MIT Course Catalogue 2007–2008

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Bachelor of Science Degree Requirements

General Institute Requirements (GIRs)	Subjects
Science Requirement: Chemistry (3.091, 5.111, or 5.112) Physics (8.01, 8.011, 8.012, or 8.01L; and 8.02, 8.022) Calculus (18.01, 18.01A , 18.014; and 18.02, 18.02A, 18.022, 18.023, or 18.024) Biology (7.012, 7.013, 7.014, or 7.015)	6
Laboratory (LAB) Requirement (12 units)	1
Restricted Electives in Science and Technology (REST) Requirement	2
Humanities, Arts, and Social Sciences Requirement includes 2 Communication Requirement subjects (CI-H)	8
Total GIR Subjects Required for SB Degree	**17**
Physical Education Requirement	
For freshmen entering in the summer of 2001 or later: Communication Requirement, to be satisfied by 4 subjects: 2 Communication-Intensive HASS subjects (CI-H) 2 Communication-Intensive Major subjects (CI-M)[1]	
PLUS Departmental Program and Unrestricted Electives	

The departmental program may specify some of the GIR subjects and includes an additional 180-198[2] units beyond the GIRs. Students track their progress by checking off the subjects that count towards the 17 GIR subjects. The remaining units then count toward the additional 180-198 units beyond the General Institute Requirements. Students are allowed a minimum of 48 units of unrestricted electives. Students schedule their programs each year within a normal load of the equivalent 8 or 8 1/2 subjects, and complete all degree requirements within the equivalent of 32-34 subjects.

Notes

Transfer students generally will graduate under the requirements that apply to the class they join when they enter MIT.

(1) Communication-Intensive Major subjects (CI-M) are designated on the degree charts in Part 2.

(2) The total of 180-198 units does not include ROTC subjects, if elected.

General Inst. Reg.

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Bachelor of Science Degree Requirements

MIT

General Institute Requirements (GIRs)	Subjects
Science Requirement: Chemistry (3.091, 5.111, or 5.112) Physics (8.01, 8.011, 8.012, or 8.01L; and 8.02, 8.022) Calculus (18.01, 18.01A , 18.014; and 18.02, 18.02A, 18.022, 18.023, or 18.024) Biology (7.012, 7.013, 7.014, or 7.015)	6
Laboratory (LAB) Requirement (12 units)	1
Restricted Electives in Science and Technology (REST) Requirement	2
Humanities, Arts, and Social Sciences Requirement includes 2 Communication Requirement subjects (CI-H)	8
Total GIR Subjects Required for SB Degree	**17**
Physical Education Requirement	

For freshmen entering in the summer of 2001 or later:
Communication Requirement, to be satisfied by 4 subjects:
2 Communication-Intensive HASS subjects (CI-H)
2 Communication-Intensive Major subjects (CI-M)[(1)]

PLUS Departmental Program and Unrestricted Electives

The departmental program may specify some of the GIR subjects and includes an additional 180-198[(2)] units beyond the GIRs. Students track their progress by checking off the subjects that count towards the 17 GIR subjects. The remaining units then count toward the additional 180-198 units beyond the General Institute Requirements. Students are allowed a minimum of 48 units of unrestricted electives. Students schedule their programs each year within a normal load of the equivalent 8 or 8 1/2 subjects, and complete all degree requirements within the equivalent of 32-34 subjects.

Notes

Transfer students generally will graduate under the requirements that apply to the class they join when they enter MIT.

[(1)] Communication-Intensive Major subjects (CI-M) are designated on the degree charts in Part 2.

[(2)] The total of 180-198 units does not include ROTC subjects, if elected.

12×6 = 72
Lab 12
REST 24
HASS 72
180

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Bachelor of Science in Mathematics/Course 18

General Institute Requirements (GIRs)	**Subjects**
Science Requirement	**6**
Humanities, Arts, and Social Sciences Requirement	**8**
Restricted Electives in Science and Technology (REST) Requirement [one subject can be satisfied by 18.03 or 18.034 in the Departmental Program]	**2**
Laboratory Requirement	**1**
Total GIR Subjects Required for SB Degree	**17**

Communication Requirement

The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program	**Units**
Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).	
Required Subjects	**132**

18.03 Differential Equations, 12, REST; *18.02**
or
18.034 Differential Equations, 12, REST; *18.02**

Restricted Electives	**96**

To satisfy the requirements that students take two CI-M subjects, students must take two of the following subjects: 18.096, 18.100C, 18.104, 18.304, 18.384, 18.424, 18.434, 18.504, 18.704, 18.784, 18.821, 18.904, or 18.994
or
one from the above list and one of the following subjects: 6.033, 6.111, 8.06, or 18.310C.

General Mathematics Option
Eight 12-unit subjects of different content, including at least six advanced subjects (first decimal digit one or higher).

Applied Mathematics Option
18.310 or **18.310C** Principles of Applied Mathematics, 12; 18.02*
18.311 Principles of Applied Mathematics, 12; 18.03*

One of the following two subjects:
18.04 Complex Variables with Applications, 12; 18.03*
18.112 Functions of a Complex Variable, 12; 18.100

One of the following two subjects:
18.06 Linear Algebra, 12, REST; 18.02*
18.700 Linear Algebra, 12; 18.02

Four additional 12-unit Course 18 subjects from the following two groups with at least one subject from each group:(1)
Group I - Probability and statistics, combinatorics, computer science
Group II - Numerical analysis, physical mathematics, nonlinear dynamics

Theoretical Mathematics Option

18.100B Analysis I, 12; 18.03*
18.701 Algebra I, 12; 18.700*
18.702 Algebra II, 12; 18.701
18.901 Introduction to Topology, 12; 18.100

One of the following subjects:
18.101 Analysis II, 12; 18.100, 18.700*
18.103 Fourier Analysis—Theory and Applications, 12; 18.100

An upper-level mathematics seminar[2] (12 units)
Two additional Course 18 subjects of essentially different content, with the first decimal digit one or higher (24 units)

Departmental Program Units That also Satisfy the GIRs	**(12)**
Unrestricted Electives	**60**
Total Units Beyond the GIRs Required for SB Degree	**180**

No subject can be counted *both* as part of the 17-subject GIRs *and* as part of the 180 units required beyond the GIRs. *Every* subject in the student's departmental program will count toward one or the other, *but not both.*

Notes

*Alternate prerequisites are listed in the subject description.

