economic analysis including costs and benefits; special features of hydro plants; and appurtenances for hydro plants. **TBA**

303-585B GROUNDWATER HYDROLOGY. 3(3-0-6) (Prerequisite: Permission of instructor.) Groundwater geology; steady-state and transient-state regional groundwater; infiltration and recharge; hydrological cycle; chemical constituents; adsorption/desorption processes; Groundwater exploration techniques; pumping tests; groundwater pollution; diffusion and dispersion; thermal processes; groundwater resource management. **Professor Selvadurai**

● **303-586A EARTHWORK ENGINEERING.** 3(3-0-6) (Prerequisite: Permission of instructor.) Stability of natural slopes and cuts, stability analysis; design of earth and rock fills, dykes and dams; techniques to improve stability; compaction of soil, compaction control; soil improvement by in-situ processes; reinforced earth. **TBA**

● **303-587A PAVEMENT DESIGN.** 3(3-0-6) (Prerequisite: Permission of instructor.) Properties of bituminous materials, design of bituminous concrete mixes, construction control; evaluation of design parameters, factors controlling their variability; soil stabilization; frost effects; stresses and displacements in layered systems, analysis of rigid and flexible pavement systems; design of highway and airport pavements; pavement evaluation and strengthening; recycling. **TBA**

4.5 Department of Electrical and Computer Engineering

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Chair
David A. Lowther; B.Sc.(Lond.), Ph.D.(C.N.A.A.), F.C.A.E., Eng.

Associate Chair
Jonathan P. Webb; B.A. Ph.D.(Cantab.)

Emeritus Professors
Eric L. Adler; B.Sc.(Lond.), M.A.Sc.(Tor.), Ph.D.(McG.), F.I.E.E.E., Eng.
Gerry W. Farnell; B.A.Sc.(Tor.), S.M.(M.I.T.), Ph.D.(McG.), F.I.E.E.E., Eng.
Tomas J.F. Pavlasek; B.Eng., M.Eng., Ph.D.(McG.), Eng.

Professors
Pierre R. Bélanger; B.Eng.(McG.), S.M., Ph.D.(M.I.T.), F.I.E.E.E., Eng.
Maier L. Blostein; B.Eng., M.Eng.(McG.), Ph.D.(III.), F.I.E.E.E., Eng.
Peter E. Caines; B.A.(Oxon.), D.I.C. Ph.D.(Lond.), F.I.E.E.E., F.C.I.A.R.
Clifford H. Champness; M.Sc.(Lond.), Ph.D.(McG.) (part-time)
Frank D. Galiana; B.Eng.(McG.), S.M., Ph.D.(M.I.T.), F.I.E.E.E., Eng.
Peter Kabal; B.A.Sc., M.A.Sc., Ph.D.(Tor.)
Theo Le-Ngoc; M.Eng.(McG.), Ph.D.(Ott.), F.I.E.E.E.
Martin D. Levine; B.Eng., M.Eng.(McG.), Ph.D.(Lond.), F.C.I.A.R., F.I.E.E.E., Eng.
David A. Lowther; B.Sc.(Lond.), Ph.D.(C.N.A.A.), F.C.A.E., Eng.
Boon-Teck Ooi; B.E.(Adel.), S.M.(M.I.T.), Ph.D.(McG.), Eng.
Nicholas C. Rumin; B.Eng., M.Sc., Ph.D.(McG.), Eng.
Jonathan Webb; B.A., Ph.D.(Cantab.)

Associate Professors
James Clark; B.Sc., Ph.D.(Br.Col.)
Frank Ferrie; B.Eng., Ph.D.(McG.)
Vincent Hayward; Dip.d'Ing.(ENSM, Nantes), Doc.Ing.(Orsay), Eng.
Harry Leib; B.Sc.(Technion), Ph.D.(Tor.)
Steve McFee; B.Eng., Ph.D.(McG.)
Hanna Michalska; B.Sc., M.Sc.(Warsaw), Ph.D.(Lond.)
David V. Plant; M.S., Ph.D.(Brown)
Gordon Roberts; B.A.Sc.(Waterloo), M.A.Sc., Ph.D.(Tor.), Eng.
Ishiang Shih; M.Eng., Ph.D.(McG.)

Assistant Professors
Jan Bajcsy; B.Sc.(Harv.), M.Eng., Ph.D.(Prin.)
Benoit Boulet; B.Sc.(Laval), M.Eng.(McG.) Ph.D.(Tor.)
Benoit Champagne; B.Eng., M.Eng.(Montr.), Ph.D.(Tor.)
Jeremy R. Cooperstock; A.Sc.(U.B.C.), M.Sc., Ph.D.(Tor.)
Mourad El-Gamal; B.Sc.(Cairo), M.Sc.(Nashville), Ph.D.(McG.)
Karim Khordoc; B.Eng., M.Eng., Ph.D. (McG.)
Andrew Kirk; B.Sc.(Brist.), Ph.D.(London)
Radu Negulescu; M.Sc.(Romania), M.Sc.(France), Ph.D.(Wat.)
Zilic Zeljko; B.Eng.(Zagreb), M.S.c, Ph.D.(Tor.)

Visiting Professors
Michael Kaplan; M.Sc., Ph.D.(Cornell)
Birendra Prasada; M.Sc.(Ban.), Ph.D.(Lond.)
Jean Regnier; B.Eng., M.Eng.(Montr.), Ph.D.(M.I.T.)

Lecturers
Kenneth L. Fraser; B.Eng., M.Eng.(McG.), Eng.
Florence Danilo; M.Eng.(McG.)
Dennis Giannacopoulos; M.Eng., Ph.D.(McG.)

Associate Members
Martin Buehler; M.Sc., Ph.D.(Yale)
Gregory Dudek; B.Sc.(Queen's), M.Sc., Ph.D.(Tor.)
Alan C. Evans; M.Sc.(Surrey), Ph.D.(Leeds)
William R. Funnell; M.Eng., Ph.D.(McG.)
Henrietta L. Galiana; M.Eng., Ph.D.(McG.)
Jean Gotman; M.E.(Dartmouth, N.S.), Ph.D.(McG.)
Robert E. Kearney; M.Eng., Ph.D.(McG.)
Bruce Pike; M.Eng., Ph.D.(McG.)

Adjunct Professors
Vinod K. Agarwal, Eduard Cerny, Danny Grant, Paul Freedman, M. Gavrilovic, Jeremiah F. Hayes, Cheng K. Jen, Geza Joos, Stanley Kubina, Irene Leszkowicz, Lin Lin, Miguel Marin, Donald McGillis, Douglas O'Shaughnessy, Januz Rajski, Fazlollah M. Reza, Farouk Rizk, Mohamad A. Sawan, Mohammad R. Soleymani, Oryal Tanir, Lucjan A. Wegrowicz.

General Information on Programs

The Department of Electrical and Computer Engineering offers undergraduate degree programs in Electrical Engineering, Electrical Engineering (Honours), and Computer Engineering. All programs provide students with a strong background in mathematics, basic sciences, engineering science, engineering design and complementary studies, in conformity with the requirements of the Canadian Engineering Accreditation Board (CEAB).

The program in Electrical Engineering gives students a broad understanding of the key principles that are responsible for the extraordinary advances in the technology of computers, microelectronics, automation and robotics, telecommunications and power systems. These areas are critical to the development of our industries and, more generally, to our economy. A graduate of this program is exposed to all basic elements of electrical engineering and can function in any of our client industries. This breadth is what distinguishes an engineer from, say, a computer scientist or physicist.

The program in Electrical Engineering (Honours) is designed for students who wish to pursue postgraduate work and look to a career in advanced research and development. The technical complementaries are selected from graduate courses, facilitating the transition to postgraduate studies. Students in this curriculum benefit from smaller classes and have more contact with professorial staff and graduate students. However, the program is quite demanding. Students are expected to register for at least 14 credits per semester; they may register for a smaller number only with the permission of the Chair of this Department. Students in the Honours program must maintain a minimum GPA of 3.00. Those who fail to maintain this standard are transferred to the regular program.

The program in Computer Engineering provides students with greater depth and breadth of knowledge in the hardware and software aspects of computers. Students are exposed to both theoretical and practical issues of both hardware and software in well-equipped laboratories. Although the program is designed to meet the growing demands by industry for engineers with a strong back-

ground in modern computer technology, it also provides the underlying depth for graduate studies in all fields of Computer Engineering.

In addition to technical complementary courses, students in all three programs take general complementary courses in social sciences, administrative studies and humanities. These courses allow students to develop specific interests in areas such as psychology, economics, management or political science.

Entrance Requirements and Advanced Standing

The curricula for the various programs offered by the Department are outlined below. Students entering Electrical or Computer Engineering from CEGEP may obtain advanced credit for 189-260 Intermediate Calculus by passing the Advanced Credit examination described in section 2.3.

Entry into the Honours Program

The Honours Program is a limited enrollment program and entry is highly competitive. There is no direct entry to the Honours program in the first year. Students may enter the Honours Program in the following ways:

– Students from CEGEP (7 semester) will be admitted, on the basis of their grades, at the start of the third semester.

– Students from outside Quebec (8 semester) will be admitted, at the start of the fifth semester, on the basis of their grades.

Though not required to do so, students in the Honours Program or wishing to enter the Honours Program are encouraged to take the following advanced math and physics courses:

189-325	Ordinary Differential Equations	instead of 189-261
189-247	Linear Algebra	instead of 189-270
189-248	Advanced Calculus I	instead of 189-265
189-249	Advanced Calculus II	instead of 189-381
198-251	Mechanics	instead of 303-281

To remain in the Honours program and to be awarded the Honours Degree, a student must have completed at least 14 credits in each semester since entering Electrical Engineering and maintained a CGPA of at least 3.00 since entering Electrical Engineering. For more information, please contact the Departmental office at (514) 398-7344.

CURRICULUM FOR THE B.ENG. DEGREE IN ELECTRICAL ENGINEERING (HONOURS)

REQUIRED COURSES		COURSE CREDIT	
Non-Departmental Courses			
189-260	Intermediate Calculus	3	
189-247*	Linear Algebra	3	
or 189-270	Applied Linear Algebra (3)		
189-248*	Advanced Calculus I	3	
or 189-265	Advanced Calculus (3)		
189-249	Advanced Calculus II	3	
or 189-381	Complex Variables & Transforms (3)		
189-325	Ordinary Differential Equations	3	
or 189-261	Differential Equations (3)		
198-251	Mechanics	3	
or 303-281	Analytical Mechanics (3)		
198-271	Quantum Physics	3	
306-221	Engineering Professional Practice	1	
306-310	Engineering Economy	3	
308-202	Intro. to Computer Science I	3	
455-206	Communication in Engineering	3	**31**

** CGPA of 3.30 is required to register for 189-247 and 189-248.*

Departmental Courses			
304-200	Fundamentals of Electrical Engineering	3	
304-210	Circuit Analysis	5	
304-221	Intro to Computer Engineering I	3	
304-222	Intro to Computer Engineering II	3	
304-303	Signals & Systems I	3	
304-304	Signals & Systems II	3	
304-305	Probability & Random Sig. I	3	
304-323	Digital System Design	5	
304-330	Electronic Circuits I	3	
304-334	Electronic Circuits II	5	
304-351	Electromagnetic Fields	3	
304-352	EM Waves and Optics	3	
304-361	Power Engineering	3	
304-498	Honours Thesis I	3	
304-499	Honours Thesis II	3	**51**

COMPLEMENTARY COURSES

Technical Complementaries **15**

Five technical complementary courses (15 credits), which must be Electrical Engineering Courses at the 500-level (or 304-427, 304-428). Students must choose their technical complementary courses so that they complete at least 9 credits in one of the following concentrations. However, with Departmental approval, the Honours Thesis I and II (304-498 and 304-499) can count as 6 of the 9 credits.

Computer Systems Technology

304-427	Operating Systems
304-428	Software Engineering Practice
304-525	Computer Architecture
304-532	Computer Graphics
304-548	Introduction to VLSI

Control and Automation

304-502	Control Engineering
304-503	Linear Stochastic Systems I
304-504	Computer Control
304-505	Nonlinear Control Systems
304-507	Optimization and Optimal Control
304-512	Digital Signal Processing I
304-529	Image Processing & Communication
304-531	Real Time Systems

Integrated Circuits and Electronics

304-522	Asynchronous Circuits and Systems
304-527	Optical Engineering
304-530	Logic Synthesis
304-533	Physical Basis of Semiconductors
304-534	Analog Microelectronics
304-545	Microelectronics Technology
304-548	Introduction to VLSI
304-571	Optoelectronic Devices
304-573	Microwave Electronics

Power Engineering

304-502	Control Engineering
304-549	Expert Systems in Electrical Design
304-559	Flexible AC Transmission Systems
304-560	Power Systems II
304-563	Power Systems Operation and Planning
304-565	Power Electronics

Telecommunications

304-509	Probability and Random Sig. II
304-511	Intro. to Digital Comm.
304-512	Digital Signal Processing I
304-521	Digital Communications I
304-523	Speech Communications
304-527	Optical Engineering
304-528	Telecom. Network Architecture
304-571	Optoelectronic Devices
304-592	Microwave Theory and Techniques
304-593	Antennas and Propagation
304-596	Optical Waveguides

Laboratory Complementaries **4**

Two 400-level laboratory courses in Electrical Engineering.

