ADMISSION – JOINT PH.D.

Candidates will normally hold an M.B.A. or other related Master's level degree, with a strong academic record from a recognized university. In certain cases, candidates without related Master's degree but with exceptional backgrounds may be considered for the program. Experience judged relevant to the course of study will be considered a desirable feature of the applicant's background.

A recent GMAT score (within 5 years) and two recent letters of recommendation are required as part of the application.

Students may apply for admission to one or more of the participating universities.These applications will be processed by both the individual university and the joint committee of the four schools. Students' preferences will prevail when more than one participating university is prepared to accept them. The Ph.D. degree will be granted by the university that admits the student. The program requires a minimum full-time residency of six semesters.

These applications must be completed by February 1st for September admission. January admissions are exceptional and subject to the approval of the Program Director.

Completed McGill application forms should be sent to:

Program Coordinator, Ph.D. Program
Faculty of Management
McGill University
1001 Sherbrooke Street West
Montreal, QC H3A 1G5

Telephone: (514) 398-4074
Fax: (514) 398-3876
E-mail: phd@management.mcgill.ca

The addresses of the three other institutions are:

Concordia University,Faculty of Commerce and Administration, 1455 de Maisonneuve Blvd West, Montreal, QC H3G 1M8

École des Hautes Études Commerciales, 3000 Chemin de la Cote Ste-Catherine, Montréal, QC H3T 2A7

Université du Québec à Montréal, Département des Sciences Administratives, 315 Ste-Catherine Est, Montréal, Québec H3C 4R2

46 Mathematics and Statistics

Department of Mathematics and Statistics
Burnside Hall
805 Sherbrooke Street West
Montreal, QC H3A 2K6
Canada

Telephone: (514) 398-3800
Fax: (514) 398-3899
E-mail: gradprog@math.mcgill.ca
Website: http://www.math.mcgill.ca

Chair — K. GowriSankaran

Chair of Committee on Graduate Affairs — K. Peter Russell

46.1 Staff

Emeritus Professors
J. Lambek; M.Sc., Ph.D.(McG.), F.R.S.C.*(Peter Redpath Emeritus Professor of Pure Mathematics)*
W.O.J. Moser; B.Sc.(Manit.), M.A.(Minn.), Ph.D.(Tor.)

Professors
W.J. Anderson; B.Eng., Ph.D.(McG.)
W. Brown; B.A.(Tor.), M.A.(Col.), Ph.D.(Tor.)
M. Bunge; M.A., Ph.D.(Penn.)
S. Drury; M.A., Ph.D.(Cantab.)
K. GowriSankaran; B.A., M.A.(Madr.), Ph.D.(Bomb.)
J. Hurtubise; B.Sc.(Montr.), D.Phil.(Oxon.)
N. Kamran; B.Sc., M.Sc.(Bruxelles), Ph.D.(Wat.)
O. Kharlampovich; M.A., (Ural State), Ph.D.(Lenin.), Dr. of Sc., (Steklov Inst.)
M. Makkai; M.A., Ph.D.(Bud.)
S. Maslowe; B.Sc.(Wayne St.), M.Sc., Ph.D.(Calif.)
C. Roth; M.Sc.(McG.), Ph.D.(Hebrew)
K.P. Russell; Vor. Dip.(Hamburg), Ph.D.(Calif.)
G. Schmidt; B.Sc.(Natal), M.Sc.(S.A.), Ph.D.(Stan.)
G. Styan; M.A., Ph.D.(Col.)
K.K. Tam; M.A., Ph.D.(Tor.)
L. Vinet; B.Sc., M.Sc., Ph.D.(Montr.), Doctorat 3^{e} cycle(Paris VI) *(joint appt with Physics)*
D. Wolfson; M.Sc.(Natal), Ph.D.(Purdue)
K.J. Worsley; B.Sc., M.Sc., Ph.D.(Auck.)
J.J. Xu; B.S.(Beijing), Ph.D.(Ren. Poly.)
S. Zlobec; M.Sc.(Zagreb), Ph.D.(Northwestern)

Associate Professors
H. Darmon; B.Sc.(McG.), Ph.D.(Harv.)
W. Jonsson; M.Sc.(Manit.), Dr.Rer.Nat.(Tubingen)
I. Klemes; B.Sc.(Tor.), Ph.D.(Cal.Tech.)
J. Labute; B.Sc.(Windsor), M.A., Ph.D.(Harv.)
B. Lawruk; M.Sc., Ph.D.(Lwow)
J. Loveys; B.A.(St.Mary's), M.Sc., Ph.D.(S. Fraser)
R. Rigelhof; B.Sc.(Sask.), M.Sc.(Wat.), Ph.D.(McM.)
N. Sancho; B.Sc., Ph.D.(Belf.)

Assistant Professors
M.J. Gander; M.S.(E.T.H.), M.S., Ph.D.(Stanford)
E.Z. Goren; B.A., M.S., Ph.D.(Hebrew)
J.A. Toth; B.Sc., M.Sc.(McM.) Ph.D.(M.I.T.)

Adjunct Professors
T. Fox; B.A.(Oakland), M.Sc., Ph.D.(McG.)
V.P. Havin; M.Sc., Ph.D.(Leningrad)
R. Murty; B.Sc.(Car.), Ph.D.(M.I.T.), F.R.S.C.
B. Rowley; B.Sc.(Wat.), M.Sc., Ph.D.(McG.)
R.A. Seely; B.Sc.(McG.), Ph.D.(Cantab.)

Associate Members
L.P. Devroye *(Computer Science);* P.R.L. Dutilleul *(Plant Science);* L.Glass *(Physiology);* J.-L. Goffin *(Management);* L. Joseph *(Epidemiology & Biostatistics);* M. Mackey *(Physiology);* L.A. Mysak *(AOS);* P. Panangaden *(Computer Science);* J.O. Ramsay *(Psychology);* G.A. Whitmore *(Management)*

46.2 Programs Offered

The brochure “Information for Graduate Students in Mathematics and Statistics”, available on the Department website, supplements the information contained in this Calendar.

The Department offers both a Master’s degree (in the form of an M.A. or an M.Sc.) and a Ph.D. degree.

By the choice of courses and thesis (or project topic) these degrees can be focussed in applied mathematics, pure mathematics or statistics.

The Institut des Sciences Mathématiques (ISM), among other activities, coordinates intermediate and advanced level graduate courses among the following universities: Concordia University, Université Laval, McGill, Université de Montréal, UQAM, Université de Sherbrooke. A list of courses available under the ISM auspices at the other universities can be obtained by consulting the ISM website (http://www.math.uqam.ca/ISM/). The ISM also offers fellowships and promotes a variety of joint academic activities greatly enhancing the mathematical environment in Montreal and indeed in the province of Quebec.

46.3 Admission Requirements

In addition to the general Graduate Faculty requirements the Department requirements are as follows:

Master's Degree

The normal entrance requirement for the Master's programs is a Canadian Honours degree or its equivalent, with high standing, in mathematics, or a closely related discipline in the case of applicants intending to concentrate in statistics or applied mathematics. For applicants intending to continue in a doctoral program, an Honours degree or its equivalent is the preferred background.

Applicants wishing to concentrate in pure mathematics should have a strong background in linear algebra, abstract algebra, and real and complex analysis.

Applicants wishing to concentrate in an applied area of statistics should have a strong background in matrix algebra, advanced calculus and undergraduate statistics; some knowledge of computer programming and numerical analysis is also desirable.

Applicants wishing to concentrate in applied mathematics should have a strong background in linear algebra, real and complex analysis, ordinary differential equations and numerical analysis. Some knowledge of computer programming is also desirable.

Students whose preparation in mathematics is insufficient may have to register for a Qualifying Year.

