5103 at Carleton University.
Course Component: Lecture

ELG 6114 Methodologies for Discrete-Event Modeling and Simulation (3 units)
Methodological aspects of simulation. Modelling discrete events systems. Modelling formalisms: FSA, FSM, Petri Nets, DEVS, others. Verification and validation. Cellular models: cellular automata, cell-DEVS. Continuous and hybrid models. Parallel and distributed simulation (PADS) techniques. PADS middleware: HLA, parallel-DEVS, Time-warp. This course is equivalent to SYSC 5104 at Carleton University.
Course Component: Lecture

ELG 6115 Software Quality Engineering and Management (3 units)
All aspects of software quality engineering. Software testing, at all stages of the software development and maintenance life cycle. Software reviews and inspections. Use of software measurement and quantitative modelling for the purpose of software quality control and improvement. Courses ELG 6115, CSI 5111 (COMP 5501) cannot be combined for units. This course is equivalent to SYSC 5105 at Carleton University.
Course Component: Lecture

ELG 6118 Topics in Information Systems (3 units)
Recent and advanced topics in the field of Information Systems and its related areas. This course is equivalent to SYSC 5108 at Carleton University.
Course Component: Lecture

ELG 6120 Algebraic Coding Theory (3 units)
Review of Algebra, Finite Fields, Linear Block Codes and their Properties, Hamming Codes, Cyclic codes; Hadamard Matrices and Hadamard Codes, Golay Codes, Reed-Muller Codes, BCH and Reed-Solomon Codes, Decoding Algorithms, Coding Bounds. Courses ELG 6120, ELG 6157 (SYSC 5507) cannot be combined for units. This course is equivalent to SYSC 5200 at Carleton University.
Course Component: Lecture

ELG 6121 Computer Communication (3 units)
Computer network types, introductory queueing theory and performance analysis. OSI layering and BISDN layering modifications. Data link layer. Local area networks and random access (CSMA - CD, switched ethernet, token ring, wireless LAN). Public Networks. IP networks, addressing, routing. Transport layer, flow control. Introduction to ISDN. Courses ELG 6121, ELG 5374 (EACJ 5607) or ELG 4181 (SYSC 4602) cannot be combined for units. This course is equivalent to SYSC 5201 at Carleton University.
Course Component: Lecture

ELG 6127 Distributed Systems Engineering (3 units)
Techniques for representing distributed systems: precedence graphs, petrinets, communicating state-machines etc. Processes, threads, synchronization and interprocess communication techniques, RPC. Protocol: OSI model, application and presentation layers. Middleware for client-server application management, CORBA. Resource management: processor allocation and load sharing. Real-time issues and scheduling. This course is equivalent to SYSC 5207 at Carleton University.
Course Component: Lecture

ELG 6130 Health Care Engineering (3 units)
Overview of health care system/participants; biophysical measurements for diagnosis/monitoring; biomedical sensors/technology; telemedicine and applications; safety considerations; managing medical technologies/funding models for clinical engineering departments; considerations for developing countries. This course is equivalent to SYSC 5402 at Carleton University.
Course Component: Lecture
Courses ELG 6130 and ELG 5123 cannot be combined for units. This course is equivalent to SYSC 5402 at Carleton University.

ELG 6131 Advanced Topics in Biomedical Engineering (3 units)
Topics vary from year to year. This course is equivalent to SYSC 5301/ EACJ 5127 at Carleton University.
Course Component: Lecture

ELG 6136 Mobile Computing Systems (3 units)
Systems to build mobile applications. Covers data link layer to application layer. Emphasis on existing wireless infrastructure and IETF protocols. Focuses on view of mobile application developer; communication systems, middleware and application frameworks, de facto standards proposed/developed by industry consortia. This course is equivalent to SYSC 5306 at Carleton University.
Course Component: Lecture

ELG 6141 Adaptive Control (3 units)
System identification. Least squares and recursive identification techniques. Asymptotic and theoretical properties. Model structure selection. Prediction and estimation. Model reference adaptive control and self tuning regulators. Nonlinear adaptive systems. Stability. Neural networks and neuro-control. Applications to robotics, control and pattern recognition. This course is equivalent to SYSC 5401 at Carleton University.
Course Component: Lecture

ELG 6143 Network Access Techniques (3 units)
A range of access technologies with emphasis on broadband access. Physical channels and the state-of-the-art of coding, modulation, multiplexing strategies to overcome physical impairments, including high-speed transmission over twisted pair, wireless, fibre and co-axial media.This course is equivalent to SYSC 5403 at Carleton University.
Course Component: Lecture

ELG 6152 Advanced Linear Systems (3 units)
Modelling and state space realization. Review of signals and systems. Solution to the matrix DE. Discrete time systems and the Z transform. Canonical representations and transformations. Controllability, observability and controller and observer design. LQR design and the Kalman filter. Numerous examples and applications. This course is equivalent to SYSC 5502 at Carleton University.
Course Component: Lecture

ELG 6153 Stochastic Processes (3 units)
Basic concepts of randomness, as applied to communications, signal processing, and queueing systems; probability theory, random variables, stochastic processes; random signals in linear systems; introduction to decision and estimation; Markov chains and elements of queueing theory. Courses ELG 6153, ELG 5119 (EACJ 5109) cannot be combined for units. This course is equivalent to SYSC 5503 at Carleton University.
Course Component: Lecture
Exclusion: ELG 5119.