[1] A list of acceptable subjects is available in Room 2-108.

[2] These seminars are 18.104, 18.504, 18.704, 18.784, 18.904, and 18.994.

For an explanation of credit units, or hours, please refer to the Subject Key in Part 3 of this Bulletin.

See next page

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M

Bachelor of Science in Mathematics with Computer Science/Course 18-C

General Institute Requirements (GIRs)	**Subjects**
Science Requirement	6
Humanities, Arts, and Social Sciences Requirement	8
Restricted Electives in Science and Technology (REST) Requirement [can be satisfied by 18.03 or 18.034 and 6.001 in the Departmental Program]	2
Laboratory Requirement	1
Total GIR Subjects Required for SB Degree	**17**

Communication Requirement

The program includes a Communication Requirement of 4 subjects:
2 subjects designated as Communication Intensive in Humanities, Arts, and Social Sciences (CI-H); and 2 subjects designated as Communication Intensive in the Major (CI-M).

PLUS Departmental Program **Units**

Subject names below are followed by credit units, and by prerequisites, if any (corequisites in italics).

Required Subjects **84-90**

18.03 Differential Equations, 12, REST; *18.02**
or
18.034 Differential Equations, 12, REST; *18.02**

6.001 Structure and Interpretation of Computer Programs, 15, REST
or
6.01 Introduction to EECS I, 12, 1/2 LAB

18.410J Introduction to Algorithms, 12; 6.001, 18.062J*

18.06 Linear Algebra, 12; 18.02*
or
18.700 Linear Algebra, 12; 18.02

84

One subject from each of the following groups:

18.062J Mathematics for Computer Science, 12; 18.01
or
18.310 Principles of Applied Mathematics, 12; 18.02
or
18.310C Principles of Applied Mathematics, 12; 18.02

84
72
48
204

18.400J Automata, Computability, and Complexity, 12; 6.042J
or
18.404J Theory of Computation,(1) 12; 18.062J*

6.033 Computer System Engineering, 12; 6.004
or
6.170 Laboratory in Software Engineering, 15; 6.001

Restricted Electives 6x12=72 **72**

Four additional Course 18 subjects and two additional Course 6 subjects.

The overall program must consist of subjects of essentially different content, and must include at least five Course 18 subjects with first decimal digit one or higher.

To satisfy the requirements that students take two CI-M subjects, students must take two of the following subjects: 18.096, 18.100C, 18.104, 18.304, 18.424, 18.434, 18.504, 18.704, 18.784, 18.821, 18.904, or 18.994

or

one from the above list and one of the following subjects: 6.033, 6.111, 8.06, or 8.310C.

Departmental Program Units That also Satisfy the GIRs	**(27)**
Unrestricted Electives	**48-51**
Total Units Beyond the GIRs Required for SB Degree	**180**

No subject can be counted *both* as part of the 17-subject GIRs *and* as part of the 180 units required beyond the GIRs. *Every* subject in the student's departmental program will count toward one or the other, *but not both*.

Notes

*Alternate prerequisites are listed in the subject description.

(1) Recommended alternative.

For an explanation of credit units, or hours, please refer to the Subject Key in Part 3 of this Bulletin.

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Department of Mathematics

Mathematics provides a language and tools for understanding the physical world around us and the abstract world within us. MIT's Mathematics Department is one of the strongest in the world. It offers a broad spectrum of fields ranging from the traditional areas of pure mathematics, such as analysis, algebra, geometry, and topology, to applied mathematics areas such as combinatorics, computational biology, fluid dynamics, theoretical computer science, and theoretical physics.

The Mathematics Department offers a choice of two undergraduate degrees: a Bachelor of Science in Mathematics and a Bachelor of Science in Mathematics with Computer Science. Undergraduate students may elect one of three options leading to the degree in mathematics: applied mathematics, theoretical mathematics, or general mathematics. The general mathematics option provides a great deal of flexibility and allows students to design their own programs in conjunction with their advisors. The Mathematics with Computer Science degree is offered for students who want to pursue interests in mathematics and theoretical computer science within a single undergraduate program. Nearly 40 percent of the graduating seniors in mathematics are double majors. Popular second majors include computer science, physics, and economics.

There are a variety of opportunities available to our students after graduation. Some students go on to graduate school in mathematics, computer science, and other fields such as medicine, finance, and engineering. Many begin careers in consulting, actuarial science, software engineering, and investment banking.

At the graduate level, the department offers the PhD in mathematics where students learn to conduct original research.

For more information, visit http://www-math.mit.edu/.

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Undergraduate Study

An undergraduate degree in mathematics provides an excellent basis for graduate work in mathematics or computer science, or for employment in such mathematics-related fields as systems analysis, operations research, finance, or actuarial science.

Because the career objectives of undergraduate mathematics majors are diverse, each undergraduate's program is individually arranged through collaboration between the student and his or her faculty advisor. Students are encouraged to explore the various branches of mathematics, both pure and applied.

Undergraduates in mathematics are encouraged to elect an upper-level mathematics seminar during their junior or senior year. The experience gained from active participation in a seminar conducted by a research mathematician is particularly valuable for a student planning to pursue graduate work. These seminars additionally provide training in communicating mathematics effectively.

Bachelor of Science in Mathematics/Course 18
[see degree chart]

General Mathematics Option

This option is the one followed by most students who major in mathematics. In addition to the General Institute Requirements, the requirements consist of 18.03 Differential Equations, or 18.034 Differential Equations, and eight 12-unit subjects in Course 18 of essentially different content, including at least six advanced subjects (first decimal digit one or higher). This leaves available 84 units of unrestricted electives. The requirements are flexible in order to accommodate several categories of students: students who pursue programs that combine mathematics with a related field (such as physics, economics, or management); students who are interested in both theoretical and applied mathematics; and students who choose mathematics as a general Institute major.

Applied Mathematics Option

Applied mathematics is the mathematical study of general scientific concepts, principles, and phenomena that, because of their widespread occurrence and application, relate or unify various disciplines. The core of the program at MIT concerns the following principles and their mathematical formulations: propagation, equilibrium, stability, optimization, computation, statistics, and random processes.