Ph.D. Degree

Students normally enter the Ph.D. program after completing a Master's degree program with high standing.

46.4 Application Procedures

Applications will be considered upon receipt of:

1. Application form
2. Transcripts
3. Two letters of reference
4. $60 application fee
5. TOEFL test results (if applicable)

All information is to be submitted directly to the Graduate Secretary in the Department of Mathematics and Statistics.

Deadline: Applicants are urged to submit complete applications by March 1 for September admission, or by August 1 for January admission.

46.5 Program Requirements

Master's Degrees

Students must choose between the thesis option, which requires a thesis (24 credits) and 6 approved courses for a total of at least 22 credits, and the project option, which requires a project (15 credits) and 8 approved courses for at least 30 credits. Normally students must declare which option they choose to follow after one semester. It is expected that the degree be completed in at most four semesters.

The choice of courses must be approved by the advisor or thesis supervisor as well as by the Chair of the Committee on Graduate Affairs.

Some suggestions for the choice of courses in the Master's programs are:

- For students in applied mathematics: at least two of the following course sequences: 189-487 and 189-560; 189-578 and 189-579; 189-586 and 189-585.
- For students in pure mathematics: at least two of the following course sequences: 189-564, 189-565 and 189-566; 189-570 and 189-571; 189-576 and 189-577.
- Students in statistics are required to take 189-556 and 189-557 and, if they intend to continue in a doctoral program, they should also take 189-587 and 189-589.

Master's students who wish to keep open the possibility of continuing in a doctoral program should adhere closely to these suggestions since they will provide the background necessary for the comprehensive examination which all doctoral students are required to pass.

Further courses can be chosen from the departmental list of course offerings. A comprehensive list of courses, from which annual offerings are selected, is given below.

Ph.D. Degree

To complete a Ph.D. program students must:

a) pass twelve approved courses beyond the Bachelor's level ;
b) pass a Comprehensive Examination consisting of a written Part A, which is concerned with their general mathematical background, and an oral Part B concerned with two topics at an advanced graduate level;
c) demonstrate a reading knowledge of French;
d) submit a thesis judged to be an original contribution to knowledge.

46.6 Courses

● Denotes not offered in 2000-01.

This Calendar is prepared long before it is known precisely which courses will be offered. In 2000-01 most 500-level and approximately 15 of the 600- and 700-level courses will be given. Students should consult the Departmental website for an updated list of offerings.

NOTE: With the permission of the instructor, prerequisites and corequisites for courses may be waived in individual cases.

189-523B GENERALIZED LINEAR MODELS. (4) (Prerequisite: 189-423 or 513-697) (Not open to students who have taken 189-426.) Modern discrete data analysis. Exponential families, orthogonality, link functions. Inference and model selection using analysis of deviance. Shrinkage (Bayesian, frequentist viewpoints). Smoothing. Residuals. Quasi-likelihood. Sliced inverse regression. Continency tables: logistic regression, log-linear models. Censored data. Applications to current problems in medicine, biological and physical sciences. GLIM, S, software.

189-524A NONPARAMETRIC STATISTICS. (4) (Prerequisite: 189-324 or equivalent.) (Not open to students who have taken 189-424.) Distribution free procedures for 2-sample problem: Wilcoxon rank sum, Siegel-Tukey Smirnov tests. Shift model: power and estimation. Single sample procedures: Sign, Wilcoxon signed rank tests. Nonparametric ANOVA: Kruskal-Wallis, Friedman tests. Association: Spearman's rank correlation, Kendall's tau. Goodness of fit: Pearson's chi-square, likelihood ratio, Kolmogorov-Smirnov tests. Statistical software packages used.

189-555 FLUID DYNAMICS. (4) Kinematics. Dynamics of general fluids. Inviscid fluids, Navier-Stokes equations. Exact solutions of Navier-Stokes equations. Low and high Reynolds number flow.

189-556A MATHEMATICAL STATISTICS I. (4) (Prerequisite: 189-357) Probability and distribution theory (univariate and multivariate). Exponential families. Laws of large numbers and central limit theorem.

189-557B MATHEMATICAL STATISTICS II. (4) (Prerequisite: 189-556) Sampling theory (including large-sample theory). Likelihood functions and information matrices. Hypothesis testing, estimation theory, and decision theory. Regression and correlation theory.

189-560 OPTIMIZATION. (4) (Prerequisites: undergraduate background in analysis and linear algebra, with instructor's approval.) Classical optimization in *n* variables. Convex sets and functions. Optimality conditions for single-objective and multi-objective nonlinear optimization problems with and without constraints. Duality theories and their economic interpretations. Optimization with functionals. Connections with calculus of variations and optimal control. Stability of mathematical models. Selected numerical methods.

189-561 ANALYTICAL MECHANICS. (4) (Prerequisites: 189-354 and 189-380 or instructor's approval.) Basic differential geometry. Lagrangian formulation: Euler-Lagrange equations, Noether's theorem, applications. Hamiltonian formalism: symplectic forms and Legendre transformation, symmetry and conserved quantities, completely integrable systems, Poisson brackets.

189-564A ADVANCED REAL ANALYSIS I. (4) (Prerequisites: 189-354, 189-355 or equivalents.) Review of theory of measure and integration; product measures, Fubini's theorem; L spaces; basic principles of Banach spaces; Riesz representation theorem for C(X); Hilbert spaces; part of the material of 189-565B may be covered as well.

189-565B ADVANCED REAL ANALYSIS II. (4) (Prerequisite: 189-564) Continuation of topics from 189-564. Signed measures,

Hahn and Jordan decompositions. Radon-Nikodym theorems, complex measures, differentiation in R^N. Fourier series and integrals, additional topics.

189-566B ADVANCED COMPLEX ANALYSIS. (4) (Prerequisites: 189-466, 189-564) Simple connectivity, use of logarithms; argument, conservation of domain and maximum principles; analytic continuation, monodromy theorem; conformal mapping; normal families, Riemann mapping theorem; harmonic functions, Dirichlet problem; introduction to functions of several complex variables.

189-570A HIGHER ALGEBRA I. (4) (Prerequisite: 189-371 or equivalent) Review of group theory; free groups and free products of groups, Sylow theorems. The category of R-modules; chain conditions, tensor products, flat, projective and injective modules. Basic commutative algebra; prime ideals and localization, Hilbert Nullstellensatz, integral extensions. Dedekind domains. Part of the material of 189-571B may be covered as well.

189-571B HIGHER ALGEBRA II. (4) (Prerequisite: 189-570 or consent of instructor.) Completion of the topics of 189-570. Rudiments of algebraic number theory. A deeper study of field extensions; Galois theory, separable and regular extensions. Semi-simple rings and modules. Representations of finite groups. Cohomology of finite groups if time permits.

● **189-574 ORDINARY DIFFERENTIAL EQUATIONS.** (4) (Prerequisites: 189-325,-354)

189-575 PARTIAL DIFFERENTIAL EQUATIONS. (4) (Prerequisite: 189-375A)

189-576A GEOMETRY AND TOPOLOGY I. (4) (Prerequisite: 189-354) Basic point-set topology, including connectedness, compactness, product spaces, separation axioms, metric spaces. The fundamental group and covering spaces. Simplicial complexes. Singular and simplicial homology. Part of the material of 189-577B may be covered as well.

189-577B GEOMETRY AND TOPOLOGY II. (4) (Prerequisite: 189-576) Continuation of the Topics of 189-576. Manifolds and differential forms. De Rham's theorem. Riemannian geometry. Connections and curvature. 2-Manifolds and imbedded surfaces.

