11.16 Mathematics and Statistics (189)

Burnside Hall, Room 1005
805 Sherbrooke Street West
Montreal, QC H3A 2K6
Telephone: (514) 398-3800
Fax: (514) 398-3899
Website: http://www.math.mcgill.ca

Chair — Georg Schmidt

Emeritus Professors
Joachim Lambek; M.Sc., Ph.D.(McG.), F.R.S.C.*(Peter Redpath Emeritus Professor of Pure Mathematics)*
William O.J. Moser; B.Sc.(Manit.), M.A.(Minn.), Ph.D.9Tor.)

Professors
William J. Anderson; B.Eng., Ph.D.(McG.)
Michael Barr; A.B., Ph.D.(Penn.)*(Peter Redpath Professor of Pure Mathematics)*
William G. Brown; M.A.(Col.), B.A., Ph.D.(Tor.)
Marta C. Bunge; M.A., Ph.D.(Penn.)
Jal R. Choksi; B.A.(Cantab.), Ph.D.(Manc.)
Stephen W. Drury; M.A., Ph.D.(Cantab.)
Kohur GowriSankaran; B.A., M.A.(Madras), Ph.D.(Bombay)
Jacques C. Hurtubise; B.Sc.(Montr.), Ph.D.(Oxon.)
Niky Kamran; B.Sc., M.Sc.(Brussels), Ph.D.(Wat.)
Michael Makkai; M.A., Ph.D.(Bud.)
Sherwin A. Maslowe; B.Sc.(Wayne State), M.Sc., Ph.D.(Calif.)
Arak M. Mathai; M.Sc.(Kerala), M.A., Ph.D.(Tor.)
Charles Roth; M.Sc.(McG.), Ph.D.(Hebrew
Karl Peter Russell; Vor.Dip.(Hamburg), Ph.D.(Calif.
Georg Schmidt; B.Sc.(Natal), M.Sc.(S.A.), Ph.D.(Stan.)
George P.H. Styan; M.A., Ph.D.(Col.)
Kwok Kuen Tam; M.A., Ph.D.(Tor.)
John C. Taylor; B.Sc.(Acad.), M.A.(Queen's), Ph.D.(McM.)
Keith J. Worsley; B.Sc., M.Sc., Ph.D.(Auckland)
Sanjo Zlobec; M.Sc.(Zagreb), Ph.D.(Northwestern)

Associate Professors
Henri Darmon; B.Sc.(McG.), Ph.D.(Harv.)
Wilbur Jonsson; M.Sc.(Manit.), Dr.Rer.Nat.(Tubingen)
Olga Kharlampovich; M.A.(Ural State), Ph.D.(Leningrad), Dr.of Sc.(Steklov Institute)
Ivo Klemes; B.Sc.(Tor.), Ph.D.(Cal.Tech.)
John P. Labute; B.Sc.(Windsor), M.A., Ph.D.(Harv.)
Bohdan Lawruk; M.Sc., Ph.D.(Lwow)
James G. Loveys; B.A.(St.M.), M.Sc., Ph.D.(S.Fraser)
Roger Rigelhof; B.Sc.(Sask.), M.Sc.(Wat.), Ph.D.(McM.)
Neville G.F. Sancho; B.Sc., Ph.D.(Belf.)
David Sussman; M.A., Ph.D.(McG.)
James E. Turner; B.Sc.(Tor.), Ph.D.(Birm.)
David Wolfson; M.Sc.(Natal), Ph.D.(Purdue)
Jian-Ju Xu; B.Sc., M.Sc.(Beijing), M.Sc., Ph.D.(Renss.)

Assistant Professor
John A. Toth; B.Sc., M.Sc.(McM.), Ph.D.(M.I.T.)

Associate Members
Luc P. Devroye *(Computer Science),* P.R.L. Dutilleul *(Plant Science),* Leon Glass *(Physiology),* Jean-Louis Goffin *(Management),* Lawrence Joseph *(Epidemiology & Biostatistics),* Michael Mackey *(Physiology),* Lawrence A. Mysak *(A.O.S.),* Prakash Panangaden *(Computer Science),* James O. Ramsay *(Psychology),* George Alexander Whitmore *(Management)*

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

Mathematics has evolved to a discipline which is mainly characterized by its method of proof, its concern for a progressive broadening of its concepts, and by the search for mathematical entities and operations that represent aspects of reality. It is a subject which is pursued by many for its own sake, and regarded as part of the mainstream of human culture. Mathematics pervades modern society with an impact which, already immense, is rapidly growing.

The two principal divisions of mathematics are pure mathematics and applied mathematics. The pure mathematician is interested in abstract mathematical structures and in mathematics as an intellectual enterprise. The primary concern may not be with its utilitarian aspects or with the current needs of science and technology, although many problems in pure mathematics have developed from the sciences.

The applied mathematician is more interested in how mathematics can be used to study some aspects of the world. Mathematicians are engaged in the creation, study and application of advanced mathematical methods relevant to scientific problems. Statistical science and methodology today is concerned with phenomena in which there is a background of uncertainty arising from inherent variability and the investigator is obliged to arrive at decisions from limited data. A key tool in statistics is probability.

Some of the fields in which pure mathematicians work are algebra, analysis, geometry, topology, number theory and foundations. Applied mathematics which once referred to the application of mathematics to such disciplines as mechanics and fluid dynamics, has currently assumed a much broader meaning and embraces such diverse fields as communication theory, theory of optimization, theory of games and numerical analysis.

Mathematics offers many vocational possibilities. Such fields as teaching, computing, applied statistics and actuarial science offer opportunities for B.Sc. graduates. Opportunities to do original research in pure and applied mathematics are available in universities and research institutions. Employment is to be found in financially or technologically oriented business firms. The Department of Mathematics and Statistics through its various programs attempts to provide courses to suit the diverse interests within mathematics and statistics.

The Honours Program in Mathematics demands of the student a talent for abstraction in addition to a high level of competence in the use of mathematical tools. This program is intended for students who plan to work in an area where mathematical innovations may be needed. It is almost essential for students contemplating a career in mathematical research.

The Major Program involves the same subjects as the Honours Program but is less demanding in terms of abstraction. It is designed primarily for students who will need mathematical tools in their work but whose creative activity will involve applications of mathematics to other areas. Within the framework of the Mathematics Major, various combinations of courses are suggested to meet the needs of different students. These include course suggestions for secondary school teachers, careers in management, and for careers in industry, government or actuarial sciences.

It is possible for Major students to include a number of Honours courses in their programs. This will be an advantage for those students who plan to use their mathematics in graduate studies.

Students interested in a less intensive mathematics program linked to other disciplines are advised to consider the available Faculty Programs.

In planning their programs students are advised to seriously consider developing some depth in another discipline – preferably one for which mathematics has some relevance and use. Mathematics has been closely linked to areas such as computer science, physics and engineering but has recently come to play an increasingly important role in fields such as biology, linguistics, management and psychology. Students should consider completing the requirements for Minor programs such as those available in Cognitive Science, Computer Science and Statistics.

Students considering programs in Mathematics and Statistics should contact the Department to arrange for academic advising.

The student's attention is called to the fact that a B.Com. degree with a Major in Mathematics is available from the Faculty of Management. In addition the Faculty of Music offers the B.Mus. degree with Honours in Theory with Mathematics Option.

An industrial internship year is available to students enrolled in some Mathematics programs. IYES, the internship year program in Engineering and Science, is a pre-graduate work experience program available to eligible students and normally taken between their U2 and U3 years. See the Faculty of Engineering section 2.8 for further information on IYES.

MINOR PROGRAM IN MATHEMATICS (24 credits)
[MARS Program Code 6-630000]

The Minor may be taken in conjunction with any primary program in the Faculty of Science (other than programs in Mathematics). Students should declare their intention to follow the Minor in Mathematics at the beginning of the penultimate year and should obtain approval for the selection of courses to fulfill the requirements for the Minor from the Departmental Chief Adviser (or delegate).

It is strongly recommended that students in the Minor Program take 189-323. The remaining credits may be freely chosen from the required and complementary courses for Majors and Honours students in Mathematics, with the obvious exception of courses that involve duplication of material. Alternatively up to six credits may be allowed for appropriate courses from other departments.

All courses counted towards the Minor must be passed with a grade of C or better.

Generally no more than six credits of overlap are permitted between the Minor and the primary program. However, with an approved choice of substantial courses the overlap restriction may be relaxed to nine credits for students whose primary program requires 60 credits or more and to 12 credits when the primary program requires 72 credits or more.

Required Courses (9 credits)

	189-222	(3)	Calculus III
	189-223*	(3)	Linear Algebra
	189-315	(3)	Ordinary Differential Equations I

*189-223 may be replaced by 189-235 and 189-236. In this case the complementary credit requirement is reduced by three.

Complementary Courses (15 credits)
To be selected from the required and complementary courses for Majors and Honours students in Mathematics, with 189-323 strongly recommended; alternatively up to 6 credits may be allowed for appropriate courses from other departments.

MINOR PROGRAM IN STATISTICS (24 credits)
[MARS Program Code 6-630200]

The Minor may be taken in conjunction with any primary program in the Faculty of Science. Students should declare their intention to follow the Minor in Statistics at the beginning of the penultimate year and must obtain approval for the selection of courses to fulfil the requirements for the Minor from the Departmental Chief Adviser (or delegate).

All courses counted towards the Minor must be passed with a grade of C or better. Generally no more than six credits of overlap are permitted between the Minor and the primary program. However, with an approved choice of substantial courses the overlap restriction may be relaxed to nine credits for students whose primary program requires 60 credits or more and to 12 credits when the primary program requires 72 credits or more.

Required Courses (15 credits)

	189-222	(3)	Calculus III
	189-223*	(3)	Linear Algebra
	189-323	(3)	Probability Theory
or	189-356	(3)	Probability
	189-324	(3)	Statistics
or	189-357	(3)	Statistics
	189-423	(3)	Regression and Analysis of Variance

*189-223 may be replaced by 189-235 and 189-236. In this case the complementary credit requirement is reduced by three.

Complementary Courses (9 credits)
selected from:

189-425	(3)	Sampling Theory and Applications
189-447	(3)	Stochastic Processes
189-523	(4)	Generalized Linear Models
189-556	(4)	Mathematical Statistics I
189-557	(4)	Mathematical Statistics II
166-504	(3)	Quantitative Methods of Social Research I
166-505	(3)	Quantitative Methods of Social Research II
180-593	(3)	Statistical Thermodynamics
183-351	(3)	Quantitative Methods in Geography
198-362	(3)	Statistical Mechanics
198-559	(3)	Advanced Statistical Mechanics

No more than 6 credits may be taken outside the Department of Mathematics and Statistics.

Further credits (if needed) may be freely chosen from the required and complementary courses for Majors and Honours students in Mathematics, with the obvious exception of courses that involve duplication of material.

FACULTY PROGRAMS

Programs linking mathematics and other disciplines are available. With careful selection of courses in U1, it is possible to transfer to a Major program in Mathematics in U2. Except where otherwise noted these Faculty Programs lead to a B.Sc. degree. Students interested in any of these Faculty Programs should consult the Department of Mathematics and Statistics for an adviser.

FACULTY PROGRAM IN BIOLOGY AND MATHEMATICS See page 354 in the Biology section for complete program information.

FACULTY PROGRAM IN CHEMISTRY AND MATHEMATICS
See page 364 in the Chemistry section for complete program information.

FACULTY PROGRAM IN MATHEMATICS AND COMPUTER SCIENCE (54 credits) [MARS Program Code 4-632500]
27 credits in Mathematics and 27 credits in Computer Science

Required Courses (48 credits)

	189-222	(3)	Calculus III
	189-223*	(3)	Linear Algebra
	189-315	(3)	Ordinary Differential Equations I
	189-317	(3)	Numerical Analysis
	189-323	(3)	Probability Theory
	189-324	(3)	Statistics
	189-343	(3)	Discrete Mathematics & Applied Algebra
or	189-240	(3)	Discrete Structures & Computing
	308-202**	(3)	Introduction to Computing I
	308-203**	(3)	Introduction to Computing II
	308-251	(3)	Data Structures and Algorithms
	308-273	(3)	Introduction to Computer Systems
	308-302	(3)	Programming Languages and Paradigms
	308-305	(3)	Computer System Architecture
	308-310	(3)	Computer Systems and Organization
	308-420	(3)	Files and Databases
	308-530	(3)	Formal Languages

*189-223 may be replaced by 189-235 and 189-236. In this case the complementary credit requirement is reduced by three.
**308-202 and 308-203 may be replaced by 308-250 with an additional three credits at the 300 level.

Complementary Courses (6 credits)
selected from:

189-314	(3)	Advanced Calculus
189-318	(3)	Mathematical Logic
189-327	(3)	Matrix Numerical Analysis
189-328	(3)	Computability & Mathematical Linguistics
189-407	(3)	Dynamic Programming
189-417	(3)	Mathematical Programming

FACULTY PROGRAM IN MATHEMATICS, STATISTICS AND COMPUTER SCIENCE (54 credits)
[MARS Program Code 4-635100]

Required Courses (30 credits)

189-222	(3)	Calculus III
189-223*	(3)	Linear Algebra

189-315 (3) Ordinary Differential Equations I
189-323 (3) Probability Theory
189-324 (3) Statistics
189-423 (3) Regression and Analysis of Variance
308-202** (3) Introduction to Computing I
308-203** (3) Introduction to Computing II
308-251 (3) Data Structures and Algorithms
308-273 (3) Introduction to Computer Systems

*189-223 may be replaced by 189-235 and 189-236. In this case the complementary credit requirement is reduced by three.
**308-202 and 308-203 may be replaced by 308-250 with an additional three credits at the 300 level.

Complementary Courses (24 credits)
at least 6 credits selected from:

189-314 (3) Advanced Calculus
189-317 (3) Numerical Analysis
189-318 (3) Mathematical Logic
189-319 (3) Partial Differential Equations
189-327 (3) Matrix Numerical Analysis
189-328 (3) Computability & Mathematical Linguistics
189-343 (3) Discrete Mathematics & Applied Algebra
189-407 (3) Dynamic Programming
189-417 (3) Mathematical Programming

at least 6 credits in Statistics selected from:

189-329 (3) Theory of Interest
189-425 (3) Sampling Theory and Applications
189-447 (3) Stochastic Processes
189-523 (4) Generalized Linear Models

at least 6 credits in Computer Science selected from:

308-302 (3) Programming Languages and Paradigms
308-305 (3) Computer System Architecture
308-310 (3) Computer Systems and Organization
308-420 (3) Files and Databases
308-530 (3) Formal Languages

FACULTY PROGRAM IN MATHEMATICS, CHEMISTRY AND PHYSICS (56 credits) [MARS Program Code 4-631200]

Required Courses (50 credits)

180-201 (3) Modern Inorganic Chemistry I
or 180-281 (3) Inorganic Chemistry I
180-204 (3) Physical Chem./Biol. Sci. I
or 180-213 (3) Physical Chemistry I
180-212 (4) Organic Chemistry I
180-214 (3) Physical Chem./Biol. Sci. II
180-222 (4) Organic Chemistry II
180-313 (3) Intermediate Physical Chemistry I
189-222 (3) Calculus III
189-223 (3) Linear Algebra
189-314 (3) Advanced Calculus
189-315 (3) Ordinary Differential Equations I
189-319 (3) Partial Differential Equations I
198-230 (3) Dynamics of Simple Systems
198-232 (3) Heat and Waves
198-241 (3) Signal Processing
198-340 (3) Electricity and Magnetism
308-202 (3) Introduction to Computing I

Complementary Courses (6 credits)
3 credits in Physics, 200 level or higher
3 credits in Mathematics, Chemistry or Physics, chosen in consultation with the adviser.

MAJOR PROGRAM IN MATHEMATICS (54 credits)
[MARS Program Code 1-630000]

Students entering the Major program are normally expected to have completed 189-133, 189-140 and 189-141 or their equivalents. Otherwise they will be required to make up any deficiencies in these courses over and above the 54 credits of required courses.

Major students who have done well in 189-242 and 189-235 are urged to consider, in consultation with their advisor and the instructors concerned, entering the Honours stream by registering for 189-251 and 189-255.

Guidelines for Selection of Courses in the Major Program

The following informal guidelines should be discussed with the student's adviser. Where appropriate, Honours courses may be substituted for equivalent Major courses. Students planning to pursue graduate studies are encouraged to make such substitutions.

Students interested in computer science are advised to choose courses from the following 189-317, 189-318, 189-327, 189-328, 189-343, 189-407, 189-417 and to complete the Computer Science Minor.

Students interested in probability and statistics are advised to take 189-324, 189-407, 189-423, 189-425, 189-447, 189-523. Students interested in applied mathematics should take 189-317, 189-319, 189-322, 189-324, 189-327, 189-407, 189-417.

Students considering a career in secondary school teaching are advised to take 189-318, 189-328, 189-338, 189-339, 189-346, 189-348.

Students interested in careers in business, industry or government are advised to select courses from the following list: 189-317, 189-319, 189-327, 189-329, 189-407, 189-417, 189-423, 189-425, 189-447, 189-523.

Required Courses (27 credits)

189-222 (3) Calculus III
189-235 (3) Algebra I
189-236 (3) Linear Algebra I
189-242 (3) Analysis I
189-243 (3) Real Analysis
189-314 (3) Advanced Calculus
189-315 (3) Ordinary Differential Equations I
189-316 (3) Functions of a Complex Variable
or 189-249 (3) Advanced Calculus
189-323 (3) Probability Theory

Complementary Courses (27 credits)
21 credits selected from the following list, with at least 6 credits selected from:

189-317 (3) Numerical Analysis
189-324 (3) Statistics
189-343 (3) Discrete Mathematics & Applied Algebra

the remainder of the 21 credits to be selected from:

189-318 (3) Mathematical Logic
189-319 (3) Partial Differential Equations
189-320 (3) Differential Geometry
189-322 (3) Dynamical Systems, Fractals and Chaos
189-327 (3) Matrix Numerical Analysis
189-328 (3) Computability & Mathematical Linguistics
189-329 (3) Theory of Interest
189-338 (3) History and Philosophy of Mathematics
189-339 (3) Topics in the Foundations of Mathematics
189-346 (3) Number Theory
189-348 (3) Topics in Geometry
189-407 (3) Dynamic Programming
189-417 (3) Mathematical Programming
189-423 (3) Regression and Analysis of Variance
189-425 (3) Sampling Theory and Applications
189-447 (3) Stochastic Processes
189-523 (4) Generalized Linear Models

6 additional credits in Mathematics or related disciplines selected in consultation with the adviser.

