FACULTY OF ENGINEERING
INCLUDING
SCHOOL OF ARCHITECTURE, SCHOOL OF URBAN PLANNING

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1 The Faculty

1.1 Location

Macdonald Engineering Building
McGill University
817 Sherbrooke Street West
Montreal, QC H3A 2K6
Canada

Telephone: (514) 398-7257
Website: http://www.engineering.mcgill.ca

1.2 Administrative Officers

JOHN M. DEALY, B.S.(Kansas), M.S.E., Ph.D.(Mich.), Eng.
Dean

FRANK MUCCIARDI, B.Eng., M.Eng., Ph.D.(McG.), Eng.
Associate Dean (Student Affairs)

ARUN K. MISRA, B.Tech.(I.I.T. Kharagpur), Ph.D.(U.B.C.), P.Eng.
Associate Dean (Academic)

DAVID COVO, B.Sc.(Arch.), B.Arch.(McG.), M.R.A.I.C., O.A.Q.
Director, School of Architecture

JEANNE M. WOLFE, B.Sc.(Lond.), M.Sc.(W.Ont.), M.A.(McG.)
Director, School of Urban Planning

RICHARD J. MUNZ, B.A.Sc., M.A.Sc.(Wat.), Ph.D.(McG.), Eng.
Chair, Department of Chemical Engineering

ROBERT D. JAPP, B. Eng., M.Eng., Ph.D.(McG.), P.Eng. **Chair, Department of Civil Engineering and Applied Mechanics**

DAVID A. LOWTHER, B.Sc.(London), Ph.D.(C.N.A.A.), P.Eng.
Chair, Department of Electrical and Computer Engineering

STUART J. PRICE, B.Sc., Ph.D. (Bristol) **Chair, Department of Mechanical Engineering**

G.P. DEMOPOULOS, Dipl. Eng.(Athens), M.Sc., Ph.D.(McG.), Eng. **Chair, Department of Mining and Metallurgical Engineering**

GEORGE I. FEKETE, B.Eng., M.Eng., Ph.D.(McG.), Eng.
Building Director

ANDRE LAPLANTE, B.A.Sc., M.A.Sc.(Montr.), Ph.D.(Tor.), Eng.
Secretary of Faculty

IDA GODEFROY **Assistant to the Dean**

JUDY PHARO **Student Advisor**

1.3 Historical Note

The Faculty of Engineering began in 1871 as the Department of Practical and Applied Science in the Faculty of Arts with degree programs in Civil Engineering and Surveying, Mining Engineering and Assaying, and Practical Chemistry. Diploma courses had been offered from 1859, and by 1871 the staff and enrolments had increased sufficiently to justify the creation of the Department. Continued growth led to the formation of the Faculty of Applied Science in 1878. By 1910 there were ten degree programs offered, including Architecture and Railroad Engineering. Subsequent changes in the overall pattern of the University led to the creation of the Faculty of Engineering in 1931 with a departmental structure very similar in name to that which exists at present.

1.4 The Faculty Today

The Faculty currently includes five engineering departments and two schools:

The Departments

Chemical Engineering
Civil Engineering and Applied Mechanics
Electrical and Computer Engineering
Mechanical Engineering
Mining and Metallurgical Engineering

The Schools

Architecture
Urban Planning

The Faculty serves approximately 2200 undergraduate students and 700 graduate students in a wide variety of academic programs.

Undergraduate programs leading to professional bachelor degrees are offered in all academic units except the School of Urban Planning. These programs are designed to qualify the graduates for immediate employment in a wide range of industries and for membership in the appropriate professional bodies. Additionally, a non-professional degree is offered in the School of Architecture for those who plan to work in related fields not requiring professional qualification. The curricula are also structured to provide suitable preparation for those who plan to continue their education in post-graduate studies either at McGill or elsewhere.

The academic programs, which are described in detail in section 4 on page 222 are divided into required and complementary sections. The required courses emphasize those basic principles which permit graduates to keep abreast of progress in technology throughout their careers. Exposure to current technology is provided by the wide variety of complementary courses which allow students to pursue in depth a particular interest.

An internship program involving a paid 8 to 16 month industrial work experience is available to Engineering and Science students. Generally students will enter the internship program before starting their final year of undergraduate studies. Details can be found in section 2.8 on page 219. In addition, CO-OP programs are offered in Mining Engineering and Metallurgical Engineering.

Post-graduate programs leading to Master's and Doctoral degrees are offered in all sectors of the Faculty. Numerous areas of specialization are available in each of the departments and schools. All post-graduate programs including the professional degree program in Urban Planning are described in the Calendar of the Faculty of Graduate Studies and Research.

1.5 Special Facilities and Related Programs

1.5.1 ENGINEERING INFORMATION SYSTEMS

In addition to the services provided by the Computing Center, the Faculty, in conjunction with its departments and schools, maintains specialized computing and information resources in support of teaching and research. These vary from desktop PCs distributed throughout the Engineering complex to very high performance scientific workstations found in the research laboratories. Each unit organizes and maintains facilities that are designed around specific roles, e.g. CAD/CAM, microelectronic design, software engineering, circuit simulation, process control, polymers, structural mechanics, metal processing, etc., in addition to systems dedicated to administrative support.

The role of the Faculty is to provide access to these resources on a 24-hour basis and to provide computing and information services that are not covered by individual units. Currently this consists of approximately 160 workstations and three servers in two general purpose laboratories. A Faculty-wide switched network is in place that provides global access to the over 1000 machines in the Engineering complex. The Faculty works in close cooperation with the McGill Computing Centre which provides remote access to the Faculty network.

1.5.2 AGRICULTURAL AND BIOSYSTEMS ENGINEERING

The Faculty of Engineering cooperates with the Faculty of Agricultural and Environmental Sciences in providing courses of instruction for a curriculum in agricultural and biosystems engineering to meet requirements for a professional degree awarded in the Faculty of Agricultural and Environmental Sciences. The second semester of the penultimate year of the program is given by the Faculty of Engineering on the Downtown Campus. Details of the curriculum are given on page 426 in the Agricultural and Environmental Sciences section.

Some of the courses offered by the Department of Agricultural and Biosystems Engineering may be of interest to students in the Faculty of Engineering. Students may consult the list of technical complementary choices in section 4.1.1 on page 223.

1.5.3 DEPARTMENT OF BIOMEDICAL ENGINEERING

Lyman Duff Medical Sciences Building
3775 University Street
Montreal, QC Canada H3A 2B4
Telephone: (514) 398-8278

Engineering undergraduates who are interested in the biomedical applications of engineering techniques should contact the Chair of their department or the graduate Chair of Biomedical Engineering. Some of the courses offered by the Bme may be of interest to Engineering students, and may be approved as complementary courses. A partial list follows (see Faculty of Graduate Studies and Research Calendar for more details):

399-501A SELECTED TOPICS IN BIOMEDICAL ENGINEERING.
3(3-0-6) **Instructor: Prof. H.L. Galiana**

399-503B BIOMEDICAL INSTRUMENTATION AND MEASUREMENT TECHNIQUE. 3(2-1-6) **Instructor: Prof. J. Bates**

399-519A ANALYSIS OF BIOMEDICAL SYSTEMS & SIGNALS.
3(2-0-8) **Instructor: Prof. R.E. Kearney**

1.6 Library Facilities

The University has numerous libraries. Specifically serving Engineering, Architecture and Urban Planning is the Physical Sciences and Engineering Library. Other McGill libraries of interest to students in the Faculty of Engineering are: Blackader-Lauterman Library of Architecture and Art, Walter Hitschfeld Geographic Information Center, and Edward Rosenthall Mathematics and Statistics Library. Refer to page 34 of the General University Information section for further information.

2 General Information

2.1 Admission Requirements

The Faculty of Engineering offers programs leading to the degrees of B.Eng., B.Sc.(Arch.) and B.Arch. Enrolment in some programs is limited.

Specific information on admissions requirements for Quebec students, students from provinces of Canada other than Quebec and applicants from outside of Canada can be found in "Admission Requirements" on page 10 of the General University Information section.

2.2 Exchange Programs

The Faculty of Engineering participates in a number of exchange programs that provide undergraduates with an opportunity to study at École Polytechnique and other Quebec universities, and at selected colleges and universities in the United States, Mexico and Europe. Applicants must have completed at least one year of study and have maintained an average of 3.00 or better. Further information may be obtained from the Student Advisor, Office of the Associate Dean (Student Affairs) or the Exchange Officer, Admissions, Recuitment and Registrar's Office.

2.3 Advanced Credit Examinations

Prior to their first registration, the Faculty of Engineering offers the opportunity for students entering the Faculty from a Quebec CEGEP program to receive advanced credit in 189-260 Intermediate Calculus upon successful completion of the Advanced Credit Examination. The 189-260 Intermediate Calculus examination will cover material that has a similarity to the syllabus of the CEGEP Calculus III course. In all engineering programs, students who are successful in the 189-260 Intermediate Calculus examination will automatically have the number of credits required for the completion of their program reduced by three.

2.4 Registration

Students who are currently registered and intend to return to the same degree program in the following academic session are required to register using the automated registration system MARS. MARS information sheets are available in the Student Affairs Office, Room 376, Macdonald Engineering Building. **All returning students must see their Advisor for course confirmation during the first two weeks of the fall semester and, if changes are being made, during the first two weeks of the winter semester.**

New students also register by MARS. Information is sent at the time of admission.

Non-Engineering students should obtain permission from the Associate Dean of their Faculty to register for Engineering courses listed in section 4.

2.4.1 REGISTRATION FOR CONTINUING EDUCATION COURSES

Students can register for Continuing Education courses through MARS. Students must refer to the Centre of Continuing Education Calendar and Timetable for course information and deadlines. For further information see the Records Office, Room 376, Macdonald Engineering Building.

2.4.2 COURSE WITHDRAWAL

Students may withdraw from a course using MARS without academic penalty provided they do so before the end of the seventh week of the semester. Beyond this time their names will appear on the mark reports and, in the event that they do not take the examination, they will be given a J grade.

2.5 Advising

All new students are required to seek academic advising about their programs from the Department in which they plan to study. Additional information may be obtained by calling:

General Advising	(514) 398-7256
Architecture	(514) 398-6702
Chemical Engineering	(514) 398-4494
Civil Engineering	(514) 398-6860
Electrical and Computer Engineering	(514) 398-7344
Mechanical Engineering	(514) 398-8070
Metallurgical Engineering	(514) 398-4755 ext. 4365
Mining Engineering	(514) 398-4755 ext. 0573
Urban Planning	(514) 398-4075

In addition to departmental advising, the Faculty offers a free tutorial service, known as ACE, to help students in their first year of studies. Upper year Engineering students and graduate students provide the service daily. Hours will be posted.

2.6 Student Activities

The campus offers a wide variety of extra-curricular activities for students. All are urged to participate. Many of these are organized within the Faculty under the auspices of the Engineering Undergraduate Society (EUS), or the Architectural Undergraduate Society (AUS). Both of these organizations publish handbooks describing their operations and the activities of various Faculty clubs and societies. All undergraduate students automatically become members of the EUS or the AUS, as appropriate.

2.7 Scholarships and Bursaries

Scholarships, bursaries and loans are open to students in the Faculty of Engineering. Students should consult the Undergraduate Scholarships and Awards Calendar available from the Admissions, Recuitment and Registrar's Office, and on the Web (http://www.aro.mcgill.ca). Specific information concerning these awards may be obtained from the Student Advisor, Office of the Associate Dean (Student Affairs), Faculty of Engineering.

2.8 IYES: Internship Year for Engineering and Science

Employers value experience. The IYES Program allows students to gain professional work experience during the course of their undergraduate studies.

A student will switch to the Internship Program from the regular program at the point of accepting an Internship placement. Successful completion of an 8 to 16-month internship will qualify the student to graduate with the Internship Program designation.

Employment through the IYES Program typically begins in May and continues for up to 16 months (minimum 8 months) including a 4-month probationary training period. While employed by the participating companies, students work on assignments related to their field of study. Projects generally involve research and development or design.

Employers choose the most suitable students for their organization through the application, interview and ranking process.

SPECIALIZATION AREAS OF IYES STUDENTS

All students participating in this program must have between 15 and 45 credits remaining to complete their undergraduate studies in the following areas of Engineering or Science:

Atmospheric Science	Computer Science
Biotechnology	Electrical Engineering
Chemical Engineering	Environmental Studies
Chemistry	Mathematics and Statistics
Civil Engineering	Mechanical Engineering
Computer Engineering	Physics

STUDENT BENEFITS

- professional experience related to course of study
- salary within the average range of those for entry level professional positions
- improved chance of obtaining a job upon graduation and at a higher starting salary
- opportunity to test choice of career and assess pertinence of post-graduate study before making a long-term commitment
- opportunity to develop communication skills and to acquire a business perspective that cannot be learned in school and is unlikely to be gained from a summer job
- participation in the IYES Program will be noted on the student's permanent record

COST

- There is no application fee.
- Every student hired through the Program will be assessed a charge of $700. Students will be billed this amount approximately one month after starting their internship.
- Participating companies are invited to match the student's contribution in the form of a tax deductible donation to IYES.

STUDENT ELIGIBILITY

- Canadian citizens or Permanent Residents of Canada
- full-time registration in an Engineering or Science undergraduate program with fewer than 45 credits and more than 15 credits remaining

- strong leadership/communication skills, good academic record (satisfactory standing)
- remain degree candidate and return to complete studies at McGill (internship students will receive an automatic one-year extension for the completion of their studies).Students are not allowed to complete their undergraduate degree during the internship period.

Further information can be obtained from the internet posting (http://www.mcgill.ca/stuserv/caps/iyespost.htm) or by sending an email to info@mecc.mcgill.ca

2.9 Calculators in Faculty Tests and Examinations

The use of calculators during tests and examinations is at the discretion of the course instructor. If a calculator is permitted in the examination, the instructor may require that the students use a Faculty Standard Calculator, i.e. the CASIO fx-991 or the Sharp EL-546. These calculators are non-programmable, inexpensive, available through local dealers, e.g. EUS General Store in McConnell Engineering Building, and have many features of interest to Engineering students. Any model fx-991 or EL-546 is acceptable, regardless of the letter suffix which appears after the model number. All Engineering students are expected to own one of the two Faculty Standard Calculators.

3 Academic Requirements

3.1 Degree Requirements

In order to obtain a Bachelor's degree, students must complete one of the departmental programs described in section 4.

3.1.1 ENTRANCE REQUIREMENTS

The degree programs in the Faculty of Engineering are designed for students who have completed a general and basic science program. This basic science requirement consists of two semesters of calculus, chemistry, physics, one semester of vectors, matrices and analytical geometry and one semester of humanities or social sciences. Students entering the Faculty of Engineering from Quebec complete these courses at the CEGEP and enter a seven-semester program. Students entering from outside Quebec with a high school diploma generally enter an eight-semester program and complete the basic science requirements at McGill (see section 3.1.2 on page 220).

Students who have completed Advanced Placement Exams, Advanced Levels, the International Baccalaureate, the French Baccalaureate, or McGill placement and/or advanced credit examinations may receive exemptions and/or credits for all or part of the basic science requirements. Similarly, students who have completed courses at other universities or colleges may receive exemptions and/or credits.

3.1.2 BASIC SCIENCE REQUIREMENTS FOR STUDENTS ENTERING FROM OUTSIDE QUEBEC (8-semester program)

Generally, students admitted to Engineering from outside Quebec are required to complete the basic science requirements outlined below, in addition to the departmental programs described in section 4.

180-111B	General Chemistry for Physical Science & Engineering Students	4 credits
180-121A	General Chemistry for Physical Science & Engineering Students	4 credits
189-150A	Calculus A	4 credits
189-151B	Calculus B	4 credits
189-133A/B	Vectors, Matrices & Geometry	3 credits
198-131A	Mechanics and Waves	4 credits
198-142B	Electromagnetism & Optics	4 credits
xxx-xxx	Humanities/Social Sciences course	3 credits

Calculus courses 150/151 are designed for students who have completed a course in high school calculus. If a student has no previous calculus exposure, 150/151 may be replaced with 139/141 (Password card required). In the event that the student has some prior calculus, but is not sufficiently confident to proceed with 150/151, the appropriate sequence is 140/141. Students who complete the Calculus sequence 150/151 will receive exemption with credit from 189-260 (Intermediate Calculus), in the regular Engineering program. Students who are uncertain as to which calculus course sequence is appropriate for them should contact Ms. Pharo, Student Advisor in the Office of the Associate Dean (Student Affairs) (514) 398-7256.

The Humanities/Social Science course may be selected from a list outlined in the "Welcome" book. A copy of the booklet is mailed to all students admitted to the Engineering program at McGill. A Humanities/Social Sciences course is not required of students admitted to Electrical/Computer Engineering.

Students may write McGill Placement Tests to obtain credit for 180-111, 180-121, 189-140, 189-141, 189-133, 198-131 and 198-142, in the event that they have studied similar material previously. Details on the advanced placement examinations are provided in the "Welcome" book.

Students entering with advanced standing credits (Advanced Placements, Advanced Levels, International Baccalaureate examinations, McGill Placement Tests) are required to meet with the Student Advisor, Office of the Associate Dean (Student Affairs), Room 378, Macdonald Engineering Building, to finalize their program of studies. This must be done prior to meeting with the Departmental Advisor.

3.1.3 PRE-ARCHITECTURE PROGRAM

Students admitted to the Pre-Architecture program are required to complete the following courses:.

180-111B	General Chemistry for Physical Science & Engineering Students	4 credits
180-121A	General Chemistry for Physical Science & Engineering Students	4 credits
189-140A	Calculus I	3 credits
189-141B	Calculus II	4 credits
189-133A/B	Vectors, Matrices & Geometry	3 credits
198-131A	Mechanics and Waves	4 credits
198-142B	Electromagnetism & Optics	4 credits

Students may write McGill Placement Tests to obtain credit for 180-111, 180-121, 189-140, 189-141, 189-133, 198-131 and 198-142, in the event that they have studied similar material previously. Details on the advanced placement examinations are provided in the "Welcome" book.

3.2 Degrees and Requirements for Professional Registration

Professional

Bachelor of Architecture
Bachelor of Engineering
Bachelor of Engineering (Honours)

Non-Professional

Bachelor of Science (Architecture)

The B.Eng. programs are accredited by the Accreditation Board of the Canadian Council of Professional Engineers and fulfil the academic requirements for admission to the provincial professional organizations.

The B.Arch. program is recognized in all provinces as fulfilling the educational requirements for entry to the architectural profession.

3.3 Complementary Studies

Engineering students must complete 6 credits (9 credits in Electrical and Computer Engineering) of additional complementary courses as follows:

(i) One 3-credit course on the impact of technology on society

(ii) One 3-credit course (6 credits in Electrical and Computer Engineering, of which a minimum of 3 credits must be from category A described below) in the humanities and social sciences, administrative studies and law.

The three credits under (i) are to be chosen from the following list of courses which relate to the impact of technology on society.

301-528A	History of Housing
302-230B	Environmental Aspects of Technology
302-430A	Technology Impact Assessment
303-469A	Infrastructure and Society
306-308A	Social and Economic Impacts of Technology
107-220A	Intro. to History & Philosophy of Science I
107-221B	Intro. to History & Philosophy of Science II
146-500B	Interdisciplinary Seminar in the History and Philosophy of Science
154-225A,B	Economics of the Environment
166-235A	Technology and Society
166-312B	Industrial Sociology
166-321B	Women and Work
183-200A	Geographical Perspectives on World Environmental Problems
183-203A	Introduction to Environmental Studies
183-205B	Global Change: Past, Present and Future
183-302B	Environmental Anal. and Mgmt. I: Probs. and Pol.
183-333C	The Habitable City
186-243A,B,L	Environmental Geology (not available to students who have taken or who will take 186-221A, General Geology)
260-270A,B	Religious Ethics and the Environment (Note: A term is offered at Macdonald Campus only)

The course(s) under (ii) are to be chosen from the following: Electrical and Computer Engineering students must select at least one 3-credit course from Category A (Humanities and Social Sciences).

A. Humanities and Social Sciences

Any course at the 200 level or above from the departments of:

- Anthropology
- Economics (any 200 or 300 level course excluding 154-208, 217, 227, 259 and 337)
- History
- Philosophy (excluding 107-210)
- Political Science
- Psychology (excluding 204-204, 305 and 435 but including 204-100)
- School of Social Work
- Sociology (excluding 166-305)

or 189-338A History and Philosophy of Mathematics
or 301-350A The Material Culture of Canada

B. Administrative Studies and Law

Faculty of Engineering

300-220A	Law for Architects and Engineers

Faculty of Management

270-462B	Management of New Enterprises
272-521B	Leadership, Power and Influence
279-294A,B,X,Y	Introduction to Labour-Management Relations
280-222A,B,X,Y	Organizational Behaviour
280-352A,B,X,Y	Marketing Management I
280-360B	Social Context of Business

C. Language Courses

Any language course which is deemed by the academic advisor to have a sufficient cultural component or, in the case of a student who was not already proficient in a specific language, program credit will be given for the second of two successfully completed, academically approved 3-credit language courses.

3.4 Student Progress

The B.Eng. and B.Sc.(Arch.) programs may be completed in seven semesters. The B.Arch. degree requires the completion of a minimum of two additional semesters.

A student must successfully complete the B.Eng. or B.Sc. (Arch.) programs within six years of entry. Candidates admitted to a lengthened program, or to a shortened program because of advanced standing, or who are participating in the IYES program, will have a correspondingly greater or lesser period in which to complete their program. Candidates entering the B.Arch. program must complete the degree requirements within two years. Extensions may be granted by the Committee on Standing in cases of serious medical problems or where other similarly uncontrollable factors have affected a student's progress.

3.4.1 LETTER GRADES

In the Faculty of Engineering, letter grades are assigned according to the grading scheme adopted by the professor in charge of a particular course. They have the designations:

A, A-	Very Good	J	Unexcused Absence
B+, B, B-	Good	K	Incomplete
C+, C	Satisfactory	KF	Incomplete Failed
D	Conditional Pass	L	Deferred
F	Failed	T	Credit by examination only

Grades A, B and C indicate satisfactory results. Grade D indicates marginal results which may be acceptable for peripheral courses but not for core courses required by the program. The classification of a course as core or peripheral depends on the individual student's program and will be decided by the department concerned. Grade F is a permanent grade indicating unsatisfactory results. Grade J indicates an unexcused failure to submit assignments or an unexcused absence from an examination. It is equivalent to an F grade.

3.4.2 INCOMPLETE COURSE DEADLINES

An incomplete grade is indicated by a K. The maximum delay granted for completion of course work is three months, after which the student will automatically be given a grade of KF (incomplete/fail). The last day for submission of deferred grades is March 31st for A semester courses, August 15th for B semester courses, and December 1st for summer courses. The last date for submission of grades for summer courses for students graduating in November is September 15th.

The L grade indicates a deferred grade because of medical or other valid reason. An L grade will be replaced by a J grade if the student misses the next deferred or regular examination in the course, whichever occurs first.

3.4.3 SATISFACTORY/UNSATISFACTORY OPTION FOR ELECTIVE COURSES

The University allows students to designate certain elective courses to be graded under the Satisfactory/Unsatisfactory option. The option must be added on MARS before the end of the Drop/Add period and no change can be made thereafter. See Records Office, Room 376, Macdonald Engineering, for more information.

For the programs offered within the Faculty of Engineering, "elective" refers to the complementary course component of the Engineering programs involving a Social Science/Humanities course (see section 3.3 - category (ii) or a course dealing with the impact of technology on society [category (i)], or to elective courses taken outside the School of Architecture by Architecture students. It does not apply to the "technical complementaries" or "architectural complementaries" or to any other category of courses in the Engineering or Architecture programs.

A C-grade is considered a pass under the Satisfactory/Unsatisfactory option, while a D-grade is considered a failure under this option. However, the Faculty of Engineering will continue to accept a D-grade as a pass in the complementary courses listed in section 3.3, when the course is taken in the conventional manner. Only students in Satisfactory Standing are permitted to take a course under the Satisfactory/Unsatisfactory option.

NOTE: To be considered for in-course awards and/or the renewal of entrance scholarships, students must take at least 27 credits in the regular academic session exclusive of courses completed under the Satisfactory/Unsatisfactory option.

3.4.4 COURSE CREDITS

The credit assigned to a particular course reflects the amount of effort it demands of the student. One credit normally represents three hours total work per week. This is, in general, a combination of lecture hours and other contact hours such as laboratory periods, tutorials and problem periods as well as personal study hours. As a guide, the average division of time for a course is indicated in hours in the course listing after the course credit. For example, 3(3-0-6) indicates a credit of three units consisting of three lecture hours per week, no other contact hours and six hours of personal study per week.

3.4.5 GRADE POINT AVERAGES AND EXTRA COURSES

The Faculty calculates a semestrial grade point average. Any courses taken which lie outside the program are classified as extra, are indicated by an "X" on transcripts and do not affect the grade point average. Students must receive Departmental approval for such courses and the course must be identified and recorded prior to writing the final examination.

3.4.6 STANDINGS

A student's standing is based on the CGPA according to the following criteria.

Satisfactory standing:
2.00 or better

Probationary standing:
1.20 – 1.99 first semester
1.50 – 1.99 subsequent semesters

Unsatisfactory standing:
less than 1.20 first semester – normally re-admitted to probationary standing by Faculty decision
less than 1.50 subsequent semesters

Candidates in satisfactory standing may proceed with the following conditions:

i) All core courses in which D or F grades were obtained must either be repeated successfully (grade C or better) or be replaced by an alternative approved course which is completed successfully.

ii) All other courses in which F grades were obtained must either be repeated successfully at some point before graduation or be replaced by some alternative approved course which is completed successfully before graduation.

Candidates in probationary standing may proceed for one semester under the same conditions noted above, but in addition must reduce their load to a maximum of 13 credits per semester and must achieve at the end of the semester either a CGPA of 2.00 or better or an SGPA of 2.50 or better. A student whose SGPA is 2.50 or better but whose CGPA is less than 2.00 may continue in probationary standing. Failure to achieve either of these grade point averages after the probationary semester will result in unsatisfactory standing.

Candidates with unsatisfactory standing must withdraw for at least one semester, after which they may be considered for readmission by the Committee on Standing.

3.4.7 REPEATED COURSES

Students who fail to achieve the required results in a course must either repeat it successfully or complete a substitute course approved by their department. For students who fail prerequisite courses which are offered in only one semester, the departments responsible may, in appropriate cases, arrange "reading courses" during the other semester or during the summer months. Such courses taken during a regular semester constitute a normal part of the candidate's work load. If the student is on probation, these courses must be included in the workload reduction.

3.4.8 REASSESSMENT OF A GRADE

In accordance with the Charter of Student Rights, and subject to the conditions stated therein, students have the right to consult any written submission for which they have received a mark and the right to discuss this submission with the examiner. If, after such discussion, students want to have a formal final examination reread, they must apply in writing to the Student Affairs Office.

3.4.9 REREAD OF A GRADE

A student may request the rereading of a grade by completing an application form available from the Records Office. The application deadlines are the last day of March, July, and November for fall, winter, and summer courses respectively. Payment of the $35 fee will be charged to the student's McGill account. If the grade is improved as a result of the reread, the fee will not be charged. If the grade is decreased or unchanged, the fee will be charged.

3.4.10 SUPPLEMENTAL EXAMINATIONS

Courses administered by the Faculty of Engineering do not have supplemental examinations. However, Engineering students may be eligible to write supplemental examinations in courses administered by other faculties (typically in complementary studies and science courses). For more information, please contact the Engineering Student Records Office.

3.4.11 DEFERRED EXAMINATIONS

Students who miss a final examination due to illness should submit a medical certificate to the Records Office (Room 376 Macdonald Engineering Building) within one week of the examination and apply for a deferred examination.The medical certificate must state the date of the missed examination, and the nature and duration of the illness. Students are advised that deferrals are granted only for compelling reasons.

Further information on Deferred Examinations can be found on page 27 of the General University Information of the Calendar.