189-578A NUMERICAL ANALYSIS. (4) (Prerequisites: A first course in numerical analysis – with programming – and a background in real and complex analysis, with Instructor's approval.) Errors in computation, vector and matrix norms. Iteration methods for roots in R^n and the complex plane. Interpolation including osculating and spline interpolation. Numerical differentiation and integration including Romberg and Gaussian methods and the Peano theorem. Matrix calculations with condition numbers and error bounds. Band matrices, eigenvalue calculations and applications to boundary value problems.

189-579 NUMERICAL DIFFERENTIAL EQUATIONS. (4) (Prerequisites: a background in ordinary and partial differential equations as well as numerical analysis, with instructor's approval.) Basic error analysis. Numerical solution of initial and boundary value problems for ordinary differential equations; simple, multiple shooting methods and finite difference methods. Finite difference methods for partial differential equations: parabolic equations, hyperbolic equations and elliptical equations, consistency, convergence and stability of numerical schemes. Explicit and implicit methods, alternating direction explicit and alternating direction implicit methods.

189-585 INTEGRAL EQUATIONS AND TRANSFORMS. (4) Integral transforms. Introduction to the theory of Hilbert spaces. Fredholm and Volterra integral equations; exact and approximate solutions. Equations with Hermitian kernels. Hilbert-Schmidt theorem and consequences. Representation formulas for the solutions of initial and boundary value problems. Green's functions. Applications.

189-586 APPLIED PARTIAL DIFFERENTIAL EQUATIONS. (4) (Prerequisites: 189-316, -375 or equivalent.) Partial differential equations of applied mathematics. Dirichlet and Newmann problems; complex variable methods. Homogeneous and non-homogeneous problems; Green's functions, integral transform methods, variational techniques. Pertubation theory. Applications.

189-587A ADVANCED PROBABILITY THEORY I. (4) (Prerequisite: 189-356 or equivalent and approval of instructor.) Probability spaces. Random variables and their expectations. Convergence of random variables in probability, almost surely, and in L^P Independence and conditional expectation. Introduction to martingales. Limit theorems including Kolmogorov's Strong Law of Large Numbers.

189-589B ADVANCED PROBABILITY THEORY II. (4) (Prerequisite: 189-587 or equivalent.) Characteristic functions : elementary properties, inversion formula, uniqueness, convolution and continuity theorems. Weak convergence. Central limit theorem. Additional topic(s) chosen (at discretion of instructor) from: martingale theory, Brownian motion, stochastic calculus.

189-591B MATHEMATICAL LOGIC I. (4) (Prerequisites: 189-488 or equivalent or consent of instructor.) Propositional logic and first order logic, completeness, compactness and Löwenheim-Skolem theorems. Introduction to axiomatic set theory. In the remaining time, a selection from the following topics: introduction to model theory, Herbrand's and Gentzen's theories, Lindström's characterization of first order logic.

189-592B MATHEMATICAL LOGIC II. (4) (Prerequisites: 189-488 or equivalent or consent of instructor.) Introduction to recursion theory; recursively enumerable sets, relative recursiveness. Incompleteness, undecidability and undefinability theorems of Gödel, Church, Rosser and Tarski. In the remaining time, a selection from the following topics: Turing degrees, Friedberg-Muchnik theorem, decidable and undecidable theories.

189-600A,B,C,L,T MASTER'S THESIS RESEARCH I. l(6) (Not open to students who have taken or are taking 189-640.) Thesis research under supervision.

189-601A,B,C,L,T MASTER'S THESIS RESEARCH II. (6) Thesis research under supervision.

189-604A,B,C,L,T MASTER'S THESIS RESEARCH III. (6) Thesis research under supervision.

189-605A,B,C,L,T MASTER'S THESIS RESEARCH IV. (6) Thesis research under supervision.

189-606 ALGEBRAIC TOPOLOGY. (4) (Prerequisite: 189-577B) Homology and Cohomology theories. Duality theorems. Higher homotopy groups.

189-608 LIE GROUPS AND LIE ALGEBRAS I. (4) Representation of linear groups and their Lie algebras. Commutative, nilpotent and solvable ideals of Lie algebras. Classification of classical simple Lie groups by means of Cartan's sub-algebras. Weights of irreducible representation and structure of semi-simple Lie algebras.

189-609 LIE GROUPS AND LIE ALGEBRAS II. (4) A continuation of the topics listed in the description of 189-608.

189-612 ALGEBRAIC CURVES. (4) A concrete introduction to algebraic geometry. Topics may vary from year to year and will include: plane algebraic curves, function fields in one variable, linear series and the theory of Riemann-Roch, elliptic curves.

189-614 THEORY OF RINGS. (4) Rings and modules. Prime and maximal ideals. Radicals. Semi-simple Artinian rings, semiperfect rings, semiprime Noetherian rings. Projective, injective and flat modules. Morita theory. Rings of quotients, localization and completion. Grouprings.

189-615 COMMUTATIVE ALGEBRA. (4) Localization and completion. Primary decomposition. Dimension theory. Homological theory of Noetherian rings. Regular sequences Kähler differentials. Unramified, smooth and étale extensions. The spectrum of a commutative ring and other applications to algebraic geometry.

189-616 HOMOLOGICAL ALGEBRA. (4) Modules. Diagrams. Free, injective, projective and flat modules. Tensor product and Hom. Derived functors. Dimension theory. Local rings. Cohomology of groups.

189-622 CATEGORIES I. (4) Categories, functors, natural transformations. Adjoint functors and limits. Embeddings and completions. Algebraic categories and standard constructions. Abelian and

homological categories. Categories and the foundations of mathematics.

189-623 CATEGORIES II. (4) A continuation of the topics listed in the description of 189-622.

189-624 APPLIED CATEGORY THEORY I. (4) Review of adjoint functors, triples and their algebras. Localization with applications to modules, topological spaces and sheaves. Duality theory with applications to Morita theory and the duality theorems of Pontrjagin, Stone, Gelfand and Kaplansky. Categories and deductive systems. Introduction to toposes. Applications to computer science and linguistics.

189-625 APPLIED CATEGORY THEORY II. (4) A continuation of the topics listed in the description of 189-624.

189-626 ADVANCED GROUP THEORY I. (4) The structure of groups. Special classes of groups. Representation theory. Additional topics to suit the class.

189-627 ADVANCED GROUP THEORY II. (4) A continuation of the topics listed in the description of 189-626.

189-628 MATHEMATICAL LINGUISTICS. (4) (Given in collaboration with the Department of Linguistics. Prerequisites: 189-328 or 104-360A, or equivalent.) Phrase structure, production, categorial and transformational grammars, with applications to fragments of English and French and to kinship systems. Machines for generating and recognizing sentences; parsers. Introduction to lambda calculus and type theory; logical form and Montague semantics.

189-631 COMPLEX FUNCTION THEORY I. (4) (Prerequisite 189-564, -565, and -566 or equivalent.) Advanced topics in one complex variable, and some topics in several complex variables.

189-632 COMPLEX FUNCTION THEORY II. (4) (Prerequisite 189-631) Topics in the theory of functions of several complex variables.

189-633 HARMONIC ANALYSIS I. (4) (Prerequisite 189-564, -565, and -566) Classical harmonic analysis on the circle (Fourier series) and on the line (Fourier integrals). A brief introduction to harmonic analysis on locally compact groups.

189-634 HARMONIC ANALYSIS II. (4) (Prerequisites: 189-633 and -635.) The contents of this course will consist of further topics in classical harmonic analysis and a more detailed study of abstract harmonic analysis on locally compact groups.

189-635 FUNCTIONAL ANALYSIS I. (4) (Prerequisite 189-564, -565, and -566) Banach spaces. Hilbert spaces and linear operators on these. Spectral theory. Banach algebras. A brief introduction to locally convex spaces.