Sophomores interested in applied mathematics typically survey the field by enrolling in 18.310 or 18.310C, and 18.311 Principles of Applied Mathematics. Subjects 18.310 and 18.310C, offered only in the first term, are devoted to the discrete aspects of applied mathematics and may be taken concurrently with 18.03. Subject 18.311, given only in the second term, is devoted to continuous aspects and makes considerable use of differential equations.

The subjects in Group I of the program correspond roughly to those areas of applied mathematics that make heavy use of discrete mathematics, while Group II emphasizes those subjects that deal mainly with continuous processes. Some subjects, such as probability or numerical analysis, have both discrete and continuous aspects.

Students planning to go on to graduate work in applied mathematics also should take some basic subjects in analysis and algebra.

Theoretical Mathematics Option

Theoretical mathematics (or "pure" mathematics) is the study of the basic concepts and structures that underlie the mathematical tools used in science and engineering. Its purpose is to search for a deeper understanding and an expanded knowledge of mathematics itself.

Traditionally, pure mathematics has been classified into three general fields: analysis, which deals with continuous aspects of mathematics; algebra, which deals with discrete aspects; and geometry. The undergraduate program is designed so that students become familiar with each of these areas. Students also may wish to explore other topics such as logic, number theory, complex analysis, and subjects within applied mathematics.

The subject 18.100B Analysis I is basic to the program. Since this subject is strongly proof oriented, many students find an intermediate subject such as 18.06 Linear Algebra or 18.700 Linear Algebra useful as preparation.

The subject 18.701 Algebra I is more advanced and should not be elected until the student has had some experience with proofs (as in 18.100B or 18.700).

Bachelor of Science in Mathematics with Computer Science/Course 18-C

[see degree chart]

Mathematics and computer science are closely related fields. Problems in computer science are often formalized and solved with mathematical methods. It is likely that many important problems currently facing computer scientists will be solved by researchers skilled in algebra, analysis, combinatorics, logic and/or probability theory, as well as computer science.

This program allows students to study a combination of these mathematical areas and potential application areas in computer science. Required subjects include linear algebra (18.06 or 18.700) because it is so broadly used; discrete mathematics (18.062J or 18.310) to give experience with proofs and the necessary tools for analyzing algorithms; and complex systems (6.033 or 6.170) in which mathematical issues may arise. The required subjects covering complexity (18.404J or 18.400J) and algorithms (18.410J) provide an introduction to the most theoretical aspects of computer science.

Some flexibility is allowed in this program. In particular, students may substitute the more advanced subject 18.701 Algebra I for 18.06 and, if they already have strong theorem-proving skills, may substitute 18.314 for 18.062 or 18.310.

Minor Program in Mathematics
The requirements for a Minor in Mathematics are as follows:

Six 12-unit subjects in mathematics, beyond the Institute calculus requirement, of essentially different content, including at least four advanced subjects (first decimal digit one or higher).

For a general description of the minor program, see Undergraduate Education in Part 1.

Inquiries
Inquiries regarding academic programs may be addressed to Joanne Jonsson, Undergraduate Mathematics Office, Room 2-108, MIT, 617-253-2416.

Additionally, the following information sheets are available in Room 2-108 and online at http://www-math.mit.edu/undergraduate/:

What Math Subject Shall I Take?
Careers in Mathematics
Thinking of Majoring in Mathematics?

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Graduate Study

The Mathematics Department offers programs covering a broad range of topics leading to the Doctor of Philosophy and the Doctor of Science degrees. Numerous formal and informal seminars, as well as a joint weekly mathematics colloquium sponsored alternately by MIT, Brandeis, Harvard, and Northeastern, supplement the subject offerings.

Entrance Requirements for Graduate Study
Students are expected to have one year of college-level natural science in addition to an undergraduate mathematics program approximating that of mathematics majors at MIT. Students may enter the applied mathematics program from any undergraduate field of concentration; however, special consideration is given to students with a strong scientific background.

Doctor of Philosophy and Doctor of Science
The Institute requirements for these degrees are given under Graduate Education in Part 1. The details of the departmental requirements are explained on the department's

MIT Subject Listing & Schedule Symbol Definitions

Type

Undergraduate class
Graduate class

Semester

Fall   IAP   Spring   Summer
Click these buttons to add a scheduled subject to your selection.
(only one will show next to the schedule information, depending on the semester)
Click this button in a subject in your selection to remove it.

Offering

Not offered THIS year
Not offered NEXT year
? Not currently listed in the schedule. Check with the instructor for availability.
Can be repeated for credit

Categories (click the icon to find a list of courses that satisfy the requirement)

- Biology
- Calculus 1 and 2
- Chemistry
- HASS (Humanities, Arts, and Social Sciences):
  Elective, Language Option,
- HASS-D Categories 1, 2, 3, 4, and 5
- CI-H CI-H Communication-Intensive HASS
- CI-HW CI-HW Communication-Intensive HASS Writing
- Institute LAB
- Physics 1 and 2
- REST (Restricted Electives in Science and Technology)
- H-LEVEL Grad Credit

Comments and questions to catalog-help@mit.edu URL Updates Form (need certificates)
Registrar's Office Rooms 5-111 and 5-119, 77 Massachusetts Ave, Cambridge, MA 02139-4307

Course 18: Mathematics

General Mathematics

18.01 Calculus

U (,) ∫1dx
Prereq: --
Units: 5-0-7
Credit cannot also be received for 18.014, 18.01A
URL: http://www-math.mit.edu/18.01/
Lecture: *TR1,F2* (2-142) **Recitation:** *MW2* (2-143) ***+final***

Differentiation and integration of functions of one variable, with applications. Informal treatment of limits and continuity. Differentiation: definition, rules, application to graphing, rates, approximations, and extremum problems. Indefinite integration; separable first-order differential equations. Definite integral; fundamental theorem of calculus. Applications of integration to geometry and science. Elementary functions. Techniques of integration. Polar coordinates. L'Hôpital's rule. Improper integrals. Infinite series: geometric, p-harmonic, simple comparison tests, formal power series for some elementary functions.
Fall: *D. S. Jerison*
Spring: *Y. Ostrover*

18.01A Calculus

U () ∫1dx
Prereq: Knowledge of differentiation and elementary integration
Units: 5-0-7
Credit cannot also be received for 18.01, 18.014
URL: http://math.mit.edu/~apm/1801A.html