4 Academic Programs

Please note:

● Denotes courses not offered in 1999-2000
◎ Elective courses
▭ Courses with Limited Enrolment

Where asterisks appear with a prerequisite, they have the following significance:

* a D grade is acceptable for prerequisite purposes.

** under special circumstances, the Department may permit this course to be taken as a co-requisite.

The curricula and courses described in the following pages have been approved for the 1999-2000 session, but the Faculty reserves the right to introduce changes as may be deemed necessary or desirable.

4.1 Faculty Courses

A number of Faculty courses are offered and are listed below. These courses are of a more general nature than the departmental courses.

300-220A LAW FOR ARCHITECTS AND ENGINEERS. 3(3-0-6)
Aspects of the law which affect architects and engineers. Definition and branches of law; Federal and Provincial jurisdiction, civil and criminal law and civil and common law; relevance of statutes; partnerships and companies; agreements; types of property, rights of ownership; successions and wills; expropriation; responsibility for negligence; servitudes/easements, privileges/liens, hypothecs/mortgages; statutes of limitations; strict liability of architect, engineer and builder; patents, trade marks, industrial design and copyright; bankruptcy; labour law; general and expert evidence; court procedure and arbitration. **Mtre J.A. Woods**

▭ **302-230B ENVIRONMENTAL ASPECTS OF TECHNOLOGY.** 3(3-0-6)
The impact of urbanization and technology on the environment.

Topics include urbanization: causes, effects, land use regulations; transportation technology and environmental implications; environmental impact of energy conversions; energy policy alternatives; formulation of energy and environmental policy; air pollution: sources, effects, control; water pollution: sources, effects, control. Limited enrolment, MARS passwords distributed after the first class. **Staff**

▭ **302-430A TECHNOLOGY IMPACT ASSESSMENT.** 3 (3-1-5) The power of technology to shape our physical, economic and social environment: historical - effects of technological transitions (e.g. industrial revolution, post-industrial era) on culture and ecology; practical-technology impact assessment (TIA), methodologies, public participation, engineering contributions, regulations; implications of TIA on social and economic development, and to the education and career of the engineer. Limited enrolment. Restricted to final year students. Mars passwords distributed in Department of Chemical Engineering. **Mr. Q. Samak**

303-469A INFRASTRUCTURE AND SOCIETY. 3(3-2-4) (Prerequisite: 306-310A,B) Infrastructure systems, historical background and socio-economic impact; planning, organization, communication and decision support systems; budgeting and management; operations, maintenance, rehabilitation and replacement issues; public and private sectors, privatization and governments; infrastructure crisis and new technologies; legal, environmental, socio-economic and political aspects of infrastructure issues; professional ethics and responsibilities; case studies. **Professor Mirza**

306-221A,B ENGINEERING PROFESSIONAL PRACTICE. 1(1-0-2) Professional practice and ethics, professional liability, occupational health and safety, environmental responsibility. University Code of Student Rights and Responsibilities. **Professors Laplante and Smith**

306-308A SOCIAL & ECONOMIC IMPACTS OF TECHNOLOGY. 3(3-0-6) (Enrolment encouraged by students outside the Faculty of Engineering.) Critical examination of the socio-economic costs and benefits of technology, case studies of old engineering works and new technologies. The integration of applied ethics and engineering practice, analysis of basic concepts of technology assessment, the inter-connected processes of risk assessment, management, and communication. **Professor Finch**

306-310A,B ENGINEERING ECONOMY. 3(3-1-5) Introduction to the basic concepts required for the economic assessment of engineering projects. Topics include: accounting methods, marginal analysis, cash flow and time value of money, taxation and depreciation, discounted cash flow analysis techniques, cost of capital, inflation, sensitivity and risk analysis, analysis of R and D, ongoing as well as new investment opportunities. **Professors Bilodeau and Laplante**

4.1.1 FACULTY TECHNICAL COMPLEMENTARIES

Each Engineering program requires a certain number of technical complementary courses. Departments list the approved courses together with the program descriptions that appear in the following sections. In addition, some programs permit students to select one or more courses from the faculty-wide listing of technical complementaries that follow. Students should check the program description to determine if a course may be selected from the following list. It is advisable that students discuss their choice with an academic advisor, review the prerequisite requirements for the course choices, and if in doubt approach the course instructor to ensure that they have the appropriate background for the course selection. Refer to the following departmental sections for prerequisites and course descriptions.

Agricultural and Biosystems Engineering

330-435A,B Soil and Water Quality Management
336-200B Elements of Agricultural Engineering
336-217B Hydrology and Drainage
336-314B Agricultural Structures
336-322A Agro-Food Waste Management
336-325A Food Engineering
336-330B GIS and Biosystems Management
336-411A Off-Road Power Machinery
336-412A Agricultural Machinery
336-416A Engineering for Land Development
336-500B Advanced Applications of Microcomputers in Agriculture
336-504B Instrumentation and Control
336-518A Pollution Control for Agriculture
336-530B Advanced Food & Fermentation Engineering

Architecture

301-350A The Material Culture of Canada
301-377B Energy, Environment & Buildings
301-378A Site Usage
301-526B Philosophy of Structures
301-527B Civic Design
301-528A History of Housing

Chemical Engineering

302-200A Introduction to Chemical Engineering
302-204B Chemical Manufacturing Processes
302-220B Chemical Engineering Thermodynamics
302-230B Environmental Aspects of Technology
302-430A Technology Impact Assessment
302-438B Engrg. Principles in Pulp & Paper Processes
302-452B Particulate Systems
302-471A Industrial Water Pollution Control
302-472B Industrial Air Pollution Control
302-481A Polymer Engineering
302-487A Chem. Processing in the Electronics Industry
302-541A Thermal Plasma Technology
302-581B Polymer Composites Engineering
302-370A Elements of Biotechnology
302-474A Biochemical Engineering

Civil Engineering

303-207A Solid Mechanics
303-208A Civil Engineering Systems Analysis
303-225B Environmental Engineering
303-311A Geotechnical Mechanics
303-317A Structural Engineering
303-323A Hydrology and Water Resources
303-327B Fluid Mechanics & Hydraulics
303-430A Water Treatment & Pollution Control
303-433B Urban Planning
303-451A Geoenvironmental Engineering
303-469A Infrastructure & Society
303-526B Solid Waste Management
303-540A Urban Transportation Planning
303-541B Rail Engineering

Computer Science

308-203A,B Introduction to Computing II
308-250A Introduction to Computer Science
308-273A,B Introduction to Computer Systems
308-302A,B Programming Languages and Paradigms
308-305A Computer System Architecture
308-350A Numerical Analysis
308-360A Algorithms Design Techniques
308-424A Topics in Artificial Intelligence I

Electrical and Computer Engineering

304-404A Control Systems
304-411A Communications Systems
304-412B Discrete Time Signal Processing
304-425A Computer Organization and Architecture
304-427B Operating Systems
304-428B Software Engineering
304-461 Electric Machinery
304-462B Electromechanical Energy Conversion
304-526B Artificial Intelligence

Mechanical Engineering

305-409B Numerical Methods in Mech. Eng.
305-471A Industrial Engineering
305-472A Case Studies in Project Management
305-474B Sel. Topics in Operations Research
305-522B Production Systems

305-554A Process Automation
305-577A Optimum Design
305-525B Introduction to Nuclear Engineering

Metallurgical Engineering
306-250A Introduction to Extraction Metallurgy
306-311A Computer Applications in Mineral and Materials Engineering
306-317A Materials Characterization
306-341B Introduction to Mineral Processing
306-362A Engineering Materials
306-367B Electronic Properties of Materials
306-412A Corrosion and Degradation
306-555A Thermal Remediation of Wastes
306-560B Joining Processing

Mining Engineering
306-200A Mining Technology
306-320B Extraction of Energy Resources
306-322B Rock Fragmentation
306-323B Rock/Soil Mass Characterization
306-325A Mineral Industry Economics
306-333B Materials Handling
306-420B Feasibility Study

Urban Planning
409-501A,B Principles and Practice of Planning I
409-612A History and Theory of Planning
409-614B Urban Environmental Planning
409-619B Transportation and Land Development
409-621B Theory of Urban Form
409-505B GIS in Planning

4.2 School of Architecture

Director
David Covo; B.Sc.(Arch.), B.Arch. (McG.), F.R.A.I.C., O.A.Q.

Emeritus Professors
John Bland; B.Arch.(McG.), A.A. Dipl., D.Sc.(Carleton), R.C.A., F.R.A.I.C., O.A.Q. *(William C. Macdonald Emeritus Professor of Architecture)*
Norbert Schoenauer; B.Arch.(Bud.), M.Arch.(McG.), R.C.A., F.R.A.I.C., O.A.Q., C.P.U.Q., M.C.I.P. *(William C. Macdonald Emeritus Professor of Architecture)*
Harold Spence-Sales; A.A.Dipl., M.R.T.P.I., F.C.I.P.

Professors
Bruce Anderson; B.Arch.(McG.), M.Arch.(Harv.), F.R.A.I.C., O.A.Q.
Derek Drummond; B.Arch. (McG.), F.R.A.I.C., O.A.A. *(William C. Macdonald Professor of Architecture)*
Alberto Pérez-Gómez; Dipl.Eng.(Nat.Pol.Inst.Mexico), M.A., Ph.D.(Essex) *(Saidye Rosner Bronfman Professor of Architectural History)*
Radoslav Zuk; B.Arch.(McG.), M.Arch.(M.I.T.), D.Sc. (Ukr.Acad.Art), F.R.A.I.C., F.R.S.A., F.A.R.C., O.A.Q., O.A.A.

Associate Professors
Annmarie Adams; B.A.(McG.), M.Arch., Ph.D.(Berkeley), M.R.A.I.C.
Vikram Bhatt; N.Dip.Arch.(Ahmedabad), M.Arch.(McG.)
Ricardo Castro; B.Arch.(Los Andes), M.Arch., M.A.(Art History) (Ore.) M.R.A.I.C.
David Covo; B.Sc.(Arch.), B.Arch. (McG.), F.R.A.I.C., O.A.Q.
Avi Friedman; B.Arch.(Technion), M.Arch.(McG.), Ph.D. (Montr.), O.A.Q., I.A.A.
Adrian Sheppard; B.Arch.(McG.), M.Arch.(Yale), F.R.A.I.C., A.A.P.P.Q., O.A.Q.
Pieter Sijpkes; B.Sc.(Arch.), B.Arch.(McG.)
Gentile Tondino; R.C.A.

Faculty Lecturers
Greg Caicco, Rhona Kenneally

Adjunct Professors
Manon Asselin, Cecile Baird, Julia Bourke, Joseph Baker, Randy Cohen, Anne Cormier, Nathalie David, Howard Davies, Gordon Edwards, François Émond, Julia Gersovitz, Dan Hanganu, Alka Jain, Phyllis Lambert, Seymour Levine, Luci Mastropasqua, Harry Mayerovitch, Serge Melanson, Joanna Nash, Daniel Pearl, Mark Poddubiuk, Daniella Rohan, Jacques Rousseau, Richard Russell, Robert Thibodeau, Fred Weiser, Samson Yip, Jozef Zorko

Research Associates
Jim Donaldson, Terrance Galvin, David Krawitz, Rafik Salama

Associate Members
Clarence Epstein, Tania Martin, Howard Schubert

Visiting Critics and Lecturers
Each year visitors are involved in the teaching of certain courses as lecturers and critics. These visitors change from year to year; in 1998, they were:

Gavin Affleck, Eduardo Aquino, Philip Bobrow, Martin Bressani, Louis Brillant, Aurèle Cardinal, Jenny Cook, Cynthia Cooper, Ulker Copur, Richard De La Riva, Nan Griffiths, George Hersey, Michael Jemtrud, Barry Johns, Stuart Kinmond, David Leatherbarrow, Annie Lebel, Marie-Claude Leblond, Wen Lee, Andrew Levitt, Andrea MacElwee, Robert Magne, Eric Marosi, Gilles Marty, Detlef Mertins, Yves Morin, Desmond Morton, Rosanne Moss, Katsuhiko Muramoto, Fred Oehmichen, Louise Pelletier, Pamela Plumb-Dhindsa, John Schreiber, Daniel Smith, Will Straw, Mohamed Talaat, Dalibor Vesely, Darius Wiecha.

PROGRAMS

The McGill architectural program is divided into two parts. The first leads to a non-professional degree, Bachelor of Science (Architecture), as a preparation for professional studies in architecture. The second, consisting of a minimum of two semesters for those with the McGill B.Sc.(Arch.) degree, leads to the professional degree, Bachelor of Architecture, which is accredited by the Canadian Architecture Certification Board (CACB), and by the National Council of Architectural Review Boards (NCARB) in the USA.

Students in the B.Sc.(Arch.) program who plan to go on to the professional degree in architecture must apply to the B.Arch. program and must have fulfilled a number of requirements in order to be accepted. These requirements include:

1. The B.Sc.(Arch.) degree, including the series of required and complementary courses stipulated for professional studies, with overall grade point averages of at least 2.65 in the B.Sc.(Arch.) program and at least 2.65 in the sequence of architectural design courses (201A, 202B, 303A, 304B, 405A, 406B);
2. A minimum of six months relevant work experience.

Other students may make appropriate substitutions for certain of the required courses in order to improve their preparation for studies in associated areas.

Special note to applicants:
The School of Architecture at McGill is presently restructuring the professional program in architecture, in order to develop the Master of Architecture as the first professional degree in architecture. The new structure retains the B.Sc.(Arch.) program, with a slight reduction in the total number of credits, and replaces the two-semester 34-credit B.Arch. program with a revised three-semester 45-credit M.Arch. program. Admission to the new professional M.Arch. program, once approved, will very likely be based on requirements similar to those listed above for the existing B.Arch. program.

The new program is scheduled for final approval early in 1999 and may be in place by September 1999. For further information, please direct enquiries to the Student Advisor by email at marylc@urbarc.lan.mcgill.ca or telephone (514) 398-6702.

Pre-Architecture – Students who are admitted to the eight-semester program enter a first year which includes the courses outlined in section 3.1.3 on page 220.

Student Exchanges

A limited number of qualified students may participate in an exchange with Schools of Architecture at other universities which have agreements with the McGill School of Architecture, for a maximum of one semester in the second year of the B.Sc.(Arch.) program. These include: Facultad de Arquitectura, Universidad de Los Andes, Bogota, Colombia; Istituto Universitario di Architettura di Venezia, Venice, Italy; Fakultät für Raumplanung und Architektur, Technische Universität Wien, Vienna, Austria; The Technion - Israel Institute of Technology, Haifa, Israel; Institut Supérieur d'Architecture, Saint-Luc Bruxelles, Brussels, Belgium; École d'architecture de Grenoble, Grenoble, France; École d'architecture Clermont-Ferrand, Clermont-Ferrand, France.

ANCILLARY ACADEMIC FACILITIES

Laboratories

Architectural Workshops – Jonathan Rousham, Technician.

Communications Laboratory, including Photo Lab – Professor Ricardo Castro and Dr. Donald Chan.

Computers in Architecture Laboratory and the Apple Design and Modeling Centre – Dr. Donald Chan, System Manager.

Collections

The Visual Resources Collection, under the direction of Dr. Annmarie Adams.

The Blackader-Lauterman Library of Architecture and Art, located in the Redpath Library, under the direction of Marilyn Berger.

The Canadian Architecture Collection housed in the Blackader-Lauterman Library, under the direction of Irena Murray.

CURRICULUM FOR THE B.Sc.(Arch.) DEGREE

REQUIRED COURSES		COURSE CREDIT	
Non-Departmental Subjects			
303-205A,B	Statics	3	
303-229A	Surveying for Architects	2	
303-283B	Strength of Materials	4	
† 303-384A	Soil Mechanics and Foundations	2	
† 303-385A	Structural Steel and Timber Design	3	
† 303-388B	Reinforced Concrete Design	2	
† 303-492A	Structures	2	**18**

† Candidates intending not to proceed to the B.Arch. degree may substitute other courses of equal total weight for any of these.

Architectural Subjects			
301-201A	Communication, Behaviour & Arch.	6	
301-202B	Arch. Graphics and Design Elements	6	
301-217A	Freehand Drawing I	1	
301-218B	Freehand Drawing II	1	
301-240B	Organization of Materials in Building	3	
301-250A	Architectural History I	3	
301-251B	Architectural History II	3	
301-303A	Design and Construction I	6	
301-304B	Design and Construction II	6	
301-321A	Freehand Drawing III	1	
301-322B	Freehand Drawing IV	1	
301-324T	Sketching School I	1	
301-327T	Summer Project I	1	
301-405A	Design and Construction III	6	
301-406B	Design and Construction IV	6	
301-428T	Summer Project II	1	
301-435B	Urban Planning I	2	
301-446A	Mechanical Services	2	
301-447A	Electrical Services	2	
301-448B	Environmental Acoustics	2	**60**

COMPLEMENTARY COURSES **18**

Students must complete 18 credits of architectural complementaries which must include at least one course from each of the areas of concentration listed below in order to qualify for the B.Sc.(Arch.) degree.

A. History	B. Theory	C. Environmental Design	D. Technics
301-372A	301-363A	301-350A	301-364B
301-388A	301-383B	301-375A	301-377B
301-522A	301-523B	301-378B	301-461B
301-528A	301-524A	301-521B	301-471A,B
301-531A	301-525A	301-527B	301-526B
301-532B	301-529B	580-442B	
301-533B			

Students may also fulfil the remaining architectural complementary credit requirements by taking one or more of the summer courses listed below:

301-317C	301-318C	301-319C	301-379L

OUTSIDE ELECTIVES: **6**

6 credits must be completed outside the School of Architecture, subject to School approval.

TOTAL CREDITS, B.Sc.(Arch.): **102**

Architectural Complementaries

301-252A	(3)	intro. to Architectural History I
301-253B	(3)	Intro. to Architectural History II
301-317C	(4)	Avant-Garde Art and Design
301-318C	(4)	Design Sketching
301-319C	(4)	The Camera and Perception
301-350A	(3)	The Material Culture of Canada
301-364B	(2)	Architectural Modeling
301-372A	(2)	History of Architecture in Canada
301-375A	(2)	Landscape
301-377B	(2)	Energy, Environment and Buildings
301-378A	(3)	Site Usage
301-379L	(4)	Summer Course Abroad
301-383B	(2)	Geometry, Architecture and Environment
301-388A	(2)	Introduction to Historic Preservation
301-461B	(1)	Freehand Drawing & Sketching
301-471A,B	(2)	Computer-Aided Building Design
301-490A,B	(2)	Selected Topics in Design
301-521B	(3)	Structure of Cities
301-522A	(3)	History of Domestic Arch. in Quebec
301-523B	(3)	Significant Texts and Buildings
301-524B	(3)	Seminar on Architectural Criticism
301-525A	(3)	Seminar on Analysis and Theory
301-526B	(3)	Philosophy of Structure
301-527B	(3)	Civic Design
301-528A	(3)	History of Housing
301-529B	(3)	Housing Theory
301-531A	(3)	Arch. Intentions from Vitruvius to the Renaissance
301-532B	(3)	Origins of Modern Architecture
301-533B	(3)	New Approaches to Architectural History
301-540A,B	(3)	Selected Topics in Architecture I
301-541A,B	(3)	Selected Topics in Architecture II
580-442B	(2)	Enabling Environments

CURRICULUM FOR THE B.Arch. DEGREE

REQUIRED COURSES		COURSE CREDIT	
Non-Departmental Subjects			
300-220A	Law for Architects & Engineers	3	
306-310A,B	Engineering Economy	3	**6**
Architectural Subjects			
301-411A	Design and Construction VI	7	
301-413B	Design and Construction VIII	7	
301-429T	Summer Project III	1	
301-430T	Sketching School II	1	
301-436A	Urban Planning II	2	
301-449A	Professional Practice	2	
301-450B	Specifications and Building Costs	2	
301-451A	Building Regulations and Safety	2	**24**

COMPLEMENTARY COURSES **4**
4 credits of complementaries; 2 credits must be taken from the architectural complementary list above.

TOTAL CREDITS, B.Arch **34**
Following completion of the B.Sc.(Arch.)

COURSES OFFERED BY THE SCHOOL

● Denotes courses not offered in 1999-2000.

▭ Denotes limited enrolment.

★ Denotes courses offered only in alternate years.

Unless otherwise indicated, students not registered in the B.Sc.(Arch.)/B.Arch. programs who wish to take courses offered by the School of Architecture must obtain a password card from the Student Advisor.

301-201A COMMUNICATION, BEHAVIOUR & ARCH. 6(2-10-6) Introduction to design; development of design judgement and communication skills in a series of exercises addressing light, scale, space, form and colour in the built environment; introduction to techniques of oral and graphic presentation, including model making, photography, sketching and architectural drawing. The course is based in the studio and includes lectures, seminars and field trips. **Professor Covo and Adjunct Faculty**

301-202B ARCH. GRAPHICS & ELEMENTS OF DESIGN. 6(2-10-6) (Prerequisite: 301-201A) Introduction to architectural design; consideration of building form in relation to program, structural system, material selection, site and climate; further development of skills in model making, conventional architectural drawing, axonometric and perspective drawing, sketching and architectural rendering. The course is based in the studio and includes lectures, seminars and field trips. **Professor Zuk and Adjunct Faculty**

301-217A FREEHAND DRAWING I. 1(0-3-0) Drawing in pencil and charcoal. Section 01 reserved for Architecture students. Section 02, reserved for others; limited enrolment, password card required. **Professors Tondino and Nash**

301-218B FREEHAND DRAWING II. 1(0-3-0) (Prerequisite: 301-217A) A continuation of course 301-217A. Section 01 reserved for Architecture students. Section 02, reserved for others; limited enrolment, password card required.
Professors Tondino and Nash

301-240B ORGANIZATION OF MATERIALS IN BLDGS. 3(2-3-4) The characteristics of basic building materials: wood, steel, masonry and concrete. How building materials are shaped into building components, and how these components are integrated into the building envelope. Problems, laboratory projects and field trips to illustrate principles. **Professor Friedman**

301-250A ARCHITECTURAL HISTORY I. 2(2-0-4) The study of architecture and cities in their social, political and cultural contexts from the earliest settlements to the end of the Middle Ages.
Professor Castro

301-251B ARCHITECTURAL HISTORY II. 2(2-0-4) (Prerequisite: 301-250B) The study of architecture and cities in their social, political and cultural contexts from the Renaissance to the present. In-depth study of the language of architectural history.
Professor Adams

▭ **301-252A INTRO. TO ARCHITECTURAL HISTORY I.** 3(3-0-6) The study of architecture and cities in their social, political and cultural contexts from the earliest settlements to the end of the Middle Ages. Introduction to the language of architectural history. Open only to students outside the School of Architecture. Limited enrolment, password card required. **Professor Castro**

▭ **301-253B INTRO. TO ARCHITECTURAL HISTORY II.** 3(3-0-6) The study of architecture and cities in their social, political and cultural contexts from the Renaissance to the present. In-depth study of the language of architectural history. Open only to students outside the School of Architecture. Limited enrolment, password card required. **Professor Adams**

301-303A DESIGN AND CONSTRUCTION I. 6(2-10-6) (Prerequisite: 301-202B) An exploration of the design of buildings. Projects emphasize the major social, technological, environmental, and symbolic aspects of the design process. Introduction to specific modelling, presentation, and documentation techniques. Discussions, readings, field trips and practical exercises.
Professors Bourke, Castro and Rousseau

301-304B DESIGN AND CONSTRUCTION II. 6(2-10-6) (Prerequisite: 301-303A) Continuation of Design and Construction I with projects of increasing complexity. Projects deal with particular aspects of architectural design and/or explore approaches to design methodology. Discussions, readings, field trips and practical exercises.
Professors Adams, Castro and Rousseau

▭ **301-318C DESIGN SKETCHING.** 4(2-5-5) (Prerequisite: 301-202B) Pictorial drawing in the design process; relationship of drawing type to design intention; strategies for visualization and representation based on perspective sketching, axonometric and oblique projection in selected media; studio work based on design exercises and problems varying in length from several minutes to several days. Limited enrolment; password card required.
Professor Covo

▭ **301-319C THE CAMERA AND PERCEPTION.** 4(2-5-5) (Prerequisite: 301-202B) An intensive study of man and the urban environment. Through the use of still photography, the relationship of time, motion, space, place and light are explored in order to gain insights into the urban environment. Topics include: "photographic seeing", light, survey of masters, history of photography, camera and darkroom techniques, tonal control, composition, etc. Limited enrolment; password card required. **Staff**

301-321A FREEHAND DRAWING III. 1(0-3-0) (Prerequisite: 301-218B) A continuation of course 301-218B. Section 01 reserved for Architecture students. Section 02, reserved for others; limited enrolment, password card required.
Professors Tondino and Nash

301-322B FREEHAND DRAWING IV. 1(0-3-0) (Prerequisite: 301-321A) A continuation of course 301-321A. Section 01 reserved for Architecture students. Section 02, reserved for others; limited enrolment, password card required.
Professors Tondino and Nash

301-324T SKETCHING SCHOOL I. 1(0-0-3) (Prerequisite: 301-218B) An eight-day supervised field trip in the late summer to sketch places or things having specific visual characteristics. Students are required to include Sketching School 1 in the B.Sc.(Arch.) program. **Professors Castro, Covo and Tondino**

301-327T SUMMER PROJECT I. 1(0-0-3) (Prerequisite: 301-202B) These projects are assigned by staff members before the end of the session to be submitted at registration for the fall semester.
Professors Adams, Castro and Sijpkes

301-350A THE MATERIAL CULTURE OF CANADA. 3(2-1-6) A study of Material Culture in Canada, the "stuff" of our lives; using a multidisciplinary approach to the interpretation of the non-textual materials which have shaped the lives of past and present Canadians, using the resources of the McCord Museum and other Montreal museums, galleries and collections. Section 01, reserved for Architecture, Section 02, reserved for Canadian Studies, Section 03, reserved for others. **Professors Adams, Kenneally and visitors**

▭ **301-364B ARCHITECTURAL MODELING.** 3(2-1-6) (Prerequisite: 301-202B and 301-471B) Architectural modeling using digital media. Topics include: advanced 3-D modeling and rendering techniques; raster and vector image editing; digital animation; hypertext and the World Wide Web; issues of representation and methodology; comparison of various publishing media. Limited enrolment. (Credit weight change – Awaiting University Approval)
Professor Yip

● ▭ ★ **301-372A HISTORY OF ARCHITECTURE IN CANADA.** 2(2-0-4) (Prerequisite: 301-202B) (Given alternate years, alternating with 301-388A.) French, British and American influences in the

Maritime Provinces, Quebec and Ontario. Limited enrolment; password card required. **Professor Gersovitz**

301-375A LANDSCAPE. 2(2-2-2) (Prerequisite: 301-202B) Land form, plant life, microclimate; land use and land preservation; elements and methods of landscape design. **Professor Émond**

301-377B ENERGY, ENVIRONMENT AND BUILDINGS. 2(2-0-4) (Prerequisite: 301-202B or permission of instructor) Energy consumption in the built environment; architectural means to conserve energy; the potential and limitations of unconventional sources of energy; a comparative study of energy conserving buildings and their long-term environmental impact; effects of legislation and financing. Section 01 reserved for Architecture students. Section 02 for others; limited enrolment; password card required.

Professors Bhatt and Thibodeau

301-378A SITE USAGE. 3(2-0-7) (Prerequisite: 301-202B or permission of instructor) The study of the creation, form and usage of the exterior space generated in various patterns of low-rise housing. Socio-cultural aspects of patterns; exterior space as a logical extension of the living unit; social control of the use of urban and suburban land; comparative model for low-rise housing patterns. Section 01 reserved for Architecture students. Section 02, for others; limited enrolment; password card required.

Professor Drummond

▭ **301-379L SUMMER COURSE ABROAD.** (4 credits) (Prerequisite: 301-202B or permission of instructor) Study of a distinct urban environment and its key buildings; graphic recording and analysis of physical configuration, constructional peculiarities and present use. Excursions to neighbouring sites of special architectural interest. Limited enrolment; password card required.

