

requirements, as ECON 5807, for which additional credit is precluded.

Prerequisite: ECON 2001 or ECON 2002 (with a grade of C- or better), or permission of the Department.
Lectures three hours a week.

ECON 4900 [1.0 credit] (formerly 43.490)

Honours Seminar

This seminar focuses on the use of basic economic analysis in a small number of research topics to be selected by the instructors. A major research paper is required. This seminar is intended for fourth-year Honours Economics students.

Prerequisites: ECON 4200 and ECON 4201 or permission of the Department.

Lectures three hours a week.

ECON 4903 [0.5 credit] (formerly 43.493*)

Tutorial in Economics

An additional tutorial in Economics may be taken subsequent to, or concurrently with ECON 4900.

Prerequisite: permission of the Department.

ECON 4904 [0.5 credit] (formerly 43.494*)

Tutorial in Economics

An additional tutorial in Economics may be taken subsequent to or concurrently with ECON 4900.

Prerequisite: permission of the Department.

ECON 4908 [1.0 credit] (formerly 43.498)

Honours Essay

Students taking Honours in Economics may write an Honours essay during their final year. This essay counts for one credit. Students work under an individual faculty adviser.

Prerequisite: permission of the Department.

Electronics (ELEC)

Department of Electronics

Faculty of Engineering

ELEC 1908 [0.5 credit] (formerly 97.198*)

First Year Project

A practical introduction to engineering design. Students work in small teams to specify, design and implement a system, formally managing the project progress and submitting oral and written reports.

Prerequisite: registration in the Engineering Physics program.
Lectures and tutorials two hours a week, laboratory four hours a week.

ELEC 2501 [0.5 credit] (formerly 97.251*)

Circuits and Signals

Properties of signals. Basic circuit elements: voltage and current sources. Kirchhoff's laws, linearity, superposition. Thevenin and Norton's theorems. Circuit simplification. AC steady-state analysis: impedance, admittance, phasors, frequency response. Transient response of RL and RC circuits: form of response, initial and final conditions. RLC circuits: resonance.

Prerequisites: MATH 1005 and PHYS 1004 (or PHYS 1001 and PHYS 1002).

Lectures three hours a week, laboratory and problem analysis three hours a week.

ELEC 2507 [0.5 credit] (formerly 97.257*)

Electronics I

Qualitative semiconductor physics, leading to the diode equation. Diode applications. Operational amplifiers and their application in feedback configurations including active filters. Introduction to bipolar transistors and MOSFETs, biasing and simple circuit applications. Transistor structure of digital logic gates.

Prerequisite: ELEC 2501.

Lectures three hours a week, laboratory and problem analysis three hours a week.

ELEC 2607 [0.5 credit] (formerly 97.267*)

Switching Circuits

Boolean algebra, gate, combinatorial circuits. DeMorgan notation, sum-of-product and product-of-sum forms. Logic arrays, PLAs and PALs. Flip-ops, latches, sequential circuits, state graphs and state minimization. Counters and controllers. Hazards. Asynchronous sequential circuits, race free assignment, realization.

Precludes additional credit for SYSC 2607/SYSC 3607 or ELEC 3607.

Prerequisite: PHYS 1004 or permission of the Department.

Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 3105 [0.5 credit] (formerly 97.315*)

Basic EM and Power Engineering

Electrostatics and magnetostatics. Solution of Poisson's and Laplace's equations. The Lorenz equation and force. Time varying fields. Magnetic circuits and transformers. DC and AC motors.

Precludes additional credit for ELEC 2601 or ELEC 3504.

Prerequisites: MATH 2004 and PHYS 1004 (or PHYS 1001 and PHYS 1002).

Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 3500 [0.5 credit] (formerly 97.350*)

Digital Electronics

Digital circuit design using verilog and logic synthesis, the electronic properties of logic gates, electrical interfacing between logic families, asynchronous to synchronous interfacing, clock distribution and timing, VLSI design options. Students implement substantial circuits with field-programmable gate arrays.

Prerequisites: ELEC 2507 and ELEC 2607.

Lectures three hours a week, laboratory three hours a week.

ELEC 3509 [0.5 credit] (formerly 97.359*)

Electronics II

Introduction to semiconductor devices and ICs. DC, AC and switching properties of BJTs. Linear amplifiers; bandwidth considerations; two-port analysis. Large signal amplifiers; power amplifiers; transformerless circuits. Feedback and operational amplifiers; gain, sensitivity, distortion and stability. Filter design. Oscillators.

Prerequisite: ELEC 2507.

Lectures three hours a week, laboratory three hours a week.

ELEC 3605 [0.5 credit] (formerly 97.365*)

Electrical Engineering

DC circuits: elements, sources, analysis. Single phase AC circuits: phasors, RLC circuits, real and reactive power, impedance, network analysis, three phase systems. Power transformers. DC motors: operation and characteristics. AC motors: single phase and three phase.