Six-week review of one-variable calculus, emphasizing material not on the high-school AB syllabus: integration techniques and applications, polar coordinates, improper integrals, infinite series. Prerequisites: one year of high-school calculus or the equivalent, with a score of 4 or 5 on the AB Calculus test (or the AB portion of the BC test, or an equivalent score on a standard international exam), or equivalent college transfer credit, or a passing grade on the first half of the 18.01 advanced standing exam.
A. P. Mattuck

18.014 Calculus with Theory

U (Fall)

Prereq: --
Units: 5-0-7
Credit cannot also be received for 18.01, 18.01A
URL: http://stellar.mit.edu/S/course/18/fa07/18.014/

Covers the same material as 18.01, but at a deeper and more rigorous level. Emphasizes careful reasoning and understanding of proofs. Assumes knowledge of elementary calculus. Topics: axioms for the real numbers; the Riemann integral; limits, theorems on continuous functions; derivatives of functions of one variable; the fundamental theorems of calculus; Taylor's theorem; infinite series, power series, rigorous treatment of the elementary functions.
V. M. Hur

18.02 Calculus

U (Fall, Spring)

Prereq: 18.01
Units: 5-0-7
Credit cannot also be received for 18.022, 18.023, 18.024, 18.02A
URL: http://www-math.mit.edu/18.02/

Lecture: *TR1,F2* (54-100) **Recitation:** *MW9* (2-131) or *MW10* (2-131) or *MW11* (2-139, 2-142) or *MW12* (2-131, 2-142) or *MW1* (2-131, 2-135`) or *MW2* (2-151, 2-135, 4-261) or *MW3* (2-151, 2-135) ***+final***

Calculus of several variables. Vector algebra in 3-space, determinants, matrices. Vector-valued functions of one variable, space motion. Scalar functions of several variables: partial differentiation, gradient, optimization techniques. Double integrals and line integrals in the plane; exact differentials and conservative fields; Green's theorem and applications, triple integrals, line and surface integrals in space, Divergence theorem, Stokes' theorem; applications.
Fall: *D. S. Auroux*
Spring: *G. Staffilani*

18.02A Calculus

U (Fall, IAP, Spring)

Prereq: 18.01A or 18.01
Units: 5-0-7
Credit cannot also be received for 18.02, 18.022, 18.023, 18.024
URL: http://math.mit.edu/~mahlburg/07-1802A.html

Lecture: *TR1,F2* (4-159) **Recitation:** *MW2* (2-142)

First half is taught during the last six weeks of the Fall term; covers material in the first half of 18.02 (through double integrals). Second half of 18.02A can be taken either during IAP (daily lectures) or during the first half of the Spring term; it covers the remaining material in 18.02.
A. P. Mattuck

18.022 Calculus

MIT 2007-08

U (fall) (REST)
Prereq: 18.01
Units: 5-0-7
Credit cannot also be received for 18.02, 18.023, 18.024, 18.02A
URL: http://www-math.mit.edu/18.022/

Calculus of several variables. Topics as in 18.02 but with more focus on mathematical concepts. Vector algebra, dot product, matrices, determinant. Functions of several variables, continuity, differentiability, derivative. Parametrized curves, arc length, curvature, torsion. Vector fields, gradient, curl, divergence. Multiple integrals, change of variables, line integrals, surface integrals. Manifolds with boundary, Stokes' theorem in one, two, and three dimensions.
L. Hesselholt

18.023 Calculus with Applications

U (fall) (REST)
Prereq: 18.01
Units: 5-0-7
Credit cannot also be received for 18.02, 18.022, 18.024, 18.02A

Calculus of several variables, emphasizing applications. Vector algebra, partial differentiation, multiple integrals, and vector calculus. Asymptotic and numerical methods.
D. J. Benney

18.024 Calculus with Theory

U (spring) (REST)
Prereq: 18.014
Units: 5-0-7
Credit cannot also be received for 18.02, 18.022, 18.023, 18.02A
URL: http://stellar.mit.edu/S/course/18/sp08/18.024/index.html
Lecture: *TR1,F2* (2-143) **Recitation:** *MW2* (4-146) ***+final***

Continues 18.014. Parallel to 18.02, but at a deeper level, emphasizing careful reasoning and understanding of proofs. Considerable emphasis on linear algebra and vector integral calculus.
V. M. Hur

18.03 Differential Equations

U (fall, spring, summer) R
Prereq: *18.02, 18.02A, 18.022, 18.023, or 18.024*
Units: 5-0-7
Credit cannot also be received for 18.034
URL: http://math.mit.edu/~apm/1803.html
Lecture: *MWF1* (34-101) or *MWF2* (34-101) **6 Recitation Times: (Scheduled REG Day)** ***+final***

Study of ODE's, including modeling physical systems. Solution of first-order ODE's by analytical, graphical and numerical methods. Linear ODE's, primarily second order with constant coefficients.

Complex numbers and exponentials. Inhomogeneous equations: polynomial, sinusoidal and exponential inputs. Oscillations, damping, resonance. Fourier series inputs; resonant terms. Laplace transform methods; convolution and delta function. Matrix methods for first order linear systems: eigenvalues and eigenvectors, matrix exponentials, variation of parameters. Non-linear autonomous systems: critical point analysis, phase plane diagrams, applications to modeling.
Fall: *A. Toomre*
Spring: *H. R. Miller*

18.034 Differential Equations

U ( ) R
Prereq: *18.02, 18.02A, 18.022, 18.023, or 18.024*
Units: 5-0-7
Credit cannot also be received for 18.03
Lecture: *MWF1* (2-136) **Recitation:** *TR11* (2-105) or *MW3* (2-139) ***+final***

Covers much of the same material as 18.03 with more emphasis on theory. The point of view is rigorous and results are proven. Local existence and uniqueness of solutions. First order equations, separation, initial value problems. Systems, linear equations, independence of solutions, undetermined coefficients. Singular points and periodic orbits of planar systems.
Y. Hur

18.04 Complex Variables with Applications

U ( )
Prereq: 18.02; 18.03 or 18.034
Units: 4-0-8
Credit cannot also be received for 18.075
URL: http://math.mit.edu/18.04/
Lecture: *MWF12* (2-190) **Recitation:** *W2* (2-131) or *W3* (2-131) or *R3* (2-132) ***+final***

Complex algebra and functions; analyticity; contour integration, Cauchy's theorem; singularities, Taylor and Laurent series; residues, evaluation of integrals; multivalued functions, potential theory in two dimensions; Fourier analysis and Laplace transforms.
A. Toomre

18.05 Introduction to Probability and Statistics

U ( ) R
Prereq: 18.01
Units: 3-0-9
Credit cannot also be received for 6.041
URL: http://math.mit.edu/~pak/courses/1805.htm
Lecture: *MWF10* (2-139)

Elementary introduction with applications. Basic probability models. Combinatorics. Random variables. Discrete and continuous probability distributions. Statistical estimation and testing. Confidence intervals. Introduction to linear regression.