Professors Castro and Zuk

301-383B GEOMETRY, ARCHITECTURE AND ENVIRONMENT. 2(2-0-4) (Prerequisite: 301-202B or permission of instructor) Geometry in the formal structure of design. Grids, lattices, polygons and polyhedra; proportional systems. Evidence of these figures and structures in natural objects and phenomena. Graphical and physical models. Application to architecture and the human environment.

Professor Zuk

★301-388A INTRODUCTION TO HISTORIC PRESERVATION. 2(2-2-2) (Prerequisite: 301-303A) (Given alternate years, alternating with 301-372A.) Historic attitudes and terminologies of conservation; historic research techniques. Restoration technology of building materials and principles of interior design in the 19th and 20th centuries; current preservation planning.

Professor Gersovitz

301-405A DESIGN AND CONSTRUCTION III. 6(2-10-6) (Prerequisites: 301-304B and 301-428T) A structured investigation of architectural concepts; program interpretation with respect to relevant cultural, social and environmental contexts; applications of appropriate formal languages and building technologies in integrated proposals for a variety of building forms.

Professors Anderson, Sheppard and Zuk and Adjunct Faculty

301-406B DESIGN AND CONSTRUCTION IV. 6(2-10-6) (Prerequisite: 301-405A) A detailed study and comprehensive development of architectural proposals for complex building types and site conditions; the exploration of coherent initial concepts with respect to programmatic requirements, image and form; subsequent elaboration leading to meaningful and technologically viable designs for the built environment. **Professors Anderson, Bhatt, Sheppard and Adjunct Faculty**

301-411A DESIGN AND CONSTRUCTION VI. 7(2-12-7) (Prerequisite: 301-406B) A series of studies of complex architectural and urban design issues with the intention of improving the student's facility to critically assess existing design solutions, to seek alternatives and to articulate clearly the rationale and the impact of alternative proposals. **Professor Davies, Adjunct Faculty and invited critics**

301-413B DESIGN AND CONSTRUCTION VIII. 7(2-12-7) (Prerequisite: 301-406B and 301-411A) An individual, student selected and faculty approved study of complex environmental problems involving conflicting requirements, severe restraints, optimization, adaptability to growth and change, and the integration of building systems. Demonstration of systematic design methods leading to the design of a comprehensive environmental form.

Professor Davies and Staff

301-428T SUMMER PROJECT II. 1(0-0-3) (Prerequisite: 301-304B) See course 301-327T. **Professors Anderson, Sheppard and Zuk**

301-429T SUMMER PROJECT III. (0-0-3) (Prerequisite: 301-406B) See course 301-327T. **Staff**

301-430T SKETCHING SCHOOL II. 1(0-0-3) (Prerequisite: 301-324T) Students are required to include Sketching School II in the B.Arch. program. **Professors Castro, Covo and Tondino**

301-435B URBAN PLANNING I. 2(2-2-2) (Prerequisite: 301-405A) Theory and practice. An examination of different basic approaches to urban planning with special reference to Quebec. (Not normally open to Urban Planning students.) Section 01 reserved for Architecture students. Section 02, reserved for others; limited enrolment, password card required. **Professor Wolf**

301-436A URBAN PLANNING II. 2(2-2-2) (Prerequisite: 301-406B) Urban Design and Project Development. Theory and practice. Detailed analysis of selected examples of the development process and of current techniques in urban design. Section 01 reserved for Architecture students. Section 02, reserved for others; limited enrolment, password card required. **Professor Fischler**

301-446A MECHANICAL SERVICES IN BUILDINGS. 2(2-2-2) (Prerequisite: 301-304B) Problems encountered in providing mechanical services in buildings. Physiological and environmental aspects of heat, ventilation and air conditions, estimation of heating and cooling loads and selection and specification of equipment. Sprinkler systems and plumbing. Construction problems produced by installation of this equipment. Section 01, reserved for Architecture students; section 02, reserved for others, limited enrolment, password card required. **Professor Levine**

301-447A ELECTRICAL SERVICES. 2(2-2-2) (Prerequisite: 301-304B) Production, measurement and control of light; design of lighting systems; electrical distribution in residential and commercial buildings; Canadian Electrical Code. Section 01, reserved for Architecture students; section 02, reserved for others, limited enrolment, password card required. **Professor Edwards**

301-448B ENVIRONMENTAL ACOUSTICS. 2(2-2-2) (Prerequisite: 301-304B) Acoustics in architectural design, and in environmental control of buildings. Acoustical requirements in the design of auditoria such as theatres, lecture halls, opera houses, concert halls, churches, motion picture theatres, studios. Principles of noise and vibration control, sound insulating in building construction. Practical noise control in various types of buildings. Section 01, reserved for Architecture students; section 02, reserved for others, limited enrolment, password card required. **Professor Melanson**

301-449A PROFESSIONAL PRACTICE. 2(2-2-2) (Prerequisite: 301-406B) The architect's relationship to his/her client; responsibility; business conduct; supervision; arbitration; issuing of certificates; competitions; standard forms of contracts; payment; liens; servitudes; public health; building regulations; fees.

Professor Sheppard

301-450B SPECIFICATIONS AND BUILDING COSTS. 2(2-0-4) (Prerequisite: 301-406B) Principles of architectural construction specifications; research for specification production; development of a written specification technical section. Principles of construction economis; measurement and cost estimating of construction work; cost analysis. Section 01, reserved for Architecture students; Section 02, reserved for others. Limited enrolment, password card required. **Professor Poddubiuk**

301-451A BUILDING REGULATIONS AND SAFETY. 2(2-2-2) (Prerequisite: 301-406B) The study of building codes with specific empha-

sis on the National Building and National Fire Codes of Canada. Examples of existing buildings with assignments to illustrate regulations. Development of a systematic approach to the implementation of codes during the preliminary design stage of an architectural project. Section 01, reserved for Architecture students; section 02, reserved for others, limited enrolment, password card required. **Professor Zorko**

301-461B FREEHAND DRAWING AND SKETCHING. 1(0-3-0) (Prerequisite: 301-324C) Drawing and sketching in pencil, charcoal and other media both in the studio and out-of-doors.
Professor Tondino

▭ **301-471A,B COMPUTER-AIDED BUILDING DESIGN.** 2(2-2-2) (Prerequisite: 301-202B or equivalent) An introduction to selected applications of interactive computing in architecture; emphasis on development of simple algorithms in graphic, as well as non-graphic, modes in hands-on situations in the lab; field trips to several in use installations. Limited enrolment; password card required. **Staff**

301-490A,B SELECTED TOPICS IN DESIGN. 2(2-0-4) (Prerequisite: 301-202B or permission of instructor.) A course to allow the introduction of special topics in related areas of design. **Staff**

301-520B MORPHOLOGY OF THE METROPOLIS: MONTREAL. 3(2-1-6) (Prerequisite: 301-251B) The course deals with the historical, demographical and regional evolution of the metropolis of Montreal. Important *quartiers*, the Montreal urban grid, industrialization, reform movements, geographical diversity, and urban culture are discussed. Local building techniques and materials, known as the Quebec genre, and basic concepts of urban morphology and their relationships to the contemporary urban context will be explored. Section 01, reserved for Architecture students; Section 02, reserved for others. Password card required. (Awaiting University Approval) **Professor Rohan**

301-521B STRUCTURE OF CITIES. 3(2-0-7) (Prerequisite: 301-202B or permission of instructor) Nature, pattern and life of modern cities. Urban networks, special areas, problems and prosects. Section 01 reserved for Architecture students. Section 02, reserved for others; limited enrolment, password card required. **Professor Anderson**

▭ **301-522A HISTORY OF DOMESTIC ARCH. IN QUEBEC.** 3(2-0-7) (Prerequisite: 301-251A) The architecture of houses in Quebec from 1650 to the present. Distinguished buildings are reviewed from the point of view of form, style, siting and material, as influenced by climate, culture and architectural antecedents in France, England and the United States. The course material is presented through alternating bi-weekly lectures and seminars. Limited enrolment; password card required. **Professor Anderson**

▭ ★ **301-523B SIGNIFICANT TEXTS & BUILDINGS.** 3(2-0-7) (Prerequisite: 301-251A) (Alternating with 301-524B.) Critical study of significant architectural thought since 1750 as it has been expressed in buildings and texts (treatises, manifestos, criticisms). A specific theme will be addressed every year to allow in-depth interpretations of the material presented and discussed. Limited enrolment; password card required. **Professor Castro**

● ▭ ★**301-524B SEMINAR ON ARCHITECTURAL CRITICISM.** 3(2-0-7) (Prerequisite: 301-251A) (Alternating with 301-523B.) The development and current role of architectural criticism with particular reference to its affinities with art and literary criticism. Limited enrolment; password card required. **Professor Castro**

▭ **301-525A SEMINAR ON ANALYSIS AND THEORY.** 3(2-0-7) (Prerequisite: 301-202B or permission of instructor) Analysis and evaluation of significant architectural projects with reference to contemporary architectural theories. Limited enrolment; password card required. **Professor Zuk**

301-526B PHILOSOPHY OF STRUCTURE. 3(2-0-7) (Prerequisite: 301-202B or permission of Instructor) Philosophy of Structure aims to investigate structure in its broadest sense. The course is divided in two halves; the first one gives an overview of the development of theoretical structural frameworks such as mathematics and geometry, while the second one highlights physical structures constructed by nature (geology, turbulence), man or animals. Not open to students who have taken 301-374B. Section 01, reserved for Architecture students; section 02, reserved for others; password card required. **Professor Sijpkes**

301-527B CIVIC DESIGN. 3(2-0-7) (Prerequisite: 301-378A) The elements of form in buildings and their siting design in the urban setting. Section 01 reserved for Architecture students. Section 02, reserved for others; Password card required, limited enrolment.
Professor Drummond

▭ **301-528A HISTORY OF HOUSING.** 3(2-0-7) (Prerequisite: 301-251A or permission of instructor) Indigenous housing both transient and permanent, from the standpoint of individual structure and pattern of settlements. The principal historic examples of houses including housing in the age of industrial revolution and contemporary housing. Limited enrolment. Section 01 reserved for Architecture, Section 02 reserved for Masters of Architecture students, Section 03 reserved for Urban Planning students, Section 04 reserved for Urban Systems Students, Section 05 reserved for Engineering Students. Enrolment Cap is placed on each section.
Professors Schoenauer and Sijpkes

301-529B HOUSING THEORY. 3(2-0-7) (Prerequisite: 301-528A or permission of instructor) A review of environmental alternatives in housing; contemporary housing and the physical and sociological determinants that shape it; Canadian housing. Section 01 reserved for Architecture students. Section 02 reserved for others; limited enrolment, password card required.
Professor Schoenauer

301-531A ARCH. INTENTIONS FROM VITRUVIUS TO THE RENAISSANCE. 3(2-0-7) (Prerequisite: 301-251A) Architectural intentions embodied in buildings and writings of architects from antiquity to the Renaissance. Special emphasis is placed on the cultural connections of architecture to science and philosophy. Section 01 reserved for Architecture students. Section 02 reserved for others; limited enrolment, password card required.
Professor Pérez-Gómez

301-532B ORIGINS OF MODERN ARCHITECTURE. 3(2-0-7) (Prerequisite: 301-251A) Examination of architectural intentions (theory and practice) in the European context (especially France, Italy and England), during the crucial period that marks the beginning of the modern era. Section 01 reserved for Architecture. Section 02 reserved for others; limited enrolment, password card required.
Professor Pérez-Gómez

● ▭ **301-533B NEW APPROACHES TO ARCHITECTURAL HISTORY.** 3(2-0-7) (Prerequisite: 301-251A or permission of instructor) An exploration of the aims, tools, and methods of Architectural History as a discipline; the use of primary sources from the Canadian Centre for Architecture and other archives. Limited enrolment; password card required. **Professor Adams**

301-540A,B SELECTED TOPICS IN ARCHITECTURE I. 3(2-0-7) A course to allow the introduction of new topics in Architecture as needs arise, by regular and visiting staff. **Staff**

301-541A,B SELECTED TOPICS IN ARCHITECTURE II. 3(2-0-7) A course to allow the introduction of new topics in Architecture as needs arise, by regular and visiting staff. **Staff**

▭ **580-442B ENABLING ENVIRONMENTS.** 2(1-2-3) (Prerequisite: 301-303A for Architecture students; 580-326D for Occupational Therapy students) Students work in multi-disciplinary teams under the supervision of faculty and visitors on projects in the design and construction of environments for the disabled drawn from case histories of selected institutions. Course work may include group and individual field trips to hospitals, clinics or specific project sites. Limited enrolment. **Professors Gisel, Covo and visitors**

4.3 Department of Chemical Engineering

Chair
Richard J. Munz; B.A.Sc., M.A.Sc.(Wat.), Ph.D.(McG.), Eng.

Professors
David G. Cooper; B.Sc., Ph.D.(Tor.)
John M. Dealy; B.S.(Kansas), M.S.E., Ph.D.(Mich.), Eng.
W.J. Murray Douglas; B.Sc.(Qu.), M.S.E., Ph.D.(Mich.)
Musa R. Kamal; B.S.(Ill.) M.S., Ph.D.(Carnegie-Mellon), Eng.
Arun S. Mujumdar; B.Ch.E.(Bombay), M.Eng., Ph.D.(McG.)
Juan H. Vera; B.Mat.(Chile), Ing.Quim.(U.T.E.), M.S.(Berkeley), Dr.Ing.(Santa Maria), Ing.
Bohumil Volesky; M.Sc.(Czech. Tech. Univ.), Ph.D.(W.Ont.)
Martin E. Weber; B.S.E.(Prin.), Sc.D.(M.I.T.), P.Eng.

Associate Professors
Dimitrios Berk; B.Sc.(Bosphorus), M.E.Sc.(W.Ont.), Ph.D.(Calg.), P.Eng.
Jean-Michel Charrier; Dipl. Ing., E.N.S.A.M.(Paris), M.S., Ph.D.(Akron), Ing.
Jean-Luc Meunier; Dipl. Ing., EPFL(Lausanne), M.Sc., Ph.D., INRS(Varennes), Ing.
Alejandro D. Rey; B.Ch.Eng.(CCNY), Ph.D.(Berkeley)
Jana Simandl; B.Eng.(McG.), Ph.D.(Calg.), P.Eng.

Assistant Professor (Special Category)
Paula Wood-Adams; B.Sc.(Alta), M.Eng, Ph.D.(McG.)

Associate Members
Thomas M.S. Chang; B.Sc., M.D., Ph.D.(McG.), F.R.C.P.(C)
Reinhold H. Crotogino; B.A.Sc.(U.B.C.), Ph.D.(McG.)
Harry L. Goldsmith; B.Sc., M.A.(Oxon.), Ph.D.(McG.) *(Experimental Medicine)*

PAPRICAN Adjunct Professors
George J. Kubes; B.Eng., M.Eng.(Prague), Ph.D.(Bratislava)
Gil B. Garnier; B.Appl.Sc., M.Appl.Sc.(Sherbrooke), Ph.D.(Virginia Polytechnic Institute and State University)

Adjunct Professors
Bohumil Alince, Manon Bérubé, Pierre Bisaillon, Richard Campeau, Lionel Chartier, Earl J. Chin, Norman E. Cooke, Peter Csakany, Eric Denman, Pierre Duhaime, Andrés Garcia-Rejon, Sylvain Gendron, Robert W. Gooding, Serge Guiot, Norayr Gurnagul, Bing Huang, R. Bruce Kerr, Tadeusz Kudra, Caroline Ladanowski, Pascale Lagacé, D. Cameron Lamond, Norman Liebergott, David J. McKeagan, Raman Nayar, Ky T. Nguyen, Jean R. Paris, Michel Perrier, Norman Peters, Ivan I. Pikulik, Alain A. Roche, John Sarlis, Paul Stuart, Khoa Tran, Roger C. Urquhart, Leszek A. Utracki.

The central purpose of engineering is to pursue solutions to technological problems in order to satisfy the needs and desires of society. Chemical engineers are trained to solve the kinds of problems that are typically found in the "chemical process industries", which include the chemical manufacturing, plastics, pulp and paper, petroleum refining, ceramics, and paint industries as well as substantial portions of the food processing, textile, nuclear energy, biochemical and pharmaceutical industries. The technological problems and opportunities in these industries are often closely linked to social and economic questions. For this reason, practitioners of chemical engineering often deal with these questions when they are working in management, pollution abatement, product development, marketing and equipment design.

The discipline of chemical engineering is distinctive in being based equally on physics, mathematics and chemistry. Application of these three fundamental sciences is basic to a quantitative understanding of the process industries. Those with an interest in the fourth major science, biology, will find several courses in the chemical engineering curriculum which integrate aspects of the biological sciences relevant to process industries such as food processing, fermentation and water pollution control. Courses on the technical operations and economics of the process industries are added to this foundation. The core curriculum concludes with process design courses taught by practicing design engineers. Problem-solving, experimenting, planning and communication skills are emphasized in courses throughout the core curriculum.

By means of complementary courses, students can also obtain further depth in technical areas and breadth in non-technical subjects. Some students elect to complete a minor in biotechnology, management, materials engineering, computer science, environmental engineering or chemistry.

The curriculum also provides the preparation necessary to undertake postgraduate studies leading to the M.Eng. or Ph.D. degrees in chemical engineering. Students completing this curriculum acquire a broad, balanced education in the natural sciences with the accent on application. Thus, for those who do not continue in chemical engineering, it provides an exceptionally balanced education in applied science. For others, it will form the basis of an educational program that may continue with a variety of studies such as business administration, medicine or law. Versatility is, then, one of the most valuable characteristics of the graduate of the chemical engineering program.

ACADEMIC PROGRAM

For those who have completed the Quebec CEGEP level program in Pure and Applied Sciences, the Chemical Engineering Program comprises 110 credits as outlined below. Certain students who take advantage of summer session courses can complete the departmental programs in three calendar years. Students who have passed Chemistry 202 or 302 at the CEGEP level are exempt from course 180-212 or 234, respectively (Introductory Organic Chemistry I and Selected Topics in Organic Chemistry), the corresponding courses are transferred from required courses to electives. CEGEP students who have the appropriate calculus background may write Advanced Credit Placement Examinations at a time and place to be announced by the Faculty. Successful completion will give 3 credits for course 189-260 Intermediate Calculus.

For appropriately qualified high school graduates from outside Quebec, an extended credit program is available, as described in section 3.1.2 on page 220.

In some cases students from university science disciplines have sufficient credits to complete the requirements for the B.Eng. (Chemical) program in two years. Those concerned should discuss this with their advisor.

Students must obtain a C grade or better in all core courses. For the Department of Chemical Engineering, core courses include all required courses (departmental and non-departmental) as well as complementary courses (departmental). A grade of "D" is a passing grade in other complementary courses and in any elective courses taken.

CURRICULUM FOR THE B.ENG. DEGREE IN CHEMICAL ENGINEERING

REQUIRED COURSES		COURSE CREDIT	
Non-Departmental Courses			
180-212A,B	Introductory Organic Chemistry I	4	
180-233B	Sel. Topics in Phys. Chemistry	3	
180-234A,B	Sel. Topics in Org. Chemistry	3	
189-260A,B	Intermediate Calculus	3	
189-261A,B	Differential Equations	3	
189-265A,B	Advanced Calculus	3	
306-221A,B	Engineering Professional Practice	1	
306-310A,B	Engineering Economy	3	
308-208A,B	Computers in Engineering	3	**26**
Chemical Engineering Courses			
302-200A	Intro. to Chemical Eng.	4	
302-204B	Chemical Manuf. Processes	3	
302-220B	Chem. Eng.Thermodynamics	3	
302-291A	Instr. Measurements Lab.	4	
302-314A	Fluid Mechanics	4	
302-315B	Heat and Mass Transfer	4	
302-340B	Process Modelling	3	
302-351B	Separation Processes	3	
302-360A,B	Technical Paper I	1	

302-370A	Elements of Biotechnology	3	
302-380A	Materials Science	3	
302-392A	Project Laboratory I	4	
302-393B	Project Laboratory II	5	
302-423A	Chemical Reaction Engineering	4	
302-453A	Process Design	4	
302-456A,B	Design Project I	1	
302-457A,B	Design Project II	5	
302-455B	Process Control	4	
302-462A,B	Technical Paper II	1	
302-474A	Biochemical Engineering	3	
302-484B	Materials Engineering	3	**69**

COMPLEMENTARY COURSES

Courses to be selected from those approved by the Department (see list of technical complementaries below)	**9**
See section 3.3 on page 220. The Chemical Engineering program requires 6 credits selected from categories (i) and (ii) of section 3.3.	**6**
TOTAL	**110**

If advanced credit is obtained for 189-260 Intermediate Calculus (see section 2.3 on page 219), the total number of credits is reduced by three.

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		**Credits**	
180-212A	Organic Chemistry I	4	
189-260A	Intermediate Calculus	3	
302-200A	Intro. to Chemical Eng.	4	
302-291A	Instr. Meas. Lab.	4	
306-221A,B	Engineering Professional Practice	1	**16**
Semester 2			
180-234B	Organic Chemistry II	3	
189-261B	Differential Equations	3	
302-204B	Chemical Manuf. Processes	3	
302-220B	Chem. Eng. Thermodynamics	3	
308-208B	Computers in Engineering	3	**15**

Students entering their second year of study or who are starting in January must plan their program of studies in consultation with their departmental adviser.

For students admitted to the 8-semester program (see section 3.1.2 on page 220), the additional courses are specified in the "Welcome" book, and can also be found on the Faculty website (http://www.engineering.mcgill.ca).

TECHNICAL COMPLEMENTARIES

A minimum of 9 credits of complementary courses must be chosen from a list of technical complementaries approved by the Department. The purpose of this requirement is to provide students with an area of specialization within the broad field of chemical engineering. Alternatively, some students use the technical complementaries to increase the breadth of their chemical engineering training.

At least two (2) technical complementary courses are to be selected from those offered by the Department (list below). Permission is given to take the third complementary course from other suitable undergraduate courses in the Faculty of Engineering (see for example the Faculty list of courses in section 4.1.1 on page 223).

The technical complementary courses currently approved by the Department are as follows:

302-363A,B	Projects in Chemical Engineering I
302-438B	Eng. Princ. of Pulp & Paper Processes
302-452B	Particulate Systems
302-458A	Computer Applications
302-464A,B	Projects in Chemical Engineering II
302-471A	Industrial Water Pollution Control (or 303-430A)
302-472B	Industrial Air Pollution Control (or 305-534B)
302-481A	Polymer Engineering
302-487A	Chemical Processing in the Electronics Industry
302-494A,B	Research Project and Seminar
302-495A,B	Research Project and Seminar
302-571B	Small Computer Applications in Chemical Engineering
302-581B	Polymer Composites Engineering
202-505B	Selected Topics in Biotechnology (Biotechnology Minor students only)

Courses 481A and 581B comprise a Polymeric Materials sequence. Additional courses in this area are available in the Chemistry Department (e.g. 180-455A) or at the graduate level (302-681 to 684). The Department has considerable expertise in the polymer area.

Courses 370A and 474A make up a sequence in Biochemical Engineering-Biotechnology. Students interested in this area may take additional courses, particularly those offered by the Department of Food Science and Agricultural Chemistry, Faculty of Agricultural and Environmental Sciences, and courses in biochemistry and microbiology. The food, beverage and pharmaceutical industries are large industries in the Montreal area and these courses are relevant to these industries and to the new high technology applications of biotechnology.

The third area in which there is a sequence of courses is Pollution Control. The Department offers two courses in this area: 302-471A and 302-472B. As some water pollution control problems are solved by microbial processes, course 302-474B is also relevant to the pollution control area. Likewise as the solution to pollution problems frequently involves removal of particulate matter from gaseous or liquid streams, course 302-452B is also relevant. Additional courses in this area are listed under section 5.7 on page 261.

A Minor in Biotechnology is also offered in the Faculties of Engineering and of Science with emphasis on Molecular Biology and Chemical Engineering Processes. A full description of the Minor program appears in section 5.2 on page 259.

Note that many of the technical complementaries are offered only in alternate years. Students should, therefore, plan their complementaries as far ahead as possible. With the approval of the instructor and academic adviser, students may also take graduate (302-5XX level) courses as technical complementaries.

ELECTIVE COURSES

Students who have obtained exemptions for courses, i.e. for CEGEP courses equivalent to 180-212 or 180-234, or who take more than the minimum requirements for the degree, may choose university level courses in any field. Approval of an elective course requires only that no timetable conflicts are created and that it not be a repetition of material already covered in the curriculum or already mastered by the student.

CURRICULUM COMMITTEE

The Curriculum Committee is composed of three students, elected by their classes, and two staff members. This Committee provides a forum for all matters involving undergraduate student/staff interactions. While the primary concern is with matters of curriculum and courses (their content, evaluation, scheduling, etc.), the Committee has also taken up a number of other matters in recent years, e.g. working space, facilities (equipment and libraries), etc.

CANADIAN SOCIETY FOR CHEMICAL ENGINEERING

The Chemical Engineering Student Society has for many years been affiliated both with the CSChE (Canadian Society for Chemical Engineering) and with the AIChE (American Institute of Chemical Engineers). For a nominal fee students receive "Canadian Chemical News", a monthly publication, and the AIChE Student Members Bulletin as well as other privileges of student membership in the two societies. The student chapter also organizes a series of local social, educational and sporting events. For exam-

ple, recent events have included student-professor banquets and Christmas parties, dances, speakers, broomball games and joint meetings with the Montreal Section of the CSChE. The latter gives students a chance to mix with practising chemical engineers.