ELG 6154 Principles of Digital Communication (3 units)
Elements of communication theory and information theory applied to digital communications systems. Characterization of noise and channel models. Optimum Receiver Theory. Modulation and coding for reliable transmission: MPSK, MQAM, M-ary orthogonal modulation. Channel coding, trellis coded modulation. Spread spectrum and CDMA communications. Courses ELG 6154, ELG 5375 cannot be combined for units. This course is equivalent to SYSC 5504 at Carleton University.
Course Component: Lecture

ELG 6160 Adaptive Signal Processing (3 units)
Theory and techniques of adaptive filtering, including Wiener filters, gradient and LMS methods; adaptive transversal and lattice filters; recursive and fast recursive least squares; convergence and tracking performance; implementation. Applications, such as adaptive prediction; channel equalization; echo cancellation; source coding; antenna beamforming, spectral estimation. This course is equivalent to SYSC 5600 at Carleton University.
Course Component: Lecture

ELG 6162 Digital Signal Processing (3 units)
Review of discrete time signals and systems, A/D and D/A conversions, representation in time, frequency, and Z domain, DFT/FFT transforms, FIR/IIR filter design, quantization effects. Correlation functions. Cepstrum analysis. Multi-rate signal processing. Power spectrum estimation. Introduction to joint time-frequency analysis. DSP architecture: implementation approaches. Applications. This course is equivalent to SYSC 5602 at Carleton University.
Course Component: Lecture

ELG 6165 Advanced Digital Communication (3 units)
Techniques and performance of digital signalling and equalization over linear bandlimited channels with additive Gaussian noise. Fading multipath channels: diversity concepts, modelling and error probability performance evaluation. Synchronization in digital communications. Spread spectrum in digital transmission over multipath fading channels. Courses ELG 6165, ELG 5780 (EACJ 5704) cannot be combined for units. This course is equivalent to SYSC 5605 at Carleton University.
Course Component: Lecture

ELG 6166 Multi-Access Communication Systems (3 units)
Mobile radio channel characterization: signal strength prediction techniques and statistical coverage; fading; delay spread; interference models and outage probabilities. Digital modulation and transmission system performance. Signal processing techniques: diversity and beamforming, adaptive equalization, coding. Applications to TDMA and CDMA cellular systems. This course is equivalent to SYSC 5606 at Carleton University.
Course Component: Lecture

ELG 6167 Source Coding and Data Compression (3 units)
Discrete and continuous sources. Discrete sources: Huffman coding and run length encoding. Continuous sources: waveform construction coding; PCM, DPCM, delta modulation; speech compression by parameter extraction; predictive encoding; image coding by transformation and block quantization. Fourier and Walsh transform coding. Applications to speech, television, facsimile. This course is equivalent to SYSC 5607 at Carleton University.
Course Component: Lecture

ELG 6168 Wireless Communication Systems Engineering (3 units)
Multiuser cellular and personal radio communication systems; frequency reuse, traffic engineering, system capacity, mobility and channel resource allocation. Multiple access principles, cellular radio systems, signalling and interworking. Security and authentication. Wireless ATM, satellite systems, mobile location, wireless LANs, wireless local loops, broadband wireless etc.
Course Component: Lecture

ELG 6171 Operating System Methods for Real-Time Applications (3 units)
Principles and methods for operating system design with application to real-time, embedded systems. Concurrent programming: mechanisms and languages; design approaches and issues; run-time support (kernel). Methods for hard real-time applications. Methods for distributed systems; I/O handling. This course is equivalent to SYSC 5701 at Carleton University.
Course Component: Lecture

ELG 6173 Integrated Database and Cloud Systems (3 units)
Database definitions, applications, and architectures. Conceptual design based on the entity-relationship and object-oriented models. Relational data model: relational algebra and calculus, normal forms, data definition and manipulation languages. Database management systems: transaction management, recovery and concurrency control. Current trends: object-oriented, knowledge-based, multimedia and distributed databases.
Course Component: Lecture