Prerequisites: MATH 1005 and PHYS 1004 (or PHYS 1001 and PHYS 1002). Not open to students in Communication Engineering, Computer Systems Engineering, Electrical Engineering, Engineering Physics or Aerospace Stream C.

Lectures three hours a week, problem analysis three hours alternate weeks.

ELEC 3905 [0.5 credit] (formerly 97.395*)

Professional Practice

Presentations by faculty and external lecturers on the Professional Engineers Act, professional ethics and responsibilities, practice within the discipline and its relationship with other disciplines and to society, health and safety, environmental stewardship, principles and practice of sustainable development. Communication skills are emphasized. (Also listed as SYSC 3905.)

Prerequisites: ECOR 1010, ALSS 1000, and third-year registration.

Lectures three hours a week

ELEC 3908 [0.5 credit] (formerly 97.398*)

Physical Electronics

Fundamentals of device physics and operation of the pn junction, bipolar transistor and MOSFET. Basic integrated circuit processing and application to diodes, BJTs and MOSFETs. Correlation between processing, structure, operation and modeling. Consideration of parasitic and small-geometry effects, reliability and process variation.

Prerequisites: CHEM 1101, MATH 2004, PHYS 1004 (or PHYS 1001 and PHYS 1002), ELEC 2507.

Lectures three hours a week, problem analysis three hours alternate weeks.

ELEC 3909 [0.5 credit] (formerly 97.399*)

Electromagnetic Waves

Maxwell's equations and EM wave solutions. Polarization. Poynting vector. EM waves in dielectrics and conductors; skin depth. Reflection and refraction. Standing waves. Fresnel relations, Brewster angle. Transmission lines. Line termination, basic impedance matching and transformation. Smith charts. Introduction to guided waves; slab waveguide.

Prerequisite: ELEC 3105 or permission of the Department
Lectures three hours a week, problem analysis three hours alternate weeks.

ELEC 4502 [0.5 credit] (formerly 97.452*)

Microwave Circuits

Introduction to microwave tubes, semiconductor devices, and passive components. Scattering matrix description of microwave junctions. Properties of basic reciprocal and non-reciprocal passive microwave devices. Fundamentals of microwave amplifiers and oscillators. Design of solid-state microwave amplifiers and oscillators.

Prerequisite: ELEC 4503; may be taken concurrently.

Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4503 [0.5 credit] (formerly 97.453*)

Radio Frequency Lines and Antennas

Introduction to distributed circuits, travelling and standing waves, reflection coefficient, SWR, impedance transformation, Smith charts. Introduction to transmission lines; coaxial, rectangular waveguide, resonators, optical fibers. Introduction to antennas; gain, directivity, effective area. Introduction to linear arrays.

Prerequisite: ELEC 3909.

Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4504 [0.5 credit] (formerly 97.454*)

Avionics Systems

Electromagnetic spectrum. Air data sensing, display. Communications systems. Navigation and landing systems; ground-based, inertial and satellite systems. Airborne radar. Guidance, control for aircraft, autopilots; stability augmentation; active control; sensor requirements; display techniques. Aircraft power systems. Safety systems. Vehicle/systems integration, certification.

Prerequisite: Fourth-year registration. Not open to students in Electrical Engineering, Computer Systems Engineering, Aerospace Stream C Engineering or Engineering Physics.

Lectures three hours a week.

ELEC 4505 [0.5 credit] (formerly 97.455*)

Telecommunication Circuits

A course of study of the commonly used circuit components in modern telecommunication systems. Both analog and digital systems are included. The design of the hardware is emphasized. Examples are drawn from broadcasting, telephony and satellite systems.

Prerequisites: SYSC 3501 and ELEC 3509.

Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4506 [0.5 credit] (formerly 97.456*)

CAD for Communication Circuits

Basic principles of Computer-Aided Design tools used for analysis and design of communication circuits and systems. Frequency and time-domain analysis. Noise and distortion analysis. Transmission line effects. Sensitivity analysis, and circuit performance optimization. Digital simulation.

Prerequisite: fourth-year registration.

Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4509 [0.5 credit] (formerly 97.459*)

Communication Links

Fundamentals; decibel, intermodulation, dB compression, dynamic range, SNR, noise figure, noise temperature, antenna gain, EIRP, G/T. Line-of-sight links; receiver, diversity, fade margin. Satellite links; link calculations, multiple accessing, earth stations. Fiber links, fiber types, sources, detectors, systems.

Prerequisite: fourth-year registration or permission of the Department.

Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4600 [0.5 credit] (formerly 97.460*)

Radar and Navigation

Radar: operation, minimum detectable signal, propagation effects. Surveillance Radars: Moving Target indicator and Pulse Doppler operation. Radio Navigation: pulsed and CW operation. Operational systems: Loran C., VOR/DME, TACAN, Global Positioning system. Inertial Navigation. Navigation Co-ordinate systems. Techniques for determining best estimates of position.