189-636 FUNCTIONAL ANALYSIS II. (4) (Prerequisites: 189-564, 189-565, 189-635.) A continuation of the topics listed in the description of 189-635.

189-637 PARTIAL DIFFERENTIAL EQUATIONS. (4) A modern introduction to the theory of linear differential equations, using the theory of distributions and Fourier transforms.

189-639 INTRODUCTION TO POTENTIAL THEORY. (4) Classical potential theory. Dirichlet problem. Harmonic and superharmonic functions. Introduction to modern axiomatic potential theory.

189-640A,B,C,L,T PROJECT I. (6) (Not open to students who have taken or are taking 189-600) Project research under supervision.

189-641A,B,C,L,T PROJECT II. (9) Project research under supervision.

189-651 ASYMPTOTIC EXPANSION AND PERTURBATION METHODS. (4) Asymptotic series. Summation. Asymptotic estimation of integrals. Regular and singular perturbation problems and asymptotic solution of differential equations.

189-670 STOCHASTIC PROCESSES. (4) Basic concepts. Stationary and nonstationary processes. Correlation function. Power spectra. Linear systems. Mean square periodicity and Fourier series. Sampling theorems. Series expansions. Linear mean square estimation.

189-671 APPLIED STOCHASTIC PROCESSES. (4) Discrete parameter Markov chains, including branching processes and random walks. Limit theorems and ergodic properties of Markov chains. Continuous parameter Markov chains, including birth and death process. Topics selected from the following areas: renewal processes, Brownian motion, statistical inference for stochastic processes.

189-674 EXPERIMENTAL DESIGN. (4) Review of one-way and two-way analyses of variance; randomized block, Latin square and incomplete block designs; factorial designs, confounding, fractional replications; random and mixed models; split-plot designs; nested and hierarchical designs; response surface analysis. Weighted least squares. Analysis of variance with equal and unequal numbers in cells. Latin squares, complete factorial designs. Prediction and confidence bands, multiple comparisons. Random effects models.

189-676 MULTIVARIATE ANALYSIS. (4) Properties of the multivariate normal distribution. Central and noncentral Wishart distribution. Statistical inference for multivariate normal populations. Hotelling's T^2. The product-moment correlation coefficient. Canonical correlations. Multivariate linear models. Principal components. Factor analysis.

189-677 DECISION THEORY. (4) Formulation of the statistical decision problem. Bayes and minimax solutions. Hypothesis testing and estimation from the point of view of decision theory. Sequential analysis.

189-678 APPLIED STATISTICAL METHODS AND DATA ANALYSIS I. (4) Statistical data analysis, with special reference to applications of the main statistical methods to problems in medicine, biology, chemistry, etc. Extensive use of computer methods, especially subroutine packages for statistical data description, display and analysis.

189-679 APPLIED STATISTICAL METHODS AND DATA ANALYSIS II. (4) Same emphasis as 189-678 but with a different selection of statistical methods.

189-680 COMPUTATION INTENSIVE STATISTICS. (4) (Prerequisites: 189-556, 189-557 or permission of instructor) (Not open to students who have taken or are taking 513-680.) Introduction to a statistical computing language, such as S-PLUS; random number generation and simulations; EM algorithm; bootstrap, cross-validation and other resampling schemes; Gibbs sampler. Other topics: numerical methods ; importance sampling; permutation tests.

189-681 TIME SERIES ANALYSIS. (4) Stationary stochastic processes. Autocovariance and autocovariance generating functions. The periodogram. Model estimation. Likelihood function. Estimation for autoregressive moving average and mixed processes. Computer simulation; diagnostic checking, tests with residuals. Estimation of spectral density; Bartlett, Daniell, Blackman-Tukey spectral windows. Asymptotic moments of spectral estimates.

189-682 MATRIX THEORY WITH STATISTICAL AND OTHER APPLICATIONS: (4) Inequalities for trace and rank. Generalized inverses; idempotent matrices. Schur complement. Factorizations into triangular and diagonal form; singular values. Normal matrices. Algebraic and geometric multiplicity. Computational procedures; Householder transformations, condition number. Applications to least squares. Courant-Fisher min-max theorem; related inequalities. Quadratic forms in normal variables: distribution, Characteristic function, cumulants and independance.

189-683 LINEAR MODELS. (4) General univariate linear models with full rank and with less than full rank. Best linear unbiased estimators. General linear hypothesis. Computational procedures.

189-684 APPLIED SAMPLING TECHNIQUES. (4) Sampling and subsampling of clusters (one-stage, two-stage, and multi-stage). Unequal probability sampling with and without replacement. Double-sampling procedures. Repetitive surveys. Non-sampling errors (analytical and practical treatment). Analytical surveys. Optimization problems in sampling. Topics in the foundations of sample surveys. Other recent developments.

189-686 SURVIVAL ANALYSIS. (4) (Prerequisites: 189-556, 189-557 or permission of instructor.) (Not open to students who have taken or are taking 513-686.) Parametric survival models. Nonparametric analysis: Kaplan-Meier estimator and its properties. Covariates with emphasis on Cox's proportional hazards model. Marginal and partial likelihood. Logrank tests. Residual analysis. Homework assignments a mixture of theory and applications. In-class discussion of data tests.

189-687 READING COURSE IN MATHEMATICAL LOGIC I. (4) A highly specialized study.

189-688 READING COURSE IN MATHEMATICAL LOGIC II. (4) A highly specialized study.

189-689 READING COURSE IN ALGEBRA I. (4) A highly specialized study.

189-690 READING COURSE IN ALGEBRA II. (4) A highly specialized study.

189-691 READING COURSE IN GEOMETRY AND TOPOLOGY I. (4) A highly specialized study.

189-692 READING COURSE IN GEOMETRY AND TOPOLOGY II. (4) A highly specialized study.

189-693 READING COURSE IN ANALYSIS I. (4) A highly specialized study.

189-694 READING COURSE IN ANALYSIS II. (4) A highly specialized study.

189-695 READING COURSE IN APPLIED MATHEMATICS I. (4) A highly specialized study.

189-696 READING COURSE IN APPLIED MATHEMATICS II. (4) A highly specialized study.

189-697 READING COURSE IN STATISTICS AND PROBABILITY I. (4) A highly specialized study.

189-698 READING COURSE IN STATISTICS AND PROBABILITY II. (4) A highly specialized study.

189-699 READING COURSE IN OPTIMIZATION. (4) A highly specialized study.

189-700A,B COMPREHENSIVE EXAMINATION: PART A. – WRITTEN

189-701A,B COMPREHENSIVE EXAMINATION: PART B. – ORAL

189-704 TOPICS IN MATHEMATICAL LOGIC I. (4)

189-705 TOPICS IN MATHEMATICAL LOGIC II. (4)

189-706 TOPICS IN GEOMETRY AND TOPOLOGY I.
189-707 TOPICS IN GEOMETRY AND TOPOLOGY II.
189-708 TOPICS IN GEOMETRY AND TOPOLOGY III.
189-709 TOPICS IN GEOMETRY AND TOPOLOGY IV.
(4 credits each)

189-720 TOPICS IN ALGEBRA I.
189-721 TOPICS IN ALGEBRA II.
189-722 TOPICS IN ALGEBRA III.
189-723 TOPICS IN ALGEBRA IV.
189-724 TOPICS IN ALGEBRA V.
189-725 TOPICS IN ALGEBRA VI.
(4 credits each) Each of these courses covers an advanced topic in some branch of algebra.

189-726 TOPICS IN NUMBER THEORY I.
189-727 TOPICS IN NUMBER THEORY II.
189-728 TOPICS IN NUMBER THEORY III.
189-729 TOPICS IN NUMBER THEORY IV.
(4 credits each) Each of these courses covers an advanced topic in number theory.