General Complementaries **9**
Two courses (6 credits) in Social Sciences, Administrative Studies or Humanities, selected from an approved list (category ii - section 3.3) and one course (3 credits) on the impact of technology (category i - section 3.3) in consultation with an academic advisor. At least one 3-credit course must be from category A (Humanities and Social Sciences) in section 3.3.

TOTAL CREDITS **110**

CURRICULUM FOR THE B.ENG. DEGREE IN ELECTRICAL ENGINEERING (REGULAR)

REQUIRED COURSES		COURSE CREDIT	
Non-Departmental Courses			
189-260	Intermediate Calculus	3	
189-261	Differential Equations	3	
or 189-325	Ordinary Differential Equations (3)		
189-265	Advanced Calculus	3	
or 189-248*	Advanced Calculus (3)		
189-270	Applied Linear Algebra	3	
or 189-247*	Linear Algebra (3)		
189-381	Complex Variables & Transforms	3	
198-271	Quantum Physics	3	
303-281	Mechanics	3	
or 198-251	Mechanics (3)		
306-221	Engineering Professional Practice	1	
306-310	Engineering Economy	3	
308-202	Intro. to Computing I	3	
455-206	Communication in Engineering	3	**31**

** CGPA of 3.30 is required to register for 189-247 and 189-248.*

Departmental Courses			
304-200	Fundamentals of Electrical Engineering	3	
304-210	Circuit Analysis	5	
304-221	Intro to Computer Engineering I	3	
304-222	Intro to Computer Engineering II	3	
304-303	Signals & Systems I	3	
304-304	Signals & Systems II	3	
304-305	Probability & Random Sig. I	3	
304-323	Digital System Design	5	
304-330	Electronic Circuits I	3	
304-334	Electronic Circuits II	5	
304-351	Electromagnetic Fields	3	
304-352	EM Waves and Optics	3	
304-361	Power Engineering	3	
304-494	Design Project	3	**48**

COMPLEMENTARY COURSES

Technical Complementaries **18**
Six courses (18 credits) from the list of 400-level courses in Electrical Engineering that must include 9 credits (3 courses) from one of the areas of concentration listed below:

Computer Systems Technology
304-424 Human Computer Interaction
304-425 Computer Organization and Architecture
304-427 Operating Systems
304-428 Software Engineering Practice

Control & Automation
304-404 Control Systems
304-412 Discrete Time Signal Processing
304-426 Microprocessor Systems

Integrated Circuits & Electronics
304-425 Computer Organization and Architecture
304-431 Electronic Design
304-432 Physical Basis of Transistor Devices
304-435 Mixed-Signal Test Techniques

Power Engineering
304-404 Control Systems
304-462 Electromechanical Energy Conversion
304-464 Power System Analysis I

Telecommunications*
304-411 Communications Systems I
304-412 Discrete Time Signal Processing
304-413 Communications Systems II
304-414 Intro. to Telecom. Networks
304-451 EM Transmission & Radiation

Laboratory Complementaries **4**
Two 400-level laboratory courses in Electrical Engineering

General Complementaries **9**
Two courses (6 credits) in Social Sciences, Administrative Studies or Humanities, selected from an approved list (category ii - section 3.3) and one course (3 credits) on the impact of technology (category i - section 3.3) in consultation with an academic advisor. At least one 3-credit course must be from category A (Humanities and Social Sciences) in section 3.3.

TOTAL CREDITS **110**

***Enhanced ITT Concentration in Telecommunications**

The International Institute of Telecommunications (IIT) was recently established in Montreal as a center for telecommunications education. It is funded by government and industry, and provides state-of-the-art laboratory facilities and a point of contact between local telecommunications industries and universities. Students in the Electrical Engineering B.Eng. program, who have achieved a grade of B- or better in 304-411, can enter an Enhanced (IIT) Concentration in Telecommunications, as an alternative to the regular, 3-course concentration. The benefits of the Concentration are:

– a guaranteed project lab (304-494) in telecommunications, at IIT or with an IIT company; and
– permission to take a 500-level course in Telecommunications Management at IIT.

To complete the Concentration, students must take these six courses as Technical Complementaries:
304-411 Communications Systems I
304-412 Discrete Time Signal Processing
304-413 Communications Systems II
304-414 Introduction to Telecommunications Networking
304-451 EM Signal Transmission and Radiation
304-5xx Telecommunications Management

In addition, students must take 304-491 (Communications Systems Lab) and complete 304-494 (Design Project) in telecommunications, at IIT or with an IIT company.

There may be an enrolment limitation in this concentration in any given semester.

CURRICULUM FOR THE B.ENG. DEGREE IN COMPUTER ENGINEERING

REQUIRED COURSES		COURSE CREDIT
Non-Departmental Courses		
189-260	Intermediate Calculus	3
189-261	Differential Equations	3
or 189-325	Ordinary Differential Equations (3)	
189-265	Advanced Calculus	3
or 189-248*	Advanced Calculus I (3)	
189-270	Applied Linear Algebra	3
or 189-247*	Linear Algebra (3)	
189-363	Discrete Mathematics	3
189-381	Complex Variables & Transforms	3
303-281	Mechanics	3
or 198-251	Mechanics (3)	
306-221	Engineering Professional Practice	1

306-310	Engineering Economy	3	
308-202	Intro. to Computing I	3	
308-250	Intro. to Computer Science	3	
308-302	Programming Languages	3	
455-206	Communication in Engineering	3	**37**

** CGPA of 3.30 is required to register for 189-247 and 189-248.*

Departmental Courses

304-200	Fundamentals of Electrical Engineering	3	
304-210	Circuit Analysis	5	
304-221	Intro to Computer Engineering I	3	
304-222	Intro to Computer Engineering II	3	
304-303	Signals & Systems I	3	
304-304	Signals & Systems II	3	
304-305	Probability & Random Sig. I	3	
304-321	Introduction to Software Engineering	3	
304-323	Digital System Design	5	
304-330	Electronic Circuits I	3	
304-334	Electronic Circuits II	5	
304-353	Electromagnetic Fields & Waves	3	
304-425	Computer Architecture	3	
304-427	Operating Systems	3	
304-494	Design Project	3	**51**

COMPLEMENTARY COURSES

Technical Complementaries **9**

Three courses (9 credits) selected from the list of courses below:

304-404	Control Systems
304-411	Communications Systems I
304-412	Discrete-Time Signal Processing
304-424	Human-Computer Interaction
304-426	Microprocessor Systems
304-428	Software Engineering Practice
304-431	Electronic Design
304-530	Logic Synthesis
304-526	Artificial Intelligence
304-531	Real-Time Systems
304-532	Computer Graphics
304-548	Introduction to VLSI Systems
308-420	File Systems
308-431	Algorithms & Data Structures
308-535	Computer Networks
308-575	Fundamentals of Parallel Computing

Laboratory Complementaries **4**

Two 400-level laboratory courses in Electrical Engineering

General Complementaries **9**

Two courses (6 credits) in Social Sciences, Administrative Studies or Humanities, selected from an approved list (category ii - section 3.3) and one course (3 credits) on the impact of technology (category i - section 3.3) in consultation with an academic advisor. At least one 3-credit course must be from category A (Humanities and Social Sciences) in section 3.3.

TOTAL CREDITS **110**

COURSES OFFERED BY THE DEPARTMENT

- ● Denotes courses not offered in 2000-01
- ▭ Denotes courses with limited enrolment

All courses with limitations listed for section A01 have a section A02 open to other students but with password control.

Courses with laboratory components: the average number of hours per week of scheduled lab time is indicated by the second of the three bracketed numbers after the course title, e.g. (1-3-2) means 3 hours per week. Lab schedules are determined at the start of classes.

304-200A,B FUNDAMENTALS OF ELECTRICAL ENGINEERING. 3(3-0-6) (Corequisites: 189-261 or 189-325) An introduction to part of the broad scope of electrical engineering: electrostatics, capacitance, conduction, magnetic fields, inductance, circuits and components, sine waves in time and space, electrical machines and transformers, signal amplification. **Professor McFee**

Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-210A,B CIRCUIT ANALYSIS. 5(3-4-8) (Prerequisite: 304-200) Circuit models, KCL and KVL, branch relations, resistive circuit analysis, network theorems, one- and two-port networks, networks in sinusoidal steady-state, power considerations, transient analysis of first- and second-order networks, response to exponential driving functions, frequency response of networks. Laboratory experiments involving basic instrumentation. Measurements on fundamental electrical circuits and systems. **Professor Levine and Professor Michalska**

For A Term : Section A01: Limited to Electrical Honours and Computer Engineering students only.

For B Term : Section A01: Limited to Regular Electrical Engineering students only.

304-221A,B INTRODUCTION TO COMPUTER ENGINEERING I. 3(3-1-5) (Corequisite: 308-202) Data representation in digital computers. Boolean algebra. Basic combinational circuits; their analysis and synthesis. Elements of sequential circuits: latches, flip-flops, counters and memory circuits. Computer structure, central processing unit, machine language. Assemblers and assembler language. **Professor Ferrie**

Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-222A,B INTRODUCTION TO COMPUTER ENGINEERING II. 3(3-1-5) (Prerequisite: 304-221. Corequisite: 308-202) Data structures (arrays, lists, stacks, queues, dequeues and trees) and their machine representation and simple algorithms. Peripheral devices: printers, keyboards, magnetic tape drives, magnetic disc drives. Peripheral interfacing and busses. Introduction to operating systems. System integration. Computer systems and networks. **Professor Lowther**

Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-303A,B SIGNALS AND SYSTEMS I. 3(3-0-6) (Prerequisites: 304-210, 189-270 or 189-247. Corequisite: 189-381 or 189-249.) Elementary continuous and discrete-time signals, impulse functions, basic properties of discrete and continuous linear time-invariant (LTI) systems, Fourier representation of continuous-time periodic and aperiodic signals, the Laplance transform, time and frequency analysis of continuous-time LTI systems, application of transform techniques to electric circuit analysis. **Professor Blostein**

Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-304B SIGNALS AND SYSTEMS II. 3(3-0-6) (Prerequisite: 304-303) Application of transforms to the analysis of LTI single-loop feedback systems, the discrete-time Fourier series, the discrete-time Fourier transform, the Z transform, time and frequency analysis of discrete-time LTI systems, sampling systems, application of continuous and discrete-time signal theory to communications LTI systems. **Professor Blostein**

Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-305A,B PROBABILITY AND RANDOM SIG. I. 3(3-0-6) (Prerequisite: 304-303) The basic probability model, the heuristics of model-building and the additivity of probability; classical models; conditional probability and Bayes rule; random variables and vectors, distribution and density functions, expectation; statistical independence, laws of large numbers, central limit theorem; introduction to random processes and random signal analysis. **Staff**

304-321A INTRODUCTION TO SOFTWARE ENGINEERING. 3(3-1-5) (Prerequisites: 308-203 or 308-250) Design, development and testing of software systems. Software life cycle: requirements analysis, software architecture and design, implementation, inte-

gration, test planning, and maintenance.The course involves a group project. **Professors Negulescu / Cooperstock**

304-323A,B DIGITAL SYSTEM DESIGN. 5(3-6-6) (Prerequisites: 304-210, 304-221, and 455-206) Minimization and synthesis of combinational logic and finite state machines. Synthesis of synchronous and asynchronous sequential circuits. Principles of control design. Basic concepts in design for testability. The laboratory experiments involve the design and testing of digital systems using small and medium scale integrated circuits. CAD software is used in the design process. **Professor Clark**

For A Term : Section A01: Limited to Regular Electrical Engineering students only.

For B Term : Section A01: Limited to Electrical Honours and Computer Engineering students only.

304-330A,B ELECTRONIC CIRCUITS I. 3(3-0-6) (Prerequisite: 304-210) Operational amplifier circuits; conduction in semiconductors, PN junction diodes, diode circuit applications; JFET, MOSFET and BIPOLAR transistors, terminal characteristics, small and large signal models; simple amplifier configurations, three-terminal properties of small-signal models; frequency response of simple amplifier configurations; simple multistage amplifiers. **Professor Plant**

Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-334A,B ELECTRONIC CIRCUITS II. 5(3-6-6) (Prerequisite: 304-303, 304-330 and 455-206) Differential and multistage amplifiers, power amplifiers, feedback amplifiers, active filters, tuned amplifiers, oscillators; MOS and BIPOLAR digital circuits including gates, latches and multivibrators; A/D and D/A conversion techniques. **Professor Roberts**

For A Term : Section A01: Limited to Electrical Honours and Computer Engineering students only.

For B Term : Section A01: Limited to Regular Electrical Engineering students only.