ELG 6174 Elements of Computer Systems (3 units)
Concepts in basic computer architecture, assembly languages, high level languages including object orientation, compilers and operating system concepts (including concurrency mechanisms such as processes and threads and computer communication). Designed for graduate students without extensive undergraduate preparation in computer system engineering (or the equivalent experience). This course is equivalent to SYSC 5704 at Carleton University.
Course Component: Lecture

ELG 6178 Development of Real-Time and Distributed Software With Reusable Components (3 units)
Advanced object-oriented design and programming of real-time and distributed systems using C++ and/or Java. Object-oriented features; inheritance, polymorphism, templates, exception handling. Concurrency issues. Design patterns and frameworks for distributed systems, with examples from communication applications. Design issues for reusable software. This course is equivalent to SYSC 5708 at Carleton University.
Course Component: Lecture

ELG 6179 Advanced Topics in Software Engineering (3 units)
This course is equivalent to SYSC 5709 at Carleton University.
Course Component: Lecture

ELG 6181 Advanced Topics in Computer Communications (3 units)
This course is equivalent to SYSC 5801 at Carleton University.
Course Component: Lecture

ELG 6184 Advanced Topics in Communication Systems (3 units)
This course is equivalent to SYSC 5804 at Carleton University.
Course Component: Lecture

ELG 6187 Advanced Topics in Computer Systems (3 units)
This course is equivalent to SYSC 5807 at Carleton University.
Course Component: Lecture

ELG 6189 Designing Secure Networking and Computer Systems (3 units)
Security issues in data networks and computer systems. The course considers the protocol layers, looks at issues that are associated with specific types of network architectures. Issues with Web security, protocol security and different classes of attacks and defences will also be addressed. Finally, security issues in emerging paradigms, and trends such as social networks and cloud computing, will be addressed. This course is equivalent to SYSC 5500 at Carleton University.
Course Component: Lecture

ELG 6196 Directed Studies (3 units)
Course Component: Lecture

ELG 6320 Advanced Topics in Integrated Circuits and Devices (3 units)
Recent and advanced topics in the field of Integrated Circuits and Devices and its related areas. This course is equivalent to EACJ 5208/ELEC 5200 at Carleton University.
Course Component: Lecture

ELG 6321 Principles and Design of Advanced Biomedical Instrumentation (3 units)
Principles of physiological measurements and related instrumentation with particular applications to cardiology, lung function, cerebral and muscle signals, surgery and anaesthesiology, ultrasound measurements, and critical care for infants. This course is equivalent to EACJ 5302/SYSC 5302 at Carleton University.
Course Component: Lecture

ELG 6340 Advanced Linear and Nonlinear Circuit Theory and Application (3 units)
Graph theory, incidence matrices, cutset matrices, generalized KCL, topological formulation, state-space equations, Tellegen's theorem, state-transition matrix, multi-port representation, stability, passivity, causality, synthesis of passive circuits, active networks, nonlinear dynamic circuits. This course is equivalent to ELEC 6340 at Carleton University.
Course Component: Lecture

ELG 6341 Signal Integrity in High-Speed Designs: Modeling and Analysis (3 units)
Crosstalk, distortion, ground bounce, skin effect. Interconnect modeling/ simulation, packages, ground/power planes, Elmore delay, lossy-coupled, frequency-dependent transmission lines, telegraphers equations, extraction, measured parameters, macromodeling: passivity/causality, MoC/MRA, vector fit, model reduction, electromagnetic compatibility/ interference, mixed-domain systems, concurrent analysis. This course is equivalent to ELEC 5401 at Carleton University.
Course Component: Lecture

ELG 6342 Introduction to Electronic Design Automation Algorithms and Techniques (3 units)
Digital design process; Overview of design automation tools/ methodologies; Theory of computational complexity; Layout compaction; Placement and Partitioning; Floorplanning; Routing; Digital simulation; Switch-level simulation; Logic synthesis; Verification; Analog and RF simulation. Area: Computer-Aided Design for Electronic Circuits. This course is equivalent to ELEC 5402 at Carleton University.
Course Component: Lecture

ELG 6344 Neural Networks for High-Speed /High Frequency Circuit Design (3 units)
Neural network methodologies for computer-aided design of high-speed/ high-frequency circuits, including modeling of passive and active devices/circuits, and their applications in high-level design and optimization in wired and wireless electronic systems. This course is equivalent to ELEC 5404 at Carleton University.
Course Component: Lecture

ELG 6349 Microwave and Millimeterwave Integrated Circuits (3 units)
Design of communications electronics components with emphasis on GaAs MMIC implementation. Overview of MESFET, HEMT, HBT device modeling. Integrated lumped/ distributed passive element modeling. Broadband impedance matching. Design of direct-coupled amplifiers, distributed amplifiers, power devices and amplifiers, phase shifters, switches, attenuators, mixers, oscillators. This course is equivalent to ELEC 5409 at Carleton University.
Course Component: Lecture