189-740 TOPICS IN ANALYSIS I.
189-741 TOPICS IN ANALYSIS II.
189-742 TOPICS IN ANALYSIS III.
189-743 TOPICS IN ANALYSIS IV.
189-744 TOPICS IN ANALYSIS V.

189-745 TOPICS IN ANALYSIS VI.
(4 credits each) Each of these courses covers an advanced topic in some branch of analysis.

189-756 TOPICS IN OPTIMIZATION I.
189-757 TOPICS IN OPTIMIZATION II.
189-758 TOPICS IN OPTIMIZATION III.
189-759 TOPICS IN OPTIMIZATION IV.
(4 credits each) Each of these courses covers an advanced topic in Optimization.

189-761 TOPICS IN APPLIED MATHEMATICS I.
189-762 TOPICS IN APPLIED MATHEMATICS II.
189-763 TOPICS IN APPLIED MATHEMATICS III.
189-764 TOPICS IN APPLIED MATHEMATICS IV.
189-765 TOPICS IN APPLIED MATHEMATICS V.
189-766 TOPICS IN APPLIED MATHEMATICS VI.
189-767 TOPICS IN APPLIED MATHEMATICS VII.

189-768 TOPICS IN APPLIED MATHEMATICS VIII. (4 credits each) Each of these courses covers an advanced topic in applied mathematics.

189-771 TOPICS IN STOCHASTIC PROCESSES I.
189-772 TOPICS IN STOCHASTIC PROCESSES II.
(4) Each of these courses covers an advanced topic in stochastic processes.

189-782 TOPICS IN STATISTICS AND PROBABILITY I.
189-783 TOPICS IN STATISTICS AND PROBABILITY II.
189-784 TOPICS IN STATISTICS AND PROBABILITY III.
189-785 TOPICS IN STATISTICS AND PROBABILITY IV.
(4 credits each) Each of these courses covers an advanced topic.

189-790D PH.D. LANGUAGE REQUIREMENTS.

189-791D SEMINARS IN MATHEMATICAL LOGIC. (6)

189-792D SEMINARS IN ALGEBRA. (6)

189-794D SEMINARS IN GEOMETRY AND TOPOLOGY. (6)

189-796D SEMINARS IN ANALYSIS. (6)

189-797D SEMINARS IN APPLIED MATHEMATICS. (6)

189-798D SEMINARS IN STATISTICS AND PROBABILITY. (6)

47 Mechanical Engineering

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Chair — S.J. Price

Chair of Graduate Program — J.A. Nemes

47.1 Staff

Emeritus Professors
R. Knystautas; B.Eng., M.Eng., Ph.D.(McG.), Eng.
W. Bruce; B.A.Sc., M.A.Sc.(Tor.), Eng.
J. Cherna; Dipl.Eng.(Swiss Fed. Inst.), Eng., F.E.I.C.

Professors
A.M. Ahmed; B.Sc.(Dhaka), Ph.D.(McG.), Eng.
J. Angeles; B.Sc., M.Sc.(Unam Mexico), Ph.D.(Stan.), Eng. F.A.S.M.E., F.C.S.M.E.
B.R. Baliga; B.Tech.(I.I.T. Kanpur), M.Sc.(Case), Ph.D.(Minn.)
W.G. Habashi; B.Eng., M.Eng.(McG.), Ph.D.(C'nell)
J.H.S. Lee; B.Eng.(McG.), M.Sc.(M.I.T.), Ph.D.(McG.), Eng.
A.K. Misra; B.Tech.(I.I.T., Kgp.), Ph.D.(Br.Col.), P.Eng.

M.P. Paidoussis; M.P., B.Eng.(McG.), Ph.D.(Cantab.), F.A.A.M., F.I.Mech.E., F.A.S.M.E., F.C.S.M.E., F.R.S.C., Eng.
S.J. Price; B.Sc., Ph.D.(Brist.), P.Eng.

Associate Professors
M. Buehler; M.Sc., Ph.D.(Yale)
L. Cortelezzi; M.Sc., Ph.D.(Caltech)
D.L. Frost; B.A.Sc.(Br.Col.), M.S., Ph.D.(Caltech.), P.Eng.
L. Lessard; B.Eng.(McG.), M.Sc., Ph.D.(Stan.), P.Eng.
D.F. Mateescu; M.Eng.(Poli. Univ. Buch.), Ph.D.(Rom. Acad. Sci.), Doctor Honoris Causa (Poli. Univ. Buch.), AFAIAA, AFCASI
J.A. Nemes; B.Sc.(Maryland), M.Sc., D.Sc.(GWU)
A. Post; B.S.(Ariz.), M.I.M.(AGSIM), M.S.(Stan.), Ph.D.(Hawaii)
V. Thomson; B.Sc.(Windsor), Ph.D.(McM.)
P.J. Zsombor-Murray; B.Eng., M.Eng., Ph.D.(McG.), Eng.

Assistant Professors
B. Epureanu; M.Sc.(Galati-Romania), Ph.D.(Duke)
A.J. Higgins; B.Sc.(Illinois), M.S., Ph.D.(Washington)
V.N. Krovi; B.Tech.(I.I.T. Madras), Ph.D.(Pennsylvania)
T. Lee; M.S.(Portland St.), Ph.D.(Idaho)
L. Mydlarski; B.Sc.(Wat.), Ph.D.(C'Nell)

Adjunct Professors
H. Alighanbari, M. Asselin, G.G. Bach, R. Edwards, S. Kalaycioglu, L. Kops, K. MacKenzie, W.D. May, H. Moustapha, R. Sumner, T. Yee, D. Zorbas

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

47.2 Programs Offered

M.Eng., M.Sc. and Ph.D. degrees in Mechanical Engineering.

Advanced courses and laboratory facilities are available for graduate study leading to the M.Eng. and Ph.D. degrees in Mechanical Engineering. Some of the specific areas of research are as follows:

Aerodynamics: experimental and computational studies in subsonic, transonic and supersonic, steady and unsteady flows.

Bioengineering: mechanics of the human musculoskeletal system and design of joint prostheses.

Combustion, shock wave physics and vapour explosions: dust combustion, solid and liquid propellants, explosion hazard, and nuclear reactor safety.

Computational fluid dynamics and heat transfer: turbulent, reacting and multiphase flows in engineering equipment and in the environment.

Fluid-structure interactions and dynamics: vibrations and instabilities of cylindrical bodies, fluidelasticity, aeroelasticity, dynamics of shells containing axial and annular flows.

Manufacturing and Industrial engineering: thermoelastic effects in machine tools, functional behaviour of machined surfaces, optimization in production systems.

Robotics and automation: artificial intelligence based simulation of industrial processes, design optimization of manipulators, finite automata, geometric modeling and control systems.

Solid mechanics: composite materials, fracture, fatigue and reliability, microscopic and macroscopic approaches.

Space dynamics: orbital analysis, large space structures, space manipulators and tethered satellites.

47.3 Admission Requirements

The general rules of the Faculty of Graduate Studies apply. Candidates who come from other institutions are expected to have an academic background equivalent to the undergraduate curriculum in mechanical engineering at McGill or to make up any deficiencies in a qualifying year. Applicants are requested to state in as much detail as possible their particular field of interest for graduate study.

Students who do not hold an undergraduate engineering (or equivalent) degree and who are accepted into a Master's program will register for the M.Sc. degree in Mechanical Engineering. This applies particularly to students engaged in interdisciplinary research.

M.Eng. Aerospace Degree

Applicants would normally hold a B.Eng. in Mechanical Engineering, however students with an undergraduate degree in engineering other than Mechanical Engineering are also eligible to apply.