JOINT MAJOR PROGRAM IN MATHEMATICS AND COMPUTER SCIENCE (72 credits)
[MARS Program Code 1-632500]

Required courses (48 credits)

189-222 (3) Calculus III
189-235 (3) Algebra I
189-236 (3) Linear Algebra I
189-242 (3) Analysis I
189-315 (3) Ordinary Differential Equations I
189-317 (3) Numerical Analysis

189-318 (3) Mathematical Logic
189-323 (3) Probability Theory
308-250* (3) Introduction to Computer Science
308-251 (3) Data Structures and Algorithms
308-273 (3) Introduction to Computer Systems
308-302 (3) Programming Languages and Paradigms
308-305 (3) Computer System Architecture
308-310 (3) Computer Systems and Organization
308-330 (3) Theoretical Aspects of Computer Science
308-360 (3) Algorithm Design Techniques

* Students with no basic knowledge of any high level programming language (e.g. Fortran, Basic, Pascal, C, C++, Java) may take 308-202 and have it count as a complementary course in Computer Science.

Complementary Courses (24 credits)
12 credits from the set of courses recommended for a Major or Honours Program in Mathematics.
12 credits from the set of courses recommended for a Major or Honours Program in Computer Science.

Students will not receive credit for 189-240.

JOINT MAJOR PROGRAM IN PHYSIOLOGY AND MATHEMATICS See page 404 in the Physiology section for complete program information.

HONOURS PROGRAMS

The minimum requirement for entry into the Honours program is that the student has completed with high standing the following courses: 189-133, 189-140, 189-141, or their equivalents. In addition, a student who has not completed the equivalent of 189-222 must take it in the first term without receiving credits towards the credits required in the Honours program.

Students who transfer to Honours in Mathematics from other programs will have credits for previous courses assigned, as appropriate, by the Department.

To remain in an Honours program and to be awarded the Honours degree, the student must maintain a 3.00 GPA in the required and complementary Mathematics courses of the program, as well as an overall CGPA of 3.00.

HONOURS PROGRAM IN MATHEMATICS (60 credits)
[MARS Program Code 2-630000]

Required Courses (45 credits)
189-235 (3) Algebra I
189-242 (3) Analysis I
189-248 (3) Advanced Calculus I
189-251 (3) Algebra II
189-255 (3) Analysis II
189-325 (3) Ordinary Differential Equations
189-354 (3) Analysis III
189-355 (3) Analysis IV
189-356 (3) Probability
189-357 (3) Statistics
189-370 (3) Algebra III
189-371 (3) Algebra IV
189-380 (3) Differential Geometry
189-375 (3) Differential Equations II
or 189-574 (4) Ordinary Differential Equations
189-466 (3) Complex Analysis

Complementary Courses (15 credits)
308-250* (3) Introduction to Computer Science
308-251 (3) Data Structures and Algorithms
*308-250 may be preceded by 308-202
further Honours Mathematics courses;

half of the credits from non-Honours Mathematics courses (other than 189-242, 189-235) taken by the student, for which no Honours equivalent exists;

with the approval of the Department of Mathematics and Statistics, certain courses in other departments which are at an Honours level and are closely linked to Mathematics; or half of the credits from courses taken in other departments which, while not necessarily explicitly mathematical in nature, are at an Honours level and broaden the student's scientific training.

HONOURS PROGRAM IN APPLIED MATHEMATICS
(68 credits) [MARS Program Code 2-630300]

Aside from seeking to develop a sound basis in Applied Mathematics, one of the objectives of the program is to kindle the students' interest in possible areas of application. The extra-mural courses are included to ensure that the student has some appreciation of the scope of Applied Mathematics and is familiar with at least one of the diversity of areas in which applications can be found.

Required Courses (39 credits)
189-235 (3) Algebra I
189-242 (3) Analysis I
189-248 (3) Advanced Calculus I
189-251 (3) Algebra II
189-255 (3) Analysis II
189-325 (3) Ordinary Differential Equations
189-356 (3) Probability
189-357 (3) Statistics
189-375 (3) Differential Equations II
189-387 (3) Numerical Analysis
189-466 (3) Complex Analysis
or 189-249 (3) Advanced Calculus II
308-251 (3) Data Structures and Algorithms
308-250* (3) Introduction to Computer Science
*308-250 may be preceded by 308-202

Complementary Courses (29 credits)
at least 6 credits selected from:
189-354 (3) Analysis III
189-355 (3) Analysis IV
189-370 (3) Algebra III
189-371 (3) Algebra IV
189-380 (3) Differential Geometry
at least 9 credits selected from:
189-382 (3) Dynamical Systems, Fractals and Chaos
189-397 (3) Matrix Numerical Analysis
189-470 (3) Honours Project
189-487 (3) Mathematical Programming
189-523 (4) Generalized Linear Models
189-555 (4) Fluid Dynamics
189-556 (4) Mathematical Statistics I
189-557 (4) Mathematical Statistics II
189-560 (4) Optimization
189-561 (4) Analytical Mechanics
189-574 (4) Ordinary Differential Equations
189-575 (4) Partial Differential Equations
189-579 (4) Numerical Differential Equations
189-585 (4) Integral Equations and Transforms
189-586 (4) Applied Partial Differential Equations
and the following, for which **half credit only** may be counted:
189-407 (3) Dynamic Programming
189-423 (3) Regression and Analysis of Variance
189-425 (3) Sampling Theory and Applications
189-447 (3) Stochastic Processes
12 credits of extra-mural courses:
chosen in consultation with the student's advisor from approved courses in other departments. A list of such courses is available from the Department of Mathematics and Statistics. Student initiative is encouraged in suggesting other courses that fulfil the intentions of this section as described above. Such suggestions must receive departmental approval. They must be in a field related to Applied Mathematics such as Atmospheric and Oceanic Science, Biology, Biochemistry, Chemistry, Computer Science, Earth and Planetary Science, Economics, Engineering, Management, Physics, Physiology and Psychology. At least 6 credits must be chosen from a single department other than Computer Science.

HONOURS PROGRAM IN PROBABILITY AND STATISTICS
(63 credits) [MARS Program Code 2-630400]

All Honours students are encouraged to take 189-325, 189-387, 189-423 and 189-447.

Students primarily interested in probability should include courses 189-325, 189-375 and 189-447 in their program.

Students primarily interested in statistics should include 189-423, 189-425, 189-447, 189-523 and 189-524 in their program.

Required Courses (46 credits)

189-235 (3) Algebra I
189-242 (3) Analysis I
189-248 (3) Advanced Calculus I
189-249 (3) Advanced Calculus II
or 189-466 (3) Complex Analysis
189-251 (3) Algebra I
189-255 (3) Analysis II
189-354 (3) Analysis III
189-356 (3) Probability
189-357 (3) Statistics
189-556 (4) Mathematical Statistics I
189-557 (4) Mathematical Statistics II
189-587 (4) Advanced Probability Theory I
189-589 (4) Advanced Probability Theory II
308-250* (3) Introduction to Computer Science
*308-250 may be preceded by 308-202

Complementary Courses (17 credits)
selected from:

189-325 (3) Ordinary Differential Equations
189-355 (3) Analysis IV
189-375 (3) Differential Equations II
189-387 (3) Numerical Analysis
189-397 (3) Matrix Numerical Analysis
189-470 (3) Honours Project
189-523 (4) Generalized Linear Models
189-524 (4) Nonparametric Statistics
and the following, for which **half credit only** may be counted:
189-423 (3) Regression and Analysis of Variance
189-425 (3) Sampling Theory and Applications
189-447 (3) Stochastic Processes

JOINT HONOURS PROGRAM IN MATHEMATICS AND COMPUTER SCIENCE (72 credits)
[MARS Program Code 3-632500]

Students must consult an Honours advisor in both departments.

Required Courses (42 credits)

189-235 (3) Algebra I
189-242 (3) Analysis I
189-248 (3) Advanced Calculus I
189-251 (3) Algebra II
189-255 (3) Analysis II
189-387 (3) Numerical Analysis
308-250* (3) Introduction to Computer Science
308-251 (3) Data Structures and Algorithms
308-273 (3) Introduction to Computer Systems
308-302 (3) Programming Languages and Paradigms
308-305 (3) Computer System Architecture
308-310 (3) Computer Systems and Organization
308-330 (3) Theoretical Aspects of Computer Science
308-506 (3) Advanced Analysis of Algorithms
* Students with no basic knowledge of any high level programming language (e.g. Fortran, Basic, Pascal, C, C++, Java) may take 308-202 and have it count as a complementary course in Computer Science.

Complementary Courses (30 credits)
18 credits selected from:

189-325 (3) Ordinary Differential Equations
189-354 (3) Analysis III
189-355 (3) Analysis IV
189-356* (3) Probability
189-357* (3) Statistics
189-370 (3) Algebra III
189-371 (3) Algebra IV
189-375 (3) Differential Equations II
189-466 (3) Complex Analysis
12 credits selected from:
308-335 (3) Software Engineering Methods
308-420 (3) Files and Databases
308-421 (3) Introduction to Database Systems
308-424 (3) Topics in Artificial Intelligence I
308-426 (3) Automated Reasoning
308-433 (3) Personal Software Engineering
308-505 (3) High-Performance Computer Architecture
308-507 (3) Computational Geometry
308-520 (3) Compiler Design
308-524 (3) Theoretical Found. of Prog. Languages
308-530 (3) Formal Languages
308-531 (3) Theory of Computation
308-534 (3) Team Software Engineering
308-535 (3) Computer Networks
308-538 (3) Person-Machine Communication
308-540 (3) Matrix Computations
308-557 (3) Fundamentals of Computer Graphics
308-566 (3) Computer Methods in Operations Research
308-573 (3) Microcomputers
308-575 (3) Fundamentals of Distributed Algorithms
*Students with appropriate background in probability may substitute 189-587 and 189-589 for 189-356 and 189-357 and must then also register for 189-355.

JOINT HONOURS PROGRAM IN MATHEMATICS AND PHYSICS See page 400 in the Physics section for complete program information.

COURSE DESCRIPTIONS

Note: When this Calendar went to press final information was not yet available on which courses at the 400 and 500 levels would be given in 1999-2000. Consult the Department of Mathematics and Statistics for up-to-date information on these courses.

The names appearing after the course descriptions are those of instructors who were associated with the courses during the 1998-99 academic year.

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

● Denotes courses not offered in 1999-2000.
★ Denotes courses offered only in alternate years.

189-112A,B FUNDAMENTALS OF MATHEMATICS. (3) (Not open to students who have taken CEGEP course 201-101.) (Open only to those students who are deficient in a pre-calculus background.) Equations and inequalities, graphs, relations and functions, exponential and logarithmic functions, trigonometric functions and their use, mathematical induction, binomial theorem, complex numbers. **Staff**

189-133A,B VECTORS, MATRICES AND GEOMETRY. (3) (Prerequisite: a course in functions.) (Not open to students who have taken 189-221 or CEGEP course 201-105.) Systems of linear equations, matrices, inverses, determinants; geometric vectors in three dimensions, dot product, cross product, lines and planes; introduction to vector spaces, linear dependence and independence, bases; quadratic loci in two and three dimensions. **Staff**

189-139A,B CALCULUS. (4) (3 hours lecture; 2 hours tutorial) (Prerequisite: a course in functions.) (Not open to students who have taken 189-120 or CEGEP course 201-103. This course is intended for students with no previous knowledge of Calculus; it is not open to students who have had one term of College level Calculus.) (Students continue in 189-141.) Review of functions and graphs. Limits, continuity, derivative. Differentiation of elementary functions. Antidifferentiation. Applications. Password required. Note: Each Tutorial section is enrolment limited. **Staff**

189-140A,B CALCULUS I. (3) (3 hours lecture, tutorial sessions) (Prerequisite: High School Calculus.) (Not open to students who have taken 189-120, 189-122, 189-139 or CEGEP course 201-103.) Review of functions and graphs. Limits, continuity, derivative. Differentiation of elementary functions. Antidifferentiation. Applications. **Staff**

189-141A,B CALCULUS II. (4) (3 hours lecture; 2 hours tutorial) (Not open to students who have taken 189-121 or CEGEP course 201-203) (Prerequisites: 189-139 or 189-140 or 189-150) The definite integral. Techniques of integration. Applications. Introduction to sequences and series.
Note: Each Tutorial section is enrolment limited. **Staff**

189-150A CALCULUS A. (4) (3 hours lecture, 2 hours tutorial) (Prerequisite: A course containing Vector Geometry or corequisite: 189-133. Intended for students with high school calculus who have not received six advanced placement credits.) (Not open to students who have taken CEGEP course 201-103.) (189-150 and 189-151 cover the material of 189-139, 189-141, 189-222.) Functions, limits and continuity, differentiation, L'Hospital's rule, applications, Taylor polynomials, parametric curves, functions of several variables.
Note: Each Tutorial section is enrolment limited. **Professor Drury**

189-151B CALCULUS B. (4) (3 hours lecture; 2 hours tutorial) (Prerequisite: 189-150.) (Not open to students who have taken CEGEP course 201-203.) Integration, methods and applications, infinite sequences and series, power series, arc length and curvature, multiple integration.
Note: Each Tutorial section is enrolment limited. **Professor Drury**

▭ **189-199A CHAOS, FRACTALS AND COMPLEXITY.** (3) (FYS - for first year students only, maximum 25) The mathematical concepts of chaos, fractals and complexity have attracted broad popular attention in magazines, books, and motion pictures. This course will expose the mathematical basis for these ideas and examine the implications in natural and social sciences, art, music, and literature. Students from diverse backgrounds will be expected to critically analyse readings and undertake projects related to their areas of interest. **Professor Glass**

189-203A,B PRINCIPLES OF STATISTICS I. (3) (No calculus prerequisites.) (This course is intended for students in all disciplines and is not open to students in Mathematics programs; or to students who have taken or are taking 189-324.) (Note: Credit for other statistics courses may preclude credit for this course and conversely. See "Course Overlap" on page 339.) Examples of statistical data and the use of graphical means to summarize the data. Basic distributions arising in the natural and behavioural sciences. The logical meaning of a test of significance and a confidence interval. Tests of significance and confidence intervals in the one and two sample setting (means, variances and proportions).
Professors Wolfson and Worsley

189-204B PRINCIPLES OF STATISTICS II. (3) (Prerequisite: 189-203 or equivalent. No calculus prerequisites.) (This course is intended for students in all disciplines and is not open to students in Mathematics programs; or to students who have taken or are taking 189-324.) (Note: Credit for other statistics courses may preclude credit for this course and conversely. See "Course Overlap" on page 339.) The concept of degrees of freedom and the analysis of variability. Planning of experiments. Experimental designs. Polynomial and multiple regressions. Statistical computer packages (no previous computing experience is needed). General statistical procedures requiring few assumptions about the probability model. **Staff**

● **189-211B PRACTICAL METHODS OF MATHEMATICS.** (3) (Prerequisite: 189-111 or CEGEP 101 or consent of instructor.) (Not open to students in the Faculty of Science, students in Mathematics or Computer Science programs or students who have taken or are taking any of 189-240, 189-343, 189-363 or any statistics course.)

189-222A,B CALCULUS III. (3) (Prerequisite: 189-141. Familiarity with vector geometry or Corequisite: 189-133) (Not open to students who have taken CEGEP course 201-303 or 189-150, 189-151 or 189-227.) Taylor series, Taylor's theorem in one and several variables. Review of vector geometry. Partial differentiation, directional derivative. Extreme of functions of 2 or 3 variables. Parametric curves and arc length. Polar and spherical coordinates. Multiple integrals. **Staff**

189-223A,B LINEAR ALGEBRA. (3) (Prerequisite: 189-133 or equivalent.) (Not open to students in Mathematics programs nor to students who have taken or are taking 189-236, 189-247 or 189-251. It is open to students in Faculty Programs.) Review of matrix algebra, determinants and systems of linear equations. Vector spaces, linear operators and their matrix representations, orthogonality. Eigenvalues and eigenvectors, diagonalization of Hermitian matrices. Applications. **Staff**

189-235A ALGEBRA I. (3) (3 hours lecture; 1 hour tutorial) (Prerequisite: 189-133 or equivalent.) Sets and relations. Rings and fields. Integers, rationals, real and complex numbers; modular arithmetic. Polynomials over a field. Divisibility theory for integers and polynomials. Linear equations over a field. Introduction to vector spaces.
Professor Loveys

189-236B LINEAR ALGEBRA I. (3) (Prerequisite: 189-235) Continuation of the topics of 189-235. Linear mappings. Matrix representation of linear mappings. Determinants. Eigenvectors and eigenvalues. Diagonalizable operators. Cayley-Hamilton theorem. Bilinear and quadratic forms. Inner product spaces, orthogonal diagonalization of symmetric matrices. Canonical forms.
Professor Bunge

189-240A DISCRETE STRUCTURES AND COMPUTING. (3) (Corequisites: 189-133 and 189-222. For Major and Honours students in Computer Science only. Others only with the instructor's permission.) Abstractly defined mathematical structures. Mathematical induction. Sets, relations and functions. Combinatorics; graphs; recurrences; generating functions. Lattices, Boolean algebras.
Professor Brown

189-242A ANALYSIS I. (3) (Prerequisite: 189-141) A rigorous presentation of sequences and of real numbers and basic properties of continuous and differentiable functions on the real line.
Professor GowriSankaran

189-243B REAL ANALYSIS. (3) (Prerequisite: 189-242) Infinite series; series of functions; power series. The Riemann integral in one variable. A rigorous development of the elementary functions.
Professor Klemes

189-247B LINEAR ALGEBRA. (3) (Prerequisite: 189-133 or equivalent. Intended for Honours Physics and Engineering students.) (Not open to students who have taken or are taking 189-236, 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.
Professor Schmidt

189-248A ADVANCED CALCULUS I. (3) (Prerequisites: 189-133 and 189-222 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. **Professor Roth**

189-249B ADVANCED CALCULUS II. (3) (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. **Professor Taylor**

189-251B ALGEBRA II. (3) (Prerequisites: 189-235 or permission of the Department.) (Not open to students who are taking or have taken 189-247B.) Linear maps and their matrix representation. Determinants. Canonical forms. Duality. Bilinear and quadratic forms. Real and complex inner product spaces. Diagonalization of self-adjoint operators. **Professor Loveys**

189-255B ANALYSIS II. (3) (Prerequisites: 189-242 or permission of the Department.) Series of functions including power series. Riemann integration in one variable. Elementary functions. **Professor Drury**

189-314A,B ADVANCED CALCULUS. (3) (Prerequisites: 189-133, 189-222.) (Not open to students who have taken or are taking 189-248.) Derivative as a matrix. Chain rule. Implicit functions. Constrained maxima and minima. Jacobians. Multiple integration. Line and surface integrals. Theorems of Green, Stokes and Gauss. **Staff**