304-351A,B ELECTROMAGNETIC FIELDS. 3(3-1-5) (Prerequisites: 304-200 and 189-265) Maxwell's equations, electrostatics, magnetostatics and induction for power-frequency electrical engineering problems. **Professor Kirk**

Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-352A EM WAVES AND OPTICS. 3(3-1-5) (Prerequisite: 304-351) Transient and steady state wave propagation in transmission lines. Telephone and radio frequency lines. Smith's chart and impedance matching. Maxwell's equations, Helmholtz's equations, Poynting's theorem. Plane waves, polarization, Snell's law, critical and Brewster's angle. Rectangular waveguides, optical fibres, dispersion. Radiation and antennas. **Professor Kirk**

Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-353A ELECTROMAGNETIC FIELDS AND WAVES. 3(3-1-5) (Prerequisites: 304-210 and 189-265) Maxwell's equations. Waves in free space and on transmission lines. Electric and magnetic force and energy. Magnetic materials. Faraday's law. Applications to engineering problems. **Professor Webb**

304-361A POWER ENGINEERING. 3(3-0-6) (Prerequisite: 304-210, 304-351) Characteristics and components of power systems. Generation, transmission and utilization of electric power. 3-phase ac and dc systems. Fundamentals of electromechanical energy conversion. Ampere and Faraday's law. Magnetic circuits. Systems of coupled coils. Torque and force. Rotating magnetic fields. Basic rotating machines. **Professor Galiana**

304-404A CONTROL SYSTEMS. 3(3-0-6) (Prerequisite: 304-303) Modelling of engineering systems. State variables. State and transfer function descriptions. Observability and controllability. Stability, Realizations. Performance limitations. Open-loop, feedforward, closed-loop configurations. Performance specifications. The Nyquist criterion; stability margins, unstructured uncertainty and robust stability. Classical design. Systems with delay. Pole placement, linear quadratic design. Observers, controllers based on separation. **Professor Michalska**

304-411A COMMUNICATIONS SYSTEMS I. 3(3-0-6) (Prerequisite: 304-304 and 304-305) Communication system models; AM and FM modulation, performance of AM and FM systems in noise; sampling, PCM and DPCM techniques; FDM and TDM multiplexing systems; baseband digital transmission over bandlimitted channels, digital modulation and detection techniques; illustrative examples of subscriber loop telephone systems, cable TV systems and broadcasting systems. **Professor Leib**

304-412B DISCRETE TIME SIGNAL PROCESSING. 3(3-0-6) (Prerequisite: 304-304) Discrete-time signals and systems; Fourier and Z-transform analysis techniques, the discrete Fourier transform; elements of FIR and IIR filter design, filter structures; FFT techniques for high speed convolution; quantization effects. **Professor Kabal**

304-413B COMMUNICATIONS SYSTEMS II. 3(3-0-6) (Prerequisite: 304-411) Introduction to radio communications; satellite communication systems; the cellular concept; fading channel models, digital modulation techniques over fading channels, diversity systems, spread spectrum techniques; fixed assignment multiple access (FDMA, TDMA, CDMA), duplexing methods (FDD, TDD); illustrative examples of terrestrial mobile systems, fixed wireless systems, LEOs, etc.; overview of standardization activities. **Staff**

304-414B INTRO. TO TELECOM. NETWORKS. 3(3-0-6) (Prerequisites: 304-411 and 304-222) Introduction to physical and software architecture of modern networks and to network control and signalling systems: multiplexing and the multiplexing hierarchy, links and link formatting (SONET), circuit and packet switching, protocol stacks, network resources management, switch and router architecture, local-area networking, examples (ATM, frame relay, IP overlays, Ethernet). **Professor Regnier**

304-424A HUMAN-COMPUTER INTERACTION. 3(3-4-2) (Prerequisite: 304-222) The course highlights human-computer interaction strategies from an engineering perspective. Topics include user interfaces, novel paradigms in human-computer interaction, affordances, ecological interface design, ubiquitous computing and computer-supported cooperative work. Attention will be paid to issues of safety, usability, and performance. **Professor Cooperstock**

304-425A COMPUTER ORGANIZATION AND ARCHITECTURE. 3(3-0-6) (Prerequisites: 304-222 and 304-323) Design of instruction sets, data path, hard-wired control and microprogramming. Memory hierarchy. Virtual memory organization and management, paging and segmentation. Associative memories and caches. Look ahead systems and pipeline computers. Systolic arrays. Case studies of advanced system organization. **Professor Hayward**

▭ **304-426A,B MICROPROCESSOR SYSTEMS.** 3(1-3-5) (Prerequisites: 304-323 and 455-206) Introduction to current microprocessors, their architecture, programming, interfacing and operating systems. The course includes lectures, use of crossassemblers, and simulators as well as laboratory experiments on actual microprocessor hardware. (This course may be counted as a technical complementary or a lab complementary.) Limited Enrolment (50). **Professor Zilic**

304-427B OPERATING SYSTEMS. 3(3-3-3) (Prerequisite: 304-222) Operating system services, file system organization, disk and cpu scheduling, virtual memory management, concurrent processing and distributed systems, protection and security. Aspects of the DOS and UNIX operating systems and the C programming language. Programs that communicate between workstations across a network. **Professor Khordoc**

304-428B SOFTWARE ENGINEERING PRACTICE. 3(3-4-2) (Prerequisite: 304-321) Software engineering practice in industry, related to the design and commissioning of large software systems. Ethical, social, economic, safety and legal issues. Metrics, project management, costing, marketing, control, standards, CASE tools and bugs. The course involves a large team project. **Professor Negulescu**

▭ **304-431A ELECTRONIC DESIGN.** 3(2-4-3) (Prerequisites: 304-323 and 304-330) The computer-aided design of digital circuits. Hardware description languages, automatic synthesis, design for testability, technology mapping, simulation, timing analysis, generation of test vectors and fault coverage analysis. CAE tools supporting this design methodology are presented in the laboratory. The course includes a design project based on the gate ar-

ray technology. This course may be counted as a technical complementary or a lab complementary. Limited enrolment (30).
Professor El-Gamal

304-432B PHYSICAL BASIS OF TRANSISTOR DEVICES. 3(3-0-6) (Prerequisites: 304-330, 304-351 and 198-271) Quantitative analysis of diodes and transistors. Semiconductor fundamentals, equilibrium and non-equilibrium carrier transport, and Fermi levels. PN junction diodes, the ideal diode, and diode switching. Bipolar Junction Transistors (BJT), physics of the ideal BJT, the Ebers-Moll model. Field effect transistors, metal-oxide semiconductor structures, static and dynamic behaviour, small-signal models.
Professor Plant

304-435B MIXED-SIGNAL TEST TECHNIQUES. 3 (3-4-2) (Prerequisities: 304-304, 304-305, and 304-334) Purpose and economics of mixed-signal test, DC measurements. Accuracy and repeatability. DSP-based theory and its applications to parametric testing of analog filters, DACs, and ADC. Timing and PLL measurements. Design for Testability. Laboratory experiements will be performed using a Teradyne A567 mixed-signal production tester.
Professor Roberts

304-451B EM TRANSMISSION & RADIATION. 3(3-0-6) (Prerequisite: 304-352) Microwave transmission through waveguides: impedance matching, microwave devices, filters and resonators; microwave transmission though free space; near and far field behaviour of electromagnetic radiators, simple antennas, antenna arrays, practical antenna parameters; the physics of the radio communication channel: reflection, diffraction and scattering and their macroscopic impact (multipath, fading). **Professor Webb**

304-461A ELECTRIC MACHINERY. 3(3-0-6) (Prerequisite: 305-383) (Not open to students in Electrical Engineering.) Electric and magnetic circuits. Notions of electromechanical energy conversion applied to electrical machines. Basic electrical machines - transformers, direct-current motors, synchronous motors and generators, three phase and single phase induction machines. Elements of modern electronically controlled electric drive systems.
Professor Galiana

304-462B ELECTROMECHANICAL ENERGY CONVERSION. 3(3-0-6) (Prerequisite: 304-361) Lumped parameter concepts of electromechanics. Energy, co-energy in the derivation of torques and forces. Examples of electric machines: - dc, synchronous and induction types. Steady-state, transient and stability analysis. Power electronic controllers. **Professor Ooi**

304-464B POWER SYSTEMS ANALYSIS I. 3(3-0-6) (Prerequisite: 304-361) Basic principles of planning and operating interconnected power systems with emphasis on Canadian conditions. Mathematical models for system. Steady-state analysis of power systems, load flow formulation and solution algorithms. Operating strategies, economic dispatch, voltage reactive power regulation, frequency and tie-line power control. **Professor Galiana**

● **304-472A SYSTEMS DESIGN.** 3(2-2-5) (Prerequisite: At least 42 credits of Departmental courses and permission of the instructor.) A design course where the class works as a team to design a large project in either control, power, communications or computer systems. The design is carried out in close collaboration with an industrial partner who acts as a consultant to the project. **Staff**

▭ **304-485B IC FABRICATION LABORATORY.** 2(1-3-2) (Prerequisite: 304-334, 455-206. Corequisite: 304-432 or 304-533) Essential processes for silicon semiconductor device fabrication: etching, diffusion, photolithography. Fabrication of large area PN junctions, selective area PN junctions and MOSFETs. Design and fabrication of simple MOS circuits. Electrical characterization of devices and circuits. Limited Enrolment (8). **Professor Shih**

▭ **304-486B POWER LABORATORY.** 2(1-3-2) (Prerequisites: 455-206, 304-361 and 304-334) Techniques of electric power, efficiency, torque, speed measurements. Starting, running and control of electric machines: dc, synchronous, induction types. Power electronic controllers. Each group of students has access to a compact experiment bench containing a set of micro-machines and all the necessary equipment. Limited Enrolment (14). **Professor Ooi**

▭ **304-487A,B COMPUTER ARCHITECTURE LABORATORY.** 2(0-3-3) (Prerequisite: 455-206. Corequisite: 304-425 or 304-525) Basic software tools used in the design, synthesis and analysis of computer and communication systems such as data-paths, switching circuits, and arithmetic and logic circuits. Behavioral and structural modeling of hardware designs in the IEEE standard hardware description language VHDL. Synthesis and implementation of hardware designs using Programmable Logic Devices. Limited enrollment (50). **Professor Hayward**

▭ **304-488B HIGH FREQUENCY LABORATORY.** 2(1-3-2) (Prerequisite: 455-206. Corequisite: 304-451 or 304-592) High frequency measurement techniques. Vector network analyzer and spectrum analyzer. Resistors, capacitors and inductors at high frequencies. High-level signal handling of a high-frequency bandpass amplifier. Electromagnetic interference (EMI) and spectrum coordination. Cavity resonators. Standing waves in waveguides. Reciprocity of microwave networks. Scattering parameters of a microstrip network. Limited Enrolment (20). **Mr. Fraser**

▭ **304-490A,B DIGITAL SIGNAL PROCESSING LABORATORY.** 2(0-3-3) (Prerequisite: 455-206. Corequisite: 304-412 or 304-512) Experiments involving the digital processing of signals using computer-aided design tools for design, processing and visualization and real-time processing using DSP chips. Filter structures and design, multi-rate signal processing, filter banks, fast transforms, adaptive filtering, signal coding and quantization. Limited Enrolment (30). Password card required. **Professor Kabal**

▭ **304-491A,B COMMUNICATION SYSTEMS LABORATORY.** 2(0-3-3) (Prerequisite: 455-206. Corequisite: 304-411 or 304-511) Experimental studies and simulation of analog and digital transmission techniques. Performance of AM and FM systems. FSK and PSK modulation techniques and spectra. Sampling of analog signals, PCM and TDM techniques. Limited Enrolment (30). Password card required. **Professor Leib**

▭ **304-493B CONTROL AND ROBOTICS LABORATORY.** 2(0-3-3) (Prerequisite: 455-206. Corequisite: 304-404 or 304-502) Experimental studies for the design of control systems, with particular emphasis on motion control as applicable to robotics. Fundamentals of sensors and actuators. Linear compensator specification and design in the time and the frequency domain. Pole placement. Effect of model uncertainty on performance. Limited Enrolment (16). **Professor Hayward**

▭ **304-494A,B ELECTRICAL ENGINEERING DESIGN PROJECT.** 3(0-5-4) (Prerequisites: 455-206 and at least 42 Deparatmental credits.) A laboratory design project undertaken with close supervision by a staff member. The project consists of defining an engineering problem and seeking the solution through experimental investigation. Results are reported in a seminar at the end of term and in a technical paper. Limited Enrolment (50). **Mr. Fraser**

304-498A,B,C HONOURS THESIS I. 3(0-3-6) (Prerequisite: 455-206 and at least 42 Departmental credits.) A research project undertaken with close supervision by a staff member. The work consists of defining an engineering problem, reviewing the associated literature, and seeking the solution through experimental investigation. A literature review and a written thesis proposal are required along with a seminar presentation at end of term. **Mr. Fraser**

304-499A,B,C HONOURS THESIS II. 3(0-3-6) (Prerequisite: 304-498) A research project undertaken with close supervision by a staff member. A continuation of 304-498. The work consists of carrying out the research plan developed in 304-498 along with a seminar presentation at end of term. **Mr. Fraser**

304-501A LINEAR SYSTEMS. 3(3-0-6) (Prerequisite: 304-303) State equations and input-output descriptions of linear systems: basic properties and solution. Observability and controllability. Matrix Fraction Descriptions. Canonical forms. Feedback synthesis: linear quadratic control problems, pole placement, observers and compensators. **Staff**