Prerequisite: fourth-year registration or permission of the Department.

Lectures three hours a week.

ELEC 4601 [0.5 credit] (formerly 97.461*)

Microprocessor Systems

Interfacing aspects in microprocessor systems. Microprocessors and bus structures, internal architecture,

instruction set and pin functions. Memory interfacing, input-output, interrupts, direct memory accesses, special processors and multiprocessor systems.

Precludes additional credit for SYSC 3601 and COMP 3006.

Prerequisite: ELEC 2607 and one of SYSC 2003 or SYSC 3003 or SYSC 3006 or permission of the Department.

Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4609 [0.5 credit] (formerly 97.469*)

Integrated Circuit Design and Fabrication

Introduction to nMOS IC design: static logic gates, noise margin, transmission gates, factors in unencing switching speed, dynamic logic, input protection, output buffers, circuit simulation with SPICE. Laboratory work includes design and layout of a simple nMOS IC that is fabricated and returned for testing.

Prerequisite: ELEC 3500.

Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4700 [0.5 credit] (formerly 97.470*)

Modeling of Integrated Devices

The operation and modeling of integrated semiconductor devices. Topics include: physical models, analytic device models, their limitations and, where appropriate, their implementation in commercial circuit simulators, parameter extraction and numerical simulation.

Prerequisite: ELEC 3908.

Lectures three hours a week, problem analysis two hours alternate weeks.

ELEC 4702 [0.5 credit] (formerly 97.472*)

Fiber Optic Communications

Fundamentals of optoelectronics with application to fiber optic communications. Optical fibre: modes, losses, dispersion, splices and coupling to sources. Optical sources: LEDs and laser diodes. Optical detectors: photoconductor, pin and avalanche photodiodes. Optical receiver design. Fiber optic communications systems: intensity modulation/direct detection; coherent homodyne or heterodyne detection.

Prerequisites: ELEC 3908 and ELEC 3909.

Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4705 [0.5 credit] (formerly 97.475*)

Electronic Materials, Devices and Transmission Media

Review of solid-state theory, conductors, semiconductors, superconductors, insulators, and optical and magnetic properties. Devices used in modern high speed electronic and communication systems: transistors, lasers, photodiodes, fiber optics, Josephson junctions. Implications of material properties on fabrication and operation of devices and circuits.

Precludes additional credit for SYSC 4705.

Prerequisite: Fourth-year registration. Not available for credit to students in Electrical Engineering or Engineering Physics.

Lectures three hours a week.

ELEC 4706 [0.5 credit] (formerly 97.476*)

Digital Integrated Electronics

Lectures and hands-on experience introduce advanced concepts in digital interfacing and hardware simulation. Industry standard VME bus operation, VHDL programming and simulation, programmable logic devices, memory devices. A modern laboratory supports VME multiprocessing, VHDL modeling and hardware design.

Prerequisite: ELEC 3500.

Lectures two hours a week, laboratory three hours a week.

ELEC 4707 [0.5 credit] (formerly 97.477*)

Analog Integrated Electronics

Emphasis on integration of analog signal processing techniques in monolithic IC technology. Continuous active filter design. MOS IC technology. OP amp design. Basic sampled data concepts; Z-transform analysis, switched

capacitor filters. Noise aspects. Bipolar technology: radio frequency IC design.

Prerequisite: ELEC 3509.

Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4708 [0.5 credit] (formerly 97.478*)

Advanced Digital Integrated Circuit Design

VLSI design based on CMOS technology; switching characteristics of CMOS logic circuits; cell libraries; structured design and test, Computer-Aided Design tools, design for testability. Laboratory emphasis on design methods using synthesis from Verilog Code.

Prerequisite: fourth-year registration in Electronics or permission of the Department.

Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4906 [0.5 credit] (formerly 97.496*)

Special Topics in Electrical and Computer Systems Engineering

At the discretion of the Engineering Faculty Board, a course dealing with selected advanced topics of interest to Electrical and Computer Systems engineering students may be offered. (Also listed as SYSC 4906.)

Prerequisite: fourth-year registration.

Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4907 [1.0 credit] (formerly 97.497)

Engineering Project

Student teams develop professional-level experience by applying, honing, integrating, and extending previously acquired knowledge in a major design project. Lectures are devoted to discussing project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.

Prerequisite: fourth-year registration and ELEC 3905 (may be taken concurrently). Certain projects may have additional prerequisites or corequisites.

Lecture one hour a week, laboratory seven hours a week.

ELEC 4908 [1.0 credit] (formerly 97.498)

Engineering Project

Student teams develop professional-level experience by applying, honing, integrating, and extending previously acquired knowledge in a major design project. Lectures are devoted to discussing project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.

Prerequisite: fourth-year registration and ELEC 3905 (may be taken concurrently). Certain projects may have additional prerequisites or corequisites.

Lecture one hour a week, laboratory seven hours a week.