189-315A,B ORDINARY DIFFERENTIAL EQUATIONS. (3) (Prerequisite: 189-222. Corequisite 189-133.) (Not open to students who have taken or are taking 189-325.) First order ordinary differential equations including elementary numerical methods. Linear differential equations. Laplace transforms. Series solutions. **Staff**

189-316A FUNCTIONS OF A COMPLEX VARIABLE. (3) (Prerequisites: 189-314 and 189-243.) (Not open to students who have taken or are taking 189-249.) Algebra of complex numbers, Cauchy-Riemann equations, complex integral, Cauchy's theorems. Taylor and Laurent series, residue theory and applications. **Professor Russell**

189-317A NUMERICAL ANALYSIS. (3) (Prerequisites: 189-222, 308-202 or equivalents.) Error analysis. Interpolation. Numerical solutions of equations by iteration. Numerical integration. Introduction to numerical solutions of differential equations. Programming assumed. Some lab work necessary. **Professor Xu**

189-318A MATHEMATICAL LOGIC. (3) (Not open to students who are taking or have taken 107-210.) Propositional calculus, truth-tables, switching circuits, natural deduction, first order predicate calculus, axiomatic theories, set theory. **Professor Bunge**

189-319B PARTIAL DIFFERENTIAL EQUATIONS. (3) (Prerequisites: 189-223 or 189-236, 189-314, 189-315) First order equations, geometric theory; second order equations, classification; Laplace, wave and heat equations, Sturm-Liouville theory, Fourier series, boundary and initial value problems. **Professor Lawruk**

● **★189-320A DIFFERENTIAL GEOMETRY.** (3) (Prerequisites: 189-236 or 189-223 or 189-247, and 189-314 or 189-248)

★189-322A DYNAMICAL SYSTEMS, FRACTALS AND CHAOS. (3) (Prerequisites: 189-133, 189-222; a programming language or consent of instructor.) (Not open to students who have taken 189-422.) Fractals, iterated function systems computer generation of fractals, fractal dimension, Hausdorff dimension. Discrete dynamical systems, symbolic dynamics, chaos. Hyperbolicity, stable and unstable manifolds, bifurcations and routes to chaos. Complex dynamical systems, Julia and Mandelbrot sets. **Staff**

189-323A,B PROBABILITY THEORY. (3) (Prerequisites: 189-141 or equivalent. Intended for students in Science, Engineering and related disciplines, who have had differential and integral calculus.) (Not open to students who have taken or are taking 189-356.) Sample space, events. Conditional probability, independence. Bayes' theorem with applications. Random variables, univariate distributions. Mathematical expectation, moment generating function. The binominal, Poisson, exponential, normal and other distributions. Joint distributions, transformation of variables. The weak law of large numbers. Sampling distributions, chi-squared, student-t, F variables. The central limit theorem. **Staff**

189-324A,B STATISTICS. (3) (Prerequisite: 189-323 or equivalent.) (Not open to students who have taken or are taking 189-357.) (Note: Credit for other statistics courses may preclude credit for this course and conversely. See "Course Overlap" on page 339.) The notion of a random sample. Sampling distributions, with reference to those related to the normal; chi-squared, F and t (review). Point estimation. Hypothesis testing, the notion of power function. Likelihood-ratio tests. Contingency tables, goodness-of-fit. Some nonparametric procedures. Regression and the method of least squares, analysis of variance, one-way and two-way classifications. **Staff**

189-325A,B ORDINARY DIFFERENTIAL EQUATIONS. (3) (Prerequisite: 189-222. Intended for Honours Mathematics, Physics and Engineering programs.) (Not open to students who have taken 189-261, 189-315.) First and second order equations, linear equations, applications, series solutions, elementary numerical methods, Laplace transforms. **Professor Toth**

189-327B MATRIX NUMERICAL ANALYSIS. (3) (Prerequisites: 189-223 or 189-236. Corequisite: 189-317) Numerical methods for solving systems of linear algebraic equations, matrix inversion and eigenvalue problems. Topics from least squares approximation, spline approximation and boundary value problems. **Staff**

★189-328B COMPUTABILITY AND MATHEMATICAL LINGUISTICS. (3) Calculability on an infinite abacus is compared with recursive functions and Turing machines. Categorial, context-free, generative and transformational grammars are studied for formal and natural languages, with some emphasis on English and French morphology. Machines for generating and recognizing sentences are discussed. **Staff**

189-329B THEORY OF INTEREST. (3) (Prerequisite: 189-141) Simple and compound interest, annuities certain, amortization schedules, bonds, depreciation. **Professor Turner**

189-338A HISTORY AND PHILOSOPHY OF MATHEMATICS. (3) Egyptian, Babylonian, Greek, Indian and Arab contributions to mathematics are studied together with some modern developments they give rise to, for example, the problem of trisecting the angle. European mathematics from the Renaissance to the 18th century is discussed in some detail. **Professor Barr**

● **★189-339B TOPICS IN THE FOUNDATIONS OF MATHEMATICS.** (3) (Prerequisites: 189-235, 189-318)

189-340B ABSTRACT ALGEBRA AND COMPUTING. (3) (Prerequisites: 189-240, 189-223 (or -236)) (For Major and Honours students in Computer Science only. Others only with the instructor's permission.) Basic number theory: divisibility, Euclid's algorithm, congruences, Fermat's "little" theorem, primality testing, factorization. Commutative rings: basic definitions, (integers), gaussian integers, polynomial rings, euclidean rings, finite fields. Groups: symmetry groups, permutation groups. Additional topics. **Professor Brown**

189-343B DISCRETE MATHEMATICS AND APPLIED ALGEBRA. (3) (Prerequisites: 189-236, 308-202) Basic combinatorics, introductory graph theory, matching, elementary group theory and symmetry, directed graphs and networks, modular arithmetic and its applications. **Professor Kharlmapovich**

● **★189-346B NUMBER THEORY.** (3) (Prerequisite: 189-235 or consent of instructor.)

189-348A TOPICS IN GEOMETRY. (3) (Prerequisite: Previous course in Mathematics.) Selected topics – the particular selection may vary from year to year. Topics include: isometries in the plane, symmetry groups of frieze and ornamental patterns, equidecomposibility, non-Euclidean geometry and problems in discrete geometry. **Professor Kharlampovich**

189-354A ANALYSIS III. (3) (Prerequisite: 189-255 or equivalent) Introduction to metric spaces. Multivariable differential calculus, implicit and inverse function theorems. **Professor Choksi**

189-355B ANALYSIS IV. (3) (Prerequisite: 189-255 or equivalent) Lebesgue measure on R^n and integration, convergence theorems, Fubini's theorem. Further topics in metric spaces. Introduction to L^p spaces, Fourier series. **Professor Choksi**

189-356A PROBABILITY. (3) (Prerequisites: 189-255 or -243) (Not open to students who have taken or are taking 189-323.) Basic combinatorial probability. Introductory distribution theory of univariate and multivariate distributions with special reference to the Binomial, Poisson, Gamma and Normal distributions. Characteristic functions. Weak law of large numbers. Central limit theorem. **Professor Wolfson**

189-357B STATISTICS. (3) (Prerequisite: 189-356 or equivalent) (Not open to students who have taken or are taking 189-324.) Data analysis. Estimation and hypothesis testing. Power of tests. Likelihood ratio criterion. The chi-squared goodness of fit test. Introduction to regression analysis and analysis of variance. **Professor Wolfson**

189-370A ALGEBRA III. (3) (Prerequisite: 189-251) Introduction to monoids, groups, permutation groups; the isomorphism theorems for groups; the theorems of Cayley, Lagrange and Sylow; structure of groups of low order. Introduction to ring theory; integral domains, fields, quotient field of an integral domain; polynomial rings; unique factorization domains. **Professor Labute**

189-371B ALGEBRA IV. (3) (Prerequisite: 189-370) Introduction to modules and algebras; finitely generated modules over a principal ideal domain. Field extensions; finite fields; Galois groups; the fundamental theorem of Galois theory; application to the classical problem of solvability by radicals. **Professor Labute**

189-375A DIFFERENTIAL EQUATIONS. (3) (Prerequisite: 189-325) First order partial differential equations, geometric theory, classification of second order linear equations, Sturm-Liouville problems, orthogonal functions and Fourier series, eigenfunction expansions, separation of variables for heat, wave and Laplace equations, Green's function methods, uniqueness theorems. **Professor Roth**

● ★**189-377B NUMBER THEORY.** (3) (Prerequisite: Enrolment in Mathematics Honours program or consent of instructor.)

189-380B DIFFERENTIAL GEOMETRY. (3) (Prerequisites: 189-251 or 189-247, and 189-248 or 189-314) In addition to the topics of 189-320, topics in the global theory of plane and space curves, and in the global theory of surfaces are presented. These include: total curvature and the Fary-Milnor theorem on knotted curves, abstract surfaces as 2-d manifolds, the Euler characteristic, the Gauss-Bonnet theorem for surfaces. **Professor Kamran**

★**189-382A DYNAMICAL SYSTEMS, FRACTALS AND CHAOS.** (3) (Prerequisites: 189-133, 189-222; a programming language or consent of instructor.) (Not open to students who have taken 189-422.) This course consists of the lectures of 189-322 together with a special project or projects assigned after consultation between the instructor and the student. **Staff**

189-387A NUMERICAL ANALYSIS. (3) (Prerequisites: 189-222 and 308-202 or 308-250 or equivalent, or consent of instructor.) (Intended primarily for Honours students.) This course consists of the lectures of 189-317 together with a special project or projects assigned after consultation between the instructor and student. **Professor Xu**

189-397B MATRIX NUMERICAL ANALYSIS. (3) (Prerequisites: 189-251, 189-387 or consent of instructor.) The course consists of the lectures of 189-327 plus additional work involving theoretical assignments and/or a project. The final examination for this course may be different from that of 189-327. **Staff**

● ★**189-407B DYNAMIC PROGRAMMING.** (3) (Prerequisites: 308-202; 189-223 or 189-236, 189-314, 189-315 and 189-323)

189-417A MATHEMATICAL PROGRAMMING. (3) (Prerequisites: 308-202, and 189-223 or 189-236, and 189-314 or equivalent.) An introductory course in optimization by linear algebra, and calculus methods. Linear programming (convex polyhedra, simplex method, duality, multi-criteria problems), integer programming, and some topics in nonlinear programming (convex functions, optimality conditions, numerical methods). Representative applications to various disciplines. **Professor Zlobec**

189-420A,B INDEPENDENT STUDIES IN MATHEMATICS. (3) (Please see regulations concerning Project Courses, section 2.6.2 on page 339 in the Faculty Degree Requirements section.) Reading projects permitting independent study under the guidance of a staff member specializing in a subject where no appropriate course is available. Arrangements must be made with an instructor and the Chair before registration. Password required.

189-423A REGRESSION AND ANALYSIS OF VARIANCE. (3) (Prerequisites: 189-324, and 189-223 or 189-236) Least-squares estimators and their properties. Analysis of variance. Linear models with general covariance. Multivariate normal and chi-squared distributions; quadratic forms. General linear hypothesis: F-test and t-test. Prediction and confidence intervals. Transformations and residual plot. Balanced designs. **Professor Styan**

189-425B SAMPLING THEORY AND APPLICATIONS. (3) (Prerequisites: 189-324 or equivalent.) Basic sampling designs and estimators; simple random, stratified, systematic, and cluster sampling; sampling with unequal probabilities; ratio and regression techniques. **Professor Worsley**

● ★**189-437A MATHEMATICAL METHODS IN BIOLOGY.** (3) (Prerequisites: 189-315 or 189-325, and 189-323 or 189-356, a CEGEP or higher level computer programming course.)

★**189-447B STOCHASTIC PROCESSES.** (3) (Prerequisites: 189-323) Random walk on the integers and gambler's ruin problem; the Galton-Watson branching process; Markov chains and their applications in the physical and social sciences; birth and death processes and their applications to biological growth problems and queueing systems. **Staff**

189-466A COMPLEX ANALYSIS. (3) (Prerequisite: 189-354) Functions of a complex variable, Cauchy-Riemann equations, Cauchy's theorem and its consequences. Uniform convergence on compacta. Taylor and Laurent series, open mapping theorem, Rouché's theorem and the argument principle. Calculus of residues. Fractional linear transformations. **Professor Klemes**

189-470A,B HONOURS PROJECT. (3) (Prerequisites: appropriate second year honours courses with approval of coordinator.) (Please see regulations concerning Project Courses, section 2.6.2 on page 339 in the Faculty Degree Requirements section.) The student will be assigned a project supervisor and a project topic at the beginning of the semester. The project will consist of a written report including a literature survey and will be tested by an oral examination. Password required.

189-480A,B INDEPENDENT STUDIES IN MATHEMATICS. (3) (Please see regulations concerning Project Courses, section 2.6.2 on page 339 in the Faculty Degree Requirements section.) Reading projects permitting independent study under the guidance of a staff member specializing in a subject where no appropriate course is available. Arrangements must be made with an instructor and the Chair before registration. Password required.

189-487A MATHEMATICAL PROGRAMMING. (3) (Prerequisites: 189-248, 189-251 and 308-202 or 189-250 or equivalent.) Intended primarily for honours students. This course consists of the lectures of 189-417 together with a special project or projects assigned after consultation between the instructor and the student. **Professor Zlobec**

● ★**189-488A SET THEORY.** (3) (Prerequisites: 189-251 or 189-255 or permission of instructor.)

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. Contingency tables: logistic regression, log-linear models. Censored data. Applications to current problems in medicine, biological and physical sciences. GLIM, S, software. **Professor Worsley**

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. **Professor Wolfson**

189-555A FLUID DYNAMICS. (4) (Prerequisites: 189-315 and 189-319 or equivalent) Kinematics. Dynamics of general fluids. Inviscid fluids, Navier-Stokes equations. Exact solutions of Navier-Stokes equations. Low and high Reynolds number flow. **Professor Tam**

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

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

189-560B OPTIMIZATION. (4) (Prerequisite: 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 numberical methods. **Professor Zlobec**

189-561A 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^p 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. **Professor Taylor**

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. **Professor Taylor**

189-566B ADVANCED COMPLEX ANALYSIS. (4) (Prerequisites: 189-466A, 189-564A) 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. **Professor Havin**

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. **Professor Barr**

189-571B HIGHER ALGEBRA II. (4) (Prerequisites: 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. **Professor Barr**

189-574A ORDINARY DIFFERENTIAL EQUATIONS. (4) (Prerequisites: 189-325, 189-354) Existence, uniqueness, smoothness, and dependence on initial conditions of solutions of systems of ordinary differential equations. Dynamical systems. Stable and unstable manifold theorem, Hartman-Grobman Theorem. Classification of equilibria. Liapunov functions. Limit sets, limit cycles and the Poincaré-Bendixson Theorem. The van der Pol equation. Strange attractors and Hopf bifurcation. Applications. **Professor Rigelhof**

189-575B PARTIAL DIFFERENTIAL EQUATIONS. (4) (Prerequisite: 189-375) A continuation of topics introduced in 189-375. **Professor Toth**

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. **Professor GowriSankaran**

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

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.

189-579B 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, hyperbolic and elliptical equations, consistency, convergence and stability of numerical schemes. Explicit and implicit methods, alternating direction explicit and alternating direction implicit methods. **Professor Xu**

189-585B 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. **Professor Maslow**

189-586A APPLIED PARTIAL DIFFERENTIAL EQUATIONS. (4) (Prerequisites 189-316, 189-375 or equivalent.) Linear and nonlinear partial differential equations of applied mathematics. Classification and appropriate partial initial and/or boundary conditions for elliptic, hyperbolic and parabolic equations. Method of characteristics for first-order systems and quasi linear equations. Transform methods. Introduction to generalized functions. Special techniques for finding exact solutions of nonlinear equations. **Professor Maslow**

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 L^p. Independence and conditional expectation. Introduction to Martingales. Limit theorems including Kolmogorov's Strong Law of Large Numbers. **Professor Drury**

189-589B ADVANCED PROBABILITY THEORY II. (4) (Prerequisites: 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 moiton, stochastic calculus.

● **189-591B MATHEMATICAL LOGIC I.** (4) (Prerequisites: 189-488 or equivalent or consent of instructor.)

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. Some of the following topics: Turing degrees, Friedberg-Muchnik theorem, decidable and undecidable theories. **Staff**

11.17 Microbiology and Immunology (528)

Lyman Duff Medical Sciences Building, Room 511
3775 University Street
Montreal, QC H3A 2B4
Telephone: (514) 398-3915
Facsimile: (514) 398-7052
Email: office@microimm.mcgill.ca
Website: http://www.microimm.mcgill.ca

Chair — Michael S. Dubow

Professors
Nicholas H. Acheson; A.B.(Harv.), Ph.D.(Rockefeller)
Zafer Ali-Khan; B.Sc.(Bilar), M.Sc.(Karachi), Ph.D.(Tulane)
Eddie C.S. Chan; M.A.(Texas), Ph.D.(Maryland)
James W. Coulton; B.Sc.(Tor.), M.Sc.(Calg.), Ph.D.(W.Ont.)
Michael S. Dubow, B.Sc.(SUNY), M.A., Ph.D.(Ind.)
John Hiscott; B.Sc., M.Sc.,(W.Ont.), Ph.D.(N.Y.)
Jonathan L. Meakins; B.Sc., M.D.(W.Ont.)
Jack Mendelson; M.Sc.(Roch.), M.D.,C.M.(McG.), F.R.C.P.(C.)
Robert A. Murgita; B.Sc.(Me.), M.S.(Vt.), Ph.D.(McG.)
Michael J.H. Ratcliffe; B.A.(Glas.), Ph.D.(Imp.Coll.)
Hugh G. Robson; B.Sc., M.D., C.M.(McG.), F.R.C.P.(C.)
Mark A. Wainberg; B.Sc.(McG.), M.Sc., Ph.D.(Col.)

Associate Professors
Malcolm G. Baines; B.Sc., M.Sc., Ph.D.(Queen's)
Dalius J. Briedis; B.A., M.D.(Johns H.)
Andre Dascal; D.C.S.(McG.), M.D.(Montr.)
Elaine Mills; B.Sc., M.D.(Sask.)
Trevor Owens; B.Sc., M.Sc.(McG.), Ph.D.(Ott.)

Assistant Professors
Gregory T. Marczynski; B.Sc., Ph.D.(Illinois)
David Portnoy; B.Sc.(Sir G.Wms.), M.D.(Liège)
Joseph Portnoy; B.Sc., M.D.C.M., M.Sc.(McG.)
Pierre René; B.A., M.D.(Sher.)