COURSES OFFERED BY THE DEPARTMENT

● Denotes courses not offered in 1999-2000

◎ Complementary courses

▭ Courses with Limited Enrolment

* a D grade is acceptable for prerequisite purposes only

302-200A INTRODUCTION TO CHEMICAL ENGINEERING. 4(3-2-8) (Restrictions: students with DCS in PAS, HS or equivalent.) Introduction to the design of industrial processes. Survey of unit operations, and systems of units. Elementary material balances, first and second laws of thermodynamics, use of property tables and charts, steady flow processes, heat engines, refrigeration cycles. Relationships between thermodynamic properties, property estimation techniques. Laboratory and design exercise.
Professors Vera and Wood-Adams

302-204B CHEMICAL MANUFACTURING PROCESSES. 3(2-3-4) (Prerequisite: 302-200A) Introduction to degrees of freedom. Problem solving in the design of simple processes (mixing, washing, decantation) and separation processes (evaporation, binary distillation). Elements of reaction engineering and process control and design.
Professor Berk

302-220B CHEMICAL ENGINEERING THERMODYNAMICS. 3(3-1-8) (Prerequisite: 302-200A) Application of thermodynamic equilibrium; free energy and equilibrium; phase rule; chemical reaction equilibrium for homogenous and multicomponent/multiphase systems. Application to the design of binary distillation. Laboratory exercise. **Professor Cooper**

◎ ▭ **302-230B ENVIRONMENTAL ASPECTS OF TECHNOLOGY.** 3(3-0-6) The impact of urbanization and technology on the environment. Topics include urbanization: causes, effects, land use regulations; transportation technology and environmental implications; environmental impact of energy conversions; energy policy alternatives; formulation of energy and environmental policy; air pollution: sources, effects, control; water pollution: sources, effects, control. MARS passwords distributed after the first class.
Professor Volesky

302-291A INSTRUMENTAL MEASUREMENT LABORATORY. 4(2-5-5) Elements of statistical analysis associated with instrumental measurements. Principles of operation and calibration of selected measuring instruments. Principles of modern data acquisition and processing. Introduction to instrument system selection in chemical engineering. **Professor Cooper**

302-314A FLUID MECHANICS. 4(3-3-6) (Prerequisite: 302-204B. Corequisite: 189-265A.) Fluid properties; dimensional analysis; drag; packed/fluidized beds; macroscopic energy balances, Bernoulli's equation and linear momentum theorem; flowmeters, pipeline systems, non-Newtonian fluids, microscopic balances leading to continuity and Navier-Stokes equations; boundary layer approximation; turbulence. Laboratory exercises. **Professor Mujumdar**

302-315B HEAT AND MASS TRANSFER. 4(3-2-7) (Prerequisite: 302-314A) Transport of heat and mass by diffusion and convection; transport of heat by radiation; diffusion; convective mass transfer; drying; gas-liquid separations; absorption; mathematical formulation of problems and equipment design for heat and mass transfer; laboratory exercises. **Professor Meunier**

302-340B PROCESS MODELLING. 3(3-1-5) (Prerequisites: 189-261A,B; 189-265A,B; 302-314A) Principles of mathematical modelling in chemical engineering: problem formulation, solution, discrete systems; difference and difference-differential equations, methods of solution; understanding system behaviour, optimization. **Professor Rey**

302-351B SEPARATION PROCESSES. 3(3-0-6) (Prerequisites: 302-204B; 308-208A,B; 302-220B. Corequisites: 302-315B.) Concepts underlying separation processes. Equilibrium-based processes with staging and continuous contacting, distillation, evaporation, liquid-liquid extraction, leaching. Introduction to membrane based separations. **Professor Simandl**

302-360A,B TECHNICAL PAPER I. 1(0-0-3) A technical paper prepared according to instructions issued by the Department.
Mr. Denman

◎ **302-363A,B PROJECTS IN CHEMICAL ENGINEERING I.** 2(1-0-5) (Prerequisite: 302-200A*) Projects on social or technical aspects of chemical engineering practice. Students must suggest their own projects to be approved and supervised by a member of the staff. Students may work in groups. **Staff**

302-370A ELEMENTS OF BIOTECHNOLOGY. 3(3-0-6) (Prerequisite: 180-234A,B) Industrially important proteins, carbohydrates and other biochemicals, industrially significant microbes; cell structure and metabolism; laboratory exercises. **Professor Volesky**

302-380A MATERIALS SCIENCE. 3(3-1-5) (Prerequisite: 302-220B) Structure/property relationship. Atomic and molecular structure, bonds, electronic band structure. Order in solids: crystal structure, disorders, solid phases. Mechanical properties and fracture, physico-chemical properties, design. **Professor Meunier**

302-392A PROJECT LABORATORY I. 4(3-3-6) (Prerequisites: 302-291B) Planning for the solution of experimental problems; design of experiments for logical and statistical interpretation; statistical analysis of experimental data; effective work in groups; selected laboratory exercises. **Professor Weber**

302-393B PROJECT LABORATORY II. 5(2-10-4) (Prerequisite: 302-392A) Student groups execute and report on experimental projects. **Professor Weber and Staff**

302-423A CHEMICAL REACTION ENGINEERING. 4(3-1-8) (Prerequisites: 180-233B; 302-315B) Review of fundamental concepts in chemical reaction thermodynamics and kinetics. Mass and energy balances for homogenous ideal reactors. Batch, semi-batch and continuous operation. Heterogenous reactions, effect of heat and mass transfer on the global rate, introduction to catalytic and non-catalytic reactions and multiphase reactors. Laboratory exercises.
Professor Munz

● ◎ ▭ **302-430A TECHNOLOGY IMPACT ASSESSMENT.** 3(3-1-5) The power of technology to shape man's physical, economic and social environment: effects of technological transitions on culture and ecology; TIA methodologies, public participation, engineering contributions, regulations; implications of TIA on social and economic development. Limited enrolment. Restricted to final year students by permission of instructor. **Professor Ladanowski**

◎ **302-438B ENGRG PRINCIPLES IN PULP & PAPER PROCESSES.** 3(3-0-6) (Corequisites: 302-423A) Characterization of wood, pulp and paper. Flowsheets of basic pulping processes. Applications of thermodynamics, fluid mechanics, heat and mass transfer, and reaction engineering principles in the pulp and paper processes.
Dr. G.J. Kubes

◎ **302-452B PARTICULATE SYSTEMS.** 3(3-0-6) (Prerequisites: 302-201A, 302-210B*) Study of operations involving multiphase systems with one of the phases finely sub-divided as bubbles, drops or particles. Applications in grinding, agglomeration, settling, fluidization etc. **Professor Munz**

302-453A PROCESS DESIGN. 4(4-1-7) (Prerequisites: 302-315B; 306-310A,B. Corequisite: 302-351B) Analysis of design alternatives. Structure of process design systems, degrees of freedom, information flow. Computer-aided process and plant design programs, physical properties, specifications, recycle convergence, optimization, applications, economics. Safety, environmental control in plant design. **Professor Simandl**

302-455B PROCESS CONTROL. 4(3-1-8) (Prerequisites: 302-315B; 302-351B; 302-423A) Dynamic modelling of processes, transfer functions, first and higher-order systems, dead-time, open and closed loop responses, empirical models, stability, feedback control, controller tuning, transient response, frequency response, feedforward and ratio control, introduction to computer control,

sampling, discrete models, Z-transform, introduction to multivariable control. Laboratory exercises. **Professor Wood-Adams**

302-456A/B DESIGN PROJECT I. 1(1-0-2) (Prerequisite: 302-393B. Corequisite: 302-453A.) Introduction to a process design and economic evaluation project for a major industrial operation. Students work in small group under an experienced plant design supervisor. Must be taken in the semester preceding 302-547.
Professors Kamal and Simandl

302-457A/B DESIGN PROJECT II. 5(1-2-12) (Prerequisite: 302-456A/B) A process plant design and economic evaluation for a major industrial operation. Students work in small groups, under an experienced plant design supervisor. Plant visit. Must be taken in the semester following 302-456. **Professors Kamal and Simandl**

◎ **302-458A COMPUTER APPLICATIONS.** 3(2-3-4) (Prerequisites: 308-208A,B and 302-393B) Use of computers and software as problem solving aids in chemical engineering. Lectures on software engineering, computer architectures, and multitasking. In laboratory work, groups of students will produce software to be used and maintained by others. **Staff**

302-462A,B TECHNICAL PAPER II. 1(0-0-3) (Prerequisite: 302-360A) A technical paper prepared according to instructions issued by the Department. **Mr. Bisaillon**

◎ **302-464A,B PROJECTS IN CHEMICAL ENGINEERING II.** 2(1-0-5) (Prerequisite: 302-363A,B) Projects on social or technical aspects of chemical engineering practice. Students must suggest their own projects to be approved and supervised by a member of the staff. Students may work in groups. **Staff**

◎ **302-471B INDUSTRIAL WATER POLLUTION CONTROL.** 3(3-0-6) (Prerequisite: 302-314A or equivalent) Effect of wastes on streams, water quality and standard analyses, waste water sampling techniques, waste water treatment technology and processes; design of treatment operations and equipment; physical, chemical and biological methods; specific industrial applications with emphasis on Canadian case studies; industrial effluent treatability studies. **Professor Volesky**

● ◎ **302-472B INDUSTRIAL AIR POLLUTION CONTROL.** 3(2-0-7) (Prerequisite: 302-314A or equivalent) Air quality standards, air surveys, process design considerations, dispersion theory and stack design; dust cleaning methods, design of scrubbers, case studies in the Canadian context. **Professor Munz**

302-474A BIOCHEMICAL ENGINEERING. 3(3-0-6) (Prerequisites: 302-370A, 302-423A) Microbial growth kinetics; biological reactors, application of transport phenomena; instrumentation and control; selected topics in downstream processing; novel bioreactor systems. Laboratory exercises. **Professor Volesky**

◎ **302-481A POLYMER ENGINEERING.** 3(3-0-6) (Prerequisites: 180-212A,B) The application of engineering fundamentals to the preparation and processing of polymers. Classification and characterization of polymers, reaction media and kinetics of polymerization, reactor design, mechanical behaviour of polymers, visco-elasticity and rheology, processing techniques; extrusion, molding, etc.
Professor Charrier

302-484B MATERIALS ENGINEERING. 3(3-0-6) (Prerequisites: 302-315B, 302-380A) Processes for forming and producing engineering materials such as amorphous, semicrystalline, textured and crystal-oriented substances, short and long fibre-reinforced polymers, ceramics and ceramic composites. Effect of processing variables on the properties of the finished article. Process of blending and alloying. Shaping, bonding and joining operations.
Professors Rey and Vera

◎ **302-487A CHEM. PROCESSING IN THE ELECTRONICS INDUSTRY.** 3(3-0-6) (Prerequisite: 180-233B) Chemical processes and unit operations in the manufacture of microelectronic components and their supports. Fabrication of silicon wafers, purification, crystal growth. Imaging processes, deposition of semiconductive materials, plasma and chemical etching. Reclamation of reagents from waste streams. Safety and environmental concerns.
Professor Cooper

◎ **302-494A,B,D RESEARCH PROJECT & SEMINAR.** 3(1-6-2) (Prerequisite: 302-393B) Independent study and experimental work on a topic chosen by consultation between the student and Departmental Staff. **Staff**

◎ **302-495A,B,D RESEARCH PROJECT & SEMINAR.** 4(1-9-2) (Prerequisite: 302-393B) Independent study and experimental work on a topic chosen by consultation between the student and the Departmental staff. **Staff**

◎ **302-571B SMALL COMPUTER APPLICATIONS IN CHEM. ENG.** 3(2-0-7) (Prerequisite: 302-458 or permission of the instructor.) The use of small computers employing a high level language for data acquisition and the control of chemical processes. Real-time system characteristics and requirements, analog to digital, digital to analog conversions and computer control loops are examined. Block level simulation. **Professor Huang**

◎ **302-581B POLYMER COMPOSITES ENGINEERING.** 3(3-0-6) (Prerequisite: 302-481 or permission of instructor.) Characteristics of thermoplastic and thermosetting polymeric matrices and particulate/fiber dispersed elements. Associated structure characterization. Processing techniques. Quantitative engineering analyses to correlate structure with properties and processing. Product/process design. Applications in chemical process equipment, construction, transportation (land, marine, aerospace), general industrial and consumer goods. **Professor Charrier**

◎ **302-591B ENVIRONMENTAL BIOREMEDIATION.** 3(3-0-6) The presence and role of microorganisms in the environment, the role of microbes in environmental remediation either through natural or human-mediated processes, the application of microbes in pollution control and the monitoring of environmental pollutants.
Dr. Guiot

4.4 Department of Civil Engineering and Applied Mechanics

Chair
Robert D. Japp; B.Eng., M.Eng., Ph.D.(McG.) Eng.

Emeritus Professors
Louis J. Arcand; B.Sc., M.Eng.(McG.) Q.L.S., M.C.I.S., M.A.S.P.
Philip J. Harris; B.Sc.(Man.), M.Eng., Ph.D.(McG.), F.E.I.C., F.C.S.C.E., Eng.
Stuart B. Savage; B.Eng.(McG.(, M.S.Eng.(Cal.Tech.), Ph.d.(McG.), F.R.S.C.

Professors
Vincent H. Chu; B.S.Eng.(Taiwan), M.A.Sc.(Tor.), Ph.D.(M.I.T.), Eng.
M. Saeed Mirza; B.Eng.(Karachi), M.Eng., Ph.D.(McG.), F.A.C.I., F.E.I.C., F.C.S.C.E., Hon. F.I.E.P., Eng.
Denis Mitchell; B.A.Sc., M.A.Sc., Ph.D.(Tor.), F.A.C.I., Eng.
Van-Thanh-Van Nguyen; B.M.E.(Vietnam), M.C.E.(A.I.T.), D.A.Sc.(Montr.), Eng.
Ronald G. Rice; B.A.Sc.(Tor.), S.M.(M.I.T.), Dipl. U.&R.Pl., Ph.D.(Tor.), Eng.
A. Patrick S. Selvadurai; M.S.(Stan.), Ph.D., D.Sc.(Nottingham), F.E.I.C., F.I.M.A., F.C.S.C.E., P.Eng.
Suresh C. Shrivastava; B.Sc.(Eng.) (Vikram), M.C.E.(Del.), Sc.D.(Col.), Eng.

Associate Professors
Luc E. Chouinard; B.Ing., M.Ing.(Montr.), B.C.L.(McG.), Sc.D.(M.I.T.), Eng.
Ronald Gehr; B.Sc.(Eng.)(Rand), M.A.Sc.,Ph.D.(Tor.), P.Eng.
Robert D. Japp; B.Eng., M.Eng., Ph.D.(McG.), Eng.
Ghyslaine McClure; B.Ing.(Montr.), S.M.C.E.(M.I.T.), Ph.D.(Montr.), Eng.
James Nicell; B.A.Sc., M.A.Sc., Ph.D.(Windsor), P.Eng.

Assistant Professors
Susan J. Gaskin; B.Sc.(Queen's), Ph.D. (Canterbury)
Subhasis Ghoshal; B.C.E. (India), M.S.(Missouri), Ph.D. (Carnegie Melon)
Yixin Shao; B.S., M.S.(Tongji), Ph.D.(Northwestern)

Adjunct Professors
Andre Beaubien, James Byrns, Diane Girard, Serge Guiot, Jalal Hawari, Lionel Hervieux, Catherine Hirou, Graham Holder, Kenneth MacKenzie, V. Mohan Malhotra, Jahangir Mirza, John C. Osler, Richard G. Redwood, Sandro Scola, Bryan Stafford Smith, David Stringer, William Taylor, Emmanuel Triassi, Pierre Trottier, Jan Vrana, Adel R. Zaki, Ronald Zaloum

Civil engineers have traditionally applied scientific and engineering knowledge to the task of providing the built environment, from its conception and planning to its design and construction, maintenance and rehabilitation. Examples include buildings, bridges, roads, railways, dams, and facilities for water supply and treatment, and waste disposal. With the aging and deterioration of an already vast infrastructure, its maintenance and rehabilitation has become an increasingly important role of the civil engineering profession. Also, with worldwide concern about the detrimental impact of human activities on the environment, civil engineers are now in the forefront of developing and providing the means for both prevention and remediation of many aspects of environmental pollution.

The program in Civil Engineering is comprehensive in providing the fundamentals in mechanics and engineering associated with the diverse fields of the profession, in offering choices of specialization, and in fully reflecting the advances in science, mathematics, engineering and computing that have transformed all fields of engineering in recent years. The resulting knowledge and training enables graduates to not only enter the profession thoroughly well prepared, but also to adapt to further change.

The required courses ensure a sound scientific and analytical basis for professional studies through courses in solid mechanics, fluid mechanics, soil mechanics, environmental engineering, water resources management, structural analysis, systems analysis and mathematics. Fundamental concepts are applied to various fields of practice in both required and complementary courses.

By a suitable choice of complementary courses, students can attain advanced levels of technical knowledge in the specialized areas mentioned above. Alternatively, students may choose to develop their interests in a more general way by combining complementary courses within the Department with several from other departments or faculties.

Students who wish to extend their knowledge in certain areas beyond the range that the program complementary courses allow, can also take a Minor program. Minors are available in fields such as Arts, Economics, Management, Environmental Engineering, and Construction Engineering and Management. These require additional credits to be taken from a specified list of topics relating to the chosen field. Further information on the various Minor programs may be found in section 5. Details of how the Minors can be accommodated within the Civil Engineering program will be made available at the time of preregistration counselling.

Experience has shown that graduates of the program who choose to pursue advanced studies elsewhere receive favourable consideration by all the leading universities in North America and abroad.

ACADEMIC PROGRAMS

Considerable freedom exists for students to influence the nature of the program of study which they follow in the Department of Civil Engineering and Applied Mechanics. A variety of advanced complementary courses is offered in five main groupings: Environmental Engineering, Geotechnical Engineering, Hydrotechnical Engineering, Structural Engineering, and Transportation Engineering.

Guidance on the sequence in which required core courses should be taken is provided for students in the form of a sample program which covers the entire period of study. The technical complementary courses selected, usually in the last two semesters of the program, will depend upon the student's interests. U0 and U1 students should consult the "Welcome" book for the prescribed courses for the first two semesters. All students must meet with their advisor to confirm the courses for which they are registered.

Courses taken in Semester 3 or later will depend on a student's interests and ability. Information and advice concerning different possibilities are made available in the Department prior to registration. All programs require the approval of a staff adviser. Programs for students transferring into the Department with advanced standing will be dependent upon the academic credit previously achieved, and such a program will be established only after consultation with a staff adviser.

CURRICULUM FOR THE B.ENG. DEGREE IN CIVIL ENGINEERING

REQUIRED COURSES		COURSE CREDIT	
Non-departmental courses			
186-221A	General Geology	3	
189-260A,B	Intermediate Calculus	3	
189-261A,B	Differential Equations	3	
189-265A,B	Advanced Calculus	3	
305-261B,C	Measurement Laboratory	2	
305-290A	Graphics	3	
306-221A,B	Engineering Professional Practice	1	
306-310A,B	Engineering Economy	3	
308-208A,B	Computers in Engineering	3	**24**
Departmental courses			
303-202B	Construction Materials	4	
303-205A,B	Statics	3	
303-206B	Dynamics	3	
303-207A,B	Solid Mechanics	4	
303-208A	Civil Engrg Systems Analysis	3	
303-210C	Surveying	2	
303-225B	Environmental Engineering	4	
303-290A	Thermodynamics & Heat Transfer	3	
303-302B	Probabilistic Systems	3	
303-311A	Geotechnical Mechanics	4	
303-317A	Structural Engineering I	3	
303-318B	Structural Engineering II	3	
303-319B	Transportation Engineering	3	
303-320A	Numerical Methods	4	
303-323A	Hydrology & Water Resources	3	
303-324B	Construction Project Management	3	
303-327B	Fluid Mechanics & Hydraulics I	4	
303-331B*	Proj Methodology and Communication	3	
303-418A,B	Project	3	
303-432A,B	Technical Paper	1	**63**

* To be replaced by 455-206B Communication in Engineering (3)

COMPLEMENTARY COURSES

Fifteen credits to be selected from those listed below or from other suitable undergraduate or 500-level graduate courses. In exceptional cases, and with the Chair's approval, 600-level graduate courses may be taken as complementary courses. Not all of these courses are offered annually. A list of those to be given will be available prior to the commencement of lectures. **15**

Up to two technical complementary courses may be taken outside the Department, subject to approval by the student's advisor prior to registration (see list of Faculty technical complementaries in section 4.1.1 on page 223). Permission of the Department Chair is required to take more than two. No course that is similar to one available in the Department of Civil Engineering and Applied Mechanics may be taken outside, unless prior arrangements have been made, such as to accommodate courses given in alternate years.

303-416B	(3)	Geotechnical Engineering
303-421B	(3)	Municipal Systems
303-428A	(3)	Fluid Mechanics & Hydraulics II
303-430A	(3)	Water Treatment & Pollut Control
303-433B	(3)	Urban Planning
303-440A	(3)	Traffic Engineering
303-446A	(3)	Construction Engineering
303-451A	(3)	Geoenvironmental Engineering
303-460A	(3)	Matrix Structural Analysis
303-462A	(3)	Design of Steel Structures
303-463B	(3)	Design of Concrete Structures
303-470A,B	(3)	Research Project
303-512B	(3)	Advanced Civil Engrg Materials
303-514A	(3)	Structural Mechanics
303-526B	(3)	Solid Waste Management
303-527A	(3)	Renov & Preserv of Infrastructure
303-540A	(3)	Urban Transportation Planning
303-541B	(3)	Rail Engineering
303-550B	(3)	Water Resources Management
303-553A	(3)	Stream Pollution and Control
303-555B	(3)	Environmental Data Analysis
303-572A	(3)	Computational Hydraulics
303-573A	(3)	Hydraulic Structures
303-574B	(3)	Fluid Mech of Water Pollution
303-575B	(3)	Fluid Mechanics of Air Pollution
303-576B	(3)	Hydrodynamics
303-577A	(3)	River Engineering
303-579B	(3)	Water Power Engineering
303-585B	(3)	Groundwater Hydrology
303-586A	(3)	Earthwork Engineering
303-587A	(3)	Pavement Design

Two courses (6 credits) to be selected in consultation with academic advisor as prescribed by section 3.3 on page 220. **6**

TOTAL CREDITS **108**

If advanced credit given for 189-260A,B, Intermediate Calculus (see section 2.3 on page 219)

TOTAL CREDITS **105**

COURSES OFFERED BY THE DEPARTMENT

● Denotes courses not offered in 1999-2000

Where asterisks appear with a prerequisite, they have the following significance:

* a D grade is acceptable for prerequisite purposes.

** under special circumstances, the Department may permit this course to be taken as a co-requisite.

303-202B CONSTRUCTION MATERIALS. 4(4-2-6) (Prerequisite: 303-290A) Classification of materials; atomic bonds; phase diagrams; elementary crystallography, imperfections and their relationship to mechanical behaviour; engineering properties and uses of ferrous and non-ferrous metals, ceramics, cement, concrete, timber and timber products, polymers, composites; smart materials and systems; electrochemical reactions and corrosion, prevention and protection; environmental influences; group laboratory projects. **Professor Mirza**

303-205A,B STATICS. 3(3-2-4) Systems of forces and couples, resultants, equilibrium. Trusses, frames and beams, reactions, shear forces, bending moments. Centroids, centres of gravity, distributed forces, moments of inertia. Friction, limiting equilibrium, screws, belts. **Professors Chouinard and Shrivastava**

303-206B DYNAMICS. 3(3-2-4) (Prerequisite: 303-205A,B. Co-requisites: 189-260A,B and 189-261A,B.) Kinematics and kinetics of particles, systems, and rigid bodies; mass-acceleration, work-energy, impulse-momentum. Moving coordinate systems. Lagrange's equations. Vibrations and waves. **Professor Gaskin**

303-207A,B SOLID MECHANICS. 4(3-2-7) (Prerequisites: 303-205A,B*, 305-290A** or equivalent) Stress-strain relationships; elastic and inelastic behaviour; performance criteria. Elementary and compound stress states, Mohr's circle. Shear strains, torsion. Bending and shear stresses in flexural members. Deflections of beams. Statically indeterminate systems under flexural and axial loads. Columns. Dynamic loading. (Two-hour laboratory periods, alternate weeks. Weekly tutorials.) **Professors McClure and Shao**

303-208A CIVIL ENGRG SYSTEMS ANALYSIS. 3(3-1-5) (Prerequisites: 189-265A,B and 308-208A,B) Introduction to civil engineering systems; system modelling process; systems approach and optimization techniques; application of linear programming; simplex method; duality theory; sensitivity analysis; transportation problem; assignment problem; network analysis including critical path method; integer linear programming method. **Professor Nguyen**

303-210C SURVEYING 2(*). (Prerequisite: 308-208A,B) The construction and use of modern survey instruments; transit, level, etc.; linear and angular measurements and errors; horizontal and vertical curves; error analysis, significance of figures; use of computers and software; recent developments. **Mr. Scola**
** Two weeks after winter session examination period.*

303-225B ENVIRONMENTAL ENGINEERING. 4(4-2-6) (Prerequisite: 303-290A. Co-requisites: 189-261A,B; 180-293B) Principles of ecology, ecosystems and environmental chemistry and physics, cycles of elements; mass balance analyses; sources and characteristics of pollution; pollution problems and engineered solutions as applied to air, water and soil media; environmental law, policy and impact. **Professor Ghoshal**

303-229A SURVEYING FOR ARCHITECTS. 2(2-3-1) Measurement of elevations, directions and distances using engineer's level, transit and tape; development of plot plans and topographic maps; volumetric calculations of cuts and fills; area measurements using planimeter; traverse computations; architectural applications. **Mr. Scola**

303-281A ANALYTICAL MECHANICS. 3(3-1-5) (Co-requisites: 189-260A,B and 189-261A,B) Kinematics of particles, dynamics of particles. Work, conservative forces, potential energy. Relative motion and general moving frames of reference. Central force fields and orbits. Dynamics of a system of particles. General motion of rigid bodies, angular momentum and kinetic energy of rigid bodies. Generalized coordinates and forces, Lagrange's equations. **Professor Chu and Dr. Babarutsi**

303-283B STRENGTH OF MATERIALS. 4(4-1-7) (Prerequisite: 303-205A,B*) Structural behaviour, trusses, statically determinate beams, frames, and arches; moments of inertia, stress, strain, properties of materials; bending and shearing stresses; torsion; fixed and continuous beams; reinforced concrete beams; columns; combined stresses; Mohr's circle. **Dr. Babarutsi**

303-290A THERMODYNAMICS & HEAT TRANSFER. 3(3-2-4) Macroscopic vs. microscopic viewpoint; states and processes; energy conservation and transformation. Phase equilibrium; equations of state; thermodynamic properties; work; heat; First Law of thermodynamics; internal energy; enthalpy; specific heat; thermodynamic processes: reversibility, polytrophic processes, applications of First Law; Second Law; entropy; introduction to heat transfer. **Professor Nicell**

303-302B PROBABILISTIC SYSTEMS. 3(3-1-5) (Prerequisites: 189-260A,B and 308-208A,B*) An introduction to probability and statistics with applications to Civil Engineering design. Descriptive statistics, common probability models, statistical estimation, regression and correlation, acceptance sampling. **Professor MacKenzie**

303-311A GEOTECHNICAL MECHANICS. 4(3-3-6) (Prerequisite: 303-207A,B) Identification and classification of soils; physical and engineering properties; principle of effective stress; permeability, compressibility, shear strength, stress-strain characteristics; groundwater flow and seepage; earth pressure and retaining

structures; stress distributions in soils; settlement; bearing capacity of shallow foundations. **Professor Selvadurai**

303-317A STRUCTURAL ENGINEERING I. 3(3-1-5) (Prerequisites: 303-202B and 303-207A,B) The design process; loads, sources, classifications, load factors, combinations; limit states design; structural systems and foundations; choice of materials; virtual work and energy methods; statical and kinematic indeterminacy; slope deflection method, introduction to matrix methods; analysis of indeterminate systems; force envelopes. **Professor McClure**

303-318B STRUCTURAL ENGINEERING II. 3(3-1-5) (Prerequisite: 303-317A) Durability and service life; fire resistance and protection; steel, reinforced concrete and timber; behaviour and design of components in tension, compression, bending and shear; slenderness, global and local instability; axial load and moment interaction; curvature, deflection, ductility; connections; bond and anchorage of reinforcement; simple footings. **Professor Mirza**

303-319B TRANSPORTATION ENGINEERING. 3(3-1-5) (Prerequisites: 303-208A and 308-208A,B. Co-requisite: 303-302B) Introduction to design and operating principles and procedures for surface transportation systems, including vehicle motion and performance, pavements, geometric design of roadbeds, vehicle flow and capacity, traffic control, demand, supply and cost concepts. **Professor Rice and Ms. Hirou**

303-320A NUMERICAL METHODS. 4(3-3-6) (Prerequisites: 308-208A,B and 189-265A,B) Numerical procedures applicable to civil engineering problems: integration, differentiation, solution of initial-value problems, solving linear and non-linear systems of equations, boundary-value problems for ordinary-differential equations, and for partial-differential equations. **Professor Chouinard**

303-323A HYDROLOGY AND WATER RESOURCES. 3(3-2-4) (Prerequisite: 303-302B) Precipitation, evaporation and transpiration. Streamflow, storage reservoirs. Groundwater hydrology. Morphology of river basins. Statistical analysis in hydrology, stochastic modelling and simulation. Case studies in hydroelectric power development, flood damage mitigation, irrigation and drainage. **Professor Nguyen**

303-324B CONSTRUCTION PROJECT MANAGEMENT. 3(3-1-5) (Prerequisites: 306-310A,B and 303-208A) Construction fundamentals; procedures and responsibilities; tender documents, specifications, proposals, contracts; construction project organization, estimating, planning, scheduling, control; liability, claims procedures, arbitration; job safety; security and loss control; case histories, site visits. **Mr. Taylor**

303-327B FLUID MECHANICS & HYDRAULICS I. 4(3-6-3) (Prerequisites: 303-206B and 189-265A,B) Fluid properties, statics and kinematics; forces due to fluids in motion, Bernoulli's equation, analysis of experiments, streamline curvature, boundary layers, pipe flow, hydraulic machinery and introduction to open channel flow. **Professor Chu**