ELG 6351 Passive Microware Circuits (3 units)
Characteristics of homogeneous and inhomogeneous transmission lines and waveguides. Planar transmission lines: stripline, microstrip, coplanar lines, slotline. Coupled transmission lines. Modelling of discontinuities. Ferrite components. Microwave network analysis: parameters, CAD models. Design of impedance-matching networks, directional couplers, power splitters, filters. Applications in MICs and MMICs. This course is equivalent to ELEC 5501 at Carleton University.
Course Component: Lecture

ELG 6352 Analog Integrated Filters (3 units)
The fundamentals and details of analog integrated filters with emphasis on active continuous-time filters and SAW filters. Comparison to switched-capacitor filters. Review of filter concepts, types of filters, approximations, transformations. Building blocks such as op amps, transconductance amplifiers, and gyrators. Design using cascaded second-order sections, multiple loop feedback and LC ladder simulations. Discussion of issues such as tuning, linearity, dynamic range, and noise. This course is equivalent to ELEC 5502 at Carleton University.
Course Component: Lecture

ELG 6353 Radio Frequency Integrated Circuit Design (3 units)
Integrated radio front-end component design, with emphasis on a bipolar process. Overview of radio systems, discussion of frequency response, gain, noise, linearity, intermodulation, image rejection, impedance matching, stability, and power dissipation. Detailed design of low-noise amplifiers, mixers, oscillators and power amplifiers. Design alternatives through the use of one-chip inductors and baluns. The impact of process variations, parasitics, and packaging. Simulation issues and techniques. This course is equivalent to ELEC 5503 at Carleton University.
Course Component: Lecture

ELG 6354 Analysis of High-Speed Electronic Packages and Interconnects (3 units)
Introduction to techniques of modelling, simulation and optimization in designing high-speed VLSI packages and systems; models for IC packages, interconnects and ground/power planes; lumped element models, distributed models and EM-based models for high-speed VLSI interconnects; delay, crosstalk and switching noise analysis; simulation of multiconductor transmission line networks; asymptotic waveform evaluation (AWE) and moment matching techniques; concurrent thermal and electrical analysis of IC packages and boards; optimization of signal integrity in IC packages and printed circuit boards; macromodelling of linear and non-linear components and circuits. This course is equivalent to ELEC 5504 at Carleton University.
Course Component: Lecture

ELG 6355 Passive Circuit Theory (3 units)
General description of networks, leading to matrix representation of n-terminal lumped and distributed networks. Elements of matrix algebra as applied to networks. Properties of network functions; poles and zeros of driving point and transfer functions. Foster and Cauer canonic forms. Synthesis of lossless two-ports, single- and double-terminated. Modern filter theory; approximation of characteristics by rational functions; Butterworth and Chebyshev approximations. General parameter filters; graphical design. Elliptic filters, predistortion. Phase response and group delay; all-pass and Bessel filters. This course is equivalent to ELEC 5505 at Carleton University.
Course Component: Lecture

ELG 6356 Simulation and Optimization of Electronic Circuits (3 units)
Time and frequency-domain formulations for simulation, sensitivity analysis and optimization. Optimization techniques for performance, cost and yield-driven analysis of electronic circuits. Optimization approaches to modelling and parameter extraction of active and passive elements. Advanced techniques include statistical modelling, tolerance and reliability optimization, computer-aided tuning and analog diagnosis, and large-scale optimizations. Examples and case studies include FET modelling, optimization of amplifiers, filters, multiplexers, mixers, high-speed VLSI packages/interconnects, signal-integrity in high-speed ICs, printed circuit boards and multichip modules. This course is equivalent to ELEC 5506 at Carleton University.
Course Component: Lecture

ELG 6357 Active Circuit Theory (3 units)
Characterization of negative-resistance one-port networks, signal general and amplification. Active two-ports; y, z, h, k, chain and scattering parameters. Measurement of two-port parameters. Activity and passivity; reciprocity, non-reciprocity, and anti-reciprocity. Gyrator as a circuit element. Stability, inherent and conditional; power gain of conjugate and mismatched two-port amplifiers. Amplifier gain sensitivity. Stability, inherent and conditional; power gain of conjugate and mismatched two-port amplifiers. Active filter design; gyrator, negative immittance converter (NIC) and operational amplifier used as functional elements. Practical realization of gyrators and NICs. Active network synthesis. This course is equivalent to ELEC 5507 at Carleton University.
Course Component: Lecture

ELG 6358 Advanced Methods for Simulation of Large-Scale Circuits and Systems (3 units)
This course is equivalent to ELEC 5508 at Carleton University.
Course Component: Lecture