Associate Members
Institute of Parisitology: Gaeton Faubert, Paula Ribeiro
Division of Exp. Medicine: Clement Couture
Microbiology & Immunology: Lawrence Kleiman
Medicine: Francine Gervais, Vivian Loo, J.Dick Maclean, Mark A. Miller, Marianna Newkirk, C. Kirk Osterland, Roger G.E. Palfree, Joyce E. Rauch, Mary Stevenson, Bernard Turcotte, Brian J. Ward
Neurology & Neurosurgery: Jack Antel
Oncology: Antonis E. Koromilas, Stephane Richard
Surgery: Nicholas V. Christou, A. Robin Poole

Adjunct Professors
Neil Cashman; B.A.(Bowdoin), M.D.(Mass.)
Albert Descoteaux: B.Sc., M.Sc.(Montr.), Ph.D.(McG.)
Patrick Hugo; B.Sc., M.Sc., Ph.D.(McG.)
Peter Lau; Ph.D.(Ottawa)
Chris Richardson; B.Sc., M.Sc., Ph.D.(U.B.C.)
Rafick-P. Sekaly; B.A.(Stanislas), B.Sc., M.Sc.(Montr.), Ph.D.(Lausanne)

Affiliated Centre:
Centre for Host Resistance, Montreal General Hospital, 1650 Cedar Avenue, Montreal, QC H3G 1A4. Telephone: (514) 398-8038. Director: E. Skamane

Microbiology is the study of microorganisms such as bacteria, viruses, unicellular eukaryotes, and parasites. Microorganisms play an important role in human and animal disease, food production (bread, cheese, wine), decay and spoilage, contamination and purification of water and soil. Microbiologists study these tiny, self-replicating machines to understand the basic principles of life: growth, metabolism, cell division, control of gene expression, response to environmental stimuli. Microbiologists are also concerned with controlling or harnessing microorganisms for the benefit of people, by isolating antibiotics or producing vaccines to protect against disease, and by developing and perfecting microorganisms for industrial uses.

Immunology is the study of the molecular and cellular basis of host resistance and immunity to external agents such as pathogenic microorganisms. Immunologists study the mechanisms by which the body recognizes foreign antigens, generates appropriate antibodies to an enormously diverse spectrum of antigens, and sequesters and kills invading microorganisms. Their discoveries lead to vaccination against disease, transfusions and organ transplants, allergies, cancer, autoimmune diseases and immune-deficiency diseases such as AIDS. Antibodies may soon be used in conjunction with antibiotics or chemical agents as specific "magic bullets" to diagnose disease and attack microbes and cancers.

The disciplines of microbiology and immunology are natural partners in research, and both fields use the modern methods of cell biology, molecular biology and genetics to study basic life processes. The members of the Department of Microbiology and Immunology perform research on microbial physiology and genetics, microbial pathogenesis, molecular virology, cellular and molecular immunology, and parasitology. Students registered in the Department therefore are exposed to these related areas and receive an excellent background in basic biology and chemistry as well as in the more applied areas of biotechnology and medicine.

Many opportunities exist for careers in basic or applied microbiology and immunology, medical microbiology, environmental microbiology, and biotechnology. They include positions in industry (pharmaceutical and biotechnology), hospitals, universities, and government (environment, public health, and energy). A degree in microbiology also provides an excellent basis for entering professional and postgraduate programs in medicine, dentistry, the veterinary sciences, research, and education.

Notes on admission to Microbiology and Immunology programs. Please note that enrolment to Microbiology and Immunology programs is limited to a total of 120 students per year. Students seeking admission to the Faculty, Majors and Honours programs must have completed 177-111A, 177-112B, 180-110B or 180-111B, 180-120A or 180-121A, 189-112A/B, 189-139A/B or 189-140A/B,198-101A/B and 198-102A/B or their equivalent with an overall average of at least 65% (B-). Students transferring from other programs may be admitted with a B- average up to the maximum program capacity of 120 students. Applicants not admitted will be placed on a waiting list and will be considered should vacancies occur.

An Undergraduate Handbook, containing detailed course descriptions, a listing of faculty research interests, and information on careers in microbiology and immunology, is available from the Student Affairs Office in room 511 of the Lyman Duff Building.

All students (U1, U2, U3) must meet with an adviser prior to registration. For an appointment, telephone (514) 398-3915.

FACULTY PROGRAM IN MICROBIOLOGY AND IMMUNOLOGY (57 credits) [MARS Program Code 4-662800]

The Faculty Program is intended to offer a basic education in microbiology and immunology to undergraduate students who wish greater flexibility to choose a substantial number of courses from other departments or faculties within the University.

U1 Required Courses (18 credits)

	528-211A	(3)	Biology of Microorganisms
	528-212A	(2)	Laboratory in Microbiology
	177-200A	(3)	Molecular Biology
	177-201B	(3)	Cell Biology and Metabolism
or	507-212B	(3)	Molecular Mechanisms of Cell Function

177-202A,B (3) Basic Genetics
180-212A,B (4) Organic Chemistry I

U1, U2 or U3 Required Course (3 credits)
177-373A (3) Biostatistical Analysis
or 189-203A (3) Principles of Statistics I
or 204-204A,B (3) Introduction to Psychological Statistics

U2 Required Courses (15 credits)
528-314B (3) Immunology
528-323A (3) Microbial Physiology
528-324A (3) Fundamental Virology
528-386D (6) Laboratory in Microbiology & Immunology

U2 Complementary Courses (9 credits)
9 credits selected from:
528-387B (3) Applied Microbiology and Immunology
177-300A (3) Molecular Biology of the Gene
177-314A (3) Molecular Biology of Oncogenes
180-203A (3) Survey of Physical Chemistry
180-204A,B (3) Intro to Physical Chemistry/Biol. Science
180-222A,B (4) Organic Chemistry II
180-302A (3) Organic Chemistry III
504-261A (4) Introduction to Dynamic Histology
504-262B (3) Intro. Molecular and Cellular Biology
507-311A (3) Metabolic Biochemistry
507-312B (3) Biochemistry of Macromolecules
546-300B (3) Human Disease
552-209A* (3) Mammalian Physiology I
552-210B (3) Mammalian Physiology II
* timetable conflict with 528-324A, should be taken in U1 or U3.

U3 Complementary Courses (12 credits)
6 credits from courses offered by the Department of Microbiology and Immunology
6 credits chosen from the Complementary courses listed above for U2, with the addition of:
528-413B (3) Parasitology
528-414A (3) Advanced Immunology
528-465A (3) Bacterial Pathogenesis and Host Defences
528-466B (3) Viral Pathogenesis and Host Defences
528-509B (3) Seminars on Inflammatory Processes
202-505B (3) Selected Topics in Biotechnology
507-450A (3) Protein Structure and Function
507-454A (3) Nucleic Acids
549-300A (3) Drug Action
549-301B (3) Drugs and Diseases

MAJOR PROGRAM IN MICROBIOLOGY AND IMMUNOLOGY
(67 credits) [MARS Program Code 1-662800]

The Major Program is designed for students who want to acquire a substantial background in microbiology and immunology and related disciplines (chemistry, biology, biochemistry) which will prepare them for professional schools, graduate education, or entry into jobs in industry or research institutes.

U1 Required Courses (25 credits)
as for the Faculty Program, plus:
180-222A,B (4) Organic Chemistry II
180-203A (3) Survey of Physical Chemistry
or 180-204A,B (3) Physical Chem./Biol. Sc. I

U1, U2 or U3 Required Statistics Courses (3 credits)
as for the Faculty Program

U2 Required Courses (21 credits)
as for the Faculty program, plus
507-311A (3) Metabolic Biochemistry
507-312B (3) Biochemistry of Macromolecules

U3 Required Courses (9 credits)
528-413B (3) Parasitology
528-465A (3) Bacterial Pathogenesis and Host Defences
528-466B (3) Viral Pathogenesis and Host Defences

U3 Complementary Courses (9 credits)
9 credits selected from:
528-387B (3) Applied Microbiology and Immunology
528-414A (3) Advanced Immunology
528-509B (3) Seminars in Inflammatory Processes
177-300A (3) Molecular Biology of the Gene
177-314A (3) Molecular Biology of Oncogenes
180-302A (3) Organic Chemistry III
202-505B (3) Selected Topics in Biotechnology
504-261A (4) Introduction to Dynamic Histology
504-262B (3) Intro. Molecular and Cellular Biology
504-365A (3) Cell Biology of the Secretory Process
507-450A (3) Protein Structure and Function
507-454A (3) Nucleic Acids
507-456B (3) Biochemistry of Membranes
516-504A (3) Biology of Cancer
546-300B (3) Human Disease
549-300A (3) Drug Action
549-301B (3) Drugs and Diseases
552-209A (3) Mammalian Physiology I
552-210B (3) Mammalian Physiology II

HONOURS PROGRAM IN MICROBIOLOGY AND IMMUNOLOGY (73 required credits)
[MARS Program Code 2-662800]

The Honours Program is designed to offer, in addition to the substantial background given by the Major Program, a significant research experience in a laboratory within the Department during the U3 year. Students are prepared for this independent research project by following an advanced laboratory course in U2. This Program is intended to prepare students for graduate study in microbiology and immunology or related fields, but could also be chosen by students intending to enter medical research after medical school, or intending to enter the job market in a laboratory research environment.

Students intending to apply to Honours must follow the Major program in U1 and U2 and must obtain a CGPA of at least 3.3 at the end of their U2 year. For graduation in Honours, students must pass all required courses with a C or better, and achieve a sessional GPA of at least 3.1 in the U3 year.

U1 Required Courses (25 credits)
as for the Major Program

U1, U2 or U3 Required Statistics Courses (3 credits)
as for the Faculty Program

U2 Required Courses (21 credits)
as for the Major program

U3 Required Courses (21 credits)
as for the Major Program, plus:
528-502D (12) Honours Research

U2 or U3 Complementary Courses (3 credits)
3 credits selected from the Major Program complementary course list

INTERDEPARTMENTAL HONOURS PROGRAM IN IMMUNOLOGY

The Departments of Biochemistry, Microbiology and Immunology and Physiology offer an interdepartmental Honours program in Immunology. Students interested in immunology may choose between this Honours program and the Honours program of the Department of Microbiology and Immunology.

Details of this program may be found in section 11.14 or by consulting Professor Baines in the Department of Microbiology and Immunology, Room 404, telephone (514) 398-4443 or 3928 or mgbaines@microimm.mcgill.ca

COURSE DESCRIPTIONS

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

● Denotes courses not offered in 1999-2000.

528-211A BIOLOGY OF MICROORGANISMS. (3) (3 hours of lecture) (Corequisite: 177-200A) A general treatment of microbiology bear-

ing specifically on the biological properties of microorganisms. Emphasis will be on procaryotic cells. Basic principles of immunology and microbial genetics are also introduced. **Professor Chan**

528-212A LABORATORY IN MICROBIOLOGY. (2) (3 hours of laboratory, 1 hour of conference) (Corequisite: 528-211A) This laboratory course is designed to complement 528-211A. Sessions introduce general techniques peculiar to the handling of microorganisms. **Professor Chan**

528-314B IMMUNOLOGY. (3) (3 hours of lecture) (Prerequisite: 177-200A and 177-201B or 507-212B) An introduction to the immune system, antigens, antibodies and lymphocytes. The course will cover the cellular and molecular basis of lymphocyte development and mechanisms of lymphocyte activation in immune responses. **Professor Ratcliffe**

528-323A MICROBIAL PHYSIOLOGY. (3) (3 hours of lecture) (Prerequisites: 528-211A) An introduction to the composition and structure of microbial cells, the biochemical activities associated with cellular metabolism and how these activities are regulated and coordinated. The course will have a molecular and genetic approach to the study of microbial physiology. **Professor Coulton**

528-324A FUNDAMENTAL VIROLOGY. (3) (3 hours of lecture) (Prerequisites: 528-211A, 177-200A, 177-201B or 507-212B) A study of the fundamental properties of viruses and their interactions with host cells. Bacteriophages, DNA- and RNA-containing animal viruses, and retroviruses are covered. Emphasis will be on phenomena occurring at the molecular level and on the regulated control of gene expression in virus-infected cells. **Professor Acheson**

528-386D LABORATORY IN MICROBIOLOGY & IMMUNOLOGY. (6) (1 hour lecture, 6 hours laboratory, 1 hour follow-up) (Prerequisites: 528-211A, 528-212A. Corequisites: 528-314B, 528-323A, 528-324A) A series of illustrative exercises in bacterial classification, bacterial and viral molecular genetics and immunological techniques. The objective is to provide a practical introduction to microbiological and immunological research and technology. **Professor Baines**

528-387B APPLIED MICROBIOLOGY AND IMMUNOLOGY. (3) (Prerequisite: 528-211A) The ability to select and manipulate genetic material has lead to unprecedented interest in the industrial applications of procaryotic and eucaryotic cells. Beginning in the 1970s the introduction of and subsequent refinements to recombinant DNA technology and hybridoma technology transformed the horizons of the biopharmaceutical world. This course will highlight the important events that link basic research to clinical/commercial application of new drugs and chemicals. **Professor Murgita**

528-413B PARASITOLOGY. (3) (Prerequisite: 528-314B or equivalent – 504-261A is strongly recommended) A study of the biology, immunological aspects of host-parasite interactions, pathogenicity, epidemiology and molecular biological aspects of selected parasites of medical importance. Laboratory will consist of a lecture on techniques, demonstrations and practical work. **Professor Ali-Khan**

528-414A ADVANCED IMMUNOLOGY. (3) (3 hour lecture) (Prerequisite: 528-314B) An advanced extending course serving as a logical extension of 528-314B. The course will integrate molecular, cellular and biochemical events involved in the ontogeny of the lymphoid system and its activation in the immune response. The course will provide the student with an up-to-date understanding of a rapidly moving field. **Professor Ratcliffe**

528-465A BACTERIAL PATHOGENESIS AND HOST DEFENCES. (3) (3 hours of lecture) (Prerequisites: 528-211A, 528-314B, 528-323A, or the permission of the instructor) Organized by the McGill Centre for the Study of Host Resistance. This course focuses on the interplay of the host and the pathogen. The cellular and molecular basis of the host defense mechanism against infections will be considered in relationship to the virulence factors and evasion strategies used by bacteria to cause disease. **TBA**

528-466B VIRAL PATHOGENESIS AND HOST DEFENCES. (3) (3 hours of lecture) (Prerequisites: 528-211A, 528-324A, 528-314B) A study of the biological and molecular aspects of viral pathogenesis with emphasis on pathogenic viruses; of man including the human retroviruses, HIV and HTLV-1; herpes viruses; papilloma viruses; hepatitis viruses; and new emerging human viral diseases. These viruses will be discussed in terms of virus multiplication, gene expression virus-induced cytopathic effects and host immune response to infection. **Professor Hiscott**

528-502D HONOURS RESEARCH PROJECT. (12) (More than 15 hours per week for an independent research project) (U3 Honours students and Majors students are eligible. Required CGPA: 3.3 or higher.) (Please see regulations concerning Project Courses, section 2.6.2 on page 339 in the Faculty Degree Requirements section.) An information meeting about the course is held annually in February for students who intend to apply for registration. Subject to the availability of space and resources, professors in the Department of Microbiology and Immunology provide research opportunities for registrants in this course. Students present their research findings in a seminar and a final written report is required. Because this is a 12 credit course, students are expected to devote at least 40% of their academic effort towards their research. **Professor Coulton**

☐ **528-509B SEMINARS ON INFLAMMATORY PROCESSES.** (3) (3 hours of seminar) (Prerequisite: 528-314B. Corequisite: 552-513A or 528-414A) This course concentrates on the non-specific aspects of the immune response, an area which is not adequately covered by the other immunology courses presented at the university. Interactions between guest researchers (from McGill and other universities) and students will be furthered. This course will be given in conjunction with the Division of Experimental Medicine. **Professor Newkirk**

11.18 Music

Strathcona Music Building
555 Sherbrooke Street West
Montreal, QC H3A 1E3
Telephone: (514) 398-4535
Fax: (514) 398-8061
Website: http://www.music.mcgill.ca

Department of Theory — B. Minorgan *(Chair)*

Department of Performance — E. Plawutsky *(Chair)*

Advisor (B.A./B.Sc. Music programs) —
P. Helmer (514) 398-4535, ext. 5649

SCIENCE MINOR IN MUSIC PROGRAM (24 credits)
[MARS Program Code 6-666500]

Required Courses (9 credits)

210-285D	(3)	Introduction to Musical Styles
211-210A or B	(3)	Tonal Theory and Analysis I*
211-211A or B	(3)	Tonal Theory and Analysis II*

* Students must take a diagnostic placement examination before registering for this course. If the appropriate level is not achieved on the examination, students will be required to register for Melody and Counterpoint 211-110A (3 credits) and/or Elementary Harmony and Analysis 211-111B (3 credits). These courses may *not* be counted toward the 24-credit Music Minor program.

Complementary Courses (15 credits)

Music History, Literature or Performance Practice (3 credits)
a course with a 214- prefix at the 300 level – see list of courses in the Faculty of Music section; an historical performance practice course with a 215-prefix may be taken with Departmental permission.

Music Courses (12 credits)
12 credits from courses with a 211- or 214- prefix at the 300 level, or any other course from the following list of additional courses .

Complementary Course List

198-224A	(3)	Physics and Psychophysics of Music
198-225B	(3)	Musical Acoustics

211-301A	(3)	Modal Counterpoint I
211-302B	(3)	Modal Counterpoint II
211-303A	(3)	Tonal Counterpoint I
211-304B	(3)	Tonal Counterpoint II
211-310A	(3)	Mid & Late 19th-C.Theory & Analysis
or 211-327D	(4)	19th-Century Analysis
211-311B	(3)	20th-Century Theory and Analysis
or 211-427D	(4)	20th-Century Analysis
211-522D	(6)	Advanced Counterpoint
211-523D	(6)	Advanced Harmony
211-528A or B	(3)	Schenkerian Techniques
213-230D	(4)	The Art of Composition
213-260A	(2)	Instruments of the Orchestra
213-261B	(2)	Elementary Orchestration
214-220A or B	(3)	Women in Music
214-3xx		Music History complementary (maximum of 3 credits)
216-201A or B	(3)	Introduction to Music Technologies
216-305A or B	(3)	Personal Computer Applications in Music
216-306A or B	(3)	Computer Programming for Musicians I
216-307A or B	(3)	Computer Programming for Musicians II
222-205A or B	(3)	Psychology of Music
222-207A or B	(3)	Sociology of Music
243-xxx		Ensembles (maximum of 4 credits; registration contingent upon ensemble audition)

SCIENCE MINOR IN MUSIC TECHNOLOGY (24 credits)
[Program registration done by Student Affairs Office]

Space in this program is limited. Students should contact the Faculty of Music Student Affairs Office.