D. Gutfreund

18.06 Linear Algebra

U (Fall, Spring, Summer) R
Prereq: 18.02
Units: 4-0-8
Credit cannot also be received for 18.700
URL: http://web.mit.edu/18.06/www/
Lecture: *MWF11* (54-100) **Recitation:** *M2* (2-131, 4-149) or *M3* (2-131, 2-132) or *T11* (2-132, 8-205) or *T12* (2-132, 8-205, 26-142) or *T1* (2-132, 26-142, 26-168) or *T2* (2-132, 26-168) ***+final***

Basic subject on matrix theory and linear algebra, emphasizing topics useful in other disciplines, including systems of equations, vector spaces, determinants, eigenvalues, singular value decomposition, and positive definite matrices. Applications to least-squares approximations, stability of differential equations, networks, Fourier transforms, and Markov processes. Uses MATLAB. Compared with 18.700, more emphasis on matrix algorithms and many applications.
Fall: *S. G. Johnson*
Spring: *G. Strang*

18.062J Mathematics for Computer Science

U (Fall, Spring) R
(Same subject as 6.042J)
Prereq: 18.01
Units: 5-0-7
URL: http://theory.csail.mit.edu/classes/6.042
Lecture: *MWF9.30-11* (26-152) ***+final***

Elementary discrete mathematics for computer science and engineering. Emphasis on mathematical definitions and proofs as well as on applicable methods. Topics: formal logic notation, proof methods; induction, well-ordering; sets, relations; elementary graph theory; integer congruences; asymptotic notation and growth of functions; permutations and combinations, counting principles; discrete probability. Further selected topics such as: recursive definition and structural induction; state machines and invariants; recurrences; generating functions.
A. R. Meyer, T. Leighton

18.075 Advanced Calculus for Engineers

G (Fall, Spring) H (H except 2, 6, 8, 12, 13, 16, 18, 22)
Prereq: 18.02, 18.03
Units: 3-0-9
Credit cannot also be received for 18.04
Lecture: *MW2-3.30* (4-265)

Functions of a complex variable; calculus of residues. Ordinary differential equations; Bessel and Legendre functions; Sturm-Liouville theory; partial differential equations.
Fall: *M. Hancock*

Spring: *D. J. Benney*

18.085 Computational Science and Engineering I

Ⓖ (, ,) Ⓗ
Prereq: 18.02; 18.03 or 18.034
Units: 3-0-9
URL: http://www-math.mit.edu/~kasimov/teaching/18.085.html
Lecture: *MWF12* (4-370)

Review of linear algebra, applications to networks, structures, and estimation, finite difference and finite element solution of differential equations, Laplace's equation and potential flow, boundary-value problems, Fourier series, discrete Fourier transform, convolution. Frequent use of MATLAB in a wide range of scientific and engineering applications.
Fall: *G. Strang*
Spring: *A. R. Kasimov*

18.086 Computational Science and Engineering II

Ⓖ ( ) Ⓗ
Prereq: 18.02; 18.03 or 18.034
Units: 3-0-9
URL: http://math.mit.edu/18086/
Lecture: *MWF1* (2-132)

Scientific computing: Fast solvers for finite difference equations, finite elements, spectral method, and multigrid. Initial-value problems: stable methods for the wave equation and heat equation and Maxwell's equations, conservation laws and shocks, dissipation and dispersion. Optimization: network flows, KKT conditions. Includes computational projects.
B. Seibold

18.089 Review of Mathematics

Ⓖ ( )
Prereq: --
Units arranged

One-week review of one-variable calculus (18.01), followed by concentrated study covering multivariable calculus (18.02), two hours per day for five weeks. Primarily for graduate students in Course 2N. Degree credit allowed only in special circumstances.
Information: A. P. Mattuck

18.094J Teaching College-Level Science

Ⓖ ( )
(Same subject as 5.95J, 7.59J, 8.395J)
Prereq: --
Units: 2-0-2 [P/D/F]

Participatory seminar focuses on the knowledge and skills necessary for teaching science in higher education. Topics include: theories of adult learning; course development; promoting active learning, problem solving, and critical thinking in students; communicating with a diverse student body; using educational technology to further learning; lecturing; creating effective tests and assignments; and assessment and evaluation. Students research and present a relevant topic of particular interest. Subject is appropriate for both novices and those with teaching experience.
L. Breslow

18.095 Mathematics Lecture Series

Prereq: 18.01
Units: 2-0-4 [P/D/F]
URL: http://www-math.mit.edu/~davis/18.095.html

Ten lectures by mathematics faculty members on interesting topics from both classical and modern mathematics. All lectures accessible to students with calculus background and an interest in mathematics. At each lecture, reading and exercises are assigned. Students prepare these for discussion in a weekly problem session.
Information: H.R. Miller

18.096 Principles of Mathematics Presentation

Prereq: --
Units: 2-1-6
Lecture: *MW1* (2-139)

Instruction in preparing and presenting professional papers in mathematics, including a tutorial providing individual guidance in editing and formatting a paper to make it suitable for publication in MIT's Undergraduate Journal of Mathematics. Students lecture on their papers and on topics of their choice, and write reviews of each other's lectures. Students must come with a draft containing an adequate amount of technical mathematics, such as a term paper or a research report. Enrollment limited, with preference given to senior Mathematics majors.
S. Kleiman

18.098 Independent Activities

Prereq: --
Units arranged [P/D/F]

Studies or special individual reading arranged in consultation with individual faculty members and subject to departmental approval.
Information: H. R. Miller

18.099 Independent Activities

Prereq: --
Units arranged
TBA.