303-331B PROJ. METHODOLOGY & COMMUNICATION. 3(2-3-4) (Prerequisite: 308-208A,B) Engineering project, problem definition and need analysis; problem solving techniques; information search and management; effective team work; proper documentation of engineering projects; effective oral and written communication; case studies and class exercises. **TBA**

303-382B PARTIAL DIFF. EQUATIONS IN ENGINEERING. 3(3-1-5) (Prerequisites: 189-261A,B, 189-265A,B and 303-281A*) Classifications of PDEs; Laplace's Equation, steady fluid flow. Diffusion Equation; pressure transients in porous media, moisture and chemical diffusion, heat conduction; Wave Equation; waves and vibrations in strings, membranes and bars. Uniqueness of solution; variables separable solutions in rectangular and cylindrical coordinates; product solutions, elementary applications of integral transforms. **Professor Selvadurai**

303-384A SOIL MECHANICS & FOUNDATIONS. 2(2-3-1) (Prerequisites: 303-207A,B* or 303-283B*) Nature of soils, identification and classification. Physical properties of soils, permeability, compressibility, shear strength, principle of effective stresses, stress strain behaviour. Seepage, frost action. Field exploration of soil conditions. Foundations, shallow and deep. Earth pressures and retaining structures, stability of earth masses. **Professor Japp**

303-385A STRUCTURAL STEEL & TIMBER DESIGN. 3(3-1-5) (Prerequisite: 303-283B. Corequisite: 301-240B) Structural loadings, load factors, code requirements and design procedures. Characteristics of structural steel and structural timber in building construction. Structural design of axially loaded tension and compression members, joists, beams, girders, trusses and framing systems. **Mr. Vrana**

303-388B REINFORCED CONCRETE DESIGN. 2(2-2-2) (Prerequisite: 303-283B) Physical properties of concrete; behaviour and design of reinforced concrete members in compression, tension, bending, shear and combined loadings; bond and anchorage; reinforced concrete slabs and precast concrete elements; structural framing systems. **Mr. Vrana**

303-416B GEOTECHNICAL ENGINEERING. 3(3-1.5-4.5) (Prerequisite: 303-311A) Site investigation, in-situ measurement of engineering properties of soils; braced excavations; bearing capacity of shallow foundations; upper bound solutions; soil structure interaction; design aspects of footing and rafts, coefficient of subgrade reaction; deep foundations; bearing capacity of piles, pile settlement; stability of slopes; infinite slopes; frost action in soils. **Professor Japp**

303-418A,B PROJECT. 3(0-4-5) (Prerequisite: Completion of an approved set of required and complementary courses.) A study or design topic in any of the branches of Civil Engineering or their combination. Project may be analytical or experimental. Chosen in consultation with a staff member, whose approval is necessary. Guidance provided by Department staff and by practising engineers. Project normally carried out in a student's last semester. **Professors Shao, Shrivastava and Staff**

303-421B MUNICIPAL SYSTEMS. 3(3-2-4) (Prerequisite: 303-327B) Design of water-related municipal services; sources of water and intake design; estimation of water demand and wastewater production rates; design, construction and maintenance of water distribution, wastewater and stormwater collection systems; pumps and pumping stations; pipe materials, network analysis and optimization; storage; treatment objectives for water and wastewater. **Professor Nicell**

303-428A FLUID MECHANICS & HYDRAULICS II. (3-3-3) (Prerequisite: 303-327B) Open channel flow, internal hydraulics, hydraulic transient in pipes. **Professor Gaskin**

● **303-430A WATER TREATMENT & POLLUTION CONTROL.** 3(3-3-3) (Prerequisites: 303-225B and 303-327B) Principles of water and sewage treatment. Water and sewage characteristics; design of conventional unit operations and processes; laboratory analyses of potable and waste waters. **Professor Gehr**

303-432A,B TECHNICAL PAPER. 1(0-0-3) (Prerequisite: 303-331B) A technical paper, on a suitable topic, is to be prepared in accordance with detailed instructions which are provided by the Department. This paper will normally be written in the U3 year and may be submitted in September or January. **Staff**

303-433B URBAN PLANNING. 3(3-1-5) (Prerequisites: 303-421A and 306-310A,B. Co-requisite: 303-319B) The City in History. The planning profession, evolution of planning in North America, Canada and Quebec. Planning theories, the general or master plan, planning processes and techniques, planning and design of residential subdivisions. Local planning issues, housing policies, planning laws. **Professor Wolfe**

303-440A TRAFFIC ENGINEERING. 3(3-1-5) (Prerequisite: 303-319B*) Driver, vehicle and traffic flow characteristics; origin-destination studies, traffic studies and analysis, accident studies, queuing theory applications, gap acceptance, simulation, highway capacity, traffic regulations and control measures, intersection control. **Mr. Byrns**

303-446A CONSTRUCTION ENGINEERING. 3(3-1-5) (Prerequisite: 303-324B) Project management principles; construction equipment economics, selection, operation; characteristics of building,

heavy, marine, underground and route construction projects; international projects. **Mr. Triassi**

303-451A GEOENVIRONMENTAL ENGINEERING. 3(3-1.5-4.5) (Prerequisites: 303-225B and 303-311A) Geoenvironmental hazards; land management of waste; regulatory overview, waste characterization; soil-waste interaction; geosynthetics; low permeability clay barriers; contaminant transport; containment systems; collection and removal systems; design aspects; strategies for remediation; rehabilitation technologies. **Professor Ghoshal**

303-460A MATRIX STRUCTURAL ANALYSIS. 3(3-2-4) (Prerequisites: 303-206B and 303-317A) Computer structural analysis, direct stiffness applied to two and three dimensional frames and trusses, matrix force method, nonlinear problems, buckling of trusses and frames, introduction to finite element analysis. **Professor Chouinard**

303-462A DESIGN OF STEEL STRUCTURES. 3(3-3-3) (Prerequisite: 303-318B) Design of structural steel elements: plate girders, members under combined loadings, eccentrically loaded connections, structural systems. Design of structural steel systems: composite floor systems, braced frames, moment resisting frames. **TBA**

303-463B DESIGN OF CONCRETE STRUCTURES. 3(3-3-3) (Prerequisite: 303-318B) Design of continuous beams and slabs, columns under biaxial bending, retaining and structural walls, two-way and flat slabs, and combined footings. Slenderness effects in columns. Introduction to masonry structures. **Professor Mitchell**

303-469A INFRASTRUCTURE & SOCIETY. 3(3-2-4) (Prerequisite: 306-310A,B) Infrastructure systems; planning, organization, communication and decision support systems; budgeting and management; operations, maintenance, rehabilitation and replacement issues; public and private sectors, privatization and governments; infrastructure crisis and new technologies; legal, environmental, socio-economic and political aspects of infrastructure issues; professional ethics and responsibilities; case studies. **Professor Mirza**

303-470A,B RESEARCH PROJECT. 3(0-1-8) (Prerequisite: 60 credits in the Civil Engineering and Applied Mechanics program) Open to students with a high CGPA. A research project must be carried out and a technical paper prepared under the supervision of a member of staff. The project must be established with the consent of the Staff Supervisor, and must be approved by the Department before registration. May be taken in conjunction with the required course 303-418A,B and the project therefore can be carried out through two semesters. **Staff**

303-492A STRUCTURES. 2(2-2-2) (Prerequisites: 303-385A and 303-388B) A study of structural systems in concrete, steel, timber; a philosophy of structure; choice of structure; economic factors in design; recent developments and trends in structure; lateral stability by frame action, bracing shear walls; mechanics of certain structural forms. **Professor Mitchell**

303-512B ADVANCED CIVIL ENGRG MATERIALS. 3(3-3-3) (Prerequisite: 303-202B) Production, structure and properties of engineering materials; ferrous alloys, treatments, welding, special steels, cast iron; ceramic materials; polymers; composite materials; concrete, admixtures, structure, creep, shrinkage; asphalt and asphaltic materials; clay materials and bricks; impact of environment on material response, durability, quality assessment and control, industrial specifications; recent advances. **Professor Shao**

303-514A STRUCTURAL MECHANICS. 3(3-1-5) Stress, strain, and basic equations of linear elasticity. General and particular solutions of plane and axisymmetric problems. Stress concentration and failure criteria. Unsymmetrical bending of beams; shear centres; torsion of thin-walled structural members. Curved beams. Formulation and applications of energy principles, and their connection to finite-element method. **Professor Shrivastava**

303-526B SOLID WASTE MANAGEMENT. 3(3-2-4) (Prerequisite: 303-225B) Characterization of municipal and industrial solid wastes. Review of solid and hazardous waste impacts, regulations and treatment options. Collection and transportation of solid wastes. Methods of reclamation and disposal. Introduction to the design of landfill sites and incinerators. **Professor Nicell**

303-527A RENOV. & PRESERV. OF INFRASTRUCTURE. 3(3-2-4) (Prerequisites: 303-202B and 303-318B) Maintenance, rehabilitation, renovation and preservation of infrastructure; infrastructure degradation mechanisms; mechanical, chemical and biological degradation; corrosion of steel; condition surveys and evaluation of buildings and bridges; repair and preservation materials, techniques and strategies; codes and guidelines; case studies. **Professor Mirza**

303-528A REHABILITATION CASE STUDIES. 3(0-0-9) Topical case studies from industrial and governmental experience in rehabilitation of infrastructure. Course conducted in collaboration with the other four institutions. Each student is required to submit a technical report. **TBA**

303-540A URBAN TRANSPORTATION PLANNING. 3(3-1-5) (Prerequisite: 303-319B or permission of instructor.) Process and techniques of urban transportation engineering and planning, including demand analysis framework, data collection procedures, travel demand modelling and forecasting, and cost-effectiveness framework for evaluation of project and system alternatives. **Professor Rice and Mr. Trottier**

303-541B RAIL ENGINEERING. 3(3-1-5) Principles of rail system design, including vehicle motion calculations, supporting way design, and rail vehicle design. Planning and operational characteristics for rail freight systems and urban rail systems, with an assessment of operational and technological developments. **TBA**

303-546A,B SELECTED TOPICS IN CIVIL ENG. I. 3(3-0-6. (Prerequisite: Permission of instructor.) Special topics related to Civil Engineering will be presented by staff and visiting lecturers.

303-547A,B SELECTED TOPICS IN CIVIL ENG. II. 3(3-0-6) (Prerequisite: Permission of instructor.) Special topics related to Civil Engineering will be presented by staff and visiting lecturers.

303-548A,B SELECTED TOPICS IN CIVIL ENG. III. 3(3-0-6) (Prerequisite: Permission of instructor.) Special topics related to Civil Engineering will be presented by staff and visiting lecturers.

303-550B WATER RESOURCES MANAGEMENT. 3(3-0-6) (Prerequisite: 303-323A or equivalent.) State-of-the-art water resources management techniques; case studies of their application to Canadian situations; identification of major issues and problem areas; interprovincial and international river basins; implications of development alternatives; institutional arrangements for planning and development of water resources; and, legal and economic aspects. **Professor Nguyen**

303-553A STREAM POLLUTION AND CONTROL. 3(3-2-4) (Prerequisite: 303-225B) Water quality standards; physical, chemical, and bacterial contamination of surface waters; effects of specific types of pollution such as thermal, point and non-point sources; stream self-purification; effects on lake eutrophication; pollution surveys and methods of control; laboratory tests. **Professor Gehr**

303-554A ENVIRONMENTAL ENGINEERING SEMINAR 3(3-0-6)9 (Prerequisite: Permission of instructor.) The course will expose the students to various environmental engineering issues. Lectures will be given by faculty and invited speakers from industry. Each student is required to prepare a written technical paper and make an oral presentation. **Professor Gehr**

● **303-555B ENVIRONMENTAL DATA ANALYSIS.** 3(3-0-6) (Prerequisite: 303-302B or permission of instructor.) Application of statistical principles to design of measurement systems and sampling programs. Introduction to experimental design. Graphical data analysis. Description of uncertainty. Hypothesis tests. Model parameter estimation methods: linear and nonlinear regression methods. Trend analysis. Statistical analysis of censored data. Statistics of extremes. **Professor Nguyen**

303-570B WAVES AND COASTAL ENGINEERING. (3) (3-0-6) (Prerequisite: 303-327B) Waves: wave transformation and prediction, waterlevels; coastal geomorphology: geology, sediment transport,

coastal processes; coastal engineering: shore protection, harbours, dredging, coastal management. **TBA**

● **303-572A COMPUTATIONAL HYDRAULICS.** 3(3-0-6) (Prerequisite: 303-327B or equivalent.) Computation of unsteady flows in open channels; abrupt waves, flood waves, tidal propogations; method of characteristics; mathematical modelling of river and coastal currents. **Professor Chu**

303-573A HYDRAULIC STRUCTURES. 3(3-0-6) (Prerequisites: 303-323A and 303-327B) Hydraulic aspects of the theory and design of hydraulic structures. Storage dams, spillways, outlet works, diversion works, drop structures, stone structures, conveyance and control structures, flow measurement and culverts. **Mr. Holder**

303-574B FLUID MECHANICS OF WATER POLLUTION. 3(3-0-6) (Prerequisite: 303-327B or equivalent.) Mixing, dilution and dispersion of pollutants discharged into lakes, rivers, estuaries and oceans; salinity intrusion in estuaries and its effects on dispersion; biochemical oxygen demand and dissolved oxygen as water quality indicators; thermal pollution; oil pollution. **Professor Chu**

● **303-575B FLUID MECHANICS OF AIR POLLUTION.** 3(3-0-6) (Prerequisite: 303-327B or equivalent.) Fundamentals of fluid mechanics; properties and sources of air pollution; the atmospheric boundary layer; atmospheric diffusion; atmospheric stability; aerodynamics of plumes; coagulation and settling of particles; molecular diffusions. **TBA**

● **303-576B HYDRODYNAMICS.** 3(3-0-6) (Prerequisite: 303-327B or equivalent.) Equations of motion, Bernoulli, Cauchy and Bjerknes' theorems, virtual mass, complex variables and conformal mapping. Free surface flows, dynamic and kinematic boundary conditions. Shallow water flows, waves of finite amplitude. Flows on a geophysical scale, Ekman layers, homogeneous lake circulation, seiches. Linear waves, refraction and diffraction around breakwaters. **TBA**

303-577A RIVER ENGINEERING. 3(3-0-6) (Prerequisite: 303-327B) Mechanics of the entrainment, transportation and deposition of solids by fluids; sediment properties; threshold of movement; ripples, dunes and antidunes; suspended load; bed load; stable channel design; meandering of rivers; wave-induced transport; turbidity currents; transport of solids in pipelines; aeolian transport. **Professor Gaskin**

● **303-579B WATER POWER ENGINEERING.** 3(3-0-6) (Prerequisites: 303-323A and 306-310A,B) A practical approach to the planning and design of hydro-electric power installations. Fundamental theory of water availability and demand; flow, power and load duration curves; classification of power sources; project planning; 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

Chair
David A. Lowther; B.Sc.(Lond.), Ph.D.(C.N.A.A.), 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.)
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.), 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.
Johathan Webb; B.A., Ph.D.(Cantab.)
Gar Lam Yip; B.Sc.(Lond.), A.C.G.I., M.Sc.(Queen's), Ph.D.(Tor.), Eng.

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
Benoit Boulet; B.Sc.(Laval), M.Eng.(McG.) 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 Negilescu; 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.)

Lecturer
Kenneth L. Fraser; B.Eng., M.Eng.(McG.), Eng.
Florence Danilo; M.Eng.(McG.)

Associate Members
Jason H.T. Bates; B.Sc.(Cant.), Ph.D.(Otago)
Martin Buehler
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.)

Adjunct Professors
Vinod K. Agarwal, Eduard Cerny, Benoit Champagne, Paul Freedman, M. Gavrilovic, Jeremiah F. Hayes, Cheng K. Jen,

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Geza Joos, Stanley Kubina, Irene Leszkowicz, Lin Lin, Miguel Marin, Donald McGillis, Mohamad-Khaled Kaddoura, Douglas O'Shaughnessy, Amy Pinchuk, 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 3.0. 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 background 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 on page 219.

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 3.0 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	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)		
189-386	Applied Partial Differential Equations	3	
or 303-382	Partial Differential Equations in Eng. (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	**34**

** CGPA of 3.3 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 Signals	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	Electromagnetic Waves	3	
304-361	Power Engineering	3	
304-498	Honours Thesis I	3	
304-499	Honours Thesis II	3	**51**

COMPLEMENTARY COURSES

Technical Complementaries **12**

Four technical complementary courses (12 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

304-428	Software Engineering
304-525	Computer Architecture
304-427	Operating Systems
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 Multivariable Nonlinear Control
304-507 Optimization and Optimal Control
304-512 Digital Signal Processing
304-529 Image Processing & Communication
304-531 Real Time Systems

Integrated Circuits and Electronics
304-527 Optical and Photonic Systems
304-533 Physical Basis of Semiconductors
304-534 Analog Microelectronics
304-545 Microelectronics Technology
304-548 Introduction to VLSI
304-571 Introduction to Photonics
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
304-511 Communication Systems
304-512 Digital Signal Processing
304-521 Data Communications
304-523 Speech Communications
304-527 Optical and Photonic Systems
304-528 Telecommunication Networks
304-571 Introduction to Photonics
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 on page 220) 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	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)		
303-382	PDE in Engineering	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	**34**

** CGPA of 3.3 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 Signals	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	Electromagnetic Waves	3	
304-361	Power Engineering	3	
304-494	Design Project	3	**48**

COMPLEMENTARY COURSES

Technical Complementaries **15**
Five courses (15 credits) from the list of 400-level courses in Electrical Engineering that must include all the courses of one of the areas of concentration listed below:

Computer Systems Technology
304-425 Computer Organization and Architecture
304-427 Operating Systems
304-428 Software Engineering

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

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

Telecommunications
304-411 Communications Systems
304-412 Discrete Time Signal Processing
304-451 Microwave and Optical Transmission

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 on page 220) 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 COMPUTER ENGINEERING

REQUIRED COURSES		COURSE CREDIT	
Non-Departmental Courses			
189-260	Intermediate Calculus	3	
189-261	Differential Equations	3	
or 189-325	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)		

189-363	Discrete Mathematics	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	
308-250	Intro. to Computer Science	3	
308-302	Programming Languages	3	
455-206	Communication in Engineering	3	**40**

** CGPA of 3.3 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	Random Signals & Noise	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	**48**

COMPLEMENTARY COURSES

Technical Complementaries **9**

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

304-404	Control Systems
304-411	Communications Systems
304-412	Discrete-Time Signal Processing
304-426	Microprocessor Systems
304-428	Software Engineering
304-431	Electronic Design
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 on page 220) 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 1999-2000

▭ 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 McFee 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.) The Laplace Transform and its application to circuit analysis, network functions, frequency response and Bode Diagrams. Convolution models for linear time-invariant (LTI) systems, system functions, transient and steady-state response. State models for LTI systems, relationship to convolution models. Single loop feedback systems, stability analysis, root locus techniques, Nyquist criterion. **Professor Michalska**

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) Fourier representation of continuous-time signals, extensions to generalized signals, sampled signals, sampling theorem. Discrete-time signal models, convolution systems, difference equations, state models, recursive and non-recursive systems. Frequency analysis of discrete-time systems, analysis in the Z-domain. Discretization models of continuous systems. The discrete Fourier Transform (DFT), linear filtering based on DFT methods. **Professor Blostein**

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

304-305A,B PROBABILITY AND RANDOM SIGNALS. 3(3-0-6) (Corequisite: 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 in-

dependence, laws of large numbers, central limit theorem; introduction to random processes and random signal analysis.
Staff

304-323A,B DIGITAL SYSTEM DESIGN. 5(3-6-6) (Prerequisites: 304-221 and 304-210) 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. Corequisite: 304-303 and 198-271) 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: 304-330) 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 McFee**
Section A01: Limited to Electrical Honours, Regular, and Computer Engineering students only.

304-352A ELECTROMAGNETIC WAVES AND OPTICS. 3(3-1-5) (Prerequisite: 304-351 and 303-382) 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 Yip
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 or 198-350) 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. 3(3-0-6) (Prerequisite: 304-304 and 304-305) Linear and nonlinear modulation; demodulation methods; noise in communications systems, coherent and incoherent demodulation; power, bandwidth, and performance tradeoff; data transmission fundamentals; acquisition and synchronization; pulse code modulation; multiple access methods; introduction to wireless networks; international standards; fundamentals of information theory. **Staff**

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**

304-425A 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).
Staff

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 Cooperstock**

304-428B SOFTWARE ENGINEERING. 3(2-2-5) (Prerequisite: 304-222) Designing, development and commissioning of large software systems. Software life cycle: requirements specification, module decomposition, module specification, implementation and test planning. Software reliability and security, multi-user environments. Project management issues. The course involves a group project. **Dr. Pinchuk**

▭ **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 array technology. This course may be counted as a technical complementary or a lab complementary. Limited enrolment (30).
Professor Ferrie

304-432B PHYSICAL BASIS OF TRANSISTOR DEVICES. 3(3-0-6) (Prerequisites: 304-351 and 304-330) 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

304-435A,B 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 MICROWAVE & OPTICAL TRANSMISSION. 3(3-0-6) (Prerequisite: 304-352) Microwave waveguides and circuit theory. Microstrip integrated circuits. Introduction to passive and active microwave devices. Optical slab waveguides and step-index fibres. Optical sources and detectors for fibre communication systems. Microwave antennas. Satellite communications.
Professor Yip

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). **Staff**

▭ **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**

▭ **304-493A,B 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 Departmental 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. Password card required. **Staff**

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. Password card required.
Staff

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 MULTIVARIABLE 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**

304-510A RANDOM PROCESSES. 3(3-0-6) (Prerequisite: 304-305) Gaussian random processes and linear systems: analysis and control. Markov chains in discrete time: classification of states. Markov chains in continuous time and diffusion processes: forward and backward equations. Laws of large numbers for stochastic processes. Renewal theory with applications to queuing systems. **Professor Caines**

304-511A COMMUNICATIONS SYSTEMS. 3(3-0-6) (Prerequisite: 304-304 and 304-305) 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. 3(3-0-6) (Prerequisite: 304-304 and 304-305) Review of discrete-time systems and signals including Fourier and Z-transform theory and the discrete Fourier transform; structures for discrete-time systems, FIR and IIR filter design techniques, FFT techniques, the discrete Hilbert transform, Fourier analysis of stationary and non-stationary random signals. **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**

304-521B DATA COMMUNICATIONS. 3(3-0-6) (Prerequisite: 304-411 or 304-511) System design for intersymbol interference:limits of performance, channels, lowpass equivalent systems, signal design (Nyquist theory), PAM receivers. Linear modulation (QAM, combined AM/PSK), nonlinear modulation (FSK, differential PSK). Adaptive equalization. Combined coding/modulation (TCM). Spectral shaping codes, phase and timing recovery, scramblers. Error control and automatic repeat request. **Professor Kabal**

304-523B SPEECH COMMUNICATIONS. 3(3-0-6) (Prerequisite: 304-412 or 304-512) Human speech production: articulatory and acoustic descriptions; models of speech production; speech perception; digital processing of the speech signal; vocoders (formant, linear predictive, cepstral); automatic speech recognition by computer; speech synthesis-by-rule; speaker recognition/verification. **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**

304-527 OPTICAL AND PHOTONIC SYSTEMS. 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**

304-528B TELECOMMUNICATION NETWORKS. 3(3-0-6) (Prerequisites: 304-323 and 304-411 or 304-511) Modelling, organization and performance analysis of telecommunication networks. Statistical mutiplexing, packet switching, circuit switching, datagrams, protocols, SONET, ATM, performance analysis, product-form queueing networks, local area networks, CSMA/CD, Ethernet, Fiber-Distributed-Data-Interface (FDDI), token rings, token busses, polling systems, optimal routing and flow controls. **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**

304-531B 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: 198-350, 304-330 and 304-376) 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 PHOTONICS. 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 optomechanical 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. **Professor Yip**

● **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. **Professor Yip**

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

Chair

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

Emeritus Professors

David R. Axelrad; Dipl.-Ing.(Vienna), M.Eng.Sc.(Sydney), (Dr. Techn.)(Vienna), A.M.I.M.E., M.N.A.Sc., Eng. *(Thomas Workman Emeritus Professor of Mechanical Engineering)*

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)
Nori Hori; B.Sc.(NDA, Japan), M.Sc., Ph.D.(Sask.), P.Eng. (Graduate 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.)
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
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)
James A. Nemes; B.Sc.(Maryland), M.S., D.Sc.(GWU)

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
H. Alighanbari, G.G. Bach, R.G. Edwards, S. Kalaycioglu, L. Kops, K. Mackenzie, W.D. May, H. Moustapha, 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. Specialty areas include bio-mechanics, systems, robotics and computer applications.

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.
The other course (3 credits) may be 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 on page 220).

TOTAL CREDITS **109**

If advanced credit is given for 189-260 Intermediate Calculus (see section 2.3 on page 219), 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 on page 220), 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 Management
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	Industrial Process Automation
305-555B	Applied Process Control
305-557B	Electromechanical Design
305-561B	Biomechanics of Musculoskeletal Systems
305-562B	Advanced Fluid Mechanics
305-565B	Fluid Flow & Heat Transfer Equipment and Systems
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.

AUTOMATION 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:

305-554A Industrial Process Automation
305-413A Control Systems
305-572A Mechanics of Robotic Systems I
305-576A Computer Graphics and Geometric Modelling

and two of the following:

305-474B Operations Research
305-522B Production Systems
305-540B Design: Modelling & Decision
305-555B Applied Process Control
305-561B Biomechanics of Musculoskeletal Systems
305-573B Mechanics of Robotic Systems II

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 and Manufacturing with Composite Materials
305-557B Electromechanical Design
305-565B Fluid Flow & Heat Transfer Equipment
305-576A Computer Graphics and Geometric Modelling
305-577A Optimum Design

COURSES OFFERED BY THE DEPARTMENT

● Denotes courses not offered in 1999-2000
◎ 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) Introduction to Mechanics. Statics: beams, trusses frames. Coordinate systems. Kinematics, relative motion; momentum and force, conservation of momentum; Newton's Laws; concepts of force and impulse; angular momentum and its conservation; central force motion; various classes of forces (gravity, friction, elastic, etc.) and pseudo-forces. Energy: kinetic, potential and mechanical work. Centre of mass and moment of inertia; Planar rigid-body dynamics. **Professors J. Lee and Zsombor-Murray**

305-220A,B MECHANICS II. 3(3-1-5) (Prerequisites: 305-210 and 189-260. Corequisite: 189-261) Energy methods. Equilibrium and stability of mechanical systems. Degrees of freedom, generalized coordinates and constraints. Newtonian and Lagrangian formulations of mechanics. Solution of equations of motion for simple systems. 3-D rigid-body dynamics; Euler's equations. Gyroscopic motion. **Professors Misra and Paidoussis**

305-240A,B THERMODYNAMICS I. 3(3-1-5) Basic definitions, state variables and functions, macroscopic vs. microscopic points of view. Equation of state for a perfect gas. First law of thermodynamics: work and heat; internal energy; enthalpy; basic energy transfer processes. Control volume energy analysis. Heat engine cycles; refrigerators and heat pumps; air compressors. Second law of thermodynamics; entropy; availability; irreversibility. **Professors J.Lee, Frost 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 Staff**

305-261B,C MEASUREMENT LAB. 2 (2-3-1) Basic experimental laboratory measurements, such as measurement of strain, pressure, force, position, and temperature. **Professor Hori 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, whirling of shafts. 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) Review of fluid properties; stress in a continuum; fluid kinematics; 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.
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) Steady-state conduction. Fin Theory. Unsteady-state conduction. Convective heat transfer; governing equations, dimensionless parameters, analogy between momentum, heat and mass transfer; design correlations. Natural convection. Heat exchangers. Radiative heat transfer: black-and-gray-body radiation; shape factors; enclosure theory. **Professors Baliga and Mydlarski**

305-362A,B MECHANICAL LAB I. 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. **Professor Hori and 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.
Professors Axelrad, 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. **Professors Axelrad, 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 Bach**

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 Angeles**

◎ **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. **Professor Hori**

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. **Professor J. Lee**

◎ **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. H. 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 MANAGEMENT.** 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 and Dr. Alighanbari

◎ **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 as-

pect-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. **T. 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 PROCESS AUTOMATION.** 3(2-3-4) (Prerequisites: 305-261 and 308-208 or 304-221) Introduction to digital logic and microprocessor assembler. Logic and programming laboratory exersises pertaining to simple combinatorial, sequential and analogue elements and their applications to control and signal conditioning. **Professor 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. Fundamental 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 ELECTROMECHANICAL DESIGN.** 3(3-1-5) (Prerequisites: 304-461, 305-383 and 305-412) Overview of electromechanical and mechatronic systems. Control system analysis and design. Computers for control. Electric motor drives. Sensors for position, velocity, force, torque. Transmission elements. Closed loop control. Systems safety considerations. Case studies, projects. **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 L. 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 ROBOTIC 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

Chair
George P. Demopoulos; Dipl. Eng.(NTU Athens), M.Sc., Ph.D.(McG.), Eng.