Required Courses (24 credits)

198-224A	(3)	Physics and Psychophysics of Music
198-225B	(3)	Musical Acoustics
214-342A or B	(3)	History of Electroacoustic Music
216-202A	(3)	Fundamentals of New Media
216-203B	(3)	Introduction to Digital Audio
216-301A or B	(3)	Music and the Internet
216-302A	(3)	New Media Production I
216-303B	(3)	New Media Production II

COURSES

The following courses are offered by the Faculty of Music as electives for students in the Faculties of Arts, Science, and Education. They are also open to students from other faculties. For a complete listing of the offerings of the Faculty, consult the Faculty of Music section. Music courses not listed below may be taken by qualified students from other faculties providing they obtain permission from the relevant department in the Faculty of Music and from the Associate Dean of their own faculty.

Please consult the Faculty of Music for timetable information.

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

● Denotes courses not offered in 1999-2000.
▭ Denotes courses with limited enrolment.

LIST I

No music prerequisites, other than those listed under a specific course, are required. **Courses in List I may not be credited toward the B.A. or B.Sc. Music programs.**

Students who have completed a course with a 211- teaching unit number from List II or who have Matriculation Music or McGill Conservatory Theory Secondary V or its equivalent may not register for 210-201 or 210-202.

▭ **210-201A,B BASIC MATERIALS OF WESTERN MUSIC I.** (3) (3 hours) A combination of elementary theory and ear training (sight-singing and aural recognition), and basic piano skills. Topics include: notation of pitch and rhythm, intervals, scales and modes, concept of key, triads and seventh chords, introductory melody and accompaniment writing. **Mr. Townsend (Co-ordinator)**

▭ **210-202A,B BASIC MATERIALS OF WESTERN MUSIC II.** (3) (3 hours) (Prerequisite: 210-201A,B or permission of instructor.) Integrated course in music theory with creative applications of acquired skills. Analysis and writing: concepts of melodic organization, elementary harmonic progressions, two-part contrapuntal techniques, fundamental formal procedures, examination of popular song and jazz. Development of individual skills: intermediate sightsinging, aural recognition, keyboard techniques, small group performance in class.

▭ **210-211A,B THE ART OF LISTENING.** (3) (3 hours) An introduction to the major forms and styles in Western music from the baroque to the present, with emphasis on guided listening in the classroom. The ability to read music is not a prerequisite. **TBA (Co-ordinator)**

Not all of the following courses in List I will be offered in 1999-2000; for an up-to-date listing, please consult the final 1999-2000 Faculty of Music timetable.

Students who read music and have an instrumental or vocal background may proceed directly to courses at the 300 level.

210-374A OR B SPECIAL TOPICS IN MUSIC. (3) (3 hours) A course whose topics will correspond to special historical events and their associated musical, political, and cultural contexts.

● **210-384A OR B ROMANTICISM & THE PIANO.** (3) (3 hours) (Prerequisite: 210-201 or 210-211 or permission of instructor.)

210-385A MUSIC OF THE AVANT-GARDE. (3) (3 hours) (Prerequisite: 210-201 or 210-211) Explorations into post-1945 sound environments; new timbres (Berio and Crumb); "technological" music (electronic and computer music); minimalism (Glass); new aesthetics (Cage); the World Soundscape Project (Schafer); global trends (cross-cultural influences; the New Romanticism; multimedia; protest music). **Professor Levitz**

210-387A OR B THE OPERA. (3) (3 hours) (Prerequisite: 210-201 or 210-211) A survey of opera from c.1600 to the present. Opera as ritual, opera as spectacle, opera as catharsis, opera as business, opera and its literary models. The continuing relevance of the operatic experience today. **Professor Lawton**

210-389B THE SYMPHONY AND CONCERTO. (3) (3 hours) (Prerequisite: 210-201 or 210-211) An historical overview of two major genres in the current concert repertoire: baroque foundations, the Viennese achievement, Beethoven's influence, visionaries and nationalists after 1850, cross-currents in the twentieth century.

▭ **210-392B POPULAR MUSIC AFTER 1945.** (3) (3 hours) (Prerequisite: 210-201 or 210-211 or permission of instructor.) An historical survey of major artists, genres, and styles in the most widespread traditions of postwar commercial music. The course will include practice in techniques of listening, discussion of the shaping institutions of commercial music, and consideration of the interaction of musical style and culture. **Mr. Morrison**

▭ **210-393B INTRODUCTION TO JAZZ.** (3) (3 hours) (Prerequisite: 210-201 or 210-211 or permission of instructor. Open only to non-Music majors.) A survey of the development of jazz from its late 19th-century origins in America to the present day, with an introduction to musical concepts relevant to the genre and consideration of sociocultural issues. **Professor White**

For course descriptions, please consult the Faculty of Music section 8.3.

List II

The courses in this list are intended for students who have at least high school matriculation music or the equivalent. Students who do not have the formal music prerequisites require the permission of the Chair of the Department of Theory to register for any of these courses.

THEORY

For course descriptions, please consult the Faculty of Music section 8.1.

Note: Students not in the B.A. or B.Sc. Music programs are not required to take the corequisites for the following courses. However, students intending later to enter either the B.A. Major Concentration or the B.Mus. program would then be required to sit placement tests in Musicianship and Keyboard Proficiency and may be required to take these courses.

211-110A MELODY AND COUNTERPOINT. (3) (4 hours) (Prerequisite: Matriculation Music or McGill Conservatory Theory Secondary V or its equivalent. Corequisites: 212-129 and -170 or permission of co-ordinator or instructor.)
Professor Schubert (Co-ordinator) and Staff

211-111B ELEMENTARY HARMONY AND ANALYSIS. (3) (4 hours) (Prerequisite: 211-110. Corequisites: 212-131 and 212-171)
Professor Schubert (Co-ordinator) and Staff

211-210A,B TONAL THEORY AND ANALYSIS I. (3) (3 hours) (Prerequisites: 211-110 and 111. Corequisite: 212-229. Prerequisite or corequisite: 212-171)**Professor Caplin (Co-ordinator) and Staff**

211-211A,B TONAL THEORY AND ANALYSIS II. (3) (3 hours) (Prerequisite: 211-210. Corequisite: 212-231.
Professor Caplin (Co-ordinator) and Staff

Unless otherwise indicated the following courses are prerequisites to 300-, 400- and 500- level theory courses: 211-211 or 213-240 AND 212-231 AND 212-171.

211-310A MID & LATE 19TH-C. THEORY & ANALYSIS. (3) (3 hours)
Staff

211-311B 20TH-CENTURY THEORY AND ANALYSIS. (3) (3 hours) (Prerequisite: 211-310) **Staff**

HISTORY

For course descriptions, please consult the Faculty of Music section 8.4.

214-184A HIST. SURVEY (MEDIEVAL, RENAISS., BAROQ.). (3) (3 hours) (Corequisites: 211-110 and 212-129 OR permission of instructor) **Professor Helmer**

214-185B HIST. SURVEY (CLASS., ROMANTIC, 20TH-C.). (3) (3 hours) (Corequisites: 211-111 and 212-131 OR permission of instructor) **Professor Huebner**

214-220B WOMEN IN MUSIC. (3) (3 hours) (Prerequisite: none)
Professor Levitz

Unless otherwise indicated the following courses are prerequisites to 300- and 400- level history courses: 214-184 and 214-185 AND 211-211 or 213-240 AND 212-231.

Not all of the following courses will be offered in 1999-2000; for an up-to-date listing, please consult the final 1999-2000 Faculty of Music timetable.

● **214-342A OR B HISTORY OF ELECTROACOUSTIC MUSIC.** (3) (3 hours) (Open to non-music students by permission of instructor.)

214-386B CHAMBER MUSIC LITERATURE. (3) (3 hours)
Professor Levitz

● **214-387A OR B OPERA FROM MOZART TO PUCCINI.** (3) (3 hours)

● **214-389A OR B ORCHESTRAL LITERATURE.** (3) (3 hours)

● **214-390B THE GERMAN LIED.** (3) (3 hours)

● **214-395A OR B KEYBOARD LITERATURE BEFORE 1750.** (3) (3 hours) **Professor Minorgan**

214-396B ERA OF THE MODERN PIANO. (3) (3 hours)
Professor Helmer

● **214-397B CHORAL LITERATURE AFTER 1750.** (3) (3 hours)

● **214-398A WIND ENSEMBLE LITERATURE AFTER 1750.** (3) (3 hours)

● ▭ **215-381A OR B TOPICS IN PERF. PRACTICE BEFORE 1800.** (3) (3 hours)

▭ **216-202A FUNDAMENTALS OF NEW MEDIA.** (3) (3 hours) (Prerequisites: none) (Open only to students in Music Technology, including those in Minor Programs, and students in Sound Recording, and Composition.) Combining theory and practice, the course covers the areas of MIDI, sound/image/MIDI sequencing, sampling, mixing, soundfile processing and editing, elementary music systems programming, and use of the Internet for sound/music/image. **Staff**

▭ **216-203B INTRODUCTION TO DIGITAL AUDIO.** (3) (3 hours) (Prerequisite: 216-202A) An introduction to the theory and practice of digital audio. Topics include: sampling theory; digital sound synthesis methods (additive, subtractive, summation series); sound processing (digital mixing, delay, filters, reverberation, sound localization); software-based samplers; real-time sound processing; interactive audio systems. Hands-on exercises are included.
Staff

216-301A OR B MUSIC AND THE INTERNET. (3) (3 hours) (Prerequisite: 216-201A OR 216-202A) (Not open to students in B.Mus. Honours in Music Technology.) Technologies and resources of the Internet (access tools, data formats and media) and Web authoring (HTML) for musicians; locating, retrieving and working with information; putting information online; tools for music research, music skills development, technology-enhanced learning, music productivity, and promotion of music and musicians. Evaluation of Internet music resources. **Staff**

▭ **216-302A NEW MEDIA PRODUCTION I.** (3) (3 hours) (Prerequisite: 216-201A OR 216-202A) (Not open to students in B.Mus. Honours in Music Technology.) Methods and techniques for producing and modifying musical and audiovisual content in new media applications. Media formats: audiovisual sequences (QuickTime), CD-ROMs and interactive CD-ROMs, DVD, surround sound audio. Also covered: software-based synthesis and sampling, techniques for image scanning, audio capture, content manipulation, media compression and format conversion. **Staff**

▭ **216-303B NEW MEDIA PRODUCTION II.** (3) (3 hours) (Prerequisite: 216-301A) (Not open to students in B. Mus. Honours in Music Technology.) A continuation of 216-302A. Students produce new media objects of increasing complexity and scope, integrating several types of content. **Staff**

Music Ensembles

Arts and Science students may, with the permission of the instructor and the Associate Dean of their own Faculty, participate in one of the following ensembles in a given year. Auditions are held starting the week prior to the beginning of classes in September and continuing during that first week and, in the case of the McGill Symphony Orchestra (243-497A,B), in early January for the winter term. The schedule and requirements for these auditions are available at the end of June from the Department of Performance office (514) 398-4542. Normally both the A and B sections of an ensemble are taken in the same academic year.

The deadline for withdrawing from ensembles is the end of the second week of classes in any term.

For course descriptions, please consult the Faculty of Music section 8.9.

243-489A,B WOODWIND ENSEMBLES. (1 plus 1 credit) (2-3 hours) (Prerequisite: audition) **Professor Kestenberg (Co-ordinator)**

● **243-490A,B MCGILL WINDS.** (2 plus 2 credits) (4-6 hours) (Prerequisite: audition)

243-491A,B BRASS ENSEMBLES. (1 plus 1 credit) (2-3 hours) (Prerequisite: audition) **Professor Gibson (Co-ordinator)**

243-493A,B CHORAL ENSEMBLES. (2 plus 2 credits) (4 hours) (Prerequisite: audition) Students enroling in Choral Ensembles will be assigned to one of the following groups:
Section 01 Chamber Singers

Section 02 Concert Choir
Section 03 University Chorus
Section 04 Women's Chorale **Professors Baboukis and Edwards**

243-494A,B CONTEMPORARY MUSIC ENSEMBLE. (2 plus 2 credits) (4 hours) (Prerequisite: audition) **Professors Bouliane and Vernon**

243-495A,B JAZZ ENSEMBLES. (2 plus 2 credits) (3-4 hours) (Prerequisite: audition) **Professor Foote and Mr. DiLauro**

243-496A,B OPERA STUDIO. (4 plus 4 credits) (3-6 hours) (Prerequisite: audition) **Professors Ross-Neill, Vernon and Staff**

243-497A,B ORCHESTRA. (2 plus 2 credits) (6-7 hours) (Prerequisite: audition. Corequisite for wind players: 243-478A,B)
N.B. Woodwind and brass players will take one hour per week of Repertoire Class as part of Orchestra. **Professor Vernon and Staff**

243-499A,B STRING ENSEMBLES. (1 plus 1 credit) (2-3 hours) (Prerequisite: audition) N.B. Guitar ensemble is restricted to Performance Majors only.
Section 01 Chamber Music
Section 02 Bass Ensemble
Section 03 Guitar Ensemble
Professor Saint-Cyr (Co-ordinator)

11.19 Neurology and Neurosurgery (531)

Course Lecturers – Assistant Professors
Timothy Kennedy; B.Sc.(McM.), M.Phil, Ph.D.(Columbia) *(joint appt. with Anatomy & Cell Biology)*
Peter McPherson; B.Sc.(Manit.), Ph.D.(Iowa) *(joint appt. with Anatomy & Cell Biology)*
David Ragsdale; B.S.(Ill.); Ph.D.(Calif.)
Wayne Sossin; S.B.(M.I.T.), Ph.D.(Stan.) *(joint appt. with Anatomy & Cell Biology)*

It is the brain that makes us what we are, and understanding how the brain works and how it is affected by disease is a major goal of Neuroscience. Neuroscience is both pure science, offering challenging basic research pursuits, as well as medical science, with important clinical applications. The approach to problems in Neuroscience has roots in many of the basic sciences including biology, biochemistry, pharmacology, physiology, and psychology. Powerful techniques of molecular biology, biochemistry, and genetics have revealed new molecules, given insight to how gene expression is controlled, and allowed the identification of defective genes responsible for diseases of the nervous system. Neuronal and glial cells are studied in the context of adult or developing nervous systems, and how neural networks are formed and maintained. Signalling and information transfer within and between cells are investigated by studying individual cells and their synaptic connections, or through research on complex neuronal circuitry. Higher neural functions are explored by mapping neural architecture, through the study of specific systems with sophisticated physiological and imaging techniques, and by investigations of the neurobiological mechanisms of behaviour.

The Department of Neurology and Neurosurgery sponsors an undergraduate course in Neuroscience, and additional undergraduate courses are offered in the Departments of Biology, Pharmacology, Biochemistry, Psychology, Physiology, and Anatomy and Cell Biology. Graduate studies are a very large component of the Department of Neurology and Neurosurgery. The curriculum for graduate degrees in Neurology and Neurosurgery is provided in the Faculty of Graduate Studies and Research Calendar. Inquiries should be directed to the Graduate Program Coordinator, Montreal Neurological Institute, 3801 University Street, Montreal, H3A 2B4.

531-310B CELLULAR NEUROBIOLOGY. (3) (2 lectures each week) (Prerequisite or corequisite; 177-200A and 177-201B, or 552-209A, or 552-210B) A survey of the functional organization of nerve cells, signalling in the nervous system, and principles of neural development. Topics include cell polarity, neurotransmitters, neurotrophins, receptors and second messengers, cell lineage, guidance of axon outgrowth, and nerve regeneration. Emphasis will be placed on analysis of neurons at the molecular level.
Professor Sossin (Co-ordinator)

11.20 Neuroscience

Minor Program in Neuroscience

Program Coordinator: Professor Ellis Cooper, Department of Physiology. Telephone: (514) 398-4337.

Neuroscience is a multidisciplinary science devoted to the understanding of the nervous system. The brain is one of the most complex systems in the universe, and understanding how it functions is among the most challenging questions in science. Scientists are investigating the brain at many levels, from the molecules at synapses to complex forms of behaviour, with diverse approaches ranging from genetic, biochemical, anatomical, physiological, embryological and psychological. In addition, scientists are investigating the nervous system of many different animals, from simple invertebrates to humans. These wide-ranging investigations are providing a clearer understanding of how neurons work; how they communicate with one another; how they are organized into local or distributed networks; how the connections between neurons are established and change with experience; how neuronal functions are influenced by drugs, nutrients, toxins, and disease states. As a result, we are gaining deeper insights into the neural basis of mental activity, as well as developing new therapeutic approaches to alleviate neurological and psychological diseases.

MINOR PROGRAM IN NEUROSCIENCE (24 credits)
[MARS Program Code 6-668200]

The Minor Program in Neuroscience is a program designed for undergraduate students interested in how the nervous system functions. The program consists of courses from the departments of Anatomy and Cell Biology (504), Biochemistry (507), Biology (177), Neurology and Neurosurgery (531), Pharmacology and Therapeutics (549), Physiology (552), Psychiatry (555), and Psychology (204). The Minor is composed of 24 credits, 18 of which must be selected from two of the five topic areas listed below. Twelve credits of the 18 must be at the 400/500 level and from at least two different departments. A maximum of 6 credits can be counted both for the student's primary program and for the Minor Program in Neuroscience, where appropriate.

All course selections for the Minor Program in Neuroscience must be approved by the Program Coordinator.