Studies (during IAP) or special individual reading (during regular terms). Arranged in consultation with individual faculty members and subject to departmental approval.
Information: H. R. Miller

Analysis

18.100 Analysis I

(H except 18)
Prereq: 18.02; 18.03 or 18.034
Units: 3-0-9
URL: http://www-math.mit.edu/18.100/
18.100A: Lecture: *MWF11* (2-131) ***+final***
18.100B: Lecture: *TR9.30-11* (4-163) or *MWF1* (4-163) ***+final***

Three options offered, each covering fundamentals of mathematical analysis: convergence of sequences and series, continuity, differentiability, Riemann integral, sequences and series of functions, uniformity, interchange of limit operations. Each option shows the utility of abstract concepts and teaches understanding and construction of proofs. *Option A* chooses less abstract definitions and proofs, and gives applications where possible. *Option B* is more demanding and is for students with more mathematical maturity; it places more emphasis on point-set topology and n-space, whereas Option A is concerned primarily with the real line. *Option C* is a 15-unit (4-0-11) variant of Option B, with further instruction and practice in written and oral communication.
18.100A: Information: A. P. Mattuck 18.100B: Information: R. B. Melrose 18.100C: Information: H. R. Miller

18.101 Analysis II

(H except 18)
Prereq: 18.100; 18.700 or 18.701
Units: 3-0-9
URL: http://www-math.mit.edu/~jeffv/18.101.html

Introduction to the theory of manifolds: vector fields and densities on manifolds, integral calculus in the manifold setting and the manifold version of the divergence theorem. 18.901 helpful but not required.
B.D. Parker

18.102 Introduction to Functional Analysis (New)

H-LEVEL Grad Credit (except for Course 18 students)
Prereq: 18.100; 18.06, 18.700, or 18.701
Units: 3-0-9

Normed spaces, completeness, functionals, Hahn-Banach theorem, duality, operators. Lebesgue measure, measurable functions, integrability, completeness of L-p spaces. Hilbert space. Compact, Hilbert-Schmidt and trace class operators. Spectral theorem.
R. B. Melrose

18.103 Fourier Analysis-Theory and Applications

(H except 18)
Prereq: 18.100
Units: 3-0-9
URL: http://math.mit.edu/%7Ejeffv/18.103.S05.html
Lecture: *TR11-12.30* (4-163) ***+final***

Continues 18.100. Roughly half the subject devoted to the theory of the Lebesgue integral with applications to probability, and half to Fourier series and Fourier integrals.
D. S. Jerison

18.104 Seminar in Analysis

Prereq: 18.100
Units: 3-0-9
URL: http://math.mit.edu/~ciubo/18104/
Lecture: *MWF2* (2-136)

Seminar for Mathematics majors. Students present and discuss subject matter taken from current journals or books. Topics vary from year to year. Topic for spring 2008: Problem solving in analysis. Instruction and practice in written and oral communication provided. Enrollment limited.
T.S. Mrowka

18.112 Functions of a Complex Variable

(H except 18)
Prereq: 18.100B, 18.100C or 18.901
Units: 3-0-9

The basic properties of functions of one complex variable. Cauchy's theorem, holomorphic and meromorphic functions, residues, contour integrals, conformal mapping. Infinite series and products, the Gamma function, the Mittag-Leffler theorem. Harmonic functions, Dirichlet's problem. The Riemann mapping theorem. The Riemann Zeta function. The Prime Number Theorem.
S. Helgason

18.116 Riemann Surfaces

Prereq: 18.112
Units: 3-0-9

Lecture: *TR1-2.30* (36-144)

Riemann surfaces, uniformization, Riemann-Roch Theorem. Theory of elliptic functions and modular forms. Some applications, such as to number theory.
M. E. Gualtieri

18.117 Topics in Several Complex Variables

G (*) H
Prereq: 18.112, 18.965
Units: 3-0-9

Harmonic theory on complex manifolds, Hodge decomposition theorem, Hard Lefschetz theorem. Vanishing theorems. Theory of Stein manifolds. As time permits students also study holomorphic vector bundles on K\"ahler manifolds.
T. S. Mrowka

18.125 Real and Functional Analysis

G (*) H
Prereq: 18.100
Units: 3-0-9
URL: http://www-math.mit.edu/~tkemp/18.125/
Lecture: *TR11-12.30* (2-135) ***+final***

Introductions to set theory and general topology as needed in analysis. Measure and integration on general spaces. Introduction to functional analysis, Banach and Hilbert spaces.
T. Kemp

18.135 Geometric Analysis

G (*) H
Prereq: 18.125
Units: 3-0-9
Lecture: *TR1-2.30* (2-135)

Harmonic analysis in Euclidean space. The Radon transform, its operational properties and its applications to differential equations, particularly the wave equation. The d-plane transform. Non-Euclidean Fourier analysis and potential theory. Eigenfunctions and hyperfunctions.
S. Helgason

18.152 Introduction to Partial Differential Equations

U (*) (H except 18)
Prereq: 18.100
Units: 3-0-9
URL: http://math.mit.edu/%7Egigliola/152.html

Initial and boundary value problems for the wave and heat equation, including an introduction to Fourier analysis and tempered distributions. Laplace's equation, Dirichlet problem, and potential theory. Method of characteristics for first-order partial differential equations. Schroedinger's equation and eigenfunction expansions. Introductory examples of nonlinear partial differential equations.
R.-E. Lenzmann

18.155 Differential Analysis

Prereq: 18.103
Units: 3-0-9
URL: http://www-math.mit.edu/~rbm/18.155-F04.html

18.156 Differential Analysis

Prereq: 18.155
Units: 3-0-9
Lecture: *TR11-12.30* (2-255)

Fall: Review of Lebesgue integration. L^p spaces. Distributions. Fourier transform. Sobolev spaces. Spectral theorem, discrete and continuous spectrum. Homogeneous distributions. Fundamental solutions for elliptic, hyperbolic and parabolic differential operators. Spring: Variable coefficient elliptic, parabolic and hyperbolic partial differential equations.
Fall: *K. Wehrheim*
Spring: *R. B. Melrose*