304-502A CONTROL ENGINEERING. 3(3-0-6) (Prerequisites: 304-303, 304-305) Modeling of engineering systems, simulation. Linear systems theory. Performance limitations. Stability of single-input-single-output closed-loop systems. Classical design in the

frequency domain. Sampled-data implementation of continuous-time design. **Professor Bélanger**

304-503B LINEAR STOCHASTIC SYSTEMS I. 3(3-0-6) (Prerequisites: 189-587 or 304-510) Stochastic processes: stationary processes, the Wold decomposition. The spectral representation theorem. Linear stochastic systems. Estimation Theory: Wiener-Kolmogorov prediction theory, Kalman filtering. Stochastic realization theory. Linear quadratic control theory. **Professor Caines**

● **304-504B COMPUTER CONTROL.** 3(3-0-6) (Prerequisites: 304-404 or 304-502 and 304-305) Sampling and aliasing. Conversion of continuous-time controllers using s-to-z transformations; pre- and post-filtering. Discrete time state representation and z-transfer function of sampled linear, time-invariant systems. Correspondence between system theoretic results for continuous- and discrete-time systems. Sampled-data design, including deadbeat and LQG control. Quantization. Specification of computer system. Study of control system design through case studies. **Staff**

304-505B NONLINEAR CONTROL SYSTEMS. 3(3-0-6) (Prerequisite: 304-501) Basic ODE formulation of non-linear systems; structural properties; Lyapunov and LaSalle stability theory and nonlinear and multivariable controller design; input-output stability; small gain theorem, conservation, passivity; system linearization, zero and inverse dynamics and regulator design; discontinuous and sliding mode control; applications to deterministic adaptive control. **Professors Caines and Michalska**

304-507A OPTIMIZATION AND OPTIMAL CONTROL. 3(3-0-6) (Prerequisites: 189-265 or 189-248 and 189-270 or 189-247) General Introduction to optimization methods including steepest descent, conjugate gradient, Newton algorithms. Generalized matrix inverses and the least squared error problem. Introduction to constrained optimality; convexity and duality; interior point methods. Introduction to dynamic optimization; existence theory, relaxed controls, the Pontryagin Maximum Principle. Sufficiency of the Maximum Principle. **Professor Michalska**

304-509A PROBABILITY AND RANDOM SIG. II. 3(3-0-6) (Prerequisites: 304-304 and 304-305) Multivariate Gaussian distributions; finite-dimensional mean-square estimation (multivariate case); principal components; introduction to random processes; weak stationarity: correlation functions, spectra, linear processing and estimation; Poisson processes and Markov chains: state processes, invariant distributions; stochastic simulation. **Staff**

304-510B RANDOM PROCESSES. 3(3-0-6) (Prerequisite: 304-509) Finite-dimensional distribution functions. Estimation, Orthogonal Projection Theorem. Linear stochastic systems; Kalman filtering. Stationary stochastic processes: spectral Representation Theorem, Wiener filtering, Wold decomposition; ARMA processes. Brownian Motion; Ito integral and stochastic differential equations; forward and backward equations for diffusions. Ergodic theorems. Stochastic dynamic programming. Applications to communication and control systems. **Professor Caines**

304-511A INTRO. TO DIGITAL COMM. 3(3-0-6) (Prerequisite: 303-304. Corequisite: 304-509.) (An advanced version of 304-411.) Amplitude and angle modulation including AM, FM, FDM and television systems; introduction to random processes; sampling and quantization, PCM systems, TDM; digital modulation techniques, Maximum-Likelihood receivers, synchronization issues; elements of information theory including information sources, source coding and channel capacity. **Professor Leib**

304-512A DIGITAL SIGNAL PROCESSING I. 3(3-0-6) (Prerequisite: 304-304 and 304-305) Review of discrete-time transforms, sampling and quantization, frequency analysis. Structures for IIR and FIR filters, coefficient quantization, roundoff noise. The DFT, its properties, frequency analysis and filtering using DFT methods, the FFT and its implementation. Multirate processing, subsampling and interpolation, oversampling techniques. **Professor Kabal**

● ▭ **304-513B ANALOG CIRCUIT SIMULATION.** 3(3-0-6) (Prerequisite: 304-334) Formulation of network equilibrium equations - tableau formulation. Solution in the frequency domain - sparse matrix techniques. The dc solution - electronic models, solution of nonlinear algebraic equations. Solution in the time domain - dynamic models, solution techniques for stiff systems. Design and optimization - sensitivity analysis in the frequency domain, tolerancing. Time domain design. Limited Enrolment (20). Password Card required. **Professor Rumin**

304-521A DIGITAL COMMUNICATIONS I. 3(3-0-6) (Prerequisite: 304-411 or 304-511. Corequisite: 304-509) Modulation: orthogonal and biorthogonal signalling, MPSK, QAM, modulation with memory. Detection: coherent, noncoherent and differentially coherent detection, performance issues and channel capacity, synchronization. Coding: block and convolutional codes, fast Hadamard Transform decoding, Viterbi algorithm, turbo-codes. Bandlimited channels: intersymbol interference , spectral shaping, correlative coding, data estimation and channel equalization. **Professor Kabal**

304-522A ASYNCHRONOUS CIRCUITS AND SYSTEMS. 3(3-3-3) (Prerequisite: 304-323) Specification of asynchronous behaviors. Asynchronous logic components. Hierarchical design and verification. Concurrency issues: deadlock, livelock, starvation, safety. Timing issues. Modern design styles: handshaking, micropipelines. Asynchronous analysis models for protocols and software. **Professor Negulescu**

304-523B SPEECH COMMUNICATIONS. 3(3-0-6) (Prerequisite: 304-412 or 304-512) Articulatory and acoustic descriptions of speech production, speech production models, speech perception, digital processing of speech signals, vocodors using formant, linear predictive and cepstral techniques, overview of automatic speech recognition systems, speech synthesis systems and speaker verification systems. **Dr. O'Shaughnessy**

304-525B COMPUTER ARCHITECTURE. 3(3-0-6) (Prerequisites: 304-222 and 304-323) Complex and reduced instruction set processors. The design and analysis of memory systems. Interconnection networks. Architecture design. Pipelining, parallel processing, array processors, associative computing. Systolic and wavefront architectures, data flow computers, supercomputing. Fault-tolerant computing. Performance evaluation of computer systems. **Staff**

304-526B ARTIFICIAL INTELLIGENCE. 3(3-0-6) (Prerequisite: 304-222) Fundamentals of automated reasoning in expert systems: Semantics and satisfaction, inference procedures, logical implication, proofs, unification, resolution, soundness and completeness. Searching strategies and problem solving. Limits of monotonic logic: forms of non-monotonic reasoning. The course includes a term project which consists of writing a small inference engine in Lisp. **Professor Cooperstock**

304-527A,B OPTICAL ENGINEERING. 3(3-0-6) (Prequisite: 304-304 and 304-352) A structure introduction to modern optical engineering. Topic covered include the propagation of light through space, refraction, diffraction, polarization, lens systems, ray-tracing, aberrations, computer-aided design and optimization techniques, Gaussian beam analysis, micro-optics and computer generated diffractive optical elements. Systems and applications will be stressed throughout. **Professor Kirk**

304-528A TELECOM. NETWORK ARCHITECTURE. 3(3-0-6) (Prerequisite: 304-411 or 304-511. Corequisite: 304-509) Organization of large, highspeed, multiservice telecommunication networks. Connection hierarchies, protocol stacks, transmission formats. Local-area networking: Token Ring and Ethernet. Multiplexing for wide-area transport: performance modelling and analysis, traffic scheduling and shaping. Routing and flow control. Switch architecture: performance criteria, buffer management, routers versus switches and hybrids. **Dr. Kaplan**

304-529A IMAGE PROCESSING & COMMUNICATION. 3(3-0-6) (Prerequisite: 304-304) Introduction to vision in man and machine; computer vision systems; biological vision systems; biological signal processing; edge detection; spatial- and frequency-domain processing; color. Low-level visual processing in computer vision, psychophysics, and neurobiology, and their similarities and differences. **Professor Levine**

304-530B LOGIC SYNTHESIS. 3(3-2-4) (Prerequisite: 304-323) The place of logic synthesis in microelectronics. Representations of Boolean functions: logic covers, binary decision diagrams.Two-

level synthesis algorithms, Espresso. Multi-level synthesis to Boolean networks: don't care methods, algebraic optimizations, delay modelling. Sequential synthesis: state-based optimizations, state assignment, network optimizations. Technology mapping: library cell and FPGA mapping. **Professor Zilic**

304-531B REAL TIME SYSTEMS. 3(3-3-3) (Prerequisites: 304-222 and 304-323) Real-time engineering applications of computers to on-line control, communication systems and data acquisition. Aspects of hardware, software, interfacing, operating systems, and their integration into a complete system are addressed. **Professor Khordoc**

304-532A COMPUTER GRAPHICS. 3(3-3-3) (Prerequisite: 304-222) Introduction to computer graphics systems and display devices: raster scan, scan conversion, graphical input and interactive techniques - window environments; display files: graphics languages and data structures: 2D transformations; 3D computer graphics, hidden line removal and shading; graphics system design; applications. Laboratory project involving the preparation and running of graphics programs. **Ms. Leszkowicz**

304-533B PHYSICAL BASIS OF SEMICONDUCTOR DEVICES. 3(3-0-6) (Prerequisites: 304-330, 304-351 and 198-271) Quantitative analysis of diodes and transistors. Semiconductor fundamentals, equilibrium and non-equilibrium carrier transport, and Fermi levels. PN junction diodes, the ideal diode, and diode switching. Bipolar Junction Transistors (BJT), physics of the ideal BJT, the Ebers-Moll model. Field effect transistors, metal-oxide semiconductor structures, static and dynamic behaviour, small-signal models. **Professor Plant**

304-534A ANALOG MICROELECTRONICS. 3(3-0-6) (Prerequisite: 304-334) Design of analog ICs using specialized analog CAD tools such as SPICE. Voltage and current amplifier design which encompasses the study of biasing circuits, current sources and mirrors, input and output stages, and frequency compensation; precision reference sources; analog multipliers; oscillators; waveform generators and shaping circuits, and analog switches. **Professor Roberts**

● **304-543B NUMERICAL METHODS IN ELECTRICAL ENG.** 3(3-0-6) (Prerequisites: 304-222, 304-334 and 304-352) DC resistor networks and sparse matrix methods. Nonlinear electric and magnetic circuits: curve-fitting; the Newton-Raphson method. Finite elements for electrostatics. Transient analysis of circuits: systems of Ordinary differential equations; stiff equations. Transient analysis of induced currents. Solution of algebraic eigenvalue problems. Scattering of electromagnetic waves: the boundary element method; numerical integration. **Professor Webb**

● **304-545A MICROELECTRONICS TECHNOLOGY.** 3(3-0-6) (Prerequisite: 304-432 or 304-533) Basic techniques in the fabrication of microelectronic circuits. Four-point probe, alloyed contacts, diffusion processes, ion implantation epitaxy, silicon dioxide, photolithography, selected diffusion and metallization, transistor fabrication, dry etching, monolithic integrated circuits, isolation, mask making, thin and thick film components, MOS gate voltage and integrated circuits. **Professor Champness**

304-547A FINITE ELEMENTS IN ELECTRICAL ENGINEERING. 3(3-0-6) (Prerequisites: 304-222 and 304-352) Finite elements for electrostatics. Energy minimization. Semi-conductors. Nonlinear magnetics and Newton-Raphson. Axisymmetric problems. Capacitance, inductance, and resistance through finite elements. Resonance: cavities, waveguides. High order and curvilinear elements. **Professor McFee**

▭ **304-548A INTRODUCTION TO VLSI SYSTEMS.** 3(2-2-5) (Prerequisites: 304-334 and 304-323) An interdisciplinary course for electrical engineering and computer science students. A structured design methodology for managing the complexity of VLSI system design. Sufficient information on integrated devices, circuits, digital subsystems and system architecture is presented to enable students to span the range of abstractions from device physics to VLSI digital systems. Limited Enrolment (20). Password card required. **Professor Rumin**

304-549A EXPERT SYSTEMS IN ELECTRICAL DESIGN. 3(3-0-6) (Prerequisites: 304-361 and 304-494) Design processes in electrical engineering. Hierarchical design. Computer aided design. Expert system technology. Device representations, heuristics and structures, algebraic models. Design versus diagnosis, "Shallow" and "Deep" systems, second generation (multi-paradigm) systems. Shells and their uses in design systems. Knowledge acquisition systems. **Professor Lowther**

304-559X FLEXIBLE AC TRANSMISSION SYSTEMS. 3(3-0-6) (Prerequisite: 304-361 and 304-334) Operating principles of controllers of flexible AC transmission systems (FACTS). Transformer, thyristor and gate- turn- off thyristor (GTO) technologies. Modulation methods: harmonic elimination, pulse width modulation. Applications in: shunt and series advanced static VAr Controllers (ASVC), phase shifters, unified power flow controllers (UPFC). **Professor Ooi**