47.4 Application Procedures

Applications will be considered upon receipt of:
1. application form;
2. transcripts;
3. letters of Reference;
4. $60 application fee;
5. test results (TOEFL).

All information is to be submitted directly to the Graduate Program Secretary in the Mechanical Engineering Department

Deadlines:
February 1st for Fall admission;
May 15th for Winter admission.

47.5 Program Requirements

The minimum residence requirement for the M.Eng. degree is three terms of full-time study, one of which may be a summer term. In the case of M.Eng. (Project) a part-time program is available.

M.Eng. (Thesis) Degree (minimum 45 credits)

Thesis Component – Required (29 credits)

305-609	(1)	Seminar
305-691	(3)	M.Eng. Thesis Literature Review
305-692	(4)	M.Eng. Thesis Research Proposal
305-693	(3)	M.Eng. Thesis Progress Report I
305-694	(6)	M.Eng. Thesis Progress Report II
305-695	(12)	M.Eng. Thesis

305-691 is to be completed in the first semester of the student's program.

Complementary Courses (16 credits)
a set of courses to be selected from the list below, or approved courses offered by other engineering departments, to a minimum of 16 credits.

Students who do not hold an undergraduate engineering (or equivalent) degree and who are accepted into this option will register for the M.Sc. degree in Mechanical Engineering. This applies particularly to students engaged in interdisciplinary research. A thesis describing the candidate's research is to be submitted in accordance with the rules of the Faculty and is the major requirement for the degree.

M.Eng. (Project) Degree (minimum 45 credits)

This is a course-type Master's degree which requires 12 graduate courses for completion. All candidates are required to take the following courses:

Required Courses (29 credits)

305-605A	(4)	Applied Mathematics I
305-610B	(4)	Fundamentals of Fluid Mechanics
305-632A	(4)	Stress Analysis
305-642B	(4)	Advanced Dynamics
305-603*	(6)	Design Project I
305-604*	(6)	Design Project II
305-609*	(1)	Seminar

* these three courses are taken near the end of the program. In these courses, industrial liaison is encouraged.

Complementary Courses (16 credits)
The five remaining courses (minimum 16 credits) may be selected individually by the student (based on interest and the choice of the area of specialization) from the following groups of courses, although it is not necessary that students confine their choice to one of these groups

Thermo-fluids
Solid Mechanics and Stress Analysis
System Dynamics and Control
Industrial and Production Engineering

M.Eng. Aerospace Degree (minimum 45 credits)

The M.Eng. Aerospace Degree is offered to the students who wish to specialize in the general area of aerospace engineering. This degree is given in conjunction with Concordia University, Ecole Polytechnique, Université Laval and Université de Sherbrooke. Students registered at McGill are required to take two courses from two other institutions.

Students holding an undergraduate degree in engineering other than Mechanical Engineering are also eligible to apply for this degree. Depending on their background, students would specialize in one of the three areas:

1. Aeronautics and Space Engineering;
2. Avionics;
3. Aerospace Materials and Structures.

Required Courses (9 credits)
305-687 (3) Aerospace Case Studies
305-688 (6) Industrial Stage

Complementary Courses (36 credits)
The other courses, depending on the area of concentration, will be chosen in consultation with an Aerospace Engineering Advisor.

Master in Management (Manufacturing) (56 credits)

The Master in Manufacturing Management program (M.M.M.) is offered to students who wish to have a career as manufacturing managers. The program sets a curriculum in manufacturing and management subjects as well as providing exposure to industry through case studies, seminars and a paid industry internship.

The M.M.M. program is a 12-month academic program starting in September followed by a 4-month industrial internship. The program is offered in collaboration with the Faculty of Management, and the Master in Management (Manufacturing) degree is granted jointly by the Faculties of Engineering and Management.

Students should hold an undergraduate degree in engineering or science. Two to five years industrial experience is preferred, but not mandatory. Students with other academic backgrounds and appropriate industrial experience will be considered. The program is intended for full time as well as part time students. Enrollment is limited.

The M.M.M. program is a self-funded program. Tuition is $25,000.

Management Segment – Required Courses (14 credits)
277-608 (3) Data, Decisions and Models
279-603 (3) Industrial Relations
280-611 (2) Financial Accounting
280-612 (2) Organizational Behaviour
280-616 (2) Marketing
280-641 (2) Elements of Modern Finance I

Management Segment – Complementary Courses (3 credits)
one of the following two courses:
272-632 (3) Group Dynamics and Interpersonal Behaviour
272-640 (2) Leadership, Power and Influence

A background in statistics is a prerequisite for the program; otherwise 277-671 Statistics for Business Decisions is required.

Manufacturing Segment – Required Courses (18 credits)
277-601 (3) Management of Technology in Manufacturing
277-603 (3) Logistics Management
277-605 (3) Total Quality Management
277-631 (3) Analysis of Manufacturing Systems
305-524 (3) Computer Integrated Manufacturing
305-526 (3) Manufacturing and the Environment

Manufacturing Segment – Complementary Courses (9 credits)
one of the following two courses:
277-602 (3) Manufacturing Strategies
MET 6.904 (3) Strategic Planning and Technological Forecasting

and one of the following two options:

Discrete Manufacturing Option
305-528 (3) Product Design
305-529 (3) Discrete Manufacturing Systems

Process Manufacturing Option
302-572 (3) Process Dynamics and Control
302-653 (3) Advanced Process Design

Industrial Segment – Required Courses (12 credits)
305-627 (9) Manufacturing Industrial Stage
305-628 (2) Manufacturing Case Studies
305-629 (1) Manufacturing Industrial Seminar

For more information, students should contact the Program Coordinator, Mechanical Engineering, at (514) 398-7201, mmm@mecheng.mcgill.ca, website: http://www.mecheng.mcgill.ca/mmm, or the Masters Program Office, Faculty of Management, at (514) 398-4648.

Ph.D. Degree

Candidates normally register for the M.Eng. degree in the first instance. However, in exceptional cases where the research work is proceeding very satisfactorily, or where the equivalent of the M.Eng. degree has been completed at another university, candidates may be permitted to proceed directly to the Ph.D. degree without submitting a master's thesis as long as they have satisfied the course requirements for the M.Eng. degree.

Courses of study selected for a Ph.D. program will depend upon the existing academic qualifications of the candidate and those needed for effective research.

Candidates are required to pass a preliminary oral examination within twelve months of their initial registration for the Ph.D. degree.

The residence requirement for Ph.D. candidates is outlined in the General Calendar of the Faculty.

47.6 Courses

● Denotes not offered in 2000-01.
▭ Denotes limited enrolment.

The course credit weight is given in parentheses (#) after the course title.

UNDERGRADUATE COURSES APPROVED FOR HIGHER DEGREES

The following courses, available in the undergraduate curriculum of the Mechanical Engineering Department, may be selected for graduate credit provided that both of the following conditions are met: the course is recommended by the candidate's supervisor, and no equivalent course was taken during the candidate's undergraduate program.