ELG 6359 Integrated Circuit Technology (3 units)
Survey of technology used in integrated circuit fabrication. Crystal growth and crystal defects, oxidation, diffusion, ion implantation and annealing, gettering, chemical vapour deposition, etching, materials for metallization and contacting, and photolithography. Structures and fabrication techniques for submicron devices. Applications in CMOS and BiCMOS processes. This course is equivalent to ELEC 5509 at Carleton University.
Course Component: Lecture

ELG 6360 Digital Integrated Circuit Testing (3 units)
Production testing of digital integrated circuits. Cost and difficulty of testing. Outline of methods of testing used in production. Testing schemes and design for testability. Specific topics are faults and fault models, yield estimates, testability measures, fault simulation, test generation methods, sequential testing, scan design, boundary scan, built-in self-test, CMOS testing. This course is equivalent to ELEC 5600 at Carleton University.
Course Component: Lecture

ELG 6362 Microwave Semiconductor Devices and Applications (3 units)
Theory of operation for microwave diodes (varactor, p-i-n, Gunn, IMPATT) and transistors (BJT, MESFET, HBT, HEMT). Small-signal, large-signal, and noise models for CAD. Diode oscillators and reflection amplifiers. Design of transitor oscillators and amplifiers. Discussion of technology/fabrication issues and MMIC applications. This course is equivalent to ELEC 5602 at Carleton University.
Course Component: Lecture

ELG 6363 Communications Technology (3 units)
Review of groundwave, skywave and transionospheric propagation modes relevant to radar, communications and other systems operating in the medium to extra-high frequency bands. The occurrence and magnitude of various types of electromagnetic noise: physical principles involved, modelling and prediction techniques, and limitations of such techniques in practical situations. This course is equivalent to ELEC 5603 at Carleton University.
Course Component: Lecture

ELG 6364 Radar Systems (3 units)
Fundamentals: range equation, minimum detectable signal, radar cross-section, pulse repetition frequency, range ambiguities. Classes of Radar: CW, FM-CW, MTI, tracking, air surveillance, SSR, PAR, MLS, SAR, SLAR, OTH, 3D and bistatic radars. Radar subsystems: transmitters, antennas, receivers, processors, displays. Detection criteria: CFAR receivers, noise, clutter, precipitation. Waveform design: ambiguity functions, pulse compression. Propagation characteristics: earth's curvature, refraction, diffraction, attenuation. This course is equivalent to ELEC 5604 at Carleton University.
Course Component: Lecture

ELG 6365 Optical Fibre Communication (3 units)
Transmission characteristics of and design considerations for multi-mode and single-mode optical fibre waveguides; materials, structures, and device properties of laser light sources; properties and performance of p-i-n and avalanche photodiodes; types of optical fibre signal formats, preamplifier topologies and noise, receiver sensitivity, transmitter design; link design for digital sytems. This course is equivalent to ELEC 5605 at Carleton University.
Course Component: Lecture

ELG 6366 Phase-Locked Circuits (3 units)
Phase-locked loops: components, fundamentals, stability, transient response, sinusoidal operation, noise performance, tracking, acquisition and optimization. Receiver synchronizers: carrier synchronizers including squaring loop, Costas loop, and remodulator for BPSK, QPSK BER performance; clock synchronizers including early late gate, inphase/midphase, and delay line multiplier; direct sequence spread spectrum code synchronizers including single dwell and multiple dwell serial PN acquisition, matched filter PN acquisition, delay locked loop and Tau-Dither loop PN tracking; frequency hopped spread spectrum time and frequency synchronization. This course is equivalent to ELEC 5606 at Carleton University.
Course Component: Lecture

ELG 6367 Fundamentals of Antenna Engineering (3 units)
Basic properties of antennas (gain, radiation patterns, polarization, antenna temperature). Analysis of common antennas (dipoles, loops, helices, aperture antennas, microstrip, dielectric resonator antennas, reflectors). Analysis and design of linear and planar arrays (array factors, beam scanning, amplitude weighting, feed networks). This course is equivalent to ELEC 5607 at Carleton University.
Course Component: Lecture

ELG 6368 Fourier Optics (3 units)
The theory and applications of diffractive and non-diffractive coherent optics, with emphasis on holograms, tomography and high-speed optical computing. Mathematical basis: generalized 2-D Fourier transforms, transfer function of an optical system, 2-D sampling theory, Helmholtz equation, Green's theorem, and the classical diffraction theories. Eikonal equations; the lens as an optical Fourier transformer; optical imaging and filtering. Bragg cells and their application in optical correlators and spectrum analyzers. Computed axial tomography (CAT scans) with non-diffractive and diffractive sources: Fourier Slice theorem, Filtered Backprojection, Born and Rytov approximations. Physical and computer-generated holograms, volume holograms, holographic optical elements. Optical computing: spatial filtering, holographic memory, optical processors, optical pattern recognition. This course is equivalent to ELEC 5608 at Carleton University.
Course Component: Lecture