● **304-560A POWER SYSTEMS ANALYSIS II.** 3(3-0-6) (Prerequisite: 304-464) Main power system analysis tools for system and component design. Balanced and unbalanced operation of three-phase systems, symmetrical components, fault analysis, transient behaviour due to switching and lightning. Applications for a wide range of typical situations such as line design, circuit breaker rating, protective relaying, and insulation coordination are covered. **Staff**

304-563B POWER SYSTEMS OPERATION AND PLANNING. 3(3-0-6) (Prerequisite: 304-361) Design and operation of large scale power systems: Temporal, spatial and hierarchical decomposition of tasks. Local vs. distributed control. Load-frequency control. Voltage and speed regulation. Interconnected power systems. Power flow. Security states. Optimal operation of power systems. Power system reliability. **Professor Galiana**

304-565A INTRODUCTION TO POWER ELECTRONICS. 3(3-0-6) (Prerequisite: 304-334) Semiconductor power switches – thyristors, GTO's, bipolar transistors, MOSFET's. Switch mode power amplifiers. Buck and boost principles. Modulation methods -PWM, delta, hysteresis current control. Rectifiers, inverters, choppers. **Professor Ooi**

304-571A OPTOELECTRONIC DEVICES. 3(3-0-6) (Prerequisites: 304-304, 304-305, 304-352 and 304-533) Physical basis of optoelectronic devices including Light Emitting Diodes, semiconductor optical amplifiers, semiconductor lasers, quantum well devices, and solid state lasers. Quantitative description of detectors, optical modulation, optical logic devices, optical interconnects, and opto-mechanical hardware. Throughout the course, photonic systems applications will be addressed. **Professor Plant**

304-573A MICROWAVE ELECTRONICS. 3(3-0-6) (Prerequisite: 304-432 or 304-533) Physical basis of modern microwave devices and circuits. Microwave transistors and tunnel diodes, transferred electron devices, transit time devices and infra red devices. Microwave generation and amplification, microwave FET circuits. Noise and power amplification. **Professor Shih**

● **304-578A CRYSTALS AND CONDUCTION.** 3(3-0-6) (Prerequisite: 304-432 or 304-533) Crystal lattices, point symmetry operations, Miller indices, important crystal structures, lattice matrix, reciprocal matrix, characteristics of X-rays, diffraction theory, structure factor. Kinetic theory of gases review, free electron theory of metals, mobility, classical theory anomalies, quantum treatment, density of states, Fermi Dirac distribution, Kronig Penney model, Brillouin zones, band filling, thermionic emission. **Professor Champness**

● **304-592A MICROWAVE THEORY AND TECHNIQUES.** 3(3-0-6) (Prerequisite: 304-352) Transmission lines, waveguides and surface waveguides for large capacity guided microwave trunk communications, microwave circuit theory, Smith's chart, impedance matching and transformation, passive microwave devices, resonators, periodic structures and filters, microwave antennas for satellite communications. **Staff**

● **304-593A ANTENNAS & PROPAGATION.** 3(3-0-6) (Prerequisite: 304-352) Near and far field behaviour of radiators; antennas as a boundary value problem; practical antenna parameters; wire antennas, antenna arrays, aperture methods of antenna analysis;

measurement of input impedance, field patterns, gain and noise; point-to-point propagation, fading beyond the horizon and long distance propagation, ionospheric, atmospheric and earth's surface considerations; tropospheric scatter. **Staff**

● **304-596B OPTICAL WAVEGUIDES.** 3(3-0-6) (Prerequisite: 304-352) Introduction to wave and ray optics, ray equation. Kirchhoff-Huygens diffraction theory, Fourier optics, Gaussian beams, propagation characteristics of optical fibers and dielectric waveguides for wideband optical fiber communication systems, waveguide group velocity and dispersion, thin-film waveguides. Discussion of optical fiber communication systems and guided-wave photonic devices. **Staff**

GRADUATE 600-LEVEL COURSES

Generally, undergraduate students are not permitted to enroll in graduate 600-level courses. However, in exceptional circumstances, the Faculty of Graduate Studies and Research does grant this permission upon the request of the Department on behalf of the student. Please consult the Faculty of Graduate Studies and Research Calendar for 600-level courses.

4.6 Department of Mechanical Engineering

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Chair

Stuart J. Price; B.Sc., Ph.D.(Bristol), P.Eng.

Emeritus Professors

William Bruce; B.A.Sc., M.A.Sc.(Toronto), Eng.
John C. Cherna; Dipl.-Ing.(Swiss Fed. Inst.), Eng., F.E.I.C.
Romuald Knystautas; B.Eng., M.Eng., Ph.D.(McG.), Eng.
Barry G. Newman; M.A.(Cantab.), Ph.D.(Sydney), Eng., F.C.A.S.I., F.R.Ae.S., F.R.S.C. *(Canadair Emeritus Professor of Aerodynamics)*

Professors

Abdul M. Ahmed; B.Sc.(Dhaka), M.Eng., Ph.D.(McG.), Eng.
Jorge Angeles; B.Eng., M.Eng.(UNAM Mexico), Ph.D.(Stanford), Eng., F.A.S.M.E., F.C.S.M.E.
Bantwal R. Baliga; B.Tech.(I.I.T., Kanpur), M.Sc.(Case), Ph.D.(Minnesota)
John H.S. Lee; B.Eng.(McG.), M.Sc.(M.I.T.), Ph.D.(McG.), Eng.
Arun K. Misra; B.Tech.(I.I.T.,Kharagpur), Ph.D.(U.B.C.), P.Eng.
Michael P. Paidoussis; B.Eng.(McG.), Ph.D.(Cantab.), Eng., F.I.Mech.E., F.A.S.M.E., F.A.A.M., F.C.S.M.E., F.R.S.*C. (Thomas Workman Professor of Mechanical Engineering)*

Associate Professors

Martin Buehler; M.Sc., Ph.D.(Yale)
Luca Cortelezzi; M.Sc., Ph.D.(Caltech)
David L. Frost; B.A.Sc.(U.B.C.), M.S., Ph.D.(Caltech), Eng. (Undergraduate Program Coordinator)
Larry B. Lessard; B.Eng.(McG.), M.Sc., Ph.D.(Stanford), Eng.
Dan Mateescu; M.Eng.(Poli.Univ.Buch.), Ph.D.(Rom. Acad. Sci.), Doctor Honoris Causa (Poli.Univ.Buch.)
James A. Nemes; B.Sc.(Maryland), M.S., D.Sc.(GWU) (Graduate Program Coordinator)
Alvin Post; B.S.(Ariz.), M.I.M.(A.G.S.I.M.), M.S.(Stanford), Ph.D.(Hawaii)
Vince Thomson; B.Sc.(Windsor), Ph.D.(McMaster) *(Werner Graupe Professor of Manufacturing Automation)*
Paul J. Zsombor-Murray; B.Eng., M.Eng., Ph.D.(McG.), Eng.

Assistant Professors

Andrew J. Higgins, B.Sc.(Ill.), M.S., Ph.D.(Wash.)
Venkat N. Krovi; B.Tech.(I.I.T., Madras), Ph.D.(Penn.)
Timothy Lee; M.S.(Portland State), Ph.D.(Idaho)
Laurent Mydlarski; B.A.Sc.(Waterloo), Ph.D.(Cornell)

Laboratory Superintendents

G. Dedic, A. Hueppin, G. Savard

Associate Members

R.E. Kearney; B.Eng., M.Eng., Ph.D.(McG.), Biomedical Engineering Unit
B.H.K. Lee; B.Eng., M.Eng., Ph.D.(McG.)
M. Tanzer; M.D., Orthopaedic Surgery

Adjunct Professors

G.G. Bach, R.G. Edwards, L. Kops, K. Mackenzie, W.D. May, H. Moustapha, R. Sumner, T. Yee, D. Zorbas

Mechanical engineers are traditionally concerned with the conception, design, implementation and operation of mechanical systems. Typical fields of work are aerospace, energy, manufacturing, machinery, and transportation. Because of the very broad nature of the discipline there is usually a high demand for mechanical engineers. A recent study indicated that 39% of all engineering openings were for graduates of mechanical engineering.

Many mechanical engineers follow other career paths. Graduate studies are useful for the specialists working in research establishments, consulting firms or in corporate research and development.

To prepare the mechanical engineer for a wide range of career possibilities, there is a heavy stress in our curriculum on the fundamental analytical disciplines. This is balanced by a sequence of experimental and design engineering courses which include practice in design, manufacture and experimentation. In these courses students learn how to apply their analytical groundwork to the solution of practical problems.

Specialist interests are satisfied by selecting appropriate complementary courses from among those offered with a specific subject concentration, such as management, industrial engineering, computer science, controls and robotics, bio-engineering, aeronautics, combustion, systems engineering, etc.

The Department offers an Honours Program which is particularly suitable for those with a high aptitude in mathematics and physics and which gives a thorough grounding in the basic engineering sciences. The complementary courses in this program can be utilized to take courses with applied engineering orientation, such as those offered in the regular program, or if preferred, to obtain an even more advanced education in engineering science.

Options in Aeronautical Engineering, Automation and Design are available for students in either the Regular or Honours Programs who wish to specialize in these areas.

While the program is demanding, there is time for many extracurricular activities. Students are active in such professional societies as the CASI (Canadian Aeronautics and Space Institute), and the SAE (Society of Automotive Engineers), and the ASME (American Society of Mechanical Engineers) and in various campus organizations.

Relations between faculty and students are extremely close. Social functions, at which students and professors meet to exchange views and get to know each other better, are organized frequently.

CURRICULUM FOR THE B.ENG. DEGREE IN MECHANICAL ENGINEERING (REGULAR)

REQUIRED COURSES		COURSE CREDIT	
Non-Departmental Subjects			
189-260A,B	Intermediate Calculus	3	
189-261A,B	Differential Equations	3	
189-265A,B	Advanced Calculus	3	
189-266A,B	Linear Algebra and BVP	4	
303-207A,B	Solid Mechanics	4	
304-461A	Electric Machinery	3	
306-221A,B	Engineering Professional Practice	1	
306-260A,B	Materials Science and Engineering	3	
306-310A,B	Engineering Economy	3	
308-208A,B	Computers in Engineering	3	
455-206A,B	Communication in Engineering	3	**33**
Departmental Courses			
305-201A	Intro. to Mechanical Engineering	2	

305-210A,B	Mechanics I	4	
305-220A,B	Mechanics II	3	
305-240A,B	Thermodynamics I	3	
305-260A,C	Machine Tool Laboratory	2	
305-261B,C	Measurement Laboratory	2	
305-291B	Graphics	3	
305-292A	Design I	3	
305-314A	Dynamics of Mechanisms	3	
305-315A	Dynamics of Vibrations	3	
305-321B	Mechanics of Deformable Solids	3	
305-331A,B	Fluid Mechanics I	3	
305-341A	Thermodynamics II	3	
305-346A,B	Heat Transfer	3	
305-362A,B	Mechanical Laboratory	2	
305-383A,B	Applied Electronics and Instrumentation	3	
305-393B	Design II	3	
305-409B	Numerical Methods in Mechanical Engineering	3	
305-412B	Dynamics of Systems	3	
305-430A	Fluid Mechanics II	3	
305-463D	Mechanical Engineering Project	4	**61**

COMPLEMENTARY COURSES **15**

2 courses (6 credits) at the 300 level or higher to be selected from Mechanical Engineering. For students entering in September, 2000, one of these two courses must be chosen from the following list:

305-343	Energy Conversion
305-413	Control Systems
305-432	Aircraft Structures
305-471	Industrial Engineering
305-472	Case Studies in Project Mgmt
305-495	Design III
305-496	Design IV
305-497	Value Engineering
305-524	Computer Integrated Manufacturing
305-526	Manufacturing and the Environment
305-528	Product Design
305-532	Aircraft Performance, Stability and Control
305-541	Kinematic Synthesis
305-543	Design with Composite Materials
305-554	Microprocessors for Mech. Sys.
305-557	Mechatronic Design
305-565	Fluid Flow & Heat Transfer Equipment
305-572	Mechanics of Robotic Systems I
305-573	Mechanics of Robotic Systems II
305-577	Optimum Design

1 course (3 credits) at the 300-level or higher from the Faculty of Engineering or an approved course in the Faculty of Science, including Mathematics.

2 courses (6 credits), 1 course from the Impact of Technology on Society and 1 course from Humanities and Social Sciences selected from an approved list (see section 3.3).

TOTAL CREDITS **109**

If advanced credit is given for 189-260 Intermediate Calculus (see section 2.3), the total number of credits is reduced by three.

Students entering in September or January must plan their program of studies in accordance with the regulations described in the "Welcome" book. After registering by MARS, students must consult with their academic adviser.

In addition students admitted to the 8-semester program (see section 3.1.2), must take note of the additional courses that are specified in the "Welcome" book. These can also be found on the Faculty website (http://www. engineering. mcgill.ca).