18.157 Introduction to Microlocal Analysis

Prereq: 18.155
Units: 3-0-9

The semi-classical theory of partial differential equations. Discussion of Pseudodifferential operators, Fourier integral operators, asymptotic solutions of partial differential equations, and the spectral theory of Schroedinger operators from the semi-classical perspective. Heavy emphasis placed on the symplectic geometric underpinnings of this subject.
R.B. Melrose

18.158 Topics in Differential Equations

Prereq: 18.157
Units: 3-0-9
Lecture: *TR9.30-11* (2-136)

Content varies from year to year. Topic for spring 2008: Spectral and conformal geometry.
P. Albin

18.175 Theory of Probability

Prereq: 18.125
Units: 3-0-9
URL: http://www-math.mit.edu/~dws
Lecture: *MWF11* (2-255)

Laws of large numbers and central limit theorems for sums of independent random variables, conditioning and martingales, Brownian motion, and elements of diffusion theory.
D. W. Stroock

18.177 Stochastic Processes

Prereq: 18.175
Units: 3-0-9
URL: http://www-math.mit.edu/~tkemp/18.177/

Free probability theory, from a probabilistic perspective. Topics include: classical (Ito) and free stochastic calculus; Levy processes, and free Levy processes; and random matrices and large deviations. Knowledge of 18.156 helpful but not required.
T. Kemp

18.199 Graduate Analysis Seminar

Prereq: Permission of instructor
Units: 3-0-21
Lecture: *TR12.30-2* (4-251)

Studies original papers in differential analysis and differential equations. Intended for first- and second-year graduate students. Permission must be secured in advance.
R. B. Melrose

18.238 Geometry and Quantum Field Theory

Prereq: Permission of instructor
Units: 3-0-9
Lecture: *MWF10* (2-255)

A rigorous introduction designed for mathematicians into perturbative quantum field theory, using the language of functional integrals. Basics of classical field theory. Free quantum theories. Feynman diagrams. Renormalization theory. Local operators. Operator product expansion. Renormalization group equation. The goal is to discuss, using mathematical language, a number of basic notions and results of QFT that are necessary to understand talks and papers in QFT and string theory.
K. Kremnizer

18.276 Mathematical Methods in Physics

G ( ) H
Prereq: 18.745 or some familiarity with Lie theory
Units: 3-0-9
Lecture: *MWF11* (2-135)

Content varies from year to year. Recent developments in quantum field theory require mathematical techniques not usually covered in standard graduate subjects. Topic for Spring 2008: symplectic methods in classical and semi-classical mechanics.
V. W. Guillemin

Applied Mathematics

18.303 Linear Partial Differential Equations

U ( )
Prereq: 18.02; 18.03 or 18.034
Units: 3-0-9
URL: http://math.mit.edu/18.303

The classical partial differential equations of applied mathematics: diffusion, Laplace/Poisson, and wave equations. Methods of solution, such as separation of variables, Fourier series and transforms, eigenvalue problems. Green's function methods are emphasized. 18.04 or 18.112 are useful, as well as previous acquaintance with the equations as they arise in scientific applications.
A. R. Kasimov

18.304 Undergraduate Seminar in Discrete Mathematics

U (,)
Prereq: 18.310 or 18.310C, 18.700 or permission of instructor
Units: 3-0-9
Credit cannot also be received for 18.316
Lecture: *MWF12* (2-102) or *TR9.30-11* (2-151)

Seminar in combinatorics, graph theory, and discrete mathematics in general. Participants read and present papers from recent mathematics literature. Instruction and practice in written and oral communication provided. Enrollment limited.
Fall: *T. Amdeberhan*
Spring: *D. J. Kleitman, T. Amdeberhan*

18.305 Advanced Analytic Methods in Science and Engineering

G ( ) H
Prereq: 18.04, 18.075, or 18.112
Units: 3-0-9
URL: http://math.mit.edu/18.305/

A comprehensive treatment of the advanced methods of applied mathematics. Designed to strengthen the mathematical abilities of graduate students and train them to think on their own. Expansion around singular points: special functions; the WKB method on ordinary and partial differential equations; the method of stationary phase and the saddle point method; the two-scale method and the method of renormalized perturbation; singular perturbation and boundary-layer techniques.
H. Cheng

18.306 Advanced Partial Differential Equations with Applications

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Prereq: 18.03; 18.04, 18.075, or 18.112
Units: 3-0-9
URL: http://www-math.mit.edu/18.306/index.html
Lecture: *MW9.30-11* (2-142)

Concepts and techniques for solving partial differential equations (pde), with emphasis on nonlinear pde. Diffusion, dispersion and other phenomena. Initial and boundary value problems. Characteristics and shocks. Separation of variables, transform methods, Green's functions. Asymptotics, geometrical optics theory. Dimensional analysis, self-similarity, traveling waves. Singular perturbation and boundary layers. Solitons. Variational methods. Free-boundary problems. Examples from fluid dynamics, materials science, optics, and other applications.
R. R. Rosales

18.307 Integral Equations

( )

Prereq: 18.04, 18.075, or 18.112
Units: 3-0-9

Emphasis on concepts and techniques for solving integral equations from an applied mathematics perspective. Selection of material from the following topics: Volterra and Fredholm equations, Fredholm theory, the Hilbert-Schmidt theorem; Wiener-Hopf Method; Wiener-Hopf Method and partial differential equations; the Hilbert Problem and singular integral equations of Cauchy type; inverse scattering transform; group theory. Examples from fluid and solid mechanics, acoustics, quantum mechanics, and other applications.
Information: R.R. Rosales

18.308 Wave Motion

( )

Prereq: Permission of instructor
Units: 3-0-9

Dispersive and non-dispersive waves in fluids, with emphasis on nonlinear effects and applications to Geophysical Flows and Nonlinear Acoustics. Stability of shear and stratified flows; surface and internal waves; nonlinear resonant interactions; solitons and solitary wave interactions; characteristics, nonlinear breaking, hydraulic jumps, and bores; weakly nonlinear theory; dispersive wave turbulence; weakly nonlinear geometrical optics and modulation; wave boundary layer phenomena.