305-413A CONTROL SYSTEMS. (3)

305-432A AIRCRAFT STRUCTURES. (3)

COURSES OPEN TO GRADUATE AND TO QUALIFIED UNDERGRADUATE STUDENTS

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

305-501A,B SELECTED TOPICS IN MECHANICAL ENGINEERING. (3) A course to allow the introduction of new topics in Mechanical Engineering as needs arise, by regular and visiting staff. **Staff**

305-522B PRODUCTION SYSTEMS. (3) 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) 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) 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) 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) 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) (Instructor's permission)

● **305-531B AEROELASTICITY.** (3) (Prerequisite: 305-533A)

305-532B AIRCRAFT PERFORMANCE, STABILITY AND CONTROL. (3) (Prerequisite: 305-533A) 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) Kinematics; equations of motion; vorticity and circulation; conformal mapping and flow around simple bodies. Two dimensional flow around aerofoils. Three dimensional flows; high and low aspect-ratio wings; airscrews. Wind tunnel interference. Similarity rules for subsonic irrotational flow. **Professor Mateescu**

● **305-534B AIR POLLUTION ENGINEERING.** (3) (Consent of instructor)

305-537 HIGH SPEED AERODYNAMICS. (3) 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) (Prerequisite: 305-533A) Fundamental equations of unsteady compressible flows in fixed or moving reference frames. Unsteady flows past translating bodies 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) (Pre-or Co-requisite: 305-533A 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 AND DECISION. (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 directions. Use of modern software for design decision making. Introduction to mechanism animation. Introduction to design for NC production. **Mr. T. Yee**

305-541B KINEMATIC SYNTHESIS. (3) 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) 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 manoeuvres; large space structures. **Professor Misra**

● **305-543A DESIGN WITH COMPOSITE MATERIALS.** (3) (Prerequisite: 305-530)

305-545A ADVANCED STRESS ANALYSIS. (3) (Not open to students who are taking or have taken 305-632.) Tensor Analysis: Review of continuum mechanics. Equilibrium and constitutive equations in tensor form. Finite elements 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) (Permission of instructor.) 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. **Professor Bach**

305-554A MICROPROCESSORS OF MECHANICAL SYSTEMS. (3) Digital logic and circuits – asynchronous and synchronous design. Microcontroller architectures, organization and programming – assembly and high-level. Analog/Digital conversions. Analog/Digital/Hybrid Sensors and Actuators. Sensing and conditioning subsystems. Interfacing issues. Real time issues. Operator interfaces. Lab exercises on digital logic design, interfacing and control of peripherals with a final team project. **Professor Zsombor-Murray**

● **305-555B APPLIED PROCESS CONTROL.** (3) (Prerequisite: 305-554)

● **305-557B MECHATRONIC DESIGN.** (3)

305-561B BIOMECHANICS OF MUSCULO-SKELETAL SYSTEMS. (3) 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 stimilated muscle response. Experimental approaches, case studies. **Professor Ahmed**

● **305-562A ADVANCED FLUID MECHANICS.** (3)

305-565B FLUID FLOW AND HEAT TRANSFER EQUIP. (3) 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 INTRODUCTION TO ROBOTICS. (3) (Prerequisite: Permission of the instructor. Not open to students who have taken 305-573.) Manipulator hardware structure, kinematics, statics, dynamics planning and control. Rigid-body, three-dimensional statics, kinematics and dynamics. Direct and inverse kinematics and dynamics. Trajectory planning subject to constraints. Manipulator control. In depth study of serial manipulators with extension to more complex robotic devices. **Professor Angeles**

● **305-573B MECHANICS OF ROBOTIC SYSTEMS.** (3) (Prerequisite: Consent of the instructor.)

305-576A COMPUTER GRAPHICS AND GEOMETRIC MODELLING. (3) Review of pertinent linear algebra. 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) The role of optimization within the design process: Design methodology and philosophy. Constrained optimization: The Kuhn-Tucker conditions. Techniques of linear and nonlinear 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)

● **305-581A NONLINEAR DYNAMICS AND CHAOS.** (3)

COURSES FOR GRADUATE STUDENTS ONLY

305-602A,B SPECIAL TOPICS IN MECHANICAL ENGINEERING. (4) New developments related to Mechanical Engineering will be presented either by staff or by visiting professors.

305-603A,B OR C DESIGN PROJECT I. (6) A design project undertaken under the direct supervision of at least one staff member. Examination entails the writing of a report which is examined internally by the supervisor and another staff member appointed by the Mechanical Engineering Department. **Staff**

305-604A,B OR C DESIGN PROJECT II. (6) A continuation of 305-603A,B or C. **Staff**

305-605A APPLIED MATHEMATICS I. (4) A brief treatment of tensor analysis. A review of complex variables. Analytical methods of solution for partial differential equations occurring with great frequency in engineering. Perturbation methods, integral methods, asymptotic methods and variational techniques. Numerical methods of solution. **Professor Bach**

● **305-606B APPLIED MATHEMATICS II.** (4) (Prerequisite: 305-605A)

● **305-608B NUMERICAL ANALYSIS FOR COMPUTER USERS II.** (4)

305-609A,B,C SEMINAR. (1) All candidates for a Master's degree (except those in the Aerospace Program) are required to participate and to deliver one paper dealing with their particular area of research or interest. **Staff**

305-610B FUNDAMENTALS OF FLUID DYNAMICS. (4) Conservation laws control volume analysis, Navier Stokes Equations and some exact solutions, dimensional analysis and limiting forms of Navier Stokes Equations. Vorticity, Potential flow and lift, boundary layer theory, drag, turbulence. **Professors J. Lee and Cortelezzi**

● **305-615A,B GASDYNAMICS I.** (4)

● **305-617A,B GASDYNAMICS II.** (4)

● **305-620A,B ADVANCED COMPUTATIONAL AERODYNAMICS.** (4) (Evening course)

● **305-626B ADVANCED CONCEPTS OF ENGINEERING DESIGN.** (4) (Evening course)

305-627A,B MANUFACTURING INDUSTRIAL STAGE. (9) (Restricted to students in the M.M.M. Program) An industrial work term is an integral component of the M.M.M. program which is to be completed under the supervision of an experienced engineer in the facilities of a sponsoring company. **Staff**

305-628A,B,C MANUFACTURING CASE STUDIES. (2) (Restricted to students in the M.M.M. Program) Case studies on a variety of manufacturing topics are given by industry experts. To be attended by all students in the M.M.M. program. **Staff**

305-629A,B,C MANUFACTURING INDUSTRIAL SEMINAR. (1) (Restricted to students in the M.M.M. Program) A series of presentations by industry experts and manufacturing managers. To be attended by all students in the M.M.M. program. **Staff**

305-632A THEORY OF ELASTICITY. (4) (Evening course) The continuum concepts of stress, stress boundary conditions, principal stresses and the equations of equilibrium. Small strain theory and principal strains. The elastic constitutive relations. The extension, torsion and flexure of mechanical components. Plane stress and plane strain. Variational principals and the finite element method. Computer techniques are utilized. **Professor Nemes**

● **305-634B NONLINEAR CONTINUUM MECHANICS.** (4)

● **305-635B FRACTURE AND FATIGUE.** (4) (Evening course) (Prerequisite: 305-632A)

305-642B ADVANCED DYNAMICS. (4) (Evening course) Variational methods. Hamilton's principle and equations of motion of engineering systems. Lagrangian formulations for discrete systems. Methods of discretizing continuous systems. Rigid body dynamics. Dynamic behaviour of linear and nonlinear systems. Response of engineering systems to deterministic inputs by classical methods. Stability of linear and nonlinear systems. **Professor Paidoussis**

● **305-643B VIBRATIONS IN ENGINEERING SYSTEMS.** (4) (Evening course) (Prerequisite: 305-642B)

● **305-645B FINITE ELEMENTS IN DYNAMIC SYSTEMS.** (4) (Evening course) (Prerequisite: 305-642B)

305-650A,B HEAT TRANSFER. (4) (Evening course) Heat conduction: analytical solutions; integral solutions; solid-liquid phase-change. Forced and natural convection: nondimensionalization; boundary layer theory; design correlations for external and internal flows; basic ideas of turbulence modelling. Mixed convection. Boiling and condensation. Radiation heat transfer: basic concepts; black-body enclosure theory; gray-body enclosure theory; participating media. **Professor Baliga**

● **305-652A DYNAMICS OF COMBUSTION.** (4)

● **305-654B COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER.** (4) (Evening course)

305-681 A,B,C AERONAUTICS PROJECT I. (3) (Open to students in the Aeronautical Option only.) The project is undertaken under the direct supervision of at least one staff member. Examination entails the writing of a report which is examined internally within the Mechanical Engineering Department.