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)*
Gordon W. Smith; B.Eng., M.Eng., Ph.D.(McG.), Eng.

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.
Jerzy Szpunar; B.Sc., M.Sc., Ph.D., D.Sc.(Krakow)
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.; Jozef Stachulak; Gus Van Weert; Albert E. Wraith

Mining CO-OP Program Coordinator
Michel Vachon

The Department of Mining and Metallurgical Engineering offers programs leading to the Bachelor of Engineering degree in Mining Engineering or Metallurgical Engineering. The curriculum is dynamic and evolves along with new technology in both the mining and metallurgical industries. In addition to regular courses and laboratories, the curriculum includes seminars, colloquia, and student projects reinforced by field trips to industrial operations.

The equipment operated by the Department is the best available. On the metallurgical side there is a full range of laboratory facilities for mineral processing, hydrometallurgy and high temperature extractive process metallurgy as well as excellent materials characterization and processing facilities. In mining engineering the Department has rock engineering laboratories to test the mechanical properties of both rock and backfill materials and computer-aided mine design facilities. The Department houses laboratories for two McGill Research Centres: the McGill Metals Processing Centre (MMPC) and the Canadian Centre for Automation and Robotics in Mining (CCARM), which focus on R & D and high technology applications for the minerals, metals and materials industries at large.

Metallurgical Engineering (CO-OP). The Metallurgical Engineering degree is a cooperative program leading to a B.Eng. and includes formal industrial work periods. It is built around a strong background of mathematics, basic sciences, computer skills and applications, and specific engineering and design courses to provide up-to-date training in metals/materials engineering. Students follow core courses covering a complete range of the industry, from metal extraction to processing, fabrication and applications. The program conforms with requirements of the Canadian Engineering Accreditation Board (CEAB) and is designed to offer students the best training for employment in Canada's large and vital metallurgical and manufacturing industries. The basic courses are supplemented by complementary courses which provide a good choice of specialties for the graduating engineer. The course structure is reinforced with laboratory exercises. Graduates in Metallurgical Engineering find employment in a wide range of industries which include the mineral/metal producing and processing sectors, as well as the aerospace and manufacturing industries. Students in the CO-OP program benefit from the practical learning experience arising from work-term employment in meaningful engineering jobs. Students also benefit from the non-tangible learning experience arising from the increased responsibilities required to obtain and successfully complete the work terms.

Mining Engineering (CO-OP). McGill, which has the oldest mining engineering program in Canada, has always been noted for the excellence of its courses and for the training it provides in mining technology, mineral economics and mining practice. Graduates in mining engineering are in demand not only in Canada but through-

out the world. Technical developments have been rapid in recent years. These offer a challenge to the imaginative student with a strong engineering interest. The Department offers a cooperative program leading to the B.Eng. degree in Mining Engineering. The CO-OP program is offered in collaboration with the Department of Mineral Engineering at École Polytechnique in Montreal, and includes formal industrial work periods. Students registered at McGill are required to take a series of technical mining courses from École Polytechnique in the latter part of the program. These courses are designated as such in the listings below.

Scholarships. The Department offers Entrance Scholarships each year, valued at $2,500; these scholarships are renewable. A substantial number of other scholarships and bursaries are awarded by the Department as well as by the Canadian Mineral Industry Education Foundation.

CURRICULUM FOR THE B.ENG. DEGREE IN METALLURGICAL ENGINEERING – CO-OP PROGRAM

Students registered prior to September 1997 will follow the old program. For details consult with Professor Smith.

REQUIRED COURSES		COURSE CREDITS	
Non-Departmental Courses			
180-233B	Selected Topics in Physical Chemistry	3	
189-260A,B	Intermediate Calculus	3	
189-261A,B	Differential Equations	3	
189-265A,B	Advanced Calculus	3	
303-205A,B	Statics	3	
303-207A,B	Solid Mechanics	4	
308-208A,B	Computers in Engineering	3	**22**
Departmental Courses			
306-202A	Skills for Communicating as an Engineer	2	
306-209B	Mathematical Applications	3	
306-212B	Engineering Thermodynamics	3	
306-221A,B	Engineering Professional Practice	1	
306-250A	Introduction to Extraction Metallurgy	3	
306-260A,B	Materials Science and Engineering	3	
306-280T	Industrial Training I	2	
306-310A,B	Engineering Economy	3	
306-311T	Modelling and Automatic Control	3	
306-317A	Materials Characterization	3	
306-341B	Introduction to Mineral Processing	3	
306-324B	Electrotechnology for Mining, Metallurgical and Materials Engineers	3	
306-350B,C	Extractive Metallurgical Engineering	3	
306-352A	Hydrochemical Processing	3	
306-354C	Process Engineering Laboratory	2	
306-355C	Heat, Mass and Fluid Flow	3	
306-360A	Phase Transformations in Solids	3	
306-361A	Liquid State Processing of Materials	3	
306-362B	Engineering Materials	3	
306-380B	Industrial Training II	2	
306-410A,B	Research Project	3	
306-412C	Corrosion and Degradation	3	
306-442A	Modelling in Mineral Processing	3	
306-450B	Process Design	3	
306-455A,B	Advanced Process Engineering	3	
306-463B	Deformation Processing of Materials	3	
306-465A	Ceramic Engineering	3	
306-480T	Industrial Training III	2	
306-481A	Industrial Training IV	2	**79**
COMPLEMENTARY COURSES			
Technical Courses			**9**

Three courses may be taken where one can be chosen from the Faculty list (see section 4.1.1 on page 223).

NOTE: Not all courses are given annually; verification with course instructor is advised.

302-481A	3	Polymer Engineering
306-351B	3	Non-Ferrous Extractive Metallurgy
306-367B	3	Electronic Properties of Materials
306-451A	3	Environmental Controls
306-456B	3	Steelmaking and Steel Processing
306-457B	3	Light Metals Extraction
306-515A	3	Advanced Metallurgical and Materials Thermodynamics
306-544A	3	Mineral Processing Systems I
306-545B	3	Mineral Processing Systems II
306-551B	3	Electrochemical Processing
306-555A	3	Thermal Remediation of Wastes
306-561A	3	Materials Design and Selection
306-563A	3	Hot Deformation of Metals
306-564B	3	X-ray Diffraction Analysis of Materials
306-566A	3	Texture, Structure and Properties of Polycrystalline Materials
306-567B	3	Aluminum Casting Alloys
306-569B	3	Electron Beam Analysis of Materials

Social Sciences and Humanities Courses (see section 3.3 on page 220)	**6**
TOTAL	**116**

Advanced credit is given for 189-260 Intermediate Calculus upon successful completion of a placement test (see section 2.3 on page 219).

A fee of $500 is assessed by the University for each Industrial Training course.

CURRICULUM FOR THE B.ENG. DEGREE IN MINING ENGINEERING – CO-OP PROGRAM

REQUIRED COURSES		COURSE CREDITS	
Non-Departmental Courses			
186-221A	General Geology	3	
186-225A	Properties of Minerals	1	
189-260A,B	Intermediate Calculus	3	
189-261A,B	Differential Equations	3	
189-265A,B	Advanced Calculus	3	
303-205A,B	Statics	3	
303-207A,B	Solid Mechanics	4	
305-290A	Graphics	3	
308-208A,B	Computers in Engineering	3	**26**
Departmental Mining Courses			
306-200A	Mining Technology	3	
306-202A	Skills for Communicating as an Engineer	2	
306-203C	Mine Surveying (2 weeks at beginning of summer)	2	
306-209B	Mathematical Applications	3	
306-221A,B	Engineering Professional Practice	1	
306-260A,B	Materials Science and Engineering	3	
306-290T	Industrial Work Period I	2	
306-291T	Industrial Work Period II	2	
306-310A,B	Engineering Economy	3	
306-322B	Rock Fragmentation	3	
306-323B	Rock and Soil Mass Characterization	3	
306-324B	Electrotechnology for Mining, Metallurgical & Materials Engineers	3	
306-325A	Mineral Industry Economics	3	
306-333B	Materials Handling	3	
306-340A	Applied Fluid Dynamics	3	
306-341B	Introduction to Mineral Processing	3	
306-392B	Industrial Work Period III	2	
306-419C or T	Surface Mining	3	
306-420B	Feasibility Study	3	
306-426C or T	Development and Services	3	
306-484A,B,T	Mining Project	3	
306-494A,B,T	Industrial Work Period IV	2	**58**

École Polytechnique Mining Courses

309-320A	CAO et informatique pour les mines	3	
309-321B	Mécanique des roches et contrôle des terrains	3	
309-326A	Recherche opérationnelle minière I	3	
309-328C or T	Environnement minier	3	
309-329A	Géologie minière	2	
309-330A	Mécanique des matériaux meubles	3	
309-421C or T	Exploitation en souterrain	3	
309-422A	Ventilation minière	3	**23**

COMPLEMENTARY COURSES

Technical Courses **6**

Two courses selected from those listed below or, 6 credits of any other approved technical course(s).

NOTE: Not all courses are given annually; verification with course instructor is advised.

306-320B	3	Extraction of Energy Resources
306-442B	3	Modelling in Mineral Processing
306-520B	3	Stability of Rock Slopes
306-521C or T	3	Stability of Underground Openings
306-524B	3	Mineral Resource Economics
306-526A,B	3	Mineral Economics
306-528B	3	Mining Automation
306-544A	3	Mineral Processing Systems I
306-545B	3	Mineral Processing Systems II
309-327A,B	3	Hyrdrogéologie appliquée

Social Sciences and Humanities Courses **6**

See section 3.3 on page 220.

TOTAL **119**

Advanced credit is given for 189-260 Intermediate Calculus upon successful completion of a placement test (see section 2.3 on page 219).

A fee of $250 is assessed by the University for each Industrial Work Course.

Student Advising

Students entering the Mining or Metallurgical Engineering programs must plan their schedule of studies in consultation with one of the departmental advisors: Professor A.R. Laplante (Metallurgy) or Mr. J. Mossop (Mining).

COURSES OFFERED BY THE DEPARTMENT

● Denotes courses not offered in 1999-2000

◎ Complementary Courses

Courses offered by the Department have been numbered to conform with the following classification system. The first three digits (i.e. 306) represent the departmental code. The next digit is the level of instruction. The last two digits are classified as follows:

00 to 19	Common foundation courses
20 to 39	Mining courses
40 to 49	Mineral processing courses
50 to 59	Extractive and process metallurgy courses
60 to 69	Materials engineering courses
80 to 99	Co-op work terms

DEPARTMENTAL METALLURGY COURSES

Courses associated with the CO-OP program in Mining Engineering are listed separately following this section.

306-202A SKILLS FOR COMMUNICATING AS AN ENGINEER. 2(1-2-3) Basic forms of engineering communication: memoranda, executive summaries, letters, proposals, evaluations, oral presentations and presentation graphics, email, groupware, workflow, internet, graphics and presentation tools. Adaptation into engineering. Short assignments and oral presentations. **Professor Harris**

306-209B MATHEMATICAL APPLICATIONS. 3(3-2-4) Introduction to stochastic modelling of mining and metallurgical engineering processes. Description and analysis of data distributions observed in mineral engineering applications. Modelling with linear regression analysis. Taylor series application to error and uncertainty propagation. Metallurgical mass balance adjustments.

Professor Hasan

306-212B ENGINEERING THERMODYNAMICS. 3(3-1-5) Macro versus microscopic approach: patterns of Nature. First and second laws and their use. Property relationships: free energies, chemical potentials, activities, heat capacity. Chemical equilibrium. Reaction kinetics. Phase equilibrium for a pure substance. Experimental methods. Engineering applications: high-temperature metallurgical reactors, turbines, mixtures and solutions, phase diagrams, superconductivity. **Professor Kozinski**

306-221A,B ENGINEERING PROFESSIONAL PRACTICE. 1(1-0-2) Professional practice and ethics, professional liability, occupational health and safety, environmental responsibility. University Code of Student Rights and Responsibilities. **Staff**

306-250A INTRODUCTION TO EXTRACTION METALLURGY. 3(2-3-4) Raw materials, processes and products of metallurgical operations. Mineral processing: comminution including size classification, separation of minerals with emphasis of flotation, waste disposal. Extractive metallurgy: roasting, smelting, refining, hydrometallurgy, environmental protection. **Staff**

306-260A,B MATERIALS SCIENCE AND ENGINEERING. 3(2-2-5) Structure properties and fabrication of metals, polymers, ceramics, composites; engineering properties: tensile, fracture, creep, oxidation, corrosion, friction, wear; fabrication and joining methods; principles of materials selection. **Professors Drew and Jonas**

306-280T INDUSTRIAL TRAINING I. 2 Four-month work period in industry. Technical report required upon completion.

Professor Gruzleski

306-308A SOCIAL & ECONOMIC IMPACTS OF TECHNOLOGY. 3(3-0-6) (Enrolment encouraged by students outside the Faculty of Engineering.) Critical examination of the socio-economic costs and benefits of technology, case studies of old engineering works and new technologies. The integration of applied ethics and engineering practice, analysis of basic concepts of technology assessment, the inter-connected processes of risk assessment, management, and communication. **Professor Finch**

306-310A,B ENGINEERING ECONOMY. 3(3-1-5) Introduction to the basic concepts required for the economic assessment of engineering projects. Topics include: accounting methods, marginal analysis, cash flow and time value of money, taxation and depreciation, discounted cash flow analysis techniques, cost of capital, inflation, sensitivity and risk analysis, analysis of R&D, ongoing as well as new investment opportunities. **Professors Bilodeau and Laplante**

306-311T MODELLING AND AUTOMATIC CONTROL. 3(3-2-4) (Prerequisite: 308-208A,B) Mass and energy conservation laws. Dynamic versus steady state models, dynamic behaviour of first and higher order metallurgical systems, linear and nonlinear models, interacting and noninteracting systems. Laplace domain dynamics and transfer functions. Feedback control, control valves and controllers, transducers. Feedback-feedforward control, introduction to cascade, adaptive and statistical control strategies. Digital computer control, instruments and interfaces. **Professor Hasan**

306-317A MATERIALS CHARACTERIZATION. 3(2-3-4) (Prerequisite: 306-260A,B) Bulk, surface and microanalytical techniques for materials characterization. Bulk analysis: spectrophotometry using UV, visible, flame and atomic absorption, x-ray diffraction and x-ray fluorescence. Surface and microanalysis: infrared spectroscopy, scanning and transmission electron microscopy, Auger electron and x-ray photoelectron spectroscopy.

Professors Szpunar, Kozinski and Yue

306-341B INTRODUCTION TO MINERAL PROCESSING. 3(2-3-4) (Prerequisite: 306-250A) Theory and practice of unit operations including: size reduction-crushing and grinding; size separation-screening and classification; mineral separation-flotation, magnetic and gravity separation. Equipment and circuit design and selection. Mass balancing. Laboratory procedures: grindability,

liberation, magnetic and gravity separation, flotation, and solid-liquid separation. **Professor Finch**

306-350B EXTRACTIVE METALLURGICAL ENGINEERING. 3(2-3-4) (Prerequisites: 306-250A, 306-212B) Principle non-ferrous base-metal pyrometallurgical extraction processes, relevant thermodynamics, heat and mass balances, transport phenomena (copper, nickel, lead, zinc, aluminum magnesium). Ores, gangue, fuels slag, fluxes, recovery, refining, minor elements, byproducts and the environment. Roasting, drying, smelting, converting, reverberatory furnaces, flash furnaces, continuous and batch operations, injection practices and oxygen enrichment. Simulation, modelling, control and optimization. **Professor Harris**

◎ **306-351B NON-FERROUS EXTRACTIVE METALLURGY.** 3(2-3-4) (Prerequisite: 306-350B) Extractive metallurgy of the common non-ferrous metals - copper, nickel, lead, zinc and aluminum. The production of these metals is analyzed in terms of the unit operations and the chemistry of the major commercial processes applied. The metallurgy of less-common metals is also briefly described. **Professor Distin**

306-352A HYDROCHEMICAL PROCESSING. 3(3-2-4) (Prerequisites: 180-233B, 306-212B, 306-250A) (Corequisite: 306-355A) Analysis and description of dissolution (leaching), solute separation (solvent extraction, ion exchange, carbon adsorption) and deposition operations (precipitation, crystallization, electrolysis) in aqueous reaction media as these apply to: (i) the hydrometallurgical extraction of metals from primary/secondary sources; (ii) the treatment of effluents and (iii) the production of inorganic materials. **Professor Distin**

306-354C PROCESS ENGINEERING LABORATORY. 2(0-3-3) (Prerequisite: 306-355A) A series of laboratory exercises which cover various transfer phenomena encountered in metallurgical and materials processing including mass transfer in aqueous and high temperature systems, laminar and turbulent flow characteristics, particle and bubble motion in liquids, mixing and settling. **Professors Distin, Harris and Guthrie**

306-355C HEAT, MASS AND FLUID FLOW. 3(3-3-3) (Prerequisites: 306-212B, 189-261) Applications of heat, mass and fluid flow in metallurgical processing operations. Fluid statics and dynamics, Newton's laws of viscosity and motion, differential vs. macroscopic control volume analyses. Navier Stokes, Euler, Bernoulli and Steady Flow Energy Equations, turbulence and Reynolds stress equations. Molecular conduction/diffusion processes in heat and mass transfer (Fourier/Fick Laws). Convective flows. Fundamental origins of transport coefficients in slags, metals and gases. Radiative heat transfer. Transient/steady state flows. **Professor Guthrie**

306-360A PHASE TRANSFORMATIONS IN SOLIDS. 3(2-3-4) (Prerequisites 306-212B and 306-260A,B, 180-233B) Free energy (equilibrium) and kinetic (non-equilibrium) considerations, phase diagrams and TTT diagrams, solid state diffusion, diffusional (nucleation and growth) and shear (martensitic) transformations. **Professor Yue**

306-361A LIQUID STATE PROCESSING OF MATERIALS. 3(2-3-4) (Prerequisites: 306-260A,B; 306-360A) Liquid-solid phase transformation in material processing. Topics covered include: casting techniques, nucleation and grain refining, freezing of pure materials, alloy freezing, solute redistribution, segregation, constitutional undercooling, solidification microstructures, ingot structures, gases in liquid metals, liquid metal cleansing, modification of phase morphology. **Professor Gruzleski**

306-362B ENGINEERING MATERIALS. 3(2-3-4) (Prerequisite 306-360) Stress-strain behaviour. Elasticity and plasticity of metals, ceramics and polymers. Dislocations theory. Single crystal and polycrystalline slip. Mechanical twinning. Strengthening mechanisms. Process-property and microstructure-property relationships. Notch toughness and fracture mechanics. Failure, fracture and damage accumulation. Fatigue. Creep and creep rupture. Fractography. Design considerations in materials selection. **Professor Szpunar**

◎ **306-367B ELECTRONIC PROPERTIES OF MATERIALS.** 3(3-3-3) (Prerequisite: 306-260) Structure of materials, electronic structure, electrical and thermal conductivity, semiconducting materials, fundamentals of magnetism, hard and soft magnetic materials, superconductivity and superconductive materials, dielectric materials, optical properties of materials, thermoelectricity. Advanced materials and their technological applications. **Professor Szpunar**

306-380B INDUSTRIAL TRAINING II. 2 Four-month work period in industry. Technical report required upon completion. **Staff**

306-410A,B RESEARCH PROJECT. 3(0-6-3) (Prerequisite: Recommendation of Instructor.) A research project will be carried out, usually in groups, under the guidance of a staff member. A technical report will be prepared at the end and formal presentation will be made on the research topic. **Professor Szpunar and Staff**

306-412C CORROSION AND DEGRADATION. 3(2-3-4) (Prerequisites: 306-260A,B; 306-352B) Electrochemical principles of metal oxidation in aqueous environments, Use of polarization diagrams for corrosion rate prediction. Characteristics of stress corrosion and related phenomena. High temperature, non-aqueous degradation; growth kinetics and structure of oxide films. Corrosion prevention in aqueous systems; fundamentals and applications of cathodic and anodic protection, inhibitors, metallic coatings and industrial priming paints. Use of non-metallics and their degradation; glasses, cement, plastics. Corrosion as a factor in selection of materials; use of iso-corrosion charts. **Professor Distin**

306-442A MODELLING IN MINERAL PROCESSING. 3(2-3-4) (Prerequisite: 306-341B) Basic kinetic modelling: perfect mixers, plug-flow, zero and first-order kinetics, residence time distributions. Grinding: breakage and selection functions. Overview of the modelling of flotation and gravity separation. Introduction to control: economic incentives, basic PI control, applications to grinding and flotation circuits. **Professor Laplante**

306-450B PROCESS DESIGN. 3(3-0-6) (Prerequisites: 306-350B, 306-355A) Design of new metallurgical plants, processes and products based on knowledge acquired in previous core courses. Material and heat balances, metal economics, design and optimization. **Professor Mucciardi**

● ◎ **306-451A ENVIRONMENTAL CONTROLS.** 3(3-2-4) (Prerequisite: 306-352A) A survey of the mineral/metallurgical industries from the standpoint of environmental impact and control. Characterization of gaseous, aqueous and solid wastes. Their effects on the ecosystem and government regulations. Methods of control: Particulate collection and detoxification of gaseous streams; Aqueous effluent treatment techniques; Disposal of solid wastes and their stability/containment. **Professors Demopoulos, Finch and Kozinski**

306-455A,B ADVANCED PROCESS ENGINEERING. 3(3-1-5) (Prerequisite: 306-355A) Transport phenomena in non-idealized systems. Solutions for transient heat and mass transfer processes involving thermal and molecular diffusion in materials processing systems. Natural and forced convection in heat and mass transfer. Dimensionless correlations. Fick's Laws and Fourier's Laws. Exact solutions. Numerical approximations for transient systems. Equivalences between heat and mass transfer. Finite difference modelling of conduction, convection and radiation heat transfer and diffusion and convection mass transfer. **Professor Mucciardi**

◎ **306-456B STEELMAKING & STEEL PROCESSING.** 3(2-2-5) (Prerequisites: 306-455A, 306-360A) The production and refining of liquid iron in the iron blast furnace, the production and refining of liquid steel, secondary refining operations, continuous casting and thermomechanical processing (hot rolling). Specialty steels and newly emerging technologies (e.g. thin slab casting, direct iron-making) are also discussed in terms of process/environment and productivity. "Downstream" topics will include cold rolling, batch and continuous annealing, and coating operations. **Professors Guthrie and Jonas**

◎ **306-457B LIGHT METALS EXTRACTION.** 3(2-0-7) (Prerequisites: 306-350B, 306-352A) Physiochemical, kinetic and economic

aspects of light metals extraction, refining and finishing for marketing. Alumina production, aluminum electrolysis, carbon technology, alloying and casting, magnesium smelting and electrolysis, strontium, lithium, sodium extraction. **Professor Harris**

306-463A DEFORMATION PROCESSING OF METALS. 3(3-3-3) (Prerequisite: 306-362A) Basic plasticity theory (yield criteria, plastic stress/strain relationships, etc.); friction and lubrication; analysis of simple forming operations, e.g. rolling of flat products. Workability; concept and measurement; effect of process variables, material properties and microstructure. Effect of hot and cold processing on microstructure and properties technology and equipment; computer-aided design of deformation processing. **Professor Jonas**

306-465A CERAMIC ENGINEERING. 3(2-3-4) (Prerequisite: 306-360) Classification of technical ceramics, refractories and glasses. Powder metallurgy. Structure and bonding of ceramics and glasses. Common crystal structures. Physical properties. Mechanical properties and fracture behaviour. Powder processing and consolidation techniques. Sintering and densification of powders. Refractories: production and applications. Glass forming systems, processing and properties. **Professor Drew**

306-480T INDUSTRIAL TRAINING III. (2) Four-month work period in industry. Technical report and seminar required upon completion. **Professor Gruzleski**

306-481A INDUSTRIAL TRAINING IV. (2) Four-month work period in industry. Technical report and seminar required upon completion. **Professor Gruzleski**

◎ **306-515A ADVANCED METALLURGICAL & MATERIALS THERMODYNAMICS.** 3(2-2-5) (Prerequisite: 306-212B) Computational thermodynamics including phase diagram estimation, Gibbs energy minimization, solution modelling are considered in view of the Facility of Chemical Thermodynamics (F*A*C*T) computer database. Students undertake projects developed in consultation with the instructor and prepare verbal and written reports. **Metallurgical Staff**

◎ **306-544A MINERAL PROCESSING SYSTEMS I.** 3(2-3-4) (Prerequisite: 306-341B) The course covers three main topics: principles of separation, including data presentation, properties of recovery/yield plots, technical and economic efficiency and identification of limits to separation; column flotation, hydrodynamics of collection and froth zones, mixing, scale-up and design, measurements and control; surface and electrochemistry, including absorption, surface charge, coagulation, electron transfer reactions, electrochemistry in plant practice. **Professor Finch**

◎ **306-545B MINERAL PROCESSING SYSTEMS II.** 3(4-2-3) (Prerequisite: 306-341B) Gold recovery (as a Professional Development Seminar): methods of recovery (gravity, flotation, cyanidation), refractory gold (roasting, pressure oxidation, bacterial leaching), dissolved gold recovery (Merrill-Crowe) and activated carbon methods. Sampling: definition of errors, sample extraction, size, and processing. Mass balancing: basic considerations, definition of networks, software. Blending: auto-correlation functions, transfer functions, blending systems. Effect of feed variability. **Professor Laplante**

● ◎ **306-551B ELECTROCHEMICAL PROCESSING.** 3(3-2-4) (Prerequisite: 306-352B) Characterization of aqueous, fused salt and solid electrolytes; laws of electrolysis; ion transport mechanisms; interfacial phenomena (electrolyte-electrolyte, electrode-electrolyte); reversible cells and potentials; electrode kinetics, overpotential and potential-current laws; industrial applications; electrolytic winning and refining, electroplating, surface cleaning and coating, electrodialysis and electrochemical sensors. **Professor Demopoulos**

◎ **306-555A THERMAL REMEDIATION OF WASTES.** 3(3-0-6) (Prerequisites: 180-111B and 306-212B or equivalent) Process technology and environmental concerns in thermal remediation of wastes. Design of thermal remediation systems. Waste combustion. Nature and pathways of pollutant streams during thermal treatment of wastes. Reduction and control of harmful products. Toxic metal encapsulation. Particulate removal. Destruction of gaseous contaminants. Use of models in system design. **Professor Kozinski**

◎ **306-561A MATERIALS DESIGN AND SELECTION.** 3(0-4-5) (Prerequisite: 306-362A or equivalent) Advanced topics in materials design problems. Discussion and laboratory work, supplemented by detailed technical reports. Special attention is given to selection, design and failure problems in various materials systems. **Professors Drew, Gruzleski and Yue**

◎ **306-563A HOT DEFORMATION OF METALS.** 3(2-2-5) (Prerequisite: 306-463B and 306-360A) High temperature deformation processing of metallic materials. Topics include static and dynamic recrystallization, recovery, precipitation; effect of deformation on phase transformations and microstructural evolution during industrial processing. Mathematical modelling of microstructural evolution. **Professor Yue**