ELG 6369 Nonlinear Microwaves Devices and Effects (3 units)
The physical basis and mathematical modelling of a variety of microwave/millimetre-wave devices, (some of which exhibit the most extreme nonlinear behaviour known), how they can be exploited in practical circuits and systems, and how the resulting device/circuit interactions can be analyzed. Devices include two-terminal nonlinear-resistance elements (varistors) and two two-terminal nonlinear-reactance devices (varactors) based on classical, heterostructure and superconducting technologies: pn and Schottky-barrier diodes, tunnel and resonant-tunneling diodes, BIN and BNN varactor diodes, single-barrier-varactor diodes, high-electron-mobility varactor diodes, Josephson-junction diodes, and SIS quasiparticle tunneling junctions. Three-terminal nonlinear devices include MESFETs, HBTs, and HEMTs and RHETs. Circuit applications encompass direct radiation detectors; frequency mixers; resistive, reactive, and active frequency multipliers; as well as reactive and regenerative frequency dividers. Emphasis will be placed on analytical approaches that provide global insight into the nonlinear phenomena. This course is equivalent to ELEC 5609 at Carleton University.
Course Component: Lecture

ELG 6370 Spread Spectrum Systems (3 units)
Course Component: Lecture

ELG 6371 Fibre and Waveguide Components for Communications and Sensors (3 units)
Optical wave propagation in dielectric waveguides. Theory and practice for passive photonic devices used for routing, filtering, and signal processing, including structural and biochemical sensors. Directional couplers and splitters, filters (gratings and etalons), Mach-Zehnder interferometers, Arrayed waveguide gratings, and dispersion compensators. This course is equivalent to ELEC 5701 at Carleton University.
Course Component: Lecture

ELG 6372 Principles of Photonics (3 units)
Electromagnetic wave propagation in crystals; review of geometric optics; Gaussian beam propagation; optical fibres; dielectric waveguides for optical integrated circuits; optical resonators; optical properties of materials; theory of laser oscillation; specific laser systems; electro-optic modulators; photorefractive materials and applications; holography; optical interconnects. This course is equivalent to ELEC 5702 at Carleton University.
Course Component: Lecture

ELG 6373 Advanced Topics in Solid State Devices and Ic Technology (3 units)
Recent and advanced topics in Solid State Devices and IC Technology. The subject material will vary from year to year according to research interests in the department. Students may be expected to contribute to lectures or seminars on selected topics. This course is equivalent to ELEC 5703 at Carleton University.
Course Component: Lecture
Prerequisite: Permission of the Department.

ELG 6374 Advanced Topics in Cad (3 units)
Recent and advanced topics in Computer-Aided Design (CAD). The subject material will vary from year to year according to research interests in the department. Students may be expected to contribute to lectures or seminars on selected topics. This course is equivalent to ELEC 5704 at Carleton University.
Course Component: Lecture
Prerequisite: Permission of the Department.

ELG 6375 Advanced Topics in Vlsi (3 units)
Recent and advanced topics in Very Large Scale Integration (VLSI). The subject material will vary from year to year according to research interests in the department. Students may be expected to contribute to lectures or seminars on selected topics. This course is equivalent to ELEC 5705 at Carleton University.
Course Component: Lecture
Prerequisite: Permission of the Department.

ELG 6376 Submicron Cmos and Bicmos Circuits for Sampled Data Applications (3 units)
The analog aspects of digital CMOS and BiCMOS circuit design in submicron technologies including reliability; sampled analog circuits, including amplifier nonidealities and switch charge injection; CMOS/BiCMOS amplifier design considerations, leading up to standard folded-cascode and two-stage circuits. This course is equivalent to ELEC 5706 at Carleton University.
Course Component: Lecture

ELG 6377 Microsensors and Mems (3 units)
Physical design of microelectromechanical systems (MEMS) and microfabricated sensors and actuators. An overview of thin and thick film processes and micromachining techniques will provide fabrication background. Design of a variety of devices including piezoresistive, piezoelectric, electromagnetic, thermal, optical, and chemical sensors and actuators. This course is equivalent to ELEC 5707 at Carleton University.
Course Component: Lecture

ELG 6378 Asic's in Telecommunications (3 units)
The definition of Application Specific Integrated Circuits is given along with current ASIC technology trends. CMOS and BiCMOS fabrication technologies are compared for their potential use in communications circuits. Circuit building blocks such as amplifiers, switched-capacitor filters and analog to digital converters are overviewed in the context of their communications applications. An overview of vendor technologies is followed by application examples such as line drivers, pulse shaping and equalization circuits, high-speed data transmission over twisted pair copper cables and mobile radio components and implementation issues. Students are required to submit a related literature study and design a communications integrated circuit component using a standard cell library environment. This course is equivalent to ELEC 5708 at Carleton University.
Course Component: Lecture