Complementary Courses (24 credits)
6 credits selected from:

	204-308A	(3)	Physiological Psychology I: Fundamentals
or	177-306A	(3)	Neurobiology and Behaviour
or	552-311A	(3)	Intermediate Physiology I
	504-321A	(3)	Circuitry of the Human Brain
	531-310B	(3)	Cellular Neurobiology

18 additional credits:
9 credits each from 2 of the 5 areas listed below, 6 credits in each area must be from 400- or 500-level courses

Neurobiology and Behaviour

177-306A	(3)	Neurobiology and Behaviour
177-389B	(3)	Laboratory in Neurobiology
204-318B	(3)	Physiological Psychology II: Motivation and Learning
552-311A	(3)	Intermediate Physiology I
177-430B	(3)	Neural Basis of Behaviour
177-431A	(3)	Neurobiology of Learning & Memory
204-422B	(3)	Neurochemical Basis of Behaviour
204-427B	(3)	Motor Control and Human Performance
204-505A	(3)	The Psychology of Pain
552-556B	(3)	Topics in Systems Neuroscience
555-500B	(3)	Advances in the Neurobiology of Mental Disorders

Molecular and Developmental Neurobiology
504-321A (3) Circuitry of the Human Brain
531-310B (3) Cellular Neurobiology
552-311A (3) Intermediate Physiology I
177-532B (3) Developmental Neurobiology Seminars
177-588A (3) Molecular/Cellular Neurobiology
204-431B (3) The Environment and the Developing Brain
507-455B (3) Neurochemistry
552-451A (3) Advanced Neurophysiology

Neurophysiology
177-389B (3) Laboratory in Neurobiology
504-322B (3) Neuroendocrinology
552-311A (3) Intermediate Physiology I
177-431A (3) Neurobiology of Learning & Memory
177-588A (3) Molecular/Cellular Neurobiology
204-427B (3) Motor Control and Human Performance
552-451A (3) Advanced Neurophysiology
552-520B (3) Ion Channels
552-556B (3) Topics in Systems Neuroscience

Neuropsychology
177-306A (3) Neurobiology and Behaviour
204-311A (3) Human Behaviour and the Brain
204-318B (3) Physiological Psychology II: Motivation and Learning
504-321A (3) Circuitry of the Human Brain
504-322B (3) Neuroendocrinology
204-410B (3) Special Topics in Neuropsychology
204-422B (3) Neurochemical Basis of Behaviour
204-431B (3) The Environment and the Developing Brain
204-470A (3) Memory and Brain
204-505A (3) The Psychology of Pain
204-526A (3) Advances in Visual Perception

Neuropharmacology
549-300A (3) Drug Action
549-301B (3) Drug and Disease
555-301B (3) Issues in Drug Dependence
504-321A (3) Circuitry of the Human Brain
552-311A (3) Intermediate Physiology I
204-422B (3) Neurochemical Basis of Behaviour
507-455B (3) Neurochemistry
552-451A (3) Advanced Neurophysiology
555-500B (3) Advances in the Neurobiology of Mental Disorders
552-520B (3) Ion Channels
549-562A (3) General Pharmacology I
177-588A (3) Molecular/Cellular Neurobiology

11.21 Nursing (576)

For a complete listing of Nursing courses and their descriptions, consult the School of Nursing website (http://www.nursing.mcgill.ca) or refer to the Health Sciences Calendar.

▭ Denotes limited enrolment.

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

▭ **576-308 CURRENT ISSUES IN WOMEN'S HEALTH.** (3) (Prerequisite: Introductory Psychology or Sociology or permission of the instructor.) (Complementary course for the Women's Studies and Social Studies of Medicine Concentrations.) The roles of women as providers and users of health care. Exploration of a wide range of topics on the health of women. Topics include use of health care system, poverty, roles, immigration, body image, lesbian health, and violence against women. Additional topics vary by year. A Health Science elective open to students in the Faculties of Arts, Science, and Medicine. **TBA**

▭ **576-309 CURRENT ISSUES IN WOMEN'S REPRODUCTIVE HEALTH.** (3) (Prerequisite: Introductory Psychology or Sociology or permission of the instructor.) (Restriction: not open for credit to students who have taken 576-308 prior to September 1997.) (Complementary course for the Women's Studies and Social Studies of Medicine Concentrations.) Concepts of health and medicalization. Canadian and international perspectives. Topics include contraception, abortion, infertility, menstruation, menopause, new reproductive technologies, prenatal care, childbirth. A Health Science elective open to students in the Faculties of Arts, Science, and Medicine. **TBA**

11.22 Pathology (546)

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

546-300B HUMAN DISEASE. (3) (Prerequisites: 177-200A, 177-201B or 507-212B, 552-209A. Pre- or co-requisite: 552-210B.) Provides a fundamental understanding of the diseases prevalent in North America, for upper level students in the biological sciences. Includes: general responses of cells and organ systems to injury; assessment of individual diseases by relating the causes, symptoms, diagnosis, treatment and prevention to the primary biological abnormalities in each disorder. **Professor Zorychta**

11.23 Pharmacology and Therapeutics (549)

McIntyre Medical Building
3655 Drummond
Montreal, QC H3G 1Y6
Telephone: (514) 398-3623
Website: http://www.pharma.mcgill.ca

Chair — A. Claudio Cuello

Vice-Chair — Radan Capek

Professors
Jack Aranda; M.D.(Manila Central), Ph.D.(McG.)
Radan Capek; M.D., Ph.D.(Prague)
Brian Collier; B.Sc., Ph.D.(Leeds)
A. Claudio Cuello; M.D.(Buenos Aires), M.A., D.Sc.(Oxon.)
Claude De Montigny; M.D., Ph.D.(Montr.), F.R.C.P.(C)
Barbara Hales; M.Sc.(Phil. Coll. of Pharmacy and Science), Ph.D.(McG.) *(on leave)*
Peter J. McLeod; M.D.(Manit.), F.R.C.P.(C.)
John B. Richardson; B.Sc., M.D.C.M., L.M.C.C., F.R.C.P., Ph.D.(McG.)
Bernard Robaire; B.A.(Calif.), Ph.D.(McG.)
Allan Tenenhouse; B.Sc., M.D.,C.M., Ph.D.(McG.)
Daya R. Varma; M.D.(Lucknow), Ph.D.(McG.)

Associate Professors
Guillermina Almazan; Ph.D.(McG.) *(on leave)*
Paul B.S. Clarke; M.A.(Cantab.), Ph.D.(Lond.) *(on leave)*
Barbara Esplin; M.D.(Warsaw)
Howard S. Katz; M.Sc., Ph.D., D.D.S.(McG.)
Dusica Maysinger; Ph.D.(Los Angeles)
Stanley Nattel; B.Sc., M.D.,C.M.(McG.)
Ante L. Padjen; M.D., M.Sc., D.Sc.(Zagreb);
Alfredo Ribeiro-da-Silva,; M.D., Ph.D.(Oporto) *(joint appt. with Anatomy & Cell Biology)*
H. Uri Saragovi; Ph.D.(Miami)
Betty I. Sasyniuk; B.S.P., Ph.D.(Man.)
Moshe Szyf; M.Sc., Ph.D.(Hebrew Univ.)
Jacquetta Trasler; M.D.C.M., Ph.D.(McG.)
Edith A. Zorychta; B.Sc.(F.X.), M.Sc., Ph.D.(McG.)

Assistant Professor
Yves De Koninck; Ph.D.(McG.)

Associate Members
Gerald Batist; M.D.,C.M.(McG.)
Serge Gauthier, M.D.(Montr.)
Yogesh C. Patel; M.D.(Otago), Ph.D.(Monash)
Roger Prichard; B.Sc., Ph.D.(N.S.W.)
Remi Quirion; M.Sc., Ph.D.(Sher.)

Adjunct Professors
Paul Albert; Ph.D.(Harv.)
Sylvain Chemtob; M.D.(Montr.), Ph.D.(McG.)

Anthony Ford Hutchinson; M.Sc.(Warwick), Ph.D.(Lond.)

Pharmacology is the science which deals with all aspects of drugs and their interactions with living organisms. Thus, it involves the physical and chemical properties of drugs, their biochemical and physiological effects, mechanisms of action, pharmacokinetics, and therapeutic and other uses. Since the word "drug" encompasses all chemical substances that produce an effect on living cells, it is evident that pharmacology is a very extensive subject. Pharmacology is a multi-disciplinary science. It has developed its own set of principles and methods to study the mode of the action of drugs, but it has also utilized many techniques and approaches from various disciplines including biochemistry, physiology, anatomy and molecular biology, as well as others. Pharmacology can be subdivided into a number of different areas such as neuropharmacology, molecular biology, reproductive pharmacology, endocrine pharmacology, receptor pharmacology, cardiovascular pharmacology, toxicology, developmental pharmacology, autonomic pharmacology, biochemical pharmacology, and therapeutics.

Training in pharmacology is conducted at both the undergraduate and graduate levels. Because of its breadth, students may be attracted to the subject from a variety of viewpoints; this includes those completing a Bachelor's degree in any number of basic science disciplines, such as biology, zoology, chemistry, physics, biochemistry, microbiology, anatomy and physiology. At the undergraduate level, four lecture courses are offered. A course involving research projects in pharmacology is also available to provide the student with the opportunity to get first-hand experience in a pharmacology research laboratory. These courses should provide students with knowledge concerning the actions of drugs on living systems and insight into approaches to basic pharmacological research.

MINOR PROGRAM IN PHARMACOLOGY (24 credits)
[MARS Program Code 6-680000]

The Minor Program in Pharmacology is intended for students registered in a complementary B.Sc. program who are interested in a focused introduction to specialized topics in pharmacology to prepare them for professional schools, graduate education, or entry into jobs in industry or research institutes. Students should declare their intent to enter the Minor Program in Pharmacology at the beginning of their U2 year. They must consult with, and obtain the approval of, the Coordinator for the Minor Program in the Department of Pharmacology and Therapeutics.

All courses in the Minor Program must be passed with a minimum grade C or better. Generally, no more than 6 credits of overlap are permitted between the Minor and the primary program.

Required Courses (18 credits)

549-300A	(3)	Drug Action
549-301B	(3)	Drugs and Diseases
549-562A	(3)	General Pharmacology I
549-563B	(3)	General Pharmacology II
549-599A,B,D,T	(6)	Research Projects in Pharmacology

Complementary Courses (6 credits)
one of the following sets:

177-200A	(3)	Molecular Biology
and 177-201B	(3)	Cell Biology and Metabolism
or 507-212B	(3)	Molecular Mechanisms of Cell Function
OR		
552-209A	(3)	Mammalian Physiology I
and 552-210B	(3)	Mammalian Physiology II

549-300A DRUG ACTION. (3) (Prerequisites: 177-200A and 177-201B or 507-212B, 552-209A and 552-210B or permission of instructor.) This course covers the fundamental principles of pharmacology and toxicology. Frequently encountered drugs are used as a focus to illustrate sites and mechanisms of action, distribution, metabolism, elimination and adverse effects.
Professor Zorychta

549-301B DRUGS AND DISEASE. (3) (Prerequisites: 177-200A, 177-201B or 507-212B, 552-209A and 552-210B and 549-300A or permission of instructor). This course further explores the basic principles of pharmacology as illustrated by drugs used in the treatment of disease. Emphasis is placed on drugs used for diseases prevalent in North America. **Professor Szyf and Staff**

549-562A GENERAL PHARMACOLOGY I. (3) (Prerequisites: 552-209A and 552-210B, 177-200A and 177-201B or 507-311A and 507-312B or equivalent.) (Restrictions: Open to U3 students with permission of instructors, and students registered in the Minor Pharmacology Program.) Principles of pharmacology as illustrated by current issues with an emphasis on the nervous system will be discussed. Drugs classified by their molecular target of action, their mechanism of action, and possibly a rationale for therapeutic use will be presented. Students will be required to examine and interpret scientific data, to write a paper and participate in small group discussions. **Professor Esplin and Staff**

549-563B GENERAL PHARMACOLOGY II. (3) (Prerequisites: 552-209A and 552-210B, 177-200A and 177-201B or 507-311A and 507-312B or equivalent.) (Restrictions: Open to U3 students with permission of instructors, and students registered in the Minor in Pharmacology Program.) Selected topics of basic interactions between chemicals and biological systems. Actions of drugs at the molecular and cellular levels. Principles of drug development. Chemotherapy of infections and of cancer. Toxicology and pharmacokinetics/dynamics. Drug metabolism. **Professor Saragovi and Staff**

549-599A,B,C,D,L,T RESEARCH PROJECTS IN PHARMACOLOGY. (6) (Pre- or co-requisite 549-562A and 549-563B or 549-300A and 549-301B.) (Restrictions: Open to U3 students with permission of instructors, and students registered in the Minor Pharmacology Program. Students should consult instructors 3 - 4 weeks before registration.) (Please see regulations concerning Project Courses, section 2.6.2 on page 339 in the Faculty Degree Requirements section.) This course involves individual research work. Students select a laboratory project under the supervision of a staff member. Areas of interest include toxicology, endocrine, developmental, cardiovascular, reproductive and neuropharmacology. This course requires a minimum of 6 hours per week for the full year course (D), and a minimum of 12 hours per week for the half year course (A,B) to be spent in the laboratory and/or library.
Professors Maysinger, Sasyniuk, Varma and Staff

11.24 Physics (198)

Rutherford Physics Building, Room 108
3600 University Street
Montreal, QC H3A 2T8
Telephone: (514) 398-6485
Fax: (514) 398-8434
Email: secretariat@physics.mcgill.ca
Website: http://www.physics.mcgill.ca

Chair — J. Barrette

Emeritus Professors
M.P. Langleben; B.Sc., M.Sc., Ph.D.(McG.), F.R.S.C.
E.R. Pounder; B.Sc., Ph.D.(McG.), F.R.S.C *(William C. Macdonald Emeritus Professor of Physics)*
R.T. Sharp; B.Sc., M.Sc., Ph.D.(McG.)

Post-Retirement
A.P. Contogouris; B.A.(Athens), Ph.D.(C'nell)

Professors
J. Barrette; B.Sc., M.Sc., Ph.D.(Montr.)
C. Burgess; B.Sc.(Waterloo), Ph.D.(Texas)
J.E. Crawford; B.A., M.A.(Tor.), Ph.D.(McG.)
S. Das Gupta; B.A., M.Sc.(Calc.), Ph.D.(McM.)
N. DeTakacsy; B.Sc., M.Sc.(Montr.), Ph.D.(McG.)
M. Grant; B.Sc.(P.E.I.), M.Sc., Ph.D.(Tor.)
R. Harris; B.A.(Oxon.), Ph.D.(Sus.)
C.S. Lam; B.Sc.(McG.), Ph.D.(M.I.T.) *(E. Rutherford Professor of Physics)*
J.K.P. Lee; B.Eng., M.Sc., Ph.D.(McG.)
S. Lovejoy; B.A.(Cantab.), Ph.D.(McG.)

S.K. Mark; B.Sc., M.Sc., Ph.D.(McG.)
R.B. Moore; B.Eng., M.Sc., Ph.D.(McG.)
P.M. Patel; B.Sc., M.Sc.(Manc.), Ph.D.(Harv.)
D.G. Ryan; B.Sc., M.Sc.(Queen's), Ph.D.(Birm.)
D.G. Stairs; B.Sc., M.Sc.(Queen's), Ph.D.(Harv.) *(William C. Macdonald Professor of Physics)*
J.O. Strom-Olsen; B.A., M.S., Ph.D.(Cantab.)
M. Sutton; B.Sc., M.Sc., Ph.D.(Tor.)
J.M. Trischuk; B.Eng.(McG.), Ph.D.(Cal. Tech.)
M.J. Zuckermann; M.A., D.Phil.(Oxon.), F.R.S.C. *(William C. Macdonald Professor of Physics)*

Associate Professors
F. Corriveau; B.Sc.(Laval), M.Sc.(U.B.C.), Docteur Sc.Nat.(Zär)
C. Gale; B.Sc.(Ott.), M.Sc., Ph.D.(McG.)
H. Guo; B.Sc.(Sichuan), M.Sc., Ph.D.(Pitt.)
D. Hanna; B.Sc.(McG.), M.A., Ph.D.(Harv.)
R. Myers; B.Sc.(Wat.), M.A., Ph.D.(Prin.)
K. J. Ragan; B.Sc.(Alta.), Ph.D.(Geneva)
D.H. Ryan; B.A., Ph.D.(Trin.Coll.)

Assistant Professors
J. M. Cline; B.Sc.(Calif.), M.Sc., Ph.D.(Cal Tech.)
P. Grutter; Dipl., Ph.D.(Basel)

Lecturers
Z. Altounian; B.Sc., M.Sc.(Cairo), Ph.D.(McM.)
F. Buchinger; M.Sc., Dr.(Mainz)

Associate Members
R. Davies *(Atmospheric & Oceanic Sciences),*
B.C. Eu *(Chemistry),* G. Fallone *(Radiation Oncology),*
M. Mackey *(Physiology),* E. Podgorsak *(Radiation Oncology),*
D. Ronis *(Chemistry)*

Curator (Rutherford Museum and McPherson Collection)
M. Cohen; B.Sc., Ph.D.(Lond.), F.Inst.P., A.R.C.S.

Physics is in many ways the parent of the other natural sciences and its discoveries and laws continually affect their development. Its range and scope extend in space and time from subnuclear particles to the universe itself. The subfields of physics such as mechanics, thermodynamics, electricity, atomic physics and quantum mechanics, to mention but a few, permeate all other scientific disciplines. People trained in physics are employed in industry, government, and educational systems where they find many challenges as teachers, researchers, administrators and in the rapidly developing area of scientific business.

The two main undergraduate programs in Physics at McGill are the Honours and the Major.The Honours program is highly specialized and the courses are very demanding.This program is appropriate for students who wish to make an in-depth study of the subject in preparation for graduate work and an academic or professional career in physics. The Joint Honours in Mathematics and Physics is an even more specialized and demanding program, intended for students who wish to develop a strong basis in both mathematics and physics in preparation for graduate work and a professional or academic career. Although the program is optimized for theoretical physics, it is broad enough and strong enough to prepare students for further study in either experimental physics or mathematics. High standing in CEGEP or Freshman-year mathematics and physics is a requirement for admission to these Honours programs.

The Major program, on the other hand, offers a broad training in classical and modern physics and yet leaves room for the student to take a meaningful sequence of courses in other areas. It is intended primarily for students who wish to pursue careers in fields for which physics provides a basis. However this program also provides a preparation for graduate studies, especially if a student chooses, in consultation with the departmental adviser, a number of Honours Physics courses in the U2 and U3 years.

There are also a number of other Major programs, Atmospheric Sciences and Physics, Physics and Geophysics, and Physiology and Physics, offered jointly with other departments, and a Minor program in Electrical Engineering, available only to students in the Physics Major program. In addition, there is a Faculty program in Physics and a Joint Faculty program in Mathematics, Chemistry and Physics, which both provide a broad base for students less interested in a specialized education. Almost all the Physics programs can be combined with an Internship Year, as part of the University's IYES program, which provides experience in an industrial or government laboratory as part of the degree program.

For those interested in a career as a high school science teacher, the concurrent program leading to both a B.Sc. and a B.Ed. degree provides two Physics options. Both of these combine physics courses from the Major program with Education courses. They are, respectively, the Major program in Chemistry and Physics for Teachers, and the Major program in Mathematics and Physics for Teachers. (For details, see the Science for Teachers section.)

Students from outside of the Province of Quebec will ordinarily register in the Science Freshman program. Physics offers two sequences of courses for this program: they are described below.