◎ **306-564B X-RAY DIFFRACTION ANALYSIS OF MATERIALS.** 3(2-3-4) (Prerequisite: 306-317A) The techniques of X-ray and neutron diffraction are discussed as applied to the minerals and materials production industries. Special emphasis is placed upon automated X-ray powder diffractometry as employed for determining the structure and composition of materials. The application of X-ray techniques to studies of crystal structure, crystal orientation, residual stress, short-range order in liquid metals, phase diagram determination, order-disorder transformation and chemical analysis are presented. **Professor Szpunar**

◎ **306-566A TEXTURE, STRUCTURE & PROPERTIES OF POLYCRYSTALLINE MATERIALS.** 3(2-3-4) (Prerequisite: 306-317A) Concepts and quantitative methods for the description of the structure of minerals and materials are discussed. Special emphasis is placed on experimental techniques of texture measurement. Procedures are demonstrated for the control of deformation and recrystallization textures in order to obtain the properties required of industrial products. Finally, the correlation between texture and the anisotropy of elastic, plastic and magnetic properties of engineering materials is described and analyzed. **Professor Szpunar**

◎ **306-567B ALUMINUM CASTING ALLOYS.** 3(3-0-6) (Prerequisite: 306-361B or equivalent) The family of aluminum foundry alloys; alloy systems, intermetallic phases and their formation, heat treatment processes, mechanical and physical properties of aluminum casting alloys, foundry properties, eutectic modification, porosity formation, gassing and degassing, refinement of hypereutectic alloys, grain refinement, filtration; non destructive control of microstructure. **Professor Gruzleski**

◎ **306-569B ELECTRON BEAM ANALYSIS OF MATERIALS.** 3(2-3-4) (Prerequisite: 306-317A) Emphasis on operation of scanning and transmission electron microscopes. Topics covered are electron/specimen interactions, hardware description; image contrast description; qualitative and quantitative (ZAF) x-ray analysis; electron diffraction pattern analysis. **Professor Yue**

DEPARTMENTAL MINING COURSES

306-200A MINING TECHNOLOGY. 3(3-3-3) Economic importance of the mining industry. Definition of a mining venture, and responsibilities of the mining engineer. Relevant legislation, regulations, and professional organizations. Criteria for exploiting an ore deposit. Surface and underground mining methods: preliminary selection procedure. Mining methods and mining equipment. Ethics and professionalism in the practice of engineering. **Mr. Mossop**

306-203C MINE SURVEYING. 2 (Prerequisite: 306-200 or permission of instructor) A two-week field school with laboratories and assignments. The role of the mine surveyor. Techniques and instrumentation for measurement of levels, angles and distances. Shaft, raise, drift and stope surveying techniques. Graphical presentation of survey data and computer applications. Monitoring techniques for mining excavations with deformation and displacement measurements. **Dr. Momayez and Mr. Vachon**

306-290T INDUSTRIAL WORK PERIOD I. 2 (Prerequisites: 306-200 or 306-203) A four-month work period in the mineral industry, to expose the student to an industrial environment. Candidates will receive basic industrial training. A complete report must be submitted at the end of the term. **Mr. Vachon**

306-291T INDUSTRIAL WORK PERIOD II. 2 (Prerequisite: 306-290) A four-month industrial work period in a mining company, research laboratory or government agency. The student will receive formal industrial training in a technical position. A complete report must be submitted at the end of the term. **Mr. Vachon**

◎ **306-320B EXTRACTION OF ENERGY RESOURCES.** 3(3-0-6) The extraction of energy resources, i.e. coal, gas, oil and tar sands. After a brief geological review, different extraction techniques for these substances will be discussed. Emphasis on problems such as northern mining and offshore oil extraction with reference to Canadian operations. Transportation and marketing. **Professor Hassani**

306-322B ROCK FRAGMENTATION. 3(3-3-3) (Prerequisite: 306-200) Principles of drilling, penetration rates, performance and factors to consider in the choice of a drilling method. Characteristics of explosives, firing systems and blast patterns. Blasting techniques in surface and underground workings and in permafrost. Special blasting techniques at excavation perimeters. Vibration and noise control. Economics of drill/blast practice, interface with transport and crushing systems. Legislation and safety in explosives use and handling. Ripping and fullface boring machines. **Professor Comeau**

306-323B ROCK AND SOIL MASS CHARACTERIZATION. 3(3-3-3) (Prerequisites: 186-221 and 306-200) Characteristics of soil and rock masses and the stability of mine workings. Mechanical properties of rocks and soils related to physical/chemical properties. Characterization of rock mass discontinuities. Laboratory and in-situ techniques to define mechanical properties of soils, rocks and discontinuities. Permeability and groundwater flow principles. In-situ stresses and their measurement. Rock mass quality and classification systems. **Professor Hassani**

306-324B ELECTROTECHNOLOGY FOR MINING, METALLURGICAL & MATERIALS ENGINEERS. 3(3-3-3) (Prerequisites: 189-261 and 189-265) AC theory including vector and complex number representation of sinusoidal currents, voltages and impedances. Effect of frequency on LCR circuit outputs. Logic circuits including two-state logic and logic components, logic ports and toggles, Boolean algebra, and complex circuits. Microprocessors including organization logic, programming, and microcomputers. Data acquisition including sensors, noise, A/D and D/A converters, and programming. Operational amplifiers. Applications to systems control. **Professor Hemami**

306-325A MINERAL INDUSTRY ECONOMICS. 3(3-1-5) (Prerequisite: 306-310) Geographical distribution of mineral resources. Production, consumption and prices of minerals. Market structure of selected minerals. Economic evaluation aspects: grade-tonnage considerations; capital and operating cost estimation; assessment of market conditions; estimation of revenue; taxation; sensitivity and risk analyses; economic optimization of mine development and extraction. **Professor Bilodeau**

306-333B MATERIALS HANDLING. 3(3-3-3) (Prerequisite: 306-200) Physical and mechanical characteristics of materials related to loading, transport and storage. Dynamics of particles, systems and rigid bodies, mass-acceleration, work-energy, impulse-momentum. Types and selection of excavation and haulage equipment. Layout of haul roads. Rail transport. Conveyor belts and chain conveyors. Mine hoists. Layouts of mine shafts. **Professor Mitri and Mr. Mossop**

306-340A APPLIED FLUID DYNAMICS. 3(3-3-4) (Prerequisite: 303-205) Flow analysis and manometry. Conservation of mass and momentum. Flow in pipes and ducts, analysis of pipe networks. First and second law of thermodynamics and their applications. Open channel flows. Dimensional analysis and similitude. Flow measurements. Settling and separation of particles. Non-Newtonian flow and slurry transport. Fluidized beds. Filtration of liquid/solid mixtures. **Professor Hasan**

306-392B INDUSTRIAL WORK PERIOD III. 2 (Prerequisite: 75 credits including 306-291) A four-month industrial work period in a mining company, research laboratory or government agency. Based on the experience gained during the first two work periods, the student may be asked to undertake more challenging technical tasks. A complete report must be submitted at the end of the term. **Mr. Vachon**

306-419C OR T SURFACE MINING. 3(3-3-3) (Prerequisites: 306-322, 306-333 and 306-325) Choice of a surface mining method. Analysis of soil and rock mass properties related to surface mining. Calculation and monitoring of stripping ratios, ultimate pit depth, slope stability, rock reinforcement, bench and berm dimensioning and ramp design. Loading and hauling systems. Surface layout and development. Water drainage systems. Productions and cost analysis. Computerized design techniques. **Mr. Mossop**

306-420B FEASIBILITY STUDY. 3(1-2-6) (Prerequisites: 306-419, 306-426 and 309-421) This course consists of a case study exercise in the application of the specialist skills which the student has developed in the mining engineering program. The objective is to combine these skills in carrying out a professional appraisal of the technical feasibility and economic viability of developing a mineral deposit. Students are required to prepare a professional level report and present seminars on particular aspects of the feasibility analysis. **Mr. Mossop and Professor Bilodeau**

306-426C OR T DEVELOPMENT AND SERVICES. 3(3-3-3) (Prerequisite: 306-324 and 306-333) Selection and design of the facilities required to start production at both surface and underground mines, based on design criteria dictated by mining plans, geography, geology and government regulations. Scheduling of development and construction. Staffing and health and safety considerations during development, construction and operations. **Mr. Mossop**

306-484A,B,T MINING PROJECT. 3(0-0-9) (Corequisites: 306-419, 306-426, 309-328 and 309-421) A mining research project to be completed during one semester. The project must be approved by an academic advisor. A comprehensive report and a seminar presentation are required for the project. **Mr. Mossop**

306-494A,B,T INDUSTRIAL WORK PERIOD IV. 2(0-0-6) (Prerequisites: 306-419, 306-426, 309-328 and 309-421) A four-month industrial work period after which the student must submit a report. **Mr. Vachon**

◎ **306-520B STABILITY OF ROCK SLOPES.** 3(3-0-6) (Prerequisite: permission of instructor.) The properties of rock masses and of structural discontinuities. Influence of geological structure on stability. Linear, non-linear, and wedge failures. Site investigations. Methods of slope stabilization. **Professor Hassani**

◎ **306-521C OR T STABILITY OF UNDERGROUND OPENINGS.** 3(3-3-3) (Prerequisite: permission of instructor) The properties of rock masses and stability classification systems. The influence and properties of geological structural features. Stability related to the design of underground openings and mining systems. Site investigations. Methods of stabilization. **Professor Mitri**

● ◎ **306-524B MINERAL RESOURCE ECONOMICS.** 3(3-0-6) (Prerequisite: 306-310 or equivalent, or permission of instructor.) Analysis of significant factors affecting mineral supply, including oil and gas. Role of governments, concept of economic rent and determinants of a mineral policy. Objectives, strategies and concerns of mining and oil and gas companies. International resource environment, commodity associations, mineral investment and trade patterns. **Mr. Ortslan**

◎ **306-526A,B MINERAL ECONOMICS.** 3(3-1-5) (Prerequisite: 306-310 or equivalent) Mineral project evaluation techniques and applications. Topics covered include grade-tonnage relationships, capital and operating cost estimation techniques, assessment of mineral market conditions, taxation, discounted cash flow analysis, risk analysis, and optimization of project specifications with re-

spect to capacity and cutoff grade. (This course is given only once per academic year.) **Professor Bilodeau**

● ◎ **306-528B MINING AUTOMATION.** 3(3-3-3) (Prerequisite: 306-426) System analysis and design in the frequency domain. Review of optimization methods. Mining system modelling applied to rock cutting, materials transport, and bunkerage, pitch, yaw and roll steering of mining machines. Control and robotics: digitization, discrete systems, sensors, actuators and real time algorithms. Data communication in mines. Simulation exercises. **Dr. Momayez**

COURSES OFFERED BY ÉCOLE POLYTECHNIQUE

309-320A CAO ET INFORMATIQUE POUR LES MINES. 3(2-3-4) (Prérequis: 306-200 et 308-208) Présentation de techniques informatisées et de logiciels permettant d'appliquer l'informatique dans le cadre des diverses opérations reliées à l'exploitation des mines. Utilisation de logiciels de support: chiffrier électronique, traitement de texte, éditeur graphique, utilitaires de DOS. Utilisation de graphisme, de traceurs à plumes, de tablettes numérisantes, d'interfaces pour capteurs analogique/numérique et numérique/analogique. Notions de géometrie descriptive appliquées à des problèmes miniers. **Professor Corthésy**

309-321B MÉCANIQUE DES ROCHES ET CONTRÔLE DES TERRAINS. 3(3-3-3) (Prérequis: 306-323) Pressions de terrains au pourtour des excavations: solutions analytiques et numériques. Stabilité des excavations souterraines et à ciel ouvert: analyse des instabilités structurales par projection stéréographique méridienne, analyse des instabilités causées par les excès de contraintes. Soutènement. Surveillance. Études de cas. **Professor Aubertin**

309-326A RECHERCHE OPÉRATIONNELLE MINIÈRE I. 3(3-3-3) (Prérequis: 189-260) Logistique minière. Modèles de localisation optimale: Steiner, HAP, construction itérative. Modèles de détermination des contours optimaux des exploitations à ciel ouvert: conventionnels, Lerchs et Grossman, Ford et Fulkerson. Programmation dynamique et modèles d'optimisation du taux de production et de la teneur de coupure. Modèles de planification: cheminement critique et PERT, programmation linéaire et non-linéaire, théorie des graphes. Modèles de capacité: théorie des files d'attente, simulation, silos et stockage. Modèles de mélange. **Professor Gamache**

◎ **309-327A,B HYDROGÉOLOGIE APPLIQUÉE.** 3(3-3-3) (Prérequis: 186-221 et 189-261) Eau souterraine et cycle hydrologique. Aquifère et aquitard. Charge hydraulique et piézomètre. Mouvement de l'eau souterraine. Loi de Darcy. Mesures et valeurs de perméabilité. Réseau d'écoulement. Essais de pompage: régime transitoire permanent, effet de frontière, drainage. Facteurs influençant les niveaux d'eau. Qualité des eaux souterraines. Types de pollutants et leur propagation. Méthodes de traitement et d'étanchéisation. Techniques de modélisation. Exploration et gestion des eaux souterraines. Recharge artificielle. Intrusions salines. **Professor Chapuis**

309-328C OR T ENVIRONNEMENT MINIER. 3(3-3-3) (Prérequis: 306-200 et 306-291) Effets du milieu de travail sur l'homme (hygiène du travail): législation; contraintes thermiques, problèmes de bruit, de contaminants gazeux et de poussières; techniques de mesures. Effets de l'exploitation d'une mine sur le milieu (environnement et écologie): législation; études d'impacts; effluents miniers: origine, nature et traitement des effluents; entreposage des résidus; restauration des sites. **Professors Aubertin and Simon**

309-329A GÉOLOGIE MINIÈRE. 2(2-2-2) (Prérequis: 186-221, 306-200 et 306-209) Méthodes de cartographie minière, de sondages et d'échantillonnage. Notion de teneur de coupure, calcul des réserves par les méthodes conventionnelles. Évaluation des réserves par les méthodes géostatistiques. **Professor Marcotte**

309-330A MÉCANIQUE DES MATÉRIAUX MEUBLES. 3(3-3-3) (Prérequis: 306-323) Propriétes mécaniques des matériaux meubles. Conception d'empilements et de digues de retention pour les matériaux miniers. Conception de structures enfouies. Problèmes particuliers avec les résidus miniers: liquéfaction, déposition, etc. Écoulement gravitaire des matériaux meubles. **Professor Aubertin**

309-421C OR T EXPLOITATION EN SOUTERRAIN. 3(3-3-3) (Prérequis: 306-322, 306-325 et 306-333) Étude des caractéristiques des principales méthodes d'abattage utilisées en souterrain. Méthodes d'analyse simplifiée d'un gisement quant à son exploitation en fosse ou en souterrain. Dimensionnement des ouvrages et choix des équipements. Calculs des quantités, des équipements et des coûts reliés aux excavations souterraines. Conception d'un circuit de remblai hydraulique. **Professor Corthésy**

309-422B VENTILATION MINIÈRE. 3(3-2-4) (Prérequis: 306-340) Description des composantes d'un système de ventilation. Ventilation naturelle et mécanique. Principes de mesure et de modélisation des écoulements de l'air dans les réseaux de ventilation. Techniques de calcul des pertes de charges dans un circuit. Choix des composantes pour assurer et régulariser les écoulements. Simulation informatisée des écoulements. Chauffage de l'air. **Professor Simon**

4.8 School of Urban Planning

Director and Professor
Jeanne M. Wolfe; B.Sc.(Lond.), M.Sc.(W.Ont.), M.A.(McG.)

Professors
Ronald G. Rice; B.A.Sc.(Tor.), S.M.(MIT), Dipl.U.&R.Pl.(Tor.), Ph.D.(Tor.), P.Eng.
Jane M. Glenn; B.A., LL.B.(Qu.), D. en Droit(Stras.)

Associate Professor
David F. Brown; B.A.(Bishop's), M.U.P.(McG.), Ph.D.(Sheffield)

Assistant Professor
Raphaël Fischler; B.Eng.(Eindhoven), M.Sc., M.C.P.(MIT), Ph.D.(U.C. Berk.)

Associate Members
Gordon O. Ewing; M.A.(Glas.), M.A., Ph.D.(McG.)
Mario Polèse; B.A.(CUNY), M.A., Ph.D.(Penn.)

Instructor
Pierre Gauthier; B.Arch.(Montr.), M.Arch.(Laval)

Guest Lecturers
Cameron Charlebois, Luc Danielse, Marc Denhez, David Farley, Andrew Hoffmann, Peter Jacobs, Brenda Lee, Damaris Rose, Lloyd Sankey, Martin Wexler

Modern urban planning developed into a profession in the early decades of the twentieth century, largely as a response to the appalling sanitary, social and economic conditions of rapidly developing industrial cities. Initially the disciplines of architecture, civil engineering and public health provided the nucleus of concerned professionals; beautification schemes and infrastructure works marked the early stages of public intervention in the nineteenth century. Architects, engineers and public health specialists were joined by economists, sociologists, lawyers and geographers as the complexities of the city's problems came to be more fully understood and public pressure mounted for their solution. Contemporary urban and regional planning techniques for survey, analysis, design and implementation developed from an interdisciplinary synthesis of these various fields.

Today, urban planning can be described as the collective management of urban development. It is concerned with the welfare of communities, control of the use of land, design of the built environment, including transportation and communication networks, and protection and enhancement of the natural environment. It is at once a technical and a political process which brings together actors from the public, private and community spheres. Planners participate in that process in a variety of ways, as designers and analysts, advocates and mediators.

McGill University was the first institution in Canada to offer a full-time planning program. An inter-disciplinary program was established in 1947, in which students combined a master's degree in Urban Planning with one in a related field. An autonomous pro-

gram was established in 1972. It became the School of Urban Planning in 1976.

Students come to the School from diverse backgrounds, the physical sciences, the traditional professions, such as architecture and engineering, and the social sciences. Alumni of the School work as planners and designers at various levels of government, in non-profit organizations and with private consulting firms. Their expertise ranges from historic preservation to traffic management, from housing development to computer imaging. They devote their efforts in increasing numbers to environmental planning and sustainable development.

The School is a partner in the Montreal Interuniversity Group "Urbanization and Development", a consortium recognized by CIDA as a Centre of Excellence, which is devoted to the study of urban problems and the formulation of policies in developing regions. Faculty and students collaborate actively with members of other McGill departments, notably Architecture, Geography, Civil Engineering and Law, and with colleagues at other institutions in Canada and abroad.

The objective of the School is to produce qualified professional urban planners for the public and the private sectors. Training is provided at the post-graduate level; the degree offered is the Master of Urban Planning (M.U.P.). Upon completion of the two-year program of studies, graduates are expected to have acquired basic planning skills, a broad understanding of urban issues, and specialized knowledge in a field of their own choice. (The School also accepts a limited number of Ad-Hoc Ph.D. students.)

The program of study offered by the School is fully recognized by the Ordre des Urbanistes du Québec (O.U.Q.) and the Canadian Institute of Planners (C.I.P.). Graduates can become full members of these professional organizations after meeting their internship requirements.

For details of the M.U.P. admission requirements and curriculum, consult the Faculty of Graduate Studies Calendar.

COURSES OFFERED BY THE SCHOOL

409-501A,B PRINCIPLES AND PRACTICE I. (2) This six-week intensive course exposes students to issues and techniques that are applicable in diverse professional planning contexts. The subject matter, geographic area, scale of intervention and institutional location of planning varies from semester to semester. The course focuses on a specific case study and is taught by a visiting lecturer with professional experience in the selected subject matter.
Staff and Visitors

409-505B GEOGRAPHIC INFORMATION SYSTEMS. (3) An introduction to fundamental geographic information system (GIS) concepts and a range of GIS applications in urban and regional planning.
Professor Brown

COURSES OFFERED JOINTLY BY THE SCHOOL AND OTHER ACADEMIC UNITS

183-351A APPLIED QUANTITATIVE METHODS IN GEOGRAPHY. (3) Survey design; uni- and multi-dimensional scaling; cost-benefit analysis and matrix methods of plan evaluation; multiple regression and correlation; logic models; gravity models; population projection.
Professor Ewing

301-435B URBAN PLANNING I. (2) Theory and practice. An examination of different basic approaches to urban planning with special reference to Quebec.
Professor Wolfe

301-436A URBAN PLANNING II. (2) Urban Design and Project Feasibility. Theory and practice. The course considers the urban and real-estate development process, with a focus on economic and political constraints. It introduces students to techniques in urban design, zoning, and financial analysis.
Professor Fischler

303-433B URBAN PLANNING I. (3) The City in History. The planning profession, evolution of planning in North America, Canada and Quebec. Planning theories, the general or master plan, planning processes and techniques, planning and design of residential subdivisions. Local planning issues, housing policies, planning laws.
Professor Wolfe

490-004A LAND USE PLANNING LAW. (3) A comparative study of private and public control of land use and development, involving master plans, zoning bylaws, subdivision control, urban re-development, expropriation, and regional planning.
Professor J.M. Glenn

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, described in detail in the Faculty of Graduate Studies and Research Calendar, is as follows:

409-604A	Planning Projects III
409-605A,B	Graduate Seminar
409-606B	Supervised Research Seminar
409-607D	Reading Course
409-609A	Planning Graphics
409-612A	History and Theory of Planning
409-614B	Urban Environmental Planning
409-616A,B	Selected Topics I
409-617A,B	Selected Topics II
409-618A,B	Selected Topics III
409-619B	Transport and Land Development
409-620A	Computer Applications in Planning
409-621B	Theories of Urban Form
409-622A	Planning Projects I
409-623B	Planning Projects II
409-625A,B	Principles And Practice of Planning II
409-626A,B	Principles And Practice of Planning III
409-628A,B,C	Practical Experience
409-630A,B,C	Supervised Research Project I
409-631A,B,C	Supervised Research Project II
409-632A,B,C	Supervised Research Project III

5 Minor Programs and Choice of Electives or Complementary Courses

Students of the Faculty have a considerable variety of complementary course choices, which fall into the categories of technical and complementary studies. Students should refer to their respective departments for information concerning complementary course selections. Departments also publish in this Calendar and in separate documents, information regarding the choice of courses. Students should also consult their course advisers. Some general information applicable to all students of the Faculty is given below. This mainly covers the areas of materials engineering, management, biotechnology, economics, mathematics, arts, environmental engineering, computer science and chemistry.

5.1 Arts Minor

Engineering students may obtain a Minor in Arts as part of their B.Eng. degree by satisfying the 24-credit requirement described below. In general, complementary studies courses given in the Faculty of Arts and listed under: (i) – "3 credits of studies of the Impact of Technology on Society" and (ii) – "the remaining credits to be elective social science and humanities courses" (see section 3.3), may be used to satisfy some of these requirements. In no case will more than 9 credits taken from these complementary studies requirements be credited towards the Minor in Arts.

Requirements

1. The program must consist of 24 credits as follows:
   a) at least two areas of concentration from within the Faculty of Arts must be chosen, with the minimum number of credits in any one area being 6,
   b) at least 12 credits must be at the 300 or above level.
2. All courses in the Minor program must be passed with a grade of C or better.

3. The selection of courses for the Minor is to be done in consultation with the Minor Advisor, Ms. Judy Pharo, ENGMD 378.

For further information, please contact Prof. B. Haskel, Political Science, or Ms. J. Pharo, Faculty of Engineering, ENGMD 378.

5.2 Biotechnology Minor

The Faculties of Engineering and of Science offer a Minor in Biotechnology for students interested in taking additional courses in this area. For Engineering students, the Minor has been designed specifically for students within the Chemical Engineering Department, however other Engineering students are invited to contact the Minor program supervisor, Professor Bennett, or Professor B. Volesky, Chemical Engineering (514) 398-4276, for further information. Students should identify an interest in the Minor to their academic adviser and the supervisor of the program during the U1 year, and at the time of registration for the U2 year. With the agreement of the academic advisor, students should submit their course list to the program supervisor who will certify that the proposed program conforms to the requirements for the Minor. The Biotechnology Minor Program is administered for the Faculties of Engineering and of Science by Prof. H. Bennett, Sheldon Biotechnology Centre (Lyman-Duff Building), phone 398-3998. A full description of the Minor program appears under the Biotechnology heading on page 361 of the Science section.

A Chemical Engineering student may complete the Biotechnology Minor by taking 177-200A, 177-201B, 177-202B, 528-211A, 202-505B, plus one course from the list of additional courses not including 306-310. The Department of Chemical Engineering permits students in the Minor program to complete 202-505B as one of their technical complementary requirements. The total course credit required for the Chemical Engineering student is 15 credits beyond the 110-credit B.Eng. program.

5.3 Chemistry/Chemical Engineering Minor

The Departments of Chemistry and Chemical Engineering offer a Minor Program in Chemistry, of particular interest to Chemical Engineering students and a Minor in Chemical Engineering, of interest to Chemistry students (described in the Science section).

The Minor in Chemistry consists of 25 credits as follows:

1. Required courses, 10 credits: 180-212, 233 and 234 (or CEGEP equivalent)
2. At least 15 credits from the following list, two of which must be laboratory courses (* indicates lab). Note that 180-212 is a prerequisite for most of the courses listed below. If students take 180-222* instead of 180-234, they will receive credit for one of the two laboratories that are required but they must have a total of 25 Chemistry credits for the Minor.

Inorganic Chemistry

180-281A, Inorganic Chemistry I
180-371A,B Inorganic Chemistry Laboratory*
180-381A Chemistry of Transition Elements
180-591B Advanced Coordination Chemistry

Analytical Chemistry

180-257D Introductory Analytical Chemistry*
or 180-277D Classical Methods of Analysis*
180-307A Environmental Analysis
180-367A Instrumental Analysis I
180-377B Instrumental Analysis II

Organic Chemistry

180-302A Introductory Organic Chemistry III
180-352B Structural Organic Chemistry
180-362A,B Advanced Organic Laboratory*
180-382B Organic Chemistry of Natural Products
180-402B Advanced Bio-organic Chemistry

Physical Chemistry

180-345A Molecular Properties & Structure I
180-355B Molecular Properties & Structure II
180-363A,B Physical Chemistry Laboratory*
180-393A,B Physical Chemistry Laboratory*
180-455A Introductory Polymer Chemistry

Please consult the program coordinators for more information: Prof. D. Berk (Chemical Engineering) and Prof. M. Andrews (Chemistry). A passing grade for courses within the Minor is a C.

5.4 Computer Science Courses and Minor Program

The School of Computer Science offers an extensive range of courses for Engineering students interested in computers. The course explicitly for Engineering students, 308-208 Computers in Engineering, and other courses in the core of the various Engineering programs are listed in section 6.2 on page 263. Descriptions of other Computer Science courses can be found on page 368 in the Faculty of Science section.

Engineering students may obtain a Minor in Computer Science as part of their B.Eng. degree by satisfying the 24-credit requirement described below. In general, complementary courses within Engineering Departmental programs may be used to satisfy some of these requirements, but the Minor in Computer Science will require at least 12 extra credits from Computer Science (308-) courses beyond those needed for the B.Eng. degree. Students should consult their departments about the use of complementaries, and credits that can be double counted.

Students should see the receptionist in 318 McConnell to pick-up the appropriate forms, and to make an appointment to see the Minor Advisor for approval of their course selection. Forms must be approved before the end of the Add/Drop period of the student's final term.

Requirements

The program must consist of 24 credits, from courses passed with a grade of C or better, as follows:

Required Courses (9 credits)

308-203 Introduction to Computing II
or 308-250 Introduction to Computer Science
308-302 Programming Languages and Paradigms
308-350 Numerical Analysis (or Numerical
or 305-409 Methods in Mechanical Engineering)

Complementary Courses (15 credits)

Three credits, chosen from:
308-273 Introduction to Computer Systems
304-221 Introduction to Computer Engineering I
Three credits, chosen from any Computer Science course numbered 308-305 or higher.
Nine credits, chosen from:
(a) any Computer Science course numbered 308-305 or higher.
(b) any complementary course making considerable use of computing and approved by Computer Science for the Minor.