CURRICULUM FOR THE B.ENG. DEGREE IN MECHANICAL ENGINEERING (HONOURS)

REQUIRED COURSES			COURSE CREDIT
Non-Departmental Subjects			
189-260A,B	Intermediate Calculus	3	
189-261A,B	Differential Equations	3	
189-265A,B	Advanced Calculus	3	
189-266A,B	Linear Algebra and BVP	4	
303-207A,B	Solid Mechanics	4	
306-221A,B	Engineering Professional Practice	1	
306-310A,B	Engineering Economy	3	
308-208A,B	Computers in Engineering	3	
455-206A,B	Communication in Engineering	3	**27**
Departmental Courses			
305-201A	Intro. to Mechanical Engineering	2	
305-210A,B	Mechanics I	4	
305-220A,B	Mechanics II	3	
305-240A,B	Thermodynamics I	3	
305-260A,C	Machine Tool Laboratory	2	
305-261B,C	Measurement Laboratory	2	
305-291B	Graphics	3	
305-292A	Design I	3	
305-319B	Mechanics of Systems	3	
305-321B	Mechanics of Deformable Solids	3	
305-331A,B	Fluid Mechanics I	3	
305-341A	Thermodynamics II	3	
305-346A,B	Heat Transfer	3	
305-362A,B	Mechanical Laboratory	2	
305-383A,B	Applied Electronics and Instrumentation	3	
305-403D,N	Thesis	6	
305-404A,B	Thesis	2	
305-409B	Numerical Methods in Mech. Eng.	3	
305-430A	Fluid Mechanics II	3	
305-452A	Mathematical Methods in Engineering	3	
And any three of four below:		9	**68**
305-545A	(3) Advanced Stress Analysis		
305-552B	(3) Advanced Applied Mathematics		
305-562A	(3) Advanced Fluid Mechanics		
305-578B	(3) Advanced Thermodynamics		

COMPLEMENTARY COURSES **15**

3 courses (9 credits) to be selected from those offered by the Department or from other suitable graduate or undergraduate courses.

2 courses (6 credits), 1 course from the Impact of Technology on Society and 1 course from Humanities and Social Sciences selected from an approved list (see section 3.3).

TOTAL CREDITS **110**

Students entering in September or January must plan their program of studies in accordance with the regulations described in the "Welcome" book. After registering by MARS, students must consult with their academic adviser.

In addition students admitted to the 8-semester program (see section 3.1.2), must take note of the additional courses that are specified in the "Welcome" book. These can also be found on the Faculty website (http://www.engineering.mcgill.ca).

LIST OF COMPLEMENTARY COURSES (DEPARTMENTAL)
(Each is 3 credits)

305-343A	Energy Conversion
305-413A	Control Systems
305-432A	Aircraft Structures
305-434A	Turbomachinery
305-447A	Combustion
305-471A	Industrial Engineering
305-472A	Case Studies in Project Mgmt

305-474B Operations Research
305-495A Design III
305-496B Design IV
305-497A Value Engineering
305-500A,B Selected Topics in Mechanical Engineering
305-501A,B Selected Topics in Mechanical Engineering
305-522B Production Systems
305-524B Computer Integrated Manufacturing
305-526C Manufacturing and the Environment
305-528A Product Design
305-529C Discrete Manufacturing Systems
305-530B Mechanics of Composite Materials
305-531B Aeroelasticity
305-532B Aircraft Performance Stability and Control
305-533A Subsonic Aerodynamics
305-534B Air Pollution Engineering
305-537B High Speed Aerodynamics
305-538B Unsteady Aerodynamics
305-539A Computational Aerodynamics
305-540B Design: Modelling and Decision
305-541B Kinematic Synthesis
305-542B Spacecraft Dynamics
305-543A Design with Composite Materials
305-545A Advanced Stress Analysis
305-552B Advanced Applied Mathematics
305-554A Microprocessors for Mech. Sys.
305-555B Applied Process Control
305-557B Mechatronic Design
305-561B Biomechanics of Musculoskeletal Systems
305-562B Advanced Fluid Mechanics
305-565B Fluid Flow & Heat Transfer Equipment
305-572A Mechanics of Robotic Systems I
305-573B Mechanics of Robotic Systems II
305-576A Computer Graphics and Geometric Modelling
305-577A Optimum Design
305-578B Advanced Thermodynamics
305-581A Nonlinear Dynamics and Chaos

TYPICAL PROGRAM OF STUDIES FOR REGULAR OR HONOURS

For students starting their B.Eng. studies in September who have completed the Quebec Diploma of Collegial Studies, a program for the first two semesters of study is given below:

Semester 1 (Fall)
189-260A Intermediate Calculus
305-201A Intro. to Mechanical Engineering
305-210A Mechanics I
305-260A Machine Tool Laboratory
306-221A Engineering Professional Practice
308-208A Computers in Engineering

Semester 2 (Winter)
189-261B Differential Equations
189-265B Advanced Calculus
305-220B Mechanics II
305-261B Measurement Laboratory
305-291B Graphics
455-206B Communication in Engineering

For all Minors and Options, students should complete a special form available from the Undergraduate Program Secretary indicating their intention to take the Minor or the Option.

AERONAUTICAL ENGINEERING OPTION

Students in this Option should take five courses in the area of Aeronautical Engineering. Specifically they must take the following two required courses:

305-532B Aircraft Performance, Stability and Control
305-533A Subsonic Aerodynamics

and at least one of the following:

305-432A Aircraft Structures
305-434A Turbomachinery

The remaining two courses may be chosen from the above or from the following courses:

305-531B Aeroelasticity
305-537B High Speed Aerodynamics
305-538B Unsteady Aerodynamics
305-539A Computational Aerodynamics

All courses must be passed at a level C or better.

Students should also discuss the matter with their adviser and complete a special form indicating their intention to take this Option.

DESIGN OPTION

The Design Option Program is comprised of six courses as follows:

305-495A Design III
305-496B Design IV

Plus any four below:

305-497A Value Engineering
305-540B Design: Modelling and Decision
305-541B Kinematic Synthesis
305-543A Design with Composite Materials
305-557B Mechatronic Design
305-565B Fluid Flow & Heat Transfer Equipment
305-576A Computer Graphics and Geometric Modelling
305-577A Optimum Design

MECHATRONICS OPTION

Students in this option should take six courses in the area of Control, Robotics and/or CAD/CAM. They must take the following four required courses:

305-413A Control Systems
305-554A Microprocessors for Mech. Sys.
305-557B Mechatronic Design
305-572A Mechanics of Robotic Systems I

and two of the following:

305-528A Production Design
305-541B Kinematic Synthesis
305-573B Mechanics of Robotic Systems II
305-576A Computer Graphics and Geometric Modelling
304-502A Control Engineering

COURSES OFFERED BY THE DEPARTMENT

● Denotes courses not offered in 2000-01
◎ Complementary courses
▭ Courses with Limited Enrolment

305-201A INTRODUCTION TO MECHANICAL ENGINEERING. 2(3-0-3) The practice of Mechanical Engineering: its scope and context. The role of Design. Introduction to the Design process. The role of engineering analysis and socio-economic factors in Design. Introduction to the individual mechanical engineering subjects and their role in Design. Case studies. **Professor Ahmed and Staff**

305-210A,B MECHANICS I. 4(4-1-7) Basic principles of Newtonian mechanics. Kinematics, relative motion, momentum, forces (gravity, friction, elastic, etc.), pseudo-forces, impulse, energy (kinetic and potential) and mechanical work. Conservation of momentum and angular momentum, central force motion, centre of mass and moment of inertia. Engineering applications including beams, trusses, frames, mechanisms. (Course description change Awaiting University Approval) **Professors J. Lee and Zsombor-Murray**

305-220A,B MECHANICS II. 3(3-1-5) (Prerequisites: 305-210 and 189-260. Corequisite: 189-261) Newtonian and Lagrangian formulations of mechanics. Solution of equations of motion for simple systems. Degrees of freedom, generalized coordinates and con-

straints. Energy methods. Equilibrium and stability of mechanical systems. 3-dimensional rigid-body dynamics; Euler's equations. Gyroscopic motion. (Course description change Awaiting University Approval **Professors Misra, Paidoussis and Higgins**

305-240A,B THERMODYNAMICS I. 3(3-1-5) Thermodynamic systems and properties. First law of thermodynamics: energy, work and heat. State principle, p-v-T surfaces, phase equilibrium, ideal gas model. Second law of thermodynamics, entropy, exergy analysis. Energy analysis applied to steady and transient engineering systems including heat engines, refrigerators and heat pumps, air compressors. (Course description change Awaiting University Approval) **Professors J.Lee, Frost, Mydlarski and Baliga**

▭ **305-260A,C MACHINE TOOL LAB.** 2(1-3-2) Basic machine tool operations, numerical control of machine tools, and metrology. The use of hand tools, and sheet metal work. Introduction to rapid prototyping and nontraditional machining methods. Extensive laboratory hands-on exercises. **Professor Buehler and R. Sumner**

305-261B,C MEASUREMENT LAB. 2 (2-3-1) Basic experimental laboratory measurements, such as measurement of strain, pressure, force, position, and temperature. **D. Zorbas and Staff**

305-290A GRAPHICS. 3(3-3-0) (This course is intended for Civil Engineering students.) Traditional descriptive geometry of points, lines and planes, done with modern tools. Constructed solutions with vector diagram projection; comparison with equivalent vector algebraic methods. Graphical statics, concurrent force problems including pure axial force plane structures. Structural drafting pertaining to steel, concrete and timber construction, standards and conventions. Drafting room and computer lab exercises are assigned. **Professor Zsombor-Murray**

305-291B GRAPHICS. 3(3-3-3) Descriptive geometry of points, lines and planes, intersection and developments, auxiliary view and direct methods. Drawing standards. Working drawings and conventions, fits and tolerances, representation of welding, surface finish, threaded fasteners, standard mechanical components: motors, cylinders, bearings, gears and other elements. Sections and pictorials. Bills of material and cataloging. Computer lab exercises are assigned. **Professor Zsombor-Murray**

305-292A DESIGN I. 3(1-3-5) (Prerequisites: 305-260 and 305-291. Pre- or Co-requisites: 303-207, 455-206) Introduction to design. Problem formulation; idea generation; feasibility study; preliminary design; design; optimal design. The student's creative ability will be developed by having to participate in a number of design projects. Case-study methods will be used to analyse actual design projects. **Professor Post**

305-314A DYNAMICS OF MECHANISMS. 3(3-1-5) (Prerequisite: 305-210) First principles of analysis; motion; position; displacement; velocity; acceleration; force; inertia and its effects. Kinematic and dynamic analysis of rigid bodies in pure rotation and in pin-connected systems; dynamic balance. Rigid bodies in rolling contact; planetary gear-trains. Bodies in sliding contact; lower and higher sliding pairs. **Professor Ahmed**

305-315A DYNAMICS OF VIBRATIONS. 3(3-1-5) (Prerequisites: 305-220, 303-207 and 189-266) Modelling of vibration of mechanical systems. Single-degree-of-freedom systems: free vibrations; effect of damping; response to harmonic, periodic and arbitrary excitation; vibration isolation. Free and forced vibrations of n degree-of-freedom and continuous systems. **Professor Misra**

305-319B MECHANICS OF SYSTEMS. 3(3-1-5) (Prerequisites: 305-220, 303-207, 189-265 and 189-266) Lagrangian and Hamiltonian dynamics. Variational methods. Discrete linear systems; classical and numerical solutions for conservative and non-conservative systems; matric function methods. Electrical-mechanical-acoustical analogies. Stability considerations and closed-loop systems. Vibration of distributed parameter systems. Energy methods. Non-linear vibrations; the phase plane, perturbation and other methods of solution. **Professors Paidoussis and Lessard**

305-321B MECHANICS OF DEFORMABLE SOLIDS. 3(3-1-5) (Prerequisite: 303-207) Modern phenomenological theories of the behaviour of engineering materials. Stress and strain concepts and introduction to constitutive theory. Applications of theory of elasticity and thermoelasticity. Introduction to finite element stress analysis methods. **Professors Lessard and Nemes**

305-331A,B FLUID MECHANICS I. 3(3-1-5) (Prerequisite: 305-210. Pre- or Co-requisites: 305-220, 305-240 and 189-266) Physical properties of fluids. Kinematics and dynamics of fluid flow: stress in a continuum, rates of strain, rotation. Control volume analysis; conservation of mass, linear momentum and energy; Euler and Bernoulli equations; Flow measurement. Dimensional analysis and dynamical similarity. Laminar and turbulent flow in pipes and boundary layers. (Course description change Awaiting University Approval) **Professors Price and T. Lee**

305-341A THERMODYNAMICS II. 3(3-1-5) (Prerequisite: 305-240) Review of phase equilibrium and diagrams; gas tables. Generalized thermodynamic relations; thermodynamic coefficients. Real gas effects; dense gas equations of state; generalized compressibility, enthalpy, and entropy charts. Vapour and gas power cycles (coal/nuclear power plants). Refrigerators and heat pumps. Psychrometry and air conditioning processes. Thermodynamics of reactive gas mixtures. **Professors J. Lee and Frost**