305-682 A,B,C AERONAUTICS PROJECT II. (3) (Open to students in the Aeronautical Option only.) A continuation of 305-681.

305-683 A,B,C AERONAUTICS PROJECT III. (3) (Open to students in the Aeronautical Option only.) A continuation of 305-682.

305-687A,B,C AEROSPACE CASE STUDIES. (3) (Restricted to students in the Aerospace Engineering Option/Programs at McGill, Concordia or Ecole Polytechnique.) This course covers topical case studies drawn from aerospace industrial experience. It is conducted in a modular form by experienced engineers from industry. It is given in collaboration with the other two institutions participating in this joint option/program, and may be conducted at any of the three locations in the language of convenience to the instructors. **Staff**

305-688A,B,C INDUSTRIAL STAGE. (6) (Restricted to students in the Aerospace Engineering Option/Program) An integral component of the program that is to be completed under the supervision of an experienced engineer in the facilities of a participating company. The topic is to be decided by a mutual agreement between the candidate, the participating company and the Liaison Committee on Aerospace Engineering. An evaluation of the candidate's performance during the work period becomes a part of the student's record.

305-691A,B,C M.ENG. THESIS LITERATURE REVIEW. (3) A comprehensive literature review in the general area of the thesis topic, to be completed in the first semester.

305-692A,B,C M.ENG. THESIS RESEARCH PROPOSAL. (4) Initiation of research with particular emphasis on the definition of the thesis topic.

305-693A,B,C M.ENG. THESIS PROGRESS REPORT I. (3) A first status report on the progress in the thesis research.

305-694A,B,C M.ENG. THESIS PROGRESS REPORT II. (6) A second status report on the progress in the thesis research.

305-695A,B,C M.ENG. THESIS. (12) Submission of the M.Eng. thesis for examination.

305-701A,B,C PH.D. PRELIMINARY ORAL EXAM. Presentation of the Ph.D. thesis proposal by the student and oral examination of the student's background in related areas.

48 Medical Physics

Medical Physics Unit
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Director — E.B. Podgorsak

48.1 Staff

Professors
S.M. Lehnert; B.Sc.(Nott.), M.Sc., Ph.D.(Lond.)
E.B. Podgorsak; Dipl. Ing.(Ljubljana), M.Sc., Ph.D.(Wis.), F.C.C.P.M.
C.J. Thompson; B.Sc., M.Sc., D.Sc.(Otago), F.C.C.P.M.

Associate Professors
G.W. Dean; B.Sc.(Salf.), M.Sc.(Man.), Ph.D.(E. Anglia), F.C.C.P.M.
G.B. Pike; B.Eng.(St.John's), M.Eng., Ph.D.(McG.)
J.P.F. Seuntjens; M.Sc., Ph.D.(Ghent)

Assistant Professors
M.D.C. Evans; B.A.(Queen's), M.Sc.(McG.), F.C.C.P.M.
C.J. Henri; B.Sc.(New Orleans), M.Sc., Ph.D.(McG.)
D.H. Hristov; B.Sc.(Sofia), Ph.D.(McG.)
M. Olivares; B.Sc.(Madrid), M.Sc.(Sask.), F.C.C.P.M.

Adjunct Professors
A.C. Evans; B.Sc.(Liv.), M.Sc.(Sur.), Ph.D.(Leeds)
T.M. Peters; B.Eng., Ph.D.(Cant.), F.C.C.P.M.
R.B. Richardson; B.Sc.(Lond.), M.Sc.(Aberdeen), Ph.D.(Bristol)

Lecturers
R.A. Corns; B.Sc., M.Sc., Ph.D.(Man.), M.Sc.(McG.)
G. Durante; B.Eng.(McG.)
P. Léger; B.Eng.(École Poly.) O.I.Q.
W.A. Parker; B.Sc.(C'dia), M.Sc.(McG.), M.C.C.P.M.
H.J. Patrocinio; B.Sc.(C'dia), M.Sc.(McG.), M.C.C.P.M.
N. Sharoubirn; B.Eng.(Ain Shams)

48.2 Programs Offered

The Medical Physics Unit offers an M.Sc. in Medical Radiation Physics. Facilities are available for students to undertake a Ph.D. in Medical Physics through the Department of Physics.

The Unit is a teaching and research unit concerned with the application of physics and related sciences in medicine, especially (but not exclusively) in radiation medicine, i.e. radiation oncology, medical imaging and nuclear medicine.

The research interests of members of the Unit include various aspects of medical imaging, including 3D imaging, the development of new imaging modalities and applications of imaging in radiation therapy; radiation dosimetry, especially solid state, electret and NMR systems; nuclear cardiology; and applications of radiation biology to therapy.

The M.Sc. and Ph.D. programs in Medical Physics are accredited by the Commission on Accreditation of Medical Physics Education Programs, Inc., sponsored by The American Association of Physicists in Medicine (AAPM), The American College of Medical Physics (ACMP), and The American College of Radiology (ACR).

48.3 Admission Requirements

Candidates applying to the M.Sc. program must normally hold a B.Sc. degree (Honours or Major) in Physics or Engineering, with a minimum overall GPA of 3.0/4.0 (minimum of 70%).

48.4 Application Procedures

Students are admitted to the M.Sc. program only at the start of the Fall semester in September of a given academic year. Applications for consideration for the Fall semester of 2000-2001 should be submitted between September 1, 1999 and March 15, 2000.

Only complete applications will be considered. Interested candidates should (a) ask their university(ies) to send two originals of each transcript, and (b) request that original confidential letters of recommendation be sent by professors familiar with their work. The application fee of $60 Cdn should be remitted in Canadian funds in negotiable form, such as a bank draft, money order, etc. payable to McGill University.

Non-Canadian applicants whose mother tongue is not English and who have not completed a degree using the English language must submit documented proof of competency in English by a TOEFL (Test of English as a Foreign Language) with a minimum score of 550, or an equivalent test. The original test report must be sent by the testing center, i.e. a photocopy sent by the applicant is not acceptable.

All application materials should be sent directly to the Graduate Secretary, Medical Physics Unit.

48.5 Program Requirements

M.Sc. in Medical Radiation Physics

This two-year program provides a comprehensive introduction to the academic, research and practical aspects of physics applied to radiation medicine. In addition to the thesis requirement (32 credits) there are 12 mandatory courses (28 credits). The practical and laboratory sections of the program are conducted in various McGill teaching hospitals.

The program comprises:
1) didactic courses in radiation physics, radiation dosimetry, the physics of nuclear medicine and diagnostic radiology, medical imaging, medical electronics and computing, radiation biology and radiation hazards and protection;
2) seminars in radiation oncology, diagnostic radiology and miscellaneous aspects of medical physics, e.g. lasers;
3) laboratory courses in radiation dosimetry and medical imaging;
4) an individual research thesis.

48.6 Graduate Level Courses

The course credit weight is given in parentheses (#) after the course title.

563-601A RADIATION PHYSICS. (3) The production and properties of directly and indirectly ionizing radiations and their interactions with matter; basic theoretical and experimental aspects of radiation dosimetry.

563-602B APPLIED DOSIMETRY. (3) (Prerequisite: 563-601A) Theoretical and practical dosimetry of radiation sources, both external and internal with respect to the human body, as applied to