Notes

A. Courses 308-202 Introduction to Computing I, and 308-208 Computers in Engineering (compulsory for some Engineering students) do not form part of the Minor.

B. 308-202 is a prerequisite for 308-203. Students with a substantial high level language programming course may forego this prerequisite. Some additional make-up effort may be needed at the start of the course.

Courses in Other Departments

The following is a list of courses, offered by other departments, that will normally be approved for inclusion in the Minor program under (b) in the Complementary Courses list. This list is not necessarily complete.

Department of Mathematics

189-327B Matrix Numerical Analysis
189-328A,B Computability and Mathematical Linguistics
189-407B Dynamic Programming
189-417A Mathematical Programming

189-578A Numerical Analysis
189-579B Numerical Differential Equations

Faculty of Engineering
302-453A Process Design
302-455A Process Control
302-571B Small Computer Application in Chemical Engineering
303-208A Civil Engineering Systems Analysis
303-460A Matrix Structural Analysis
304-323A,B Digital System Design
304-425B Computer Organization and Architecture
304-426A,B Microprocessor Systems
304-512A Digital Signal Processing
304-521B Data Communications
304-529A Image Processing and Communications
304-531B Real-Time Systems
304-532A Computer Graphics
304-543B Numerical Methods in Electrical Engineering
304-548A Introduction to VLSI Systems
305-474B Operations Research
305-540B Modelling and Decision
305-554A Process Automation
305-555B Applied Process Control
305-572A Mechanics of Robotic Systems I
305-573B Mechanics of Robotic Systems II
305-576A Computer Graphics and Geometric Modelling
306-311A Computer Applications in Mineral and Materials Engineering

Faculty of Management
273-431A,B Information Systems Design
273-432A,B Information Systems Administration
277-678A Simulation of Management Systems
277-679A Applied Optimization I
280-373A,B Operations Research

In addition, there are other courses that may be approved for inclusion under category (b). Students may consult with the School of Computer Science about the acceptability of particular courses. The courses in other departments are at a variety of levels. Some are required courses in the student's ordinary program; some are courses that may be taken as technical complementaries. Students should consult with their advisers about the possibility of taking specific courses.

The following categories are a guideline to the content of the available courses:

Programming and Programming Languages
308-203 or 308-250, 308-273, 308-302, 308-425, 308-426, 308-524.

Software Design
304-221, 304-425, 304-512, 304-521, 304-529, 304-532, 308-203, 308-310, 308-335, 308-360 (or 308-405), 308-420, 308-424, 308-426, 308-431, 308-433, 308-520, 308-530, 308-534, 308-535, 308-537, 308-538, 308-557, 308-560, 308-575.

Hardware Design
302-571, 304-221, 304-425, 304-426, 304-492, 304-512, 304-521, 304-532, 308-305.

Real-Time Processes
302-453, 302-455, 304-531, 305-475, 305-355.

Operations Research
189-407, 189-417, 277-679, 280-373, 303-208, 305-474, 308-566.

Numerical Analysis
189-327, 189-578, 189-579, 304-543, 308-350 (or 305-409), 308-540.

5.5 Construction Engineering and Management Minor

Students in the Faculty of Engineering may obtain a Minor in Construction Engineering and Management by completing 24 to 25 credits chosen from the required and complementary courses listed below. By a careful selection of complementary courses, a Civil Engineering student may obtain this Minor by completing as few as 9 additional credits. Students in other departments would typically require 12 to 15 additional credits to complete the Minor. For further information, contact Professor L. Chouinard at (514) 398-6446, Room 484, Macdonald Engineering Building.

Prerequisites:
303-208A Civil Engineering Systems Analysis or an equivalent course in Operations Research
303-302B Probabilistic Systems or equivalent
306-310A,B Engineering Economy
308-208A,B Computers in Engineering or equivalent

Requirements:

The 24 to 25 credits listed below must be completed with a grade of C or higher in order to fulfil the requirements of the Minor.

1. Management and Law: 15 credits,as follows:

280-211 (3) Introduction to Financial Accounting
280-341 (3) Finance I
279-294 (3) Intro to Labour-Management Relations
300-220A (3) Law for Architects and Engineers

and one of:
303-324B (3) Construction Project Management
305-472A (3) Project Management

2. Either 3 or 4 credits, as follows:
a) 4 credits -
Any two of the following relating to Building Structures:
301-446A (2) Mechanical Services in Buildings
301-447A (2) Electrical Services
301-450B (2) Specifications and Building Costs
301-451A (2) Building Regulations and Safety
303-492A (2) Structures
or:
b) 3 credits -
One of the following relating to Heavy Construction:
306-322B (3) Rock Fragmentation
306-333B (3) Materials Handling

3. Other Construction-Related Complementaries: 6 credits
Any two of the following:
270-462 (3) Management of New Enterprises
274-445 (3) Real Estate Finance
303-446A (3) Construction Engineering
303-527A (3 Renovation & Preservation of Infrastructure
303-586A (3) Earthwork Engineering
304-281B (3) Electric Power
306-520A (3) Stability of Rock Slopes
306-521A (3 Stability of Underground Openings
309-321B (3) Mécanique des roches et contrôle des pressions de terrains
336-411A (3) Off-Road Power Machinery

Total requirement: 24 or 25 credits

5.6 Economics Minor

The Minor consists of 18 credits in courses given in the Economics Department. It consists of required courses and complementaries. In addition, it is presumed that all Engineering students will have a sufficient background in statistics. Engineering Economy, 306-310, does not form part of this minor. For more information see the Department of Economics, Leacock Room 443.

Required Courses (9 credits)
154-230D* Microeconomic Theory
154-209A,B** Macroeconomic Analysis and Applications

Complementary Courses (9 credits) from:
154-225A Economics of the Environment
154-302D Money and Banking
154-303D Canadian Economic Policy

154-305A	Industrial Organization
154-306D	Labour Economics and Institutions
154-308B	Public Policies Toward Business
154-313D	Economic Development
154-316A,B	The Underground Economy
154-321A	The Quebec Economy
154-326A	Ecological Economics
154-330D	Macroeconomic Theory
154-331A	Economic Development: Russia and the USSR
154-332A	Comparative Economic Systems
154-333B	Topics in Comparative Economic Systems
154-335A	The Japanese Economy
154-337A,B	Introductory Econometrics I
154-344A	The International Economy, 1830 - 1914
154-345B	The International Economy Since 1914
154-347B	Economics of Climate Change
154-404A,B	Transportation
154-405A,B	Natural Resource Economics
154-408D	Public Sector Economics
154-423D	International Trade and Finance
154-447A	Economics of Information and Uncertainty
154-467D	Econometrics - Honours
154-546A	Game Theory
154-568B	Urban and Regional Economics

Mining Engineering students will be permitted to include Mineral Economics (306-526A,B) among these 18 credits.

* Students may, with consent of instructor, take 154-250D Introduction to Economic Theory - Honours, in place of 154-230D.

** This requirement is waived for students who choose 154-330D from the list of complementaries. Students may not take both 154-209A,B and 154-330D.

5.7 Environmental Engineering Minor

The Environmental Engineering Minor is offered for students of Engineering and the Department of Agricultural and Biosystems Engineering wishing to pursue studies in this area. The Minor program consists of 27 credits in courses. Through a judicious choice of core and complementary courses listed below, students may minimize the number of additional credits required to obtain this Minor. The Minor typically requires a minimum of 9 to 15 additional credits. This minimum depends on the department/school in which the student is registered.

The Environmental Engineering Minor Program is administered by the Department of Civil Engineering and Applied Mechanics. Further information may be obtained from Professor S. Ghoshal, Room 475C, Macdonald Engineering Building.

General Regulations

To complete the Minor in Environmental Engineering, students must:

a) complete a minimum of 21 credits of Engineering courses (a minimum of 6 credits in this category must be chosen outside the student's principal departmental program) (see section A below),
b) complete a minimum of 6 credits of non-Engineering courses (each course must be chosen from a different department, and neither from the student's home department) (see section B below),
c) complete one of the corequisite courses listed below in addition to the 27 credits counted toward the Minor.
d) in the case of Agricultural and Biosystems, Chemical, and Civil Engineering students, select all courses for the Minor program in the student's principal program, other than those taken as part of the Humanities and impact course requirements,
e) obtain a grade of C or better in all approved courses in the Minor, and
f) satisfy the requirements of both the Minor and the student's departmental program.

Note: Not all courses listed below are offered every year. Students should consult with the department concerned about the courses which are offered in a given year.

Corequisites

(Not credited to the Minor Program)

302-230 Environmental Aspects of Technology
or 303-225 Environmental Engineering
or 306-308 Social and Economic Impacts of Technology
or equivalent environmental impact course

A. ENGINEERING COURSES (21 credits)

Agricultural Engineering (Macdonald Campus)

336-217 Hydrology and Drainage (not open to students who have passed 303-323)
336-322 Agro-food Waste Management
336-416 Engineering for Land Development
336-518 Pollution Control for Agriculture

Chemical Engineering

302-351 Separation Processes
302-370 Elements of Biotechnology
302-430 Technology Impact Assessment (not open to students who have passed 375-437)
302-452 Particulate Systems (offered in alternate years)
302-471 Industrial Water Pollution Control (not open to students who have passed 303-430)
302-472 Industrial Air Pollution Control

Civil Engineering and Applied Mechanics

303-225 Environmental Engineering (not part of the Minor for Civil Engineering Students)
303-323 Hydrology and Water Resources (not open to students who have passed 336-217)
303-421 Municipal Systems
303-430 Water Treatment and Pollution Control (not open to students who have passed 302-471)
303-451 Geoenvironmental Engineering
303-526 Solid Waste Management
303-550 Water Resources Management
303-553 Stream Pollution and Control
303-572 Advanced Hydraulics
303-574 Fluid Mechanics of Water Pollution
303-575 Fluid Mechanics of Air Pollution
303-577 River Engineering
303-585 Groundwater Hydrology

Mechanical Engineering

305-343 Energy Conversion
305-434 Turbomachinery
305-447 Combustion
305-525 Intro. to Nuclear Engineering
305-526 Manufacturing and the Environment
305-534 Air Pollution Engineering

Mining and Metallurgical Engineering

306-412 Corrosion and Degradation
306-451 Environmental Controls
306-555 Thermal Remediation of Wastes
309-327 Hydrogéologie Appliquée
309-328 Environnement Minier
309-422 Ventilation Minière

B. NON-ENGINEERING COURSES (6 credits)

Agricultural Sciences (Macdonald Campus)

338-510 Agricultural Micrometeorology
344-200 Biology of Organisms I
344-201 Biology of Organisms II
344-205 Principles of Ecology
349-315 Science of Inland Waters
350-380 Food Systems and the Environment
362-230 The Microbial World (not open to students who have passed 302-370)

362-331 Microbial Ecology (not open to students who have passed 302-370)
362-341 Mechanisms of Pathogenicity
372-210 Principles of Soil Science (not part of the Minor for Agricultural Engineering Students)
372-331 Soil Physics
374-420 Environmental Issues in Forestry
375-333 Physical and Biological Aspects of Pollution
375-375 Issues in Environmental Sciences
375-415 Conservation Law
375-437 Assessing Environmental Impact (not open to students who have passed 302-430)

Anthropology
151-206 Environment and Culture

Atmospheric and Oceanic Sciences
195-210 Introduction to Atmospheric Science (not open to students who have passed 183-321)
195-220 Introduction to Oceanic Sciences

Biology
177-205 Biology of Organisms
177-208 Introduction to Ecology
177-432 Limnology
177-470 Lake Management

Chemistry
180-307 Environmental Analysis

Earth and Planetary Sciences
186-243 Environmental Geology (not open to students who have passed or who will take 186-221)
186-549 Groundwater Hydrology

Economics
154-225 Economics of the Environment
154-326 Ecological Economics
154-347 Economics of Climate Change

Geography
183-200 Geographical Perspectives on World Environmental Problems
183-201 Geographic Information Systems I
183-203 An Introduction to Environmental Studies
183-205 Global Change: Past, Present and Future
183-302 Environmental Analysis and Management
183-308 Air Photo Interpretation and Remote Sensing
183-321 Climatic Environments (not open to students who have passed 195-210)
183-404 Environmental Management for Parks and Protected Areas

Law
389-580 Environment and the Law

Microbiology and Immunology
528-211 Biology of Microorganisms

Religious Studies (Macdonald Campus)
260-270 Religious Ethics and the Environment

Sociology
166-328 Environmental Sociology

5.8 Minor in Environment

Environmental studies involve the interactions between humans and their natural or technological environment. Environmental problems are frequently comprehensive and complex, and their satisfactory solutions require the synthesis of humanistic, scientific, and institutional knowledge. The Minor in Environment is offered and administered by the McGill School of Environment (MSE). Inquiries should be directed to Mr. Peter Barry, MSE. E-mail: envstud@felix.geog.mcgill.ca or telephone: (514) 398-4306.

Since the program comprises a total of 18 credits for the Minor, additional credits beyond those needed for the B.Eng. degree are required. Students wishing to receive the Minor should prepare a program and have it approved by both their regular Engineering Advisor and the School. For program details, see "Minor in Environment" on page 458 in the MSE section.

5.9 Management Courses and Minor Program

Many engineers begin to assume management functions within a few years of graduation. They can, at this stage, take up the study of economics, behavioural science and other management subjects. Students wishing to include such studies in their undergraduate program can take suitable courses from Engineering and Management as listed below.

Engineering Economy 306-310 introduces the concept of costs into evaluations of engineering projects and architectural proposals. Several additional courses are available, subject to timetable requirements, from the core program of the Faculty of Management.

Other courses from the Management core program have considerable overlap with Engineering courses and thus are not available to Engineering students.

Note: Course 280-211, a course in statistics, and a course in Micro-economics are prerequisite for 280-341. If included in the Minor in Management, 280-423 should be taken at the end of the program.

Engineering students may obtain a Minor in Management by completing 15 credits of courses from the following list of Faculty of Management courses with a grade of C or better. Successful completion of this Minor is noted on a student's transcript.

Required Courses (6 credits)
280-211 Introduction to Financial Accounting
280-320 Managing Human Resources

Complementary Courses (9 credits)
3 credits, one of List A:
280-213 Introduction to Managerial Accounting
280-341 Finance I
280-373 Operations Research
280-382 International Business

3 credits, one of List B:
270-462 Management of New Enterprises
280-222 Organizational Behaviour
280-352 Marketing Management I
280-360 Social Context of Business
280-423 Organizational Policy

3 credits, any available 300 or 400-level Management course (for which the prerequisites, if any, have been met).

An Engineering course deemed equivalent by the Faculty of Management may be substituted for course 280-373. There are three courses in Engineering that qualify: 303-208, 305-474 and 309-326. It should be noted that 280-373 does not count as a technical complementary course.

A student embarking on the Minor must be prepared to take credits additional to the normal Engineering program. The student may choose the non-technical complementary course(s) required in his/her program from list B above, but under no circumstances will more than 6 credits of non-technical complementary courses count towards both the Engineering program and the Minor. Students considering this Minor should consult their adviser, or Ms. H. Van Eyk, Faculty of Management.

Prerequisite to entry to this Minor is a grade C or better in 306-310.

5.10 Materials Engineering Minor

Engineering students may obtain a Minor in Materials Engineering by completing 24 credits chosen from the required and complementary courses listed below. By a careful selection of complementary courses, Engineering students may obtain this Minor with a minimum of 15 additional credits. It should be noted that some departments (e.g. Mechanical Engineering) will allow their students to take courses from this list, providing they complete the

Minor prior to graduation. For further information, please contact the coordinator, Prof. R.A.L. Drew, Room 2090, Wong Building.

Required Courses (15 credits)

	306-260A,B	Materials Science and Engineering
or	302-380A	Materials Science
	306-367B	Electronic Properties of Materials
	306-465B	Ceramic Engineering
	302-481A	Polymer Engineering
	302-484B	Materials Engineering

Complementary Courses (9 credits)

Three courses to be chosen from the following list:

180-455A	Introductory Polymer Chemistry
302-381B	Polymer Technology
302-483B	Industrial Rheology
302-487B	Chemical Processing in the Electronics Industry
302-530C	Structure and Properties of Paper
302-581B	Polymer Composites Engineering
304-545A	Microelectronics Technology
305-530B	Mechanics of Composite Materials
306-360A	Phase Transformations in Solids
306-361B	Liquid State Processing of Materials
306-362A	Engineering Properties of Materials
306-412A	Corrosion and Degradation
306-560A	Joining Processes
306-561B	Advanced Materials Design
306-563B	Hot Deformation of Metals
306-564B	X-Ray Diffraction Analysis of Materials
306-566A	Texture, Structure and Properties of Polycrystalline Materials
306-569B	Electron Beam Analysis of Materials

5.11 Mathematics Minor

The Minor in Mathematics for students in the Faculty of Engineering requires satisfactory passes in 24 credits of approved courses in Mathematics not including 189-247 (or -223), -260 (or -222), -261 (or -315 or -325), -265 (or -248 or -314), -266, -270, -319.

At least 18 credits must be chosen from the Mathematics and Statistics courses approved for the Mathematics Majors or Honours program, or from Mathematics 189-249, -363, -381, -386. The remaining credits may be chosen from mathematically allied courses.

In addition to an Engineering Adviser, each student in the Minor program must have an Adviser designated by the Department of Mathematics and Statistics, normally beginning in the U2 year. The selection of courses for the Minor is to be done in conjunction with the Minor Adviser. Please consult the Department of Mathematics and Statistics for an Adviser.

5.12 Physics Minor

Students in Honours Electrical Engineering may obtain a Minor in Physics as part of their B.Eng. degree by satisfying the 18-credit requirement listed below:

198-357A	Quantum Physics I
198-362B	Statistical Mechanics
198-457B	Quantum Physics II

and at least 9 credits chosen from the following:

198-332B	Physics of Fluids
198-514B	General Relativity
198-551A	Quantum Theory
198-557A	Nuclear Physics
198-558A	Solid State Physics
198-559A	Advanced Statistical Mechanics
198-562B	Electromagnetic Theory
198-567B	Particle Physics

Students who take 198-357A and 198-457B can omit 198-271B from their normal Electrical Engineering program. Candidates must go to the Department of Physics at registration time in their U3 year to fill out a Minor Program Form.

6 Courses Given by other Faculties for Engineering Students

● Denotes courses not offered in 1999-2000

▭ Courses with limited enrolment

6.1 Department of Chemistry

180-233B SELECTED TOPICS IN PHYSICAL CHEMISTRY. 3(3-0-6) For Chemical Engineers only. Introduction to chemical kinetics, surface and colloid chemistry and electrochemistry. The topics to be discussed will be of particular interest to students in chemical engineering. **Professors Whitehead, Galley and Brown**

180-234A,B SELECTED TOPICS IN ORGANIC CHEMISTRY. 3(3-0-6) (Prerequisite: 180-212A,B or equivalent) For Chemical Engineers only. Modern spectroscopic techniques for structure determination. The chemistry of alkyl halides, alcohols, ethers, carbonyl compounds and amines with special attention to mechanistic aspects. Special topics. **Professors Damha (A) and Farrell (B)**

6.2 School of Computer Science

308-202A,B INTROUCTION TO COMPUTING 1. (3 credits) (3 hours) (Prerequisite: a CEGEP level mathematics course.) (Credit cannot be obtained for both 308-202 and 308-208.) Overview of components of microcomputers, the internet design and implementation of programs using a modern highlevel language, an introduction to modular software design and debugging. Programming concepts are illustrated using a variety of applications.

Professor Hendren

308-208A,B COMPUTERS IN ENGINEERING. (3 credits) (3 hours) (Prerequisite: differential and integral calculus. Co-requisite: linear algebra: determinants, vectors, matrix operations.) (Credit cannot be held for both 308-202 and 308-208.) Introduction to computer systems. Concepts and structures for high level programming. Elements of structured programming using FORTRAN 90 and "C". Assignments in both mainframe and microcomputer environment. Numerical algorithms such as root finding, numerical integration and differential equations. Non-numerical algorithms for sorting and searching. **Professor Ratzer**

308-250A INTRODUCTION TO COMPUTER SCIENCE. (3) (3 hours) (Prerequisites: Familiarity with a high level programming language and CEGEP level Math.) An introduction to the design of computer algorithms, including basic data structures, analysis of algorithms, establishing correctness of programs and program testing. Overview of topics in computer science. **Professor Panangaden**

308-302A,B PROGRAMMING LANGUAGES AND PARADIGMS. (3) (3 hours) (Prerequisite: 308-250 or 308-203) Programming language design issues and programming paradigms. Binding and scoping, parameter passisng, lambda abstraction, data abstraction, type checking. Functional and logic programming.

Professors Friedman and Panangaden

6.3 Department of Earth and Planetary Sciences

186-221A GENERAL GEOLOGY. 3(2-3-4) An introductory course in physical geology designed for majors in civil and mining engineering. Properties of rocks and minerals, major geological processes, together with natural hazards and their effects on engineered structures are emphasized. The laboratory is an integral part of the course which includes rock and mineral identification, basic techniques of airphoto and geological map interpretation, and structural geology. **Staff**

186-225A PROPERTIES OF MINERALS. (1) (1 hour lecture, 1 hour laboratory) (Not open to students who have taken 186-210A) Survey of the physical and chemical properties of the main mineral groups. Discussion of their relationships to the chemical composition and structure of minerals. The practical exercises emphasize the physical and chemical properties that relate to industrial uses

and environmental issues, and the identification of hand specimens. **Professor Paquette**

6.4 Faculty of Education

▭ **455-206A,B COMMUNICATION IN ENGINEERING.** (3 credits) Written and oral communication in Engineering (in English): strategies for generating, developing, organizing, and presenting ideas in a technical setting; problem-solving; communicating to different audiences, editing and revising; and public speaking. Course work based on academic, technical, and professional communication in engineering. Attendance at first class is imperative. **Staff**

6.5 Department of Mathematics and Statistics

189-247B LINEAR ALGEBRA. (3 credits) (Prerequisite: 189-133 or equivalent. Intended for Honours Physics and Engineering students. Not open to students who have taken or are taking 189-236 or 189-223 or 189-251.) Matrix algebra, determinants, systems of linear equations. Abstract vector spaces, inner product spaces, Fourier series. Linear transformations and their matrix representations. Eigenvalues and eigenvectors, diagonalizable and defective matrices, positive definite and semidefinite matrices. Quadratic and Hermitian forms, generalized eigenvalue problems, simultaneous reduction of quadratic forms. Applications.

189-248A ADVANCED CALCULUS I. (3 credits) (Prerequisites: 189-133 and 222 or consent of Department. Intended for Honours Mathematics, Physics and Engineering students. Not open to students who have taken or are taking 189-314.) Partial derivatives; implicit functions; Jacobians; maxima and minima; Lagrange multipliers. Scalar and vector fields; orthogonal curvilinear coordinates. Multiple integrals; arc length, volume and surface area. Line integrals; Green's theorem; the divergence theorem. Stokes' theorem; irrotational and solenoidal fields; applications.

189-249B ADVANCED CALCULUS II. (3 credits) (Prerequisite: 189-248. Intended for Honours Physics and Engineering students. Not open to students who have taken or are taking 189-316.) Functions of a complex variable; Cauchy-Riemann equations; Cauchy's theorem and consequences. Taylor and Laurent expansions. Residue calculus; evaluation of real integrals; integral representation of special functions; the complex inversion integral. Conformal mapping; Schwarz-Christoffel transformation; Poisson's integral formulas; applications.

189-260A,B INTERMEDIATE CALCULUS. 3(3-1-5) (Prerequisites: 189-141, 189-133 or equivalent) Review of sequences and series. Power series, Taylor's theorem and Taylor's series, computations using series. Review of vectors, lines and planes, curves and curvature, conics, polar coordinates. Surfaces. Differential calculus of several variables. Double and triple integrals.

189-261A,B DIFFERENTIAL EQUATIONS. 3(3-1-5) (Corequisite: 189-260) Ordinary differential equations: first order, linear second-order and higher order, linear with constant coefficients. Solution by series, by Laplace transform, and by some simple numerical methods.

189-265A,B ADVANCED CALCULUS. 3(3-1-5) (Prerequisites: 189-260 or 189-222 or 189-151B or equivalent) Implicit functions, constrained and unconstrained extrema for functions of several variables. Change of variables in multiple integrals, Jacobians, surface integrals. Scalar and vector fields, line integrals, vector operators. Green's, divergence and Stokes' theorems, applications to heat flow, electrostatics and fluid flow.

189-266A,B LINEAR ALGEBRA AND BVP. 4(4-1-7) (Prerequisites: 189-261, 189-265) Review of matrix algebra, vector spaces and linear transformations, eigenvalue problems and applications to systems of linear ordinary differential equations. Partial differential equations in engineering, Fourier analysis, Sturm-Liouville theory, solutions of boundary value problems in cartesian, cylindrical and spherical coordinates.

189-270A,B APPLIED LINEAR ALGEBRA. 3(3-1-5) (Prerequisite: 189-261) Review of matrix algebra, solution of linear equations, triangular factorization and Gaussian reduction, vector spaces, inner products, orthogonality concepts, projections, least squares. Eigenvalues and eigenvectors, diagonalization of matrices and quadratic forms, Cayley-Hamilton theorem, the exponential matrix, analytical and numerical techniques for solving linear systems of ordinary differential equations, nonlinear equations and stability.

189-325A,B ORDINARY DIFFERENTIAL EQUATIONS. 3(3-0-6) (Prerequisite: 189-222. Intended for Honours Mathematics, Physics and Engineering programs. Not open to students who have taken or are taking 189-315) First and second order equations; linear equations; series solutions; elementary numerical methods; Laplace transforms.

189-363B DISCRETE MATHEMATICS. 3(3-0-6) (Prerequisites: 189-265 and either 189-270 or consent of instructor) Logic and combinatorics. Mathematical reasoning and methods of proof. Sets, relations, functions, partially ordered sets, lattices, Boolean algebra. Propositional and predicate calculi. Recurrences and graph theory.

189-381A,B COMPLEX VARIABLES AND TRANSFORMS. 3(3-1-5) (Prerequisite: 189-265) Analytic functions, Cauchy-Riemann equations, simple mappings, Cauchy's theorem, Cauchy's integral formula, Taylor and Laurent expansions, residue calculus. Properties of one and two-sided Fourier and Laplace transforms, the complex inversion integral, relation between the Fourier and Laplace transforms, application of transform techniques to the solution of differential equations. The Z-transform and applications to difference equations.

● **189-386A APPLIED PARTIAL DIFFERENTIAL EQUATIONS.** 3(3-1-5) (Prerequisite: 189-325. Pre- or Co-requisite: 189-249) Steady fluid flow. Diffusion of heat. Transverse waves on strings, vibrations of membranes. Separation of variables in rectangular, cylindrical and spherical coordinates. Eigenvalues and eigenfunctions. Fourier analysis. Sturm-Liouville theory. Solution of boundary value problems. Wavelength, energy, power, phase and group velocities. Longitudinal waves in gases and solids. Integral transform methods and Green's functions.

6.6 Department of Physics

198-251A CLASSICAL MECHANICS I. (3 credits; 3 hours lectures) (Prerequisite: CEGEP physics; Corequisite: 189-222A,B) Newton's laws, work energy, angular momentum. Harmonic oscillator, forced oscillations. Inertial forces, rotating frames. Central forces, centre of mass, planetary orbits, Kepler's laws. **Professor Hanna**

198-271A,B QUANTUM PHYSICS. 3(3-0-6) (Prerequisite: 198-251 or 303-281) The observed properties of atoms and radiation from atoms. Electron waves. The Schroedinger Equation in one dimension. Quantum mechanics of the hydrogen atom. Angular momentum and spin. Quantum mechanics of many electron systems. Basic ideas of electrons in solids and solid state physics. **Professors Ryan and Cline**

198-350A ELECTROMAGNETISM. (3 credits) (3 hours lectures) (Prerequisites: 189-248A,B, 325B. Honours students or permission of the instructor) Fundamental laws of electric and magnetic fields in both integral and differential form. **Professor Lovejoy**