● ◎ **305-343A ENERGY CONVERSION.** 3(3-0-6) (Prerequisite: 305-240) An overview of different energy conversion systems is considered. The theory and practical applications are specifically covered for: thermoelectric, and photovoltaic systems, fuel cells, magneto-hydrodynamics, and solar radiation. Students will present a paper on an energy conversion subject of their choice. **Staff**

305-346A,B HEAT TRANSFER. 3(3-1-5) (Prerequisites: 305-331 and 189-266) Basic concepts and overview. Steady and unsteady heat conduction. Fin Theory. Convective heat transfer: governing equations; dimensionless parameters; analogy between momentum and heat transfer. Design correlations for forced, natural, and mixed convection. Heat exchangers. Radiative heat transfer: black- and gray-body radiation; shape factors; enclosure theory. Thermal engineering design project. (Course description change Awaiting University Approval) **Professors Baliga and Mydlarski**

305-362A,B MECHANICAL LABORATORY. 2(0-3-3) (Prerequisite: 305-261) Experiments will be performed in four areas: 305-240 Thermodynamics, 305-315 Vibrations, 305-331 Fluid Mechanics I, and 305-346 Heat Transfer. Students should sign up to do experiments in one or more areas the term following the completion of one or more of the above courses. Students will not formally register for this course until the term in which they will complete all of the experiments. **Professors Frost and Lessard**

305-383A,B APPLIED ELECTRONICS & INSTRUMENTATION. 3(3-2-4) (Prerequisites: 305-261 and 189-261) Discrete and integrated components, both analogue and digital. Characteristics of passive elements. Semiconductors, amplifiers, filters, oscillators, modulators, power supplies and nonlinear devices. Introduction to digital electronics. Transducer/signal conditioner interfacing considerations. **Mr. Zorbas**

305-393B DESIGN II. 3(3-3-3) (Prerequisites: 305-292 and 306-260. Pre- or co-requisite: 305-314) The design of machine elements for strength requirements in consideration of various methods of manufacture. Synthesis of mechanical systems to fulfill performance requirements, following the engineering design process. Failure theory and fatigue life determination. Students form groups to work on a design project. **Professor T. Lee**

305-403D,N THESIS (HONOURS). 6(0-6-12) (Prerequisite: Candidates must have completed courses in the Mechanical Engineering Program weighted at a minimum of 60 credits.) This course, together with course 305-404B, involves a research or design project undertaken by each student, encompassing interrelated aspects of engineering theory and requiring a theoretical and/or experimental investigation. Students will work under the supervision of one or more staff members; completed work will be submitted in the form of a thesis. The grade awarded for this part of the course depends on the assessment of the quality of theoretical and/or experimental work undertaken by the students. **Professor Price and Staff**

305-404A,B THESIS (HONOURS). 2(0-3-3) (Corequisite: 305-403) This course is part of the same thesis project as course 305-403D. The grade for this part of the course covers the orderly development and presentation of ideas, and their incorporation in the thesis. **Professor Price and Staff**

305-409B NUMERICAL METHODS IN MECH. ENG. 3(3-1-5) (Prerequisites: 189-261, 189-266 and 308-208) Numerical techniques for problems commonly encountered in Mechanical Engineering are presented. Chebyshev interpolation, quadrature, roots of one or more variables, matrices, curve fitting, splines and ordinary differential equations. The emphasis is on the analysis and understanding of the problem rather than the details of the actual numerical program. **Professor Cortelezzi**

305-412B DYNAMICS OF SYSTEMS. 3(3-1-5)(Prerequisites: 189-261 and 189-266) Modelling of physical systems by lumped-parameter linear elements. Unified treatment of mechanical, fluid, electrical, and thermal devices and systems. State space, formulation of state equations, time response. Frequency-response methods. Dynamic response specifications. Stability. Elementary feedback control systems. Extensive use of engineering examples. **Professor Krovi**

◎ **305-413A CONTROL SYSTEMS.** 3(3-1-5) (Prerequisite: 305-412) Stability of Linear Systems. Controller design based on root-locus and frequency response methods. Tuning of PID controllers. State-space representation of dynamic systems. Concepts of controllability and observability. Design of state feedback controller and state observer based on state-space and polynomial methods. Introduction to digital control. **Staff**

305-430A FLUID MECHANICS II. 3(3-1-5) (Prerequisite: 305-331) Flow of a compressible continuum. Speed of sound. Mach number and Mach angle. One dimensional isentropic flow and choking. Nozzles and wind tunnels. Normal and oblique shock waves. Flow in constant area ducts with friction and heat exchange. Similarity rules for irrotational flow. Prandtl-Meyer expansion. Supersonic aerofoil and wing theory. **Professors J. Lee and Higgins**

◎ **305-432A AIRCRAFT STRUCTURES.** 3(3-0-6) (Prerequisites: 305-331 and 305-321) Plane stress and strain. Theories of failure. Plastic and viscoelastic stress-strain relations. External and internal forces in spars. Bending, deflection of beams, plastic deformation and aeroelastic distortion of wings and fuselage. Structural characteristics of wings. Torsion of wings and related critical aeroelastic design parameters; divergence and aeroelastic twist. Energy methods. Buckling in aeronautical structures. Flutter. **Mr. Edwards**

◎ **305-434A TURBOMACHINERY.** 3(3-0-6) (Prerequisite: 305-331) A broad general treatment of energy transfer between a fluid and a rotor, velocity vector diagrams, and non-dimensional characteristics. Applications to hydraulic pumps and turbines. Two dimensional cascade theory leading to study of axial gas compressors and turbine stages. Three dimensional free and forced vortex configurations. Centrifugal compressors and radial inflow turbines. **Dr. Moustapha**

◎ **305-447A COMBUSTION.** 3(3-0-6) (Prerequisite: 305-240) Equilibrium analysis of reacting systems, Hugoniot analysis, flame propagation mechanisms, introduction to chemical kinetics, models for laminar flame propagation, ignition, quenching, flammability limits, turbulent flames, flame instability mechanisms, detonations, solid and liquid combustion. **Professors J. Lee and Frost**

305-452A MATHEMATICAL METHODS IN ENGINEERING. 3(3-1-5) (Prerequisite: Candidates must have completed courses in the Mechanical Engineering Program weighted at 60 credits (minimum).) The underlying theory and application of mathematical methods in fluid dynamics, vibration, stress and strain analysis, heat transfer, etc. The eigenvalue problem, methods in analysis. **Professor Bach**

305-463D MECHANICAL ENGINEERING PROJECT. (4) (Prerequisite: 305-393) Team project work typically involving design, fabrication, performance-testing and application of a real-world mechanical device/system or experimental facility. The project work will be complemented by a scheduled set of lectures in the Fall term on topics related to formulation/management of open-ended problems. **Professor Post and Staff**

● ◎ **305-471A INDUSTRIAL ENGINEERING.** 3(3-1-5) Survey of industrial engineering discussing the roles of people, technology and management. Includes: design of work systems; factory planning, location, layout, and services; human factors; productivity, process management, performance management, methods engineering; quality management; systems engineering. Overviews of operations research, and production systems. Present issues for industrial competitiveness. **Professor Thomson**

● ◎ **305-472A CASE STUDIES IN PROJECT MGMT.** 3(3-0-6) (Prerequisite: U3 and permission of the instructor) Introduction to principles of the integrated multidisciplinary approach to project management in use by engineering firms. Working in teams students will have the opportunity to assess the real-life pressures in project management by working on an actual recent project and presenting their results to a professional evaluation panel. **Staff**

◎ **305-474B SEL. TOPICS IN OPERATIONS RESEARCH.** 3(3-0-6) (Prerequisites: 189-266 and 308-208) Introduction to the general mathematical programming problem in the context of engineering design; linear programming, queueing theory, Monte Carlo simulation. The above techniques will be used to study the optimization of engineering systems. The applications of linear programming in its various manifestations will be examined in depth. **Dr. Mackenzie**

◎ **305-495A DESIGN III.** 3(0-6-3) (Prerequisite: 305-463) A design project course of two terms together with 305-496B. Project approval required. Allows the completion of a project of greater complexity than Design II and Mechanical Engineering Project with emphasis on analytical solutions, stressing, planning for production. No lectures. Weekly consultations. Interim and final reports required. **Professor T. Lee**

◎ **305-496B DESIGN IV.** 3(0-6-3) (Prerequisite: 305-495) Continuation of 305-495A. The two together constitute a design project course of two terms. The two courses permit the completion of a project of greater complexity than Design II and Mechanical Engineering Project with emphasis on analytical solutions, stressing, planning for production. No lectures. Weekly consultations. Interim and final reports required. **Professor T. Lee**

◎ ▭ **305-497A VALUE ENGINEERING.** 3(0-8-1) (Prerequisites: 305-393 and completion of 45 credits) Value Engineering is an in-depth analysis of an industrial product or process with a view to improving its design and/or performance to increase its worth. This is a workshop type of course. Projects will be supplied by industrial firms and students will work in teams with industrial personnel. **Professor Thomson and Staff**

◎ **305-500A,B SEL. TOPICS IN MECHANICAL ENG.** 3(3-0-6) A course to allow the introduction of new topics in Mechanical Engineering as needs arise, by regular and visiting staff.

● ◎ **305-501A,B SEL. TOPICS IN MECHANICAL ENG.** 3(3-0-6) A course to allow the introduction of new topics in Mechanical Engineering as needs arise, by regular and visiting staff.

◎ **305-522B PRODUCTION SYSTEMS.** 3(3-0-6) Characteristics of production systems. System boundaries, input-output, feedback time-lag effects, dynamics of production systems. Design for manufacturability. Process planning, process/machine tool selection, break-even analysis, CAPP. Production planning, scheduling and control of operations; quality management. Competitive strategies; FMS, CIM. Hands-on experience with industrial factory simulation software. **Professor Kops**

◎ ▭ **305-524B COMPUTER INTEGRATED MANUFACTURING.** 3(3-0-6) (Prerequisite: Permission of the instructor) A study of the present impact of computers and automation on manufacturing. Computer aided systems. Information modelling. Information system structures. Study of several types of production systems. Integration issues: inter-and intra-enterprise. Laboratory experience with manufacturing software systems. **Professor Thomson**

◎ ▭ **305-526C MANUFACTURING AND THE ENVIRONMENT.** 3(3-0-6) (Prerequisite: Permission of the instructor) Course topics include: clean manufacturing, product and process design for minimizing materials and energy use, the product life cycle, impact of technology on the environment, environmental impact assessment, regulatory process, and managing the "political" process. **Staff**

◎ ▭ **305-528A PRODUCT DESIGN.** 3(3-0-6)(Prerequisite: Permission of the instructor) A study of the design issues present in product life cycle demands. Computer aided systems. Rapid prototyping. Design for manufacturability. Integration of mechanics, electronics and software in products. Effect on design of product cost, maintainability, recycling, marketability. **Staff**

◎ ▭ **305-529C DISCRETE MANUFACTURING SYSTEMS.** 3(3-0-6) (Prerequisite: Permission of the instructor) An overview of present day production machines and systems with special emphasis on automation, computer control and integration techniques. Material handling, automatic inspection, process monitoring, maintenance. Socio-economic and environmental issues. Laboratory experience with factory simulation. **Staff**

◎ **305-530B MECHANICS OF COMPOSITE MATERIALS.** 3(3-0-6) (Corerequisite: 305-321 or equivalent/instructor's permission) Fiber reinforced composites. Stress, strain, and strength of composite laminates and honeycomb structures. Failure modes and failure criteria. Environmental effects. Manufacturing processes. Design of composite structures. Computer modeling of composites. Computer techniques are utilized throughout the course. **Professor Lessard**

◎ **305-531B AEROELASTICITY.** 3(3-1-5) (Prerequisites: 305-319 or 305-315 and 305-533) Wing divergence using strip theory aerodynamics. Effect of aircraft flexibility on the control and stability. Flutter calculations for two dimensional wings with discussion of three dimensional effects. Some examples of aeroelastic instability, and the relevant analysis of non-aeronautical problems. **Professor Price**

◎ **305-532B AIRCRAFT PERFORM., STABILITY & CONTROL.** 3(3-1-5) (Prerequisites: 305-412, 305-533) Aircraft performance criteria such as range, endurance, rate of climb, maximum ceiling for steady and accelerated flight. Landing and take-off distances. Static and dynamic stability in the longitudinal (stick-fixed and stick-free) and coupled lateral and directional modes. Control response for all three modes. **Professor Price and Mr. Asselin**

◎ **305-533A SUBSONIC AERODYNAMICS.** 3(3-1-5) (Prerequisite: 305-331) Kinematics: equations of motion; vorticity and circulation, conformal mapping and flow round simple bodies. Two dimensional flow round aerofoils. Three dimensional flows; high and low aspect-ratio wings; airscrews. Wind tunnel interference. Similarity rules for subsonic irrotational flows. **Professor Mateescu**

● ◎ **305-534B AIR POLLUTION ENGINEERING.** 3(3-0-6) (Prerequisites: 305-240, 305-331, 305-341 and 305-447 or consent of instructor.) Pollutants from power production and their effects on the environment. Mechanisms of pollutant formation in combustion. Photochemical pollutants and smog, atmospheric dispersion. Pollutant generation from internal combustion engines and stationary power plants. Methods of pollution control (exhaust gas treatment, absorption, filtration, scrubbers, etc.). **Professors J. Lee and Frost**