ELG 6379 Advanced Topics in Electromagnetics (3 units)
This course is equivalent to ELEC 5709 at Carleton University.
Course Component: Lecture

ELG 6380 Theory Semiconductor Devices (3 units)
Review of solid state physics underlying device mechanisms. Equilibrium and non-equilibrium conditions in a semiconductor. Carrier transport theory. Physical theory of basic semiconductor device structures and aspects of design: PN junctions and bipolar transistors, field effect devices. Current transport relationships for transistors. Charge control theory. Modelling of device mechanisms. Performance limitations of transistors. This course is equivalent to ELEC 5800 at Carleton University.
Course Component: Lecture

ELG 6381 High-Speed and Low-Power Vlsi (3 units)
High-Speed and Low-Power CMOS VLSI Circuit techniques covering the low and high levels of abstraction, including Transistor, Switch, Logic-Gate, Module, and System Levels. At each level students learn the state-of-the-art techniques to optimize the performance and energy consumption of a circuit. They also use one or more of these techniques in a design project. This course is equivalent to ELEC 5801 at Carleton University.
Course Component: Lecture
Prerequisites: ELG 6384

ELG 6382 Surface Controlled Semiconductor Devices (3 units)
Fundamentals of the MOS system: MOS capacitors. Long channel behaviour: theory, limitations and performance of the SPICE level 1 and 2 models. Small geometry effects: theory, limitations and performance of the SPICE level 3 model. Subthreshold operation and modelling. Hot electron effects and reliability. Advanced analysis: the MISNAN model. This course is equivalent to ELEC 5802 at Carleton University.
Course Component: Lecture

ELG 6383 Computer Aided Design: Automated Ic Synthesis (3 units)
Various topics related to computer analysis and synthesis of VLSI circuits including: logic synthesis, finite state machine synthesis, design methodologies, design for reuse, testing, common VLSI functions, a review of Verilog. This course is equivalent to ELEC 5803 at Carleton University.
Course Component: Lecture
Prerequisite: some IC design knowledge such as given in 4708.

ELG 6384 VLSI Design (3 units)
IC design course with strong emphasis on design methodology, to be followed by ELEC 5805 (ELG 6385) in the second term. Design philosophies considered will include Full Custom design, standard cells, gate-arrays and sea-of-gates using CMOS and BiCMOS technology. State-of-the-art computer-aided design tools are used.
Course Component: Lecture

ELG 6385 VLSI Design Project (3 units)
Using state-of-the-art CMOS and BiCMOS technologies, students will initiate their own design of an integrated circuit using tools in the CAD lab and submit it for fabrication where the design warrants.
Course Component: Lecture

ELG 6388 Signal Processing Electronics (3 units)
Signal processing from the viewpoint of analog circuit design. CCDs, BBDs, transversal filters, recursive filters, switched capacitor filters, with particular emphasis on integration of analog signal processing techniques in monolithic MOS ICs. Detailed operational amplifier design in CMOS technology. Implications of nonideal operational amplifier behaviour in filter performance. Basic sampled data concepts, detailed Z transform analysis of switched capacitor filters and more complex circuits. Noise in analog and sampled analog circuits, including calculation of dynamic range and signal-to-noise ratio. This course is equivalent to ELEC 5808 at Carleton University.
Course Component: Lecture

ELG 6389 Nonlinear Electronic Circuits (3 units)
A unified representation of non-linear circuits used in today's telecommunications ICs is introduced. Nonlinear representation of circuits based on operational amplifiers, sinusoidal oscillators, amplitude modulators, demodulators, frequency modulators, frequency demodulators, mixers and Phase Locked Loop (PLL) is introduced. Design implications for commonly used Complementory Metal-Oxide Semiconductor (CMOS) and bipolar circuits. This course is equivalent to ELEC 5809 at Carleton University.
Course Component: Lecture
Courses ELG 6389, ELG 6375 (ELEC 5705) cannot be combined for units if taken as a special topic in ELG 6375.