The list of pre- and co-requisites is not absolute. In many cases permission of the Department may be sought to have a specific prerequisite waived.The procedure is to ask the professor in charge of the course to review the request for such a waiver.The prerequisites of the 100-level courses are described in the following section entitled Science Freshman Program.

Courses 198-200A, 198-201B, 198-204A,B and 198-224A are designed for students from faculties other than Science (such as Arts and Music) and have no prerequisites as such, although a reasonable knowledge of high-school level algebra, geometry and trigonometry is desirable.

The block of numbers 198-205A, 198-206A, 198-207A, 198-208A, and 198-209A has been reserved for a series of courses "Introduction to Selected Topics in Physics". These courses, of one credit each, will introduce topics in physics which are of current interest. Topics given under numbers 198-205 or 198-206 will have CEGEP Physics* as prerequisite; those given under numbers 198-208 or 198-209 will have no Physics prerequisite. The topics will vary from year to year. For further information, enquire at the Department of Physics.

All other 200-level courses are designed primarily for Science students and assume successful completion of CEGEP level physics* and mathematics programs. The phrase "Prerequisite CEGEP Physics*" has been inserted to make this point clear. Students who have not included Calculus III in their CEGEP program, should register in the first term of the U1 year for Mathematics 189-222.

Students interested in any of the Physics programs should contact the Department for an Adviser

**Physics 203-101, 203-201, 203-301-78 or equivalent – CEGEP course numbers, standard throughout the Province of Québec.*

SCIENCE FRESHMAN PROGRAM

Students entering McGill with a Québec CEGEP profile in Science will normally begin their programs in Physics with courses at the 200 level.

Students without this profile will normally take courses 198-131A and 198-142B if they have previously taken physics at the high school level and will be taking differential calculus concurrently with 198-131A and integral calculus concurrently with 198-142B. Those students who have not previously taken physics at the high school level and who intend to do programs in the Biological Sciences may instead take courses 198-101A and 198-102B. All students are expected to have reasonable fluency in algebra, geometry and trigonometry at the high school level. If this is not the case, then Mathematics 189-112A should be taken concurrently with 198-101A. Those for whom this is not necessary are advised to take 189-139A concurrently with 198-101A.

FACULTY PROGRAM IN PHYSICS (54 credits)
[MARS Program Code 4-720000]
Required Courses (36 credits)

198-230A	(3)	Dynamics of Simple Systems
198-232B	(3)	Heat and Waves

198-241B (3) Signal Processing
198-259D (3) Lab in Mechanics, Heat & Optics
198-333B (3) Thermal and Statistical Physics
198-340A (3) Electricity and Magnetism
198-436B (3) Modern Physics
198-446A (3) Quantum Physics
189-222A,B (3) Calculus III
189-223A,B (3) Linear Algebra
189-314A,B (3) Advanced Calculus
189-315A,B (3) Ordinary Differential Equations

Complementary Courses (18 credits)
at least 3 credits selected from:
198-434B (3) Optics
198-439A (3) Lab in Modern Physics
the remainder selected from:
198-328A (3) Electronics
198-331B (3) Mechanics
198-339B (3) Measurements Laboratory
198-342B (3) Electromagnetic Waves
186-320A (3) Elementary Earth Physics
189-316B (3) Functions of a Complex Variable
189-317A (3) Numerical Analysis
189-319B (3) Partial Differential Equations
308-202A,B (3) Introduction to Computing I

JOINT FACULTY PROGRAM IN MATHEMATICS, CHEMISTRY AND PHYSICS See page 383 in the Mathematics and Statistics entry for complete program information.

MAJOR PROGRAM IN PHYSICS (60 credits)
[MARS Program Code 1-720000]

U1 Required Courses (21 or 24 credits)
198-230A (3) Dynamics of Simple Systems
198-232B (3) Heat and Waves
198-240B (3) Computers for Physics
198-259D (3) Lab in Mechanics, Heat & Optics
189-222A (3) Calculus III
189-223A (3) Linear Algebra
198-241B (3) Signal Processing
or 304-200 Fundamentals of Electrical Engineering
and 304-210 (6) Circuit Analysis

U2 Required courses (24 credits)
198-328A (3) Electronics
198-331B (3) Mechanics
198-333B (3) Thermal & Statistical Physics
198-339B (3) Measurements Laboratory
198-340A (3) Electricity and Magnetism
198-342B (3) Electromagnetic Waves
189-314A (3) Advanced Calculus
189-315B (3) Ordinary Differential Equations

U3 Required Courses (15 credits)
198-434B (3) Optics
198-436B (3) Modern Physics
198-439A (3) Lab in Modern Physics
198-446A (3) Quantum Physics
198-449B (3) Project Laboratory

JOINT MAJOR PROGRAM IN PHYSICS AND GEOPHYSICS (65 credits) [MARS Program Code 1-720400]

The Joint Major program in Physics and Geophysics provides a firm basis for graduate work in Geophysics and related fields as well as a sound preparation for those who wish to embark on a career directly after the B.Sc.

U1 Required Courses (29 credits)
198-230A (3) Dynamics of Simple Systems
198-232B (3) Heat and Waves
198-241B (3) Signal Processing
198-259D (3) Lab in Mechanics, Heat & Optics
186-203B (3) Structural Geology I
186-210A (3) Introduction to Mineralogy
186-231E (2) Field School I
189-222A (3) Calculus III
189-223A (3) Linear Algebra
189-314B (3) Advanced Calculus

U2 Required Courses (27 credits)
198-331B (3) Mechanics
198-333B (3) Thermal & Statistical Physics
198-339B (3) Measurements Laboratory
198-340A (3) Electricity and Magnetism
198-342B (3) Electromagnetic Waves
186-350B (3) Tectonics
186-510B (3) Global Geodynamics and Geomagnetism
or 186-330B (3) Earthquakes & Earth Structure
189-315A (3) Ordinary Differential Equations
189-319B (3) Partial Differential Equations

U3 Required Courses (9 credits)
198-446A (3) Quantum Physics
198-332B (3) Physics of Fluids
186-510B (3) Global Geodynamics and Geomagnetism
or 186-330B (3) Earthquakes & Earth Structure

JOINT MAJOR PROGRAM IN ATMOSPHERIC SCIENCE AND PHYSICS Students should consult undergraduate advisers in both departments. See page 348 in the Atmospheric and Oceanic Sciences section for complete program information.

The Major program in Physics and Atmospheric Science provides a firm basis for graduate work in Atmospheric Science and related fields as well as a sound preparation for those who wish to embark on a career directly after the B.Sc.

JOINT MAJOR PROGRAM IN PHYSIOLOGY AND PHYSICS See page 404 in the Physiology section for complete program information.

The Major program in Physiology and Physics provides a firm basis for graduate work in Bio-physics and other interdisciplinary fields involving the physical and biological sciences.

HONOURS PROGRAM IN PHYSICS (78 credits)
[MARS Program Code 2-720000]

Students entering this program for the first time should have high standing in mathematics and physics. In addition, a student who has not completed the equivalent of 189-222 must take it in the first term without receiving credits toward the 78 credits required in the Honours program.

A student whose average in the required and complementary courses in any year falls below a GPA of 3.00, or whose grade in any individual required or complementary course falls below a C, may not register in the Honours program the following year, or graduate with the Honours degree, except with the permission of the Department.

U1 Required Courses (27 credits)
198-241B (3) Signal Processing
198-251A (3) Classical Mechanics I
198-253B (3) Thermal Physics
198-259D (3) Lab in Mechanics, Heat & Optics
198-260A (3) Relativity and Modern Physics
189-247B (3) Linear Algebra
189-248A (3) Advanced Calculus I
189-249B (3) Advanced Calculus II
189-325A (3) Ordinary Differential Equations

U2 Required Courses (24 credits)
198-328A (3) Electronics
198-350A (3) Electromagnetism
198-357A (3) Quantum Physics I
198-359B (3) Lab in Modern Physics
198-362B (3) Statistical Mechanics
198-451B (3) Classical Mechanics
198-457B (3) Quantum Physics II
189-375A (3) Differential Equations

U3 Required Courses (12 credits)
198-551A (3) Quantum Theory
198-352A (3) Electromagnetic Waves

198-459D (6) Honours Research Project
or 198-469A (3) Lab in Modern Physics II
and 198-479B (3) Honours Project Lab

U3 Complementary Courses (15 credits)
15 credits selected from:
198-332B (3) Physics of Fluids
198-434B (3) Optics
198-514B (3) General Relativity
198-557A (3) Nuclear Physics
198-558A (3) Solid State Physics
198-559A (3) Advanced Statistical Mechanics
198-562B (3) Electromagnetic Theory
198-567B (3) Particle Physics
or other 3-credit course approved by the Department of Physics

JOINT HONOURS PROGRAM IN MATHEMATICS AND PHYSICS (81 credits) [MARS Program Code 3-634500]

This is a specialized and demanding program intended for students who wish to develop a strong basis in both Mathematics and Physics in preparation for graduate work and a professional or academic career. Although the program is optimized for theoretical physics, it is broad enough and strong enough to prepare students for further study in either experimental physics or in mathematics.

The minimum requirement for entry into the program is completion with high standing of the usual CEGEP courses in physics and in mathematics. In addition, a student who has not completed the equivalent of 189-222 must take it in the first term without receiving credits toward the 81 credits required in the Joint Honours program.

To remain in the Honours program and to be awarded the Honours degree, the student must maintain a 3.00 GPA in the required and complementary courses, and a grade of C or better in each required or complementary course.

The student will have two advisors, one from Mathematics and the other from Physics.

U1 Required Courses (30 credits)
198-241B (3) Signal Processing
198-251A (3) Classical Mechanics I
198-253B (3) Thermal Physics
198-259D (3) Lab in Mechanics, Heat & Optics
198-260A (3) Relativity and Modern Physics
189-248A (3) Advanced Calculus I
189-249B (3) Advanced Calculus II
189-325A (3) Ordinary Differential Equations
189-235A (3) Algebra I
189-251B (3) Algebra II
or 189-247B (3) Linear Algebra

U2 Required Courses (24 credits)
198-350A (3) Electromagnetism
198-357A (3) Quantum Physics I
198-362B (3) Statistical Mechanics
198-451B (3) Classical Mechanics
198-457B (3) Quantum Physics II
189-242A (3) Analysis I
189-255B (3) Analysis II
189-375A (3) Differential Equations

U3 Required Courses (15 credits)
198-359B (3) Lab in Modern Physics
198-352A (3) Electromagnetic Waves
189-354A (3) Analysis III
189-380A (3) Differential Geometry
189-370A (3) Algebra III
or 189-355B (3) Analysis IV

U3 Complementary Courses (12 credits)
9 credits selected from:
198-514B (3) General Relativity
198-551A (3) Quantum Theory
198-557A (3) Nuclear Physics
198-558A (3) Solid State Physics
198-559A (3) Advanced Statistical Mechanics
198-562B (3) Electromagnetic Theory
198-567B (3) Particle Physics
3 credits in Honours Mathematics

MINOR PROGRAM IN ELECTRICAL ENGINEERING
(23 or 25 credits) [MARS Program Code 6-280000]

The Minor program does not carry professional recognition. Only students who satisfy the requirements of the Major in Physics are eligible for this Minor. Students registered for this option cannot count 198-241 towards the requirements of the Major in Physics, and should replace this course by another Physics or Mathematics course. Students who select 304-334 in the Minor cannot count 198-328 towards the requirements of the Major in Physics, and should replace this course by another Physics or Mathematics course.

Required Courses (17 or 19 credits)
304-200 (3) Fundamentals of Electrical Engineering
304-210 (5) Circuit Analysis
304-303 (3) Signals and Systems
304-330 (3) Electronic Circuits
304-305 (3) Probability and Random Signals
or 304-334 (5) Electronic Circuits II

Complementary Courses (6 credits)

COURSE DESCRIPTIONS

Instructors' names are subject to change, since course assignments are made after this Calendar goes to press. See the Department's Web page http://www/physics.mcgill.ca for up-to-date information.

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

NOTE: In general, Honours courses are indicated when the fifth character of the six digit course number is 5 or higher.

● Denotes courses not offered in 1999-2000.
▭ Denotes limited enrolment
★ Denotes courses offered only in alternate years

198-101A INTRODUCTORY PHYSICS – MECHANICS. (4) (3 hours lectures; 2 hours laboratory; tutorial sessions) (Not open to students taking or having taken 198-131A.) The object of this course is to give the students a basic understanding of the principles of physics, illustrating these, where possible, with current examples of their use in biology and medicine. (Laboratory sections have limited enrolment.) **Professor Moore**

198-102B INTRODUCTORY PHYSICS – ELECTROMAGNETISM. (4) (3 hours lectures; 2 hours laboratory; tutorial sessions) (Prerequisite: 198-101. Corequisite: 189-139) (Not open to students taking or having taken 198-142B.) Electric field and potential. D.C. circuits and measurements. Capacitance. Magnetic field and induction. A.C. circuits Semiconductor devices and their application. Electromagnetic waves. (Laboratory sections have limited enrolment.) **Dr. Altounian**

These courses, 101A and 102B together satisfy the minimum requirement in physics for Medical School.

198-109D GENERAL PHYSICS LABORATORY. (2) (2 hours laboratory) (Not open to students who have taken or are taking 198-101 or 198-102.) The laboratory component of 198-101A and 198-102B. May be taken only by students who have completed the lecture component but not the laboratory of 198-101 and 198-102.

198-119D GENERAL PHYSICS LABORATORY. (2) (3 hours laboratory) The laboratory component of 198-131A and 198-142B. This course may be taken only by students who have completed the lecture components of these courses but not the laboratory.

198-131A MECHANICS AND WAVES. (4) (3 hours lectures; 1 hour tutorial, 3 hours laboratory in alternate weeks; tutorial sessions) (Corequisite: 189-139A) (Not open to students taking or having taken 198-101A.) The basic laws and principles of Newtonian mechanics; oscillations and waves. (Laboratory sections have limited enrolment.) **Professor Harris**

198-142B ELECTROMAGNETISM & OPTICS. (4) (3 hours lectures, 3 hours laboratory in alternate weeks; tutorial sessions) (Prerequisite: 198-131A. Corequisite: 189-141B) (Not open to students taking or having taken 198-102B.) The basic laws of electricity and magnetism; geometrical and physical optics. (Laboratory sections have limited enrolment.) **Professor Grutter**

▭ **198-199B PHYSICS AND BIOLOGY.** (3) (3 hours per week, seminar format) (Prerequisite: 198-101A or permission of instructor. Co-requisite: 198-102B or permission of instructor.) (Not open to students who are taking or have taken 198-217B.) (FYS - for first year students only, maximum 25.) This course addresses the physics of biological systems in a format which encourages active interaction of the students with the instructor and a number of guest lecturers. Topics discussed will include the physics of vision and the role of physical processes in bio-membranes. **Professor Zuckermann**

198-200A SPACE, TIME & MATTER. (3) (3 hours lectures) (Not open to students in Science or Engineering.) See "Science for Arts Students" in the Arts section. **Professor Ragan**

198-204A,B PLANETS, STARS & GALAXIES. (3) (3 hours lectures; 3 evening periods for star identification and use of telescopes.) (Not open to students who have taken or are taking 198-214A.) An elementary astronomy course for non-science students (see "Science for Arts Students" in the Arts section) and for science students not taking a Physics program. **Professors Crawford and Burgess**

198-208A TOPICS IN PHYSICS. (1 credit; 2 hours lectures, first six weeks) (Not open to students in Physics programs.) Topic for 1999-2000: The Safe Use of Nuclear Radiation. **Professor Cohen**

● **198-209A TOPICS IN PHYSICS.** (1 credit; 2 hours lectures, first six weeks) (Not open to students in Physics programs.)

198-214A ASTROPHYSICS. (3) (Prerequisite: CEGEP Physics.) (Not open to students who have taken or are taking 198-204A,B.) An introduction to astrophysics with emphasis placed on methods of observation and current models. Stellar radiation and detectors, stellar classification systems, structures and evolution. Pulsars, quasars, black holes. Galaxies, large scale structure of the university, cosmology. **Professor Ragan**

● **198-217B PHYSICS AND THE LIFE SCIENCES.** (3) (3 hours lectures) (Prerequisites: CEGEP Physics or permission of instructor.) (Not open to students who are taking or have taken 198-199B.)