● ◎ **305-537B HIGH-SPEED AERODYNAMICS.** 3(3-0-6) (Pre- or Co-requisite: 305-533) Equations of compressible flows. Planar and conical shock waves. Expansion and shock wave interference; shock tubes. Method of characteristics. Supersonic nozzle design. Aerofoil theory in high subsonic, supersonic and hypersonic flows. Conical flows. Yawed, delta and polygonal wings; rolling and pitching rotations. Wing-body systems. Elements of transonic flows. **Professor Mateescu**

◎ **305-538B UNSTEADY AERODYNAMICS.** 3(3-0-6) (Prerequisite: 305-533) Fundamental equations of unsteady compressible flows in fixed or moving reference frames. Unsteady flows past bodies in translation and having oscillatory motions. Oscillations of cylindrical pipes or shells subjected to internal flows. Vortex theory of oscillating aerofoils in incompressible flows. Theodorsen's method. Unsteady compressible flow past oscillating aerofoils. **Professor Mateescu**

● ◎ **305-539A COMPUTATIONAL AERODYNAMICS.** 3(3-0-6) (Pre- or Co-requisite: 305-533 or equivalent) Fundamental equations. Basic flow singularities. Boundary element methods. Source, doublet and vortex panel methods for 2D and 3D incompressible and compressible flows. Method of characteristics. Euler equations for inviscid rotational flows. Finite-difference and finite-volume methods. Explicit and implicit time-integration methods. Quasi 1D solutions. Nozzle and confined aerofoil applications. **Professor Mateescu**

◎ **305-540B DESIGN: MODELLING & DECISION.** 3(3-3-3) 3-D geometric modelling for design; principles and practice. Selected topics/case studies requiring use of: 3-D CAD; component selection and integration; use of machine element design analysis software; practice in developing simple applications. Use of modern software for design decision making. Introduction to mechanism animation. Introduction to design for NC production. **Mr. Yee**

● ◎ **305-541B KINEMATIC SYNTHESIS.** 3(3-0-6) Outline of kinematic synthesis and its applications. Degree of freedom, kinematic pairs and bonds. Function-generation problems: Synthesis matrix, transmission quality, six-bar linkages. Rigid-body guidance problem: Planar and spherical Burmester problem; centre-point and circle-point curves. Path generation problem and planar, spherical and spatial coupler curves. Cam mechanisms. **Professor Angeles**

◎ **305-542B SPACECRAFT DYNAMICS.** 3(3-0-6) (Prerequisite: 305-220. Corequisite: 305-319 or 305-412) Review of central force motion; Hohmann and other coplanar transfers, rotation of the orbital plane, patched conic methods. Orbital perturbations due to the earth's oblateness, solar-lunar attraction, solar radiation pressure and atmospheric drag. Attitude dynamics of a rigid spacecraft; attitude stabilization and control; attitude maneuvers; large space structures. **Professor Misra and Staff**

◎ **305-543A DESIGN WITH COMPOSITE MATERIALS.** 3(3-3-3) (Prerequisite: 305-530) Material systems/selection process. Cost vs performance. Laminate layup procedures. Theory and application of filament winding of composite cylinders. Regular oven and autoclave oven curing, analysis of resulting material performance. Practical design considerations and tooling. Analysis of environmental considerations. Joining techniques. Analysis of test methods. Theory of repair techniques. **Professor Lessard**

◎ **305-545A ADVANCED STRESS ANALYSIS.** 3(3-1-5) (Prerequisites: 303-207 and 305-321) Tensor Analysis: Review of continuum mechanics. Equilibrium and constitutive equations in tensor form. Finite element methods. Torsion of non-circular cross-sections; spherical problems; advanced airy stress function problems. Introduction to plates and shells. Thermal deformations and stresses. Introduction to plasticity and viscoelasticity. **Professors Nemes and Lessard**

◎ **305-552B ADVANCED APPLIED MATHEMATICS.** 3(3-1-5) (Prerequisite: 305-452) Solutions of ordinary differential equations using integral methods; asymptotic series, Stirling's approximation. Bessel and Laguerre functions. Green's functions. Laplace, Helmholtz, diffusion, wave, telegraph partial differential equations. Variational methods. Numerical solutions to partial differential equations. **TBA**

◎ **305-554A MICROPROCESSORS FOR MECH. SYS.** 3(2-3-4) (Prerequisites: 305-383 and 308-208) Digital logic and circuits - asynchronous and synchronous design. Microcontroller architectures, organization and programming - assembly and high-level. Analog/Digital/Hybrid Sensors and Actuators. Sensing and conditioning subsystems. Interfacing issues. Real time issues. Operator interfaces. Lab exercises on digital logic design, interfacing and control of peripherals with a final team project.) **Professors Zsombor-Murray**

● ◎ **305-555B APPLIED PROCESS CONTROL.** 3(3-2-4) (Prerequisite: 305-554 or equivalent) Hardware and software aspects of real time computers in process control and related applications. Fun-

damental hardware. Digital and analogue transducers, actuators, filters, interfaces and processors. Fundamental software: Process assembler language and machine architecture, real time operating systems, process oriented subsystems, interrupts, drivers, service routines. **Professor Zsombor-Murray**

● ◎ **305-557B MECHATRONIC DESIGN.** 3(3-1-5) (Prerequisites: 304-461, 305-383 and 305-412) Team project course on the design, modeling, model validation, and control of complete mechatronic systems, constructed with modern sensors, actuators, real time operating systems, embedded controllers, and intelligent control. **Professor Buehler**

◎ **305-561B BIOMECHANICS OF MUSCULOSKELETAL SYSTEMS.** 3(3-0-6) (Prerequisites: 305-321, 305-315 or 305-412) The musculoskeletal system; general characteristics and classification of tissues and joints. Biomechanics and clinical problems in orthopaedics. Modelling and force analysis of musculoskeletal systems. Passive and active kinematics. Load-deformation properties of passive connective tissue, passive and stimulated muscle response. Experimental approaches, case studies.
Professor Ahmed

● ◎ **305-562A ADVANCED FLUID MECHANICS.** 3(3-0-6) Conservation laws, control volume analysis, Navier stokes equations, dimensional analysis and limiting forms of N-S equation, laminar viscous flows, boundary layer theory, inviscid potential flows, lift and drag, introduction to turbulence. **Professors J. Lee and Cortelezzi**

◎ **305-565B FLUID FLOW & HEAT TRANSFER EQUIP.** 3(3-1-5) (Prerequisites: 305-240, 305-341, 305-331 and 305-346) Fluid flow machinery and systems. Metering devices and control system. Heat exchange systems. Boilers and condensers. Fouling, corrosion and vibration problems. Air conditioning and refrigeration. Humidifiers and dehumidifiers. Space heating and ventilation system. Monitoring and control units. Building materials and insulation.
Professor Baliga

◎ **305-572A MECHANICS OF ROBOTICS SYSTEMS I.** 3(3-0-6) (Prerequisites: 189-266 and 305-220 or permission of the instructor. Not open to students who have taken 305-573.) Manipulator hardware structure, planning and control. Rigid-body three-dimensional statics, kinematics and dynamics. Direct and inverse kinematics and dynamics. Trajectory planning. Manipulator control. In-depth study of serial manipulators. **Professor Angeles**

● ◎ **305-573B MECHANICS OF ROBOTIC SYSTEMS II.** 3(3-0-6) (Prerequisite: Permission of the instructor.) Numerical methods for the kinematic inversion of serial manipulators. The handling of redundancies and singularities. Kinematics and dynamics of parallel manipulators, manipulator performance evaluation and optimization, multifingered hand grasping and manipulation, robot compliant and constrained motion. Obstacle avoidance.
Professor Angeles

◎ **305-576A COMPUTER GRAPHICS AND GEOM. MODELLING.** 3(2-3-4) (Prerequisites: 189-266 and 305-290 or 305-291) Review of pertinent linear algebra and projective geometry. Explicit, implicit and parametric polynomial forms. Splines: curves and surfaces. Properties: curvature, twist, continuity. Ruled surfaces and other quad patches. Constructive solid models; Octree/Voxel, sweep wire frame, Boolean, boundary representation. Mechanical Engineering applications. **Professor Zsombor-Murray**

● ◎ **305-577A OPTIMUM DESIGN.** 3(2-3-4) The role of optimization within the design process: Design methodology and philosophy. Constrained optimization: The Kuhn-Tucker conditions. Techniques of linear and non-linear programming. The simplex and the complex methods. Sensitivity of the design to manufacturing errors. Robustness of the design to manufacturing and operation errors. **Professor Angeles**

● ◎ **305-578B ADVANCED THERMODYNAMICS.** 3(3-0-6) Review of classical mechanics; Boltzmann statistics, thermodynamics of ideal gases; Fermi-Dirac and Bose-Einstein statistics, Gibbsian ensembles; elementary kinetic theory of transport processes, Boltzmann equation, Boltzmann H-theorem and entropy, KBG approximation, discussion on the solution of Boltzmann equation; Maxwell transport equations, derivation of Navier Stokes equations. **Professor J. Lee**

● ◎ **305-581A NONLINEAR DYNAMICS AND CHAOS.** 3(3-1-5) (Prerequisite: 305-319 or 305-315) Approximate solutions to nonlinear dynamical systems: Lindstedt's, multiple-scale and averaging techniques; centre manifold, normal form theorem; applications. Transcritical, saddle-node, pitchfork, Hopf, period-doubling and homoclinic bifurcations; fractal dimensions, Lyapunov exponents and chaos. Applications to two-well potential oscillator, van der Pol, Lorenz, fluid elastic systems. **Professor Paidoussis**

GRADUATE 600-LEVEL COURSES

Generally, undergraduate students are not permitted to enrol in graduate 600-level courses. However, in exceptional circumstances, the Faculty of Graduate Studies and Research does grant this permission upon the request of the Department on behalf of the student. A list of such courses is described in detail in the Faculty of Graduate Studies and Research Calendar.

4.7 Department of Mining and Metallurgical Engineering

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Chair
Robin A.L. Drew; B.Tech.(Bradford), Ph.D.(Newcastle)

Emeritus Professors
William M. Williams; B.Sc., M.Sc.(Brist.), Ph.D.(Tor.), Eng. *(Henry Birks Emeritus Professor of Metallurgy)*

Professors
George P. Demopoulos; Dipl. Eng.(NTU Athens), M.Sc., Ph.D.(McG.), Eng.
Robin A.L. Drew; B.Tech.(Bradford), Ph.D.(Newcastle)
James A. Finch; B.Sc.(Birm.), M.Eng., Ph.D.(McG.), Eng. *(Industry Professor of Mineral Processing)*
John E. Gruzleski; B.Sc., M.Sc.(Qu.), Ph.D.(Tor.), Eng. *(Gerald G. Hatch Professor of Mining and Metallurgy)*
Rod I.L. Guthrie; B.Sc., Ph.D.(Lond.), D.I.C., A.R.S.M., Eng. *(William C. Macdonald Professor of Mining and Metallurgy)*
Farmaraz (Ferri) P. Hassani; B.Sc., Ph.D.(Nott.), C.Eng.(U.K. Reg.) *(George Boyd Webster Professor of Mining Engineering)*
John J. Jonas; B.Eng.(McG.), Ph.D.(Cantab.), F.A.S.M., Eng. *(Henry Birks Professor of Metallurgy)*
Jerzy Szpunar; B.Sc., M.Sc., Ph.D., D.Sc.(Krakow)

Associate Professors
Michel L. Bilodeau; B.Eng.(Montr.), M.Sc.App., Ph.D.(McG.), Eng.
Phil A. Distin; B.Sc., Ph.D.(Lond.), D.I.C.
Ralph Harris; B.Sc.(Qld), M.Eng., Ph.D.(McG.)
Mainul Hasan; B.Eng.(Dhaka), M.Sc.(Dhahran), Ph.D.(McG.)
André Laplante; B.A.Sc., M.A.Sc.(Montr.), Ph.D.(Tor.), Eng.
Hani S. Mitri; B.Sc.(Cairo), M.Eng., Ph.D.(McMaster), Eng. (Director, Mining Engineering Program)
Frank Mucciardi; B.Eng., M.Eng., Ph.D.(McG.), Eng.
Jacques Ouellet; B.A.Sc., M.A.Sc, Ph.D.(École Polytechnique)
Steve Yue; B.Sc., Ph.D.(Leeds)

Assistant Professor
Janusz A. Kozinski; B.A., M.Eng., D.Sc.(Krakow)

Faculty Lecturer
John Mossop; B.Eng.(McG.), Eng.

Adjunct Professors
William Caley; Wilfred Comeau, Eng.; Roussos Dimitrakopoulos; Bryn Harris; Ahmad Hemami; Hani Keira, Eng.; Yves Lizotte, Eng.; Bibhu Mohanty; Malcolm J. Scoble, P.Eng.; William T. Thompson; Viwek Vaidya, Eng.; Albert E. Wraith