ELG 6392 Advanced Linear and Nonlinear Circuit Theory and Application (3 units)
Graph theory, incidence matrices, cutset matrices, generalized KCL, topological formulation, state-space equations, Tellegen's theorem, state-transition matrix, multi-port representation, stability, passivity, causality, synthesis of passive circuits, active networks, nonlinear dynamic circuits. This course is equivalent to ELEC 6340 at Carleton University.
Course Component: Lecture

ELG 6393 Interactive Networked Systems & Telemedicine (3 units)
Telemanipulator; human motoring and sensory capabilities; typical interface devices; mathematical model of haptic interfaces; haptic rendering; stability and transparency; remote control schemes; time delay compensation; networking and real-time protocols, history and challenges of telemedicine; telemedicine applications: telesurgery, tele-monitoring, tele-diagnosis and tele-homecare. This course is equivalent to SYSC 5303 at Carleton University.
Course Component: Lecture

ELG 6396 Directed Studies (3 units)
Course Component: Lecture

ELG 6397 Solar Cells - Principles, Materials, Systems and Operation (3 units)
Solar radiation. Solar cells: crystalline silicon, thin film technologies, space and concentrator cells, organic and dye sensitized. Photovoltaic systems: introduction, balance of system components, grid-connected systems, space and concentrator systems. Testing, monitoring, and calibration standards. Economics, environment and business strategy.
Course Component: Lecture

ELG 7100 Topics in Electromagnetics I (3 units)
This course is equivalent to EACJ 5404 at Carleton University.
Course Component: Lecture

ELG 7113 Topics in Systems and Control I (3 units)
Current topics in the field, including linear semigroup theory and optimal feedback control. This course is equivalent to EACJ 5209 at Carleton University.
Course Component: Lecture

ELG 7114 Topics in Systems and Control II (3 units)
Current topics in the field, including linear and nonlinear filtering and optimal control of stochastic systems. This course is equivalent to EACJ 5300 at Carleton University.
Course Component: Lecture

ELG 7132 Topics in Electronics I (3 units)
Current topics in the field. This course is equivalent to EACJ 5006 at Carleton University.
Course Component: Lecture

ELG 7171 Topics in Signal Processing I (3 units)
Course Component: Lecture

ELG 7172 Topics in Signal Processing I (3 units)
This course is equivalent to EACJ 5600 at Carleton University.
Course Component: Lecture

ELG 7173 Topics in Signal Processing II (3 units)
This course is equivalent to EACJ 5601 at Carleton University.
Course Component: Lecture

ELG 7177 Topics in Communications I (3 units)
Current topics in the field. This course is equivalent to EACJ 5605 at Carleton University.
Course Component: Lecture

ELG 7178 Topics in Communication II (3 units)
This course is equivalent to EACJ 5606 at Carleton University.
Course Component: Lecture

ELG 7179 Topics in Signal Processing III (3 units)
This course is equivalent to EACJ 5603 at Carleton University.
Course Component: Lecture

ELG 7186 Topics in Computers I (3 units)
This course is equivalent to EACJ 5807 at Carleton University.
Course Component: Lecture

ELG 7187 Topics in Computers II (3 units)
This course is equivalent to EACJ 5808 at Carleton University.
Course Component: Lecture

ELG 7199 Directed Studies (3 units)
Various possibilities exist for pursuing directed studies on topics approved by the Department and which a full-time faculty member has agreed to direct, including any of the courses listed in the Graduate Calendar that are not being offered on a formal basis in the current academic year. This course is equivalent to EACJ 5101 at Carleton University.
Course Component: Research
Permission of the Department is required.

ELG 7500 Sujets choisis en électromagnétique (3 crédits)
Ce cours est équivalent à EACJ 5308 à la Carleton University.
Volet : Cours magistral

ELG 7572 Sujets choisis en télécommunications et traitement de signaux (3 crédits)
Ce cours est équivalent à EACJ 5702 à la Carleton University.
Volet : Cours magistral

ELG 7573 Sujets choisis sur les ordinateurs (3 crédits)
Ce cours est équivalent à EACJ 5900 à la Carleton University.
Volet : Cours magistral

ELG 7574 Sujets choisis en systèmes et réglage automatique (3 crédits)
Sujets d'intérêt courant dans le domaine. Ce cours est équivalent à EACJ 5301 à la Carleton University.
Volet : Cours magistral

ELG 7575 Sujets choisis en électronique (3 crédits)
Ce cours est équivalent à EACJ 5008 à la Carleton University.
Volet : Cours magistral

ELG 8000 Co-Op Work Term I / Co-Op Work Term I
Pour les étudiants et les étudiantes d'un programme coopératif de maîtrise qui font leur première session de travail. / For students in a co-operative master's program who are on their first work session.
Volet / Course Component: Stage / Work Term

ELG 8001 Co-Op Work Term II / Co-Op Work Term II
Pour les candidats et les candidates à un programme coopératif de maîtrise qui font leur deuxième session de travail. / For students in a co-operative master's program who are on their second work session.
Volet / Course Component: Stage / Work Term

ELG 9997 Proposition de thèse de doctorat / Ph.D. Thesis Proposal
Volet / Course Component: Recherche / Research

ELG 9998 Ph.D. Comprehensive Examination
Volet / Course Component: Recherche / Research