198-224A PHYSICS & PSYCHOPHYSICS OF MUSIC. (3) (3 hours lectures) (Designed for students in the Faculty of Music but suitable for students with an interest in music, and how it is received.) An introduction to physics and psychophysics of music with demonstrations of the relevant phenomena and the theories explaining them. Pitch, loudness and timbre in the context of the physics properties of the human ear. The basic physics of music production including modes of oscillation of mechanical systems, resonance, feedback, transmission and reflection of sound. The human voice. Modern methods of sound production using electrical analogue devices and digital computers. Room reverberation and acoustics. **Professor Hanna**

198-225B MUSICAL ACOUSTICS. (3) (3 hours lectures) (Prerequisites: CEGEP physics or both 189-112 and 198-224A) (Designed for students in music who have interests in sound recording and reproduction and also suitable for students in science with an interest in music.) Physical acoustics with applications to music. Resonators and radiators, acoustic impedance. Acoustic properties of strings, bars, membranes, pipes and horns. Application to selected musical instruments. Direction characteristics of sound sources. Room acoustics. **Professor Grant**

198-230A DYNAMICS OF SIMPLE SYSTEMS. (3) (3 hours lectures) (Prerequisite: CEGEP physics. Corequisite: Mathematics 189-222A) (Not open to students taking or having passed 198-251A.) Translational motion under Newton's laws; forces, momentum, work/energy theorem. Special relativity; Lorentz transforms, relativistic mechanics, mass/energy equivalence. Topics in rotational dynamics. Noninertial frames. **Professor Gale**

198-232B HEAT AND WAVES. (3) (3 hours lectures) (Prerequisite: 198-230A) (Not open to students taking or having passed 198-253B.) First and second laws of thermodynamics, kinetic theory of gases, optical interference, polarization, electro-optics, physics of microscopic systems. **Professor Mark**

198-240B COMPUTERS FOR PHYSICS. (3) (2 hours lectures, 3 hours laboratory) (Prerequisite 198-230A or 198-251A) (Restricted to students in first year Honours and Majors physics or by permission of instructor.)The course will extend and consolidate previous knowledge of mechanics and general physics by introducing and applying techniques for data analysis, numerical computation and simulation. Included will be an introduction to local facilities, a programming language and computer graphics. **Professor Harris**

198-241B SIGNAL PROCESSING. (3) (2 hours lectures; 3 hours laboratory alternate weeks) (Prerequisite: CEGEP physics) Linear circuit elements, resonance, network theorems, diodes, transistors, amplifiers, feedback, integrated circuits. **Professor Lee**

198-242B ELECTRICITY & MAGNETISM. (2) (2 hours lectures) (Prerequisites CEGEP Physics, 189-222A,B) Properties of electromagnetic fields, dipole and quadropole fields and their interactions, chemical binding of molecules, electromagnetic properties of materials, Maxwell's equations and properties of electromagnetic waves, propagation of waves in media. **Dr. Altounian**

198-251A CLASSICAL MECHANICS I. (3) (3 hours lectures) (Prerequisite: CEGEP physics. Corequisite: 189-222A) (Not open to student taking or having taken 198-230A.) Newton's laws, work and energy, angular momentum. Harmonic oscillator, forced oscillations. Inertial forces, rotating frames. Central forces, centre of mass, planetary orbits, Kepler's laws. **Professor Hanna**

198-253B THERMAL PHYSICS. (3) (3 hours lectures) (Prerequisite: CEGEP physics. Corequisite: 189-222A,B) (Not open to students taking or having taken 198-232B.) Energy, work, heat; first law. Temperature, entropy; second law. Absolute zero; third law. Equilibrium, equations of state, gases, liquids, solids, magnets; phase transitions. **Professor Guo**

198-259D LAB IN MECHANICS, HEAT & OPTICS. (3) (3 hours) (Prerequisite: CEGEP physics. Corequisite: 198-230A or 198-251A and 198-232B or 198-253B.) Illustrative experiments on topics in mechanics, heat and optics; a project. **Professors Lee, Muir and Dr. Buchinger**

198-260A RELATIVITY AND MODERN PHYSICS. (3) (3 hours lectures. Corequisite: 189-222A.) History of special relativity; Lorentz transformations: kinematics and dynamics; transformation of electric and magnetic forces; introduction to topics in modern physics. **Professor Lam**

198-328A ELECTRONICS. (3) (2 hours lectures; 3 hours laboratory) Semiconductor devices, basic transistor circuits, operational amplifiers, combinatorial and sequential logic, integrated circuits, analogue to digital converters. The laboratory component covers design, construction and testing of basic electronic circuits. **Professor Crawford**

198-331B MECHANICS. (3) (3 hours lectures) (Prerequisite: 198-230A. Corequisite: 189-315A,B) (Not open to students having passed 198-451A.) Forced and damped oscillators, Newtonian mechanics in three dimensions, rotational motion, Lagrangian mechanics, small vibrations, normal modes. Introduction to Hamiltonian mechanics. **Professor David Ryan**

198-332B PHYSICS OF FLUIDS. (3) (3 hours lectures) (Prerequisites: 198-230A, 189-223A, 189-314B, 189-315B) The physical properties of fluids. The kinematics and dynamics of flow. The effects of viscosity and turbulence. Applications of fluid mechanics in biophysics, geophysics and engineering. **Professor Lovejoy**

198-333B THERMAL & STATISTICAL PHYSICS. (3) (3 hours lectures) (Prerequisite:198-232B) (Not open to students taking or having

passed 198-362B.) Introductory equilibrium statistical mechanics. Quantum states, probabilities, ensemble averages. Entropy, temperature, Boltzmann factor, chemical potential. Photons and phonons. Fermi-Dirac and Bose-Einstein distributions; applications.
Professor Strom-Olsen

198-339B MEASUREMENTS LABORATORY. (3) (6 hours) (Prerequisite: 198-241B) Introduction to modern techniques of measurement. The use of computers in performing and analysing experiments. Data reduction, statistical methods, report writing. Extensive use of computers is made in this laboratory; therefore some familiarity with computers and computing is an advantage.
Professor Grutter and Dr. Buchinger

198-340A ELECTRICITY AND MAGNETISM. (3) (3 hours lectures) (Prerequisites: CEGEP physics, Mathematics 189-222A,B, 189-223A,B. Corequisites: 189-314A, 189-315A or equivalent. Not open to students who have passed 198-242A,B or 198-350B.) The electrostatic field and scalar potential. Dielectric properties of matter. Energy in the electrostatic field. Methods for solving problems in electrostatics. The magnetic field. Induction and inductance. Energy in the magnetic field. Magnetic properties of matter. Maxwell's equations. A vector treatment. **Professor Stairs**

198-342B ELECTROMAGNETIC WAVES. (3) (3 hours lectures) (Prerequisites: 198-340A or 198-242A,B, Mathematics 189-314A,B, 189-315A,B) (Not open to students having passed 304-357A.) Maxwell's equations. The wave equation. The electromagnetic wave, reflection, refraction, polarization. Guided waves. Transmission lines and wave guides. Vector potential. Radiation. The elemental dipole; the half-wave dipole; vertical dipole; folded dipoles; Yagi antennas. Accelerating charged particles. **Professor Patel**

198-350A ELECTROMAGNETISM. (3) (3 hours lectures) (Prerequisites: 189-248A,B, 189-325B. Honours students, or permission of the instructor.) (Not open to students having taken 198-340A.) Fundamental laws of electric and magnetic fields in both integral and differential form. **Professor Lovejoy**

198-352A ELECTROMAGNETIC WAVES. (3) (3 hours lectures) (Prerequisite: 198-350A. Honours students, or permission of the instructor.) Vector and scalar potentials; plane waves in homogeneous media; refraction and reflection; guided waves; radiation from simple systems; dipole and quadrupole radiation; introduction to fields of moving charges; synchrotron radiation; Bremsstrahlung. **Professor Trischuk**

K198-357A QUANTUM PHYSICS I. (3) (3 hours lectures) (Honours students or permission of instructor.) (Not open to students taking or having passed 198-446A.) Experimental basis for quantum mechanics; wave-packets; uncertainty principle. Hilbert space formalism. Schrodinger equation: eigenvalues and eigenvectors: applications to 1-d problems including the infinite and finite potential wells and the harmonic oscillator. Tunneling. Time independent perturbation theory. **Professor Myers**

198-359B LABORATORY IN MODERN PHYSICS. (3) (6 hours) (Prerequisite: 198-328A. Corequisite: 198-457B. Honours students or permission of instructor.) Advanced level experiments in modern physics stressing quantum effects and some properties of condensed matter. **Professor D.H. Ryan and Dr. Buchinger**

198-362B STATISTICAL MECHANICS. (3) (3 hours lectures) (Prerequisites: 189-248B or equivalents, 198-253B. Honours students, or permission of the instructor.) (Not open to students taking or having taken 198-333B.) Quantum states and ensemble averages. Fermi-Dirac, Bose-Einstein and Boltzmann distribution functions and their applications. **Professor Zuckermann**

★198-413A THE PHYSICAL BASIS OF PHYSIOLOGY. (3) (3 hours lectures) (Prerequisite: 189-315A,B, or 189-325B, and permission of the instructor.) (Intended for Major or Honours students in Physics, Physiology, Physiology and Physics, or Mathematics and others with permission.) Analytic and computer simulation techniques are used to examine the role of nonlinearities and time delays in determining the dynamic behaviour of physiological control systems and their relation to normal and pathophysiological states. Examples drawn from the control of respiration, cellular proliferation and differentiation, biochemical feedback networks, thermoregulatory mechanisms, and neural feedback.
Professor Mackey

198-434B OPTICS. (3) (3 hours lectures) Geometrical optics, wave optics, lasers, Fourier transform spectroscopy, holography, optical data processing, stellar interferometry. **Professor Trischuk**

198-436B MODERN PHYSICS. (3) (3 hours lectures) (Prerequisite: 198-446A) (Not open to students in Honours Physics or in Joint Honours in Mathematics and Physics.) One electron atoms, radiation, multielectron atoms, molecular bonds. Selected topics from condensed matter, nuclear and elementary particle physics.
Professor Patel

198-439A LABORATORY IN MODERN PHYSICS. (3) (6 hours) (Prerequisite: 198-339B. Corequisite: 198-446A.) (Not open to students with credit in 198-359B except with permission of instructor.) Advanced level experiments in modern physics stressing quantum effects and some properties of condensed matter.
Professor Barrette and Dr. Buchinger

198-446A QUANTUM PHYSICS. (3) (3 hours lectures) (Prerequisite: 198-230A and 198-232B, or 198-251A) (Not open to students taking or having taken 198-357A or 198-457B.) de Broglie waves, Bohr atom. Schroedinger equation, wave functions, observables. One dimensional potentials. Schroedinger equation in three dimensions. Angular momentum, hydrogen atom. Spin, experimental consequences. **Professor de Takacsy**

198-449B PROJECT LABORATORY. (3) (6 hours) (Prerequisite: 198-328A, 198-439A) Supervised project work in an area related to material covered in upper year courses. **Professor Moore and Dr. Buchinger**

198-451B CLASSICAL MECHANICS. (3) (3 hours lectures) (Prerequisite: 198-251A. Honours students, or permission of instructor.) (Not open to students having taken 198-331B.) Rigid bodies, angular momentum, gyroscope, moment of inertia, principal axes, Euler's equations. Coupled oscillations and normal modes. Lagrangian mechanics and applications. Hamiltonian mechanics. Topics in advanced analytical mechanics.
Professor Strom-Olsen

198-457B QUANTUM PHYSICS II. (3) (3 hours lectures) (Honours students or permission of instructor.) (Not open to students having taken 198-446A.) Angular momentum and spin operators. Operator methods in quantum mechanics. Coupling of spin and angular momenta. Variational principles and elements of time dependent perturbation theory (the Golden Rule). Solution of the Schrodinger equation in three dimensions. Applications to the hydrogen and helium atoms and to simple problems in atomic and molecular physics. **Professor Cline**

198-459D HONOURS RESEARCH PROJECT. (6) (6 hours) (Honours students or permission of instructor.) (Not open to students taking the sequence 198-469A/198-479B.) An experimental project, supervised by members of staff, on some topic related to the ongoing research in the department. **Professor David Ryan and Dr. Buchinger**

198-469A LAB IN MODERN PHYSICS II. (3) (6 hours) (Honours students, or permission of instructor) (Prerequisite: 198-359B) (Not open to students taking 198-459D.) Advanced level experiments in modern physics stressing quantum effects and some properties of condensed matter. Continuation of 198-359B.
Professor Sutton and Dr. Buchinger

198-479B HONOURS PROJECT LAB. (3) (6 hours) (Honours students, or permission of instructor) (Prerequisite 198-469A) (Not open to students taking 198-459D.) Supervised project work in an area related to material covered in upper year courses.
Professor David Ryan and Dr. Buchinger

198-514B GENERAL RELATIVITY. (3) (3 hours lectures) (Honours students, or permission of the instructor.) Transition from special to general relativity. Non-Euclidian geometry. The basic laws of Physics in co-variant form, Einstein's equations. Gravitational waves; neutron stars; black holes; cosmology. **Professor Myers**

198-551A QUANTUM THEORY. (3) (3 hours lectures) (Honours students, or permission of the instructor.) General formulation, scattering theory, WKBJ approximation, time-dependent perturbation, theory and applications, angular momentum, relativistic wave equations. **Professor Gale**

198-557A NUCLEAR PHYSICS. (3) (3 hours lectures) (Honours students, or permission of the instructor.) General nuclear properties, nucleon-nucleon interaction and scattering theory, radioactivity, nuclear models, nuclear reactions. **Professor Mark**

198-558A SOLID STATE PHYSICS. (3) (3 hours lectures) (Honours students, or permission of the instructor.) Properties of crystals, lattice vibrations and thermal properties of insulators, free electron model and band structure, semi-conductors, metals, optical properties. **Professor D.H. Ryan**

198-559A ADVANCED STATISTICAL MECHANICS. (3) (3 hours lectures) (Honours students, or permission of the instructor.) Self averaging and central-limit theorem; thermodynamic fluctuations; ensemble theory; surface roughening; broken symmetry and Goldstone's theorem; phase transitions; mean-field, Landau and Ornstein-Zernicke theory; Monte Carlo method; molecular dynamics; scaling; renormalization group; epsilon expansion; non-equilibrium theory. **Professor Grant**

198-562B ELECTROMAGNETIC THEORY. (3) (3 hours lectures) (Honours students, or permission of the instructor.) Electrostatics, dielectrics, magnetostatics, timevarying fields, relativity, radiating systems, fields of moving charges. **Professor De Takacsy**

198-567B PARTICLE PHYSICS. (3) (3 hours lectures) (Honours students, or permission of the instructor.) Survey of elementary particles; hadrons, leptons and hardrons' constituents (quarks). Invariance principles and conservation laws. Detectors and accelerators. Phenomenology of strong, electomagnetic and weak interactions. **Professor Stairs**

11.25 Physiology (552)

McIntyre Medical Sciences Building, Room 1021
3655 Drummond Street
Montreal, QC H3G 1Y6
Telephone: (514) 398-4316
Fax: (514) 398-7452
Website: http://www.physio.mcgill.ca

Chair — Alvin Shrier

Emeritus Professor
G. Melvill Jones; B.A., M.A., M.B., B.Ch., M.D.(Cantab.)

Professors
Catherine Bushnell; B.A.(Maryland), Ph.D.(American U.) (*Harold Griffith Professor of Anaesthesia) (joint appt. with Dentistry)*
Thomas M.S. Chang; B.Sc., M.D., C.M., Ph.D.(McG.), F.R.C.P.(C)
Monroe W. Cohen; B.Sc., Ph.D.(McG.)
Ellis J. Cooper; B.Eng.(Sir G.Wms.), M.Sc.(Surrey), Ph.D.(McM.)
Mony M. Frojmovic; B.Sc., Ph.D.(McG.)
Leon Glass; B.S.(Brooklyn), Ph.D.(Chic.)
Phil Gold; C.C., B.Sc., M.Sc., Ph.D., M.D.,C.M.(McG.), F.R.C.P.(C.), F.R.S.C. *(joint appt. with Medicine)*
David Goltzman; B.Sc., M.D.,C.M.(McG.) *(Antoine G. Massabki Professor of Medicine) (joint appt. with Medicine)*
John Hanrahan; Ph.D.(U.B.C.)
James L. Henry; B.Sc.(Tor.), M.Sc., Ph.D.(W.Ont.)
Robert E. Kearney; B.Eng., M.Eng., Ph.D.(McG.) *(joint appt. with Biomedical Engineering)*
Kresmir Krnjevic; O.C., B.Sc., Ph.D., M.B., Ch.B.(Edin.), F.R.S.C. *(joint appt. with Anaesthesia Research)*
Wayne S. Lapp; M.S.A.(Tor.), Ph.D.(McG.)
Mortimer Levy; B.Sc., M.D., C.M.(McG.), F.R.C.P.(C) *(joint appt. with Medicine)*
Michael Mackey; B.A., Ph.D.(Wash.)
Jacapo P. Mortola; M.D.(Milan)
Premsyl Ponka; M.D., Ph.D.(Prague)
Alvin Shrier; B.Sc.(C'dia), Ph.D.(Dal.) *(Hosmer Professor of Physiology)*
Douglas G.D. Watt; M.D., Ph.D.(McG.)

Associate Professors
Riaz Farookhi; B.Sc., M.Sc.(M.I.T.), Ph.D.(Tufts)
Mladen Glavinovic; B.Sc.(Zagreb), M.Sc.(Tor.), Ph.D.(McG.) *(joint appt. with Anaesthesia Research)*
Michael Guevara; B.Sc., M.Eng., Ph.D.(McG.)
Sheldon Magder; M.D.(Tor.) *(joint appt. with Medicine)*
John Orlowski; B.Sc.(McG.), M.Sc., Ph.D.(Queen's)
Teresa Trippenbach; M.D., Ph.D.(Warsaw)
Ann Wechsler; B.A.(Tor.), M.Sc., Ph.D.(McG.)
Peter Weldon; B.Sc., Ph.D.(McG.)
John White; B.Sc., M.Sc.(Car.), Ph.D.(Harv.)

Assistant Professors
Kathleen Cullen; B.Sc.(Brown), Ph.D.(Chicago
Rajender Sipehia; B.Sc.(Punjab), Ph.D.(C'dia)
Ursula Stochaj; Ph.D.(Cologne)

Lecturer
Jennifer Day; B.Eng., M.Eng.(McG.),

Associate Members
Anaesthesia: Steven Blackman;
Dentistry: James Lund;
Medicine: Albert Aguayo, Jason Bates, Andrey Cybulsky, Samuel O. Freedman, Abraham Fuks, Claude Gagnon, Raymonde Gagnon, Harry Goldsmith, Geoffrey Hendy, Gitte Jensen, Max Katz, Peter Macklem, James Martin, Shree Mulay, Mariana Newkirk, Barry Posner, Shafaat Rabbani, Ian Shrier, J. Enrique Silva, Alan Sniderman, Mary Stevenson, Simon Wing, Hans Zingg;
Neurology & Neurosurgery: Massimo Avoli, Charles Bourque, Sal T. Carbonetto, Pierre Drapeau, Daniel Guitton, Michael Rasminsky;
Otolaryngology: Bernard Segal;
Pediatrics: Immanuela Moss;
Physical & Occupational Therapy: Christina Hui-Chan;
Psychiatry: Bernardo Dubrovsky, Christina Gianoulakis; Univ. of Montreal, Medicine: Alex Grassino

Adjunct Professors
Edgar Delvin, Montreal
John Milton, Chicago
Serge Rossignol, Montreal
Malmur R.I. Sairam, Montreal

Physiology has its roots in many of the basic sciences including biology, chemistry, mathematics, and physics. Physiology overlaps with other biomedical sciences such as anatomy, biochemistry, pathology and pharmacology, and with psychology and biomedical engineering, and is one of the prime contributors of basic scientific knowledge to the clinical medical sciences.

Members of the Department of Physiology at McGill are engaged in studies dealing with molecules, single cells, or entire systems in a variety of vertebrates, including man. A wide range of interest and expertise is represented, including cardiovascular, respiratory, gastrointestinal and renal physiology, the physiology of exercise, neurophysiology, endocrinology, immunology, biophysics and biomathematics. Some faculty members have formal or informal links with the departments of mathematics, physics, electrical engineering, chemistry and clinical departments (medicine, surgery, pediatrics, neurology, obstetrics, psychiatry, anesthesia), reflecting and reinforcing the close ties between physiology and other disciplines.

Graduates at the B.Sc. level have found rewarding careers in teaching, in secondary schools and CEGEPs, government service, and laboratory technical assistance, such as in pharmaceutical houses, hospitals, and institutions of higher learning. Moreover, physiology provides an excellent background for medicine, dentistry or other postgraduate work, in such fields as physiology, experimental medicine, pharmacology, biochemistry or physiological psychology.