D. J. Benney

18.310 Principles of Applied Mathematics

( )
Prereq: 18.02
Units: 3-0-9
Credit cannot also be received for 18.310C
URL: http://math.mit.edu/%7Eshor/PAM/18.310.html

Study of illustrative topics in discrete applied mathematics including sorting algorithms, information theory, coding theory, secret codes, generating functions, linear programming, game theory.
Information: D. J. Kleitman

18.310C Principles of Applied Mathematics (New)

( )
Prereq: 18.02
Units: 3-0-9
Credit cannot also be received for 18.310

Study of illustrative topics in discrete applied mathematics including sorting algorithms, information theory, coding theory, secret codes, generating functions, linear programming, and game theory. Instruction and practice in written communication provided. Same content as 18.310, but assignments are structured with an additional focus on writing.
D. J. Kleitman, P. W. Shor

18.311 Principles of Applied Mathematics

( )
Prereq: 18.02; 18.03 or 18.034
Units: 3-0-9
URL: http://math.mit.edu/18.311/
Lecture: *TR9.30-11* (4-145)

Introduction to fundamental concepts in continuous applied mathematics. Continuum limit and conservation laws. Kinematic waves. Diffusion. Linear and nonlinear waves. Hyperbolic equations: method of characteristics, expansion fans, shock dynamics, shock structure. Green functions. Fourier series and transform. Dimensional analysis. Similarity solutions. Boundary layers. Applications from traffic flow, gas dynamics, water waves, granular flow, ion transport, etc.
R. R. Rosales

18.312 Algebraic Combinatorics

( )
Prereq: 18.700 or 18.701
Units: 3-0-9
URL: http://www-math.mit.edu/~apost/courses/18.312/

Lecture: *MWF11* (2-102)

Applications of algebra to combinatorics and conversely. Topics include enumeration methods, partially ordered sets and lattices, matching theory, partitions and tableaux, algebraic graph theory, and combinatorics of polytopes.
J. Kahn

18.314 Combinatorial Analysis

U ( )
Prereq: 18.02, 18.06
Units: 3-0-9
URL: http://math.mit.edu/~apost/courses/18.314/

Combinatorial problems and methods for their solution. Enumeration, generating functions, recurrence relations, construction of bijections. Introduction to graph theory. Prior experience with abstraction and proofs is helpful.
A. Postnikov

18.315 Combinatorial Theory

G ( ) H
Prereq: Permission of instructor
Units: 3-0-9
URL: http://math.mit.edu/~apost/courses/18.315/

Content varies from year to year. Topics for Fall 2007: (1) Basic enumeration and (2) partially ordered sets.
R. P. Stanley

18.316 Seminar in Combinatorics

G ( ) H
Prereq: Permission of instructor
Units: 3-0-9
Credit cannot also be received for 18.304
Lecture: *MWF2* (2-139)

Content varies from year to year. Readings from current research papers in combinatorics. Topics to be chosen and presented by the class.
D. J. Kleitman

18.317 Combinatorics, Probability, and Computation on Groups

G ( ) H
Prereq: Permission of instructor
Units: 3-0-9

Content varies from year to year. Covers a variety of classical and recent results on the subject. Topics include probability of generating a finite group; statistical group theory; random walks on finite and infinite

groups; algorithms for permutation and black box groups; and generating random group elements.
Information: R. P. Stanley

18.318 Topics in Combinatorics

Prereq: Permission of instructor
Units: 3-0-9
URL: http://math.mit.edu/%7Epak/courses/318.htm
Lecture: *TR9.30-11* (2-132)

Topics vary from year to year. Topic for spring 2008: Combinatorial Game Theory. Combinatorially defined games. Theory and interaction with combinatorial theory. Classical game theory, take-away games, grundy numbers, sums, number systems defined by games, surreal numbers. Interactions with Ramsey theory, probability, derandomization, communication, logic. Algorithmic questions.
C. D. Smyth

18.319 Combinatorics and Geometry

Prereq: Permission of instructor
Units: 3-0-9
URL: http://math.mit.edu/~apost/courses/18.319/
Lecture: *TR2.30-4* (2-136)

Connections between combinatorics and geometry (and algebra). Discussion of combinatorial problems that arise in algebraic geometry, convex geometry, and algebraic topology. Topics include toric varieties, polytopes and fans, hyperplane arrangements, triangulations and tilings, matroids, topological combinatorics, Schubert calculus.
A. Postnikov

18.325 Topics in Applied Mathematics

Prereq: Permission of instructor
Units: 3-0-9
URL: http://math.mit.edu/%7Estevenj/18.325/
Lecture: *MW3-4.30* (2-136)

Topics vary from year to year.
Information: A. Toomre

18.330 Introduction to Numerical Analysis

Prereq: 18.02; 18.03 or 18.034
Units: 3-0-9
URL: http://www-math.mit.edu/~lippert/classes/18.330

Lecture: *MWF2* (2-132) ***+final***

Basic techniques for the efficient numerical solution of problems in science and engineering. Root finding, interpolation, approximation of functions, integration, differential equations, direct and iterative methods in linear algebra. Knowledge of programming in Fortran, C, or Matlab helpful.
Y. Farjoun

18.335J Introduction to Numerical Methods

(Same subject as 6.337J)
Prereq: 18.03, 18.06
Units: 3-0-9
URL: http://www-math.mit.edu/%7Epersson/18.335

Advanced introduction to numerical linear algebra. Topics include direct and iterative methods for linear systems, eigenvalue decompositions and QR/SVD factorizations, stability and accuracy of numerical algorithms, the IEEE floating point standard, sparse and structured matrices, preconditioning, linear algebra software. Problem sets require some knowledge of Matlab.
Summer: A. Edelman, J. White
Fall: P.-O. Persson

18.336 Numerical Methods for Partial Differential Equations

Prereq: 18.330, 18.335J,
Units: 3-0-9
URL: http://web.mit.edu/jcnave/www/courses/18.336.htm
Lecture: *TR11-12.30* (2-136)

Advanced introduction to applications and theory of numerical methods for solution of differential equations, especially of physically-arising partial differential equations, with emphasis on the fundamental ideas underlying various methods. Topics include finite differences, spectral methods, finite elements, well-posedness and stability, particle methods and lattice gases, boundary and nonlinear instabilities.
J.-C. Nave

18.337J Parallel Computing

(Same subject as 6.338J)
Prereq: 18.06
Units: 3-0-9
URL: http://beowulf.csail.mit.edu/18.337/index.html
Lecture: *TR1-2.30* (4-231)

Advanced interdisciplinary introduction to modern scientific computing on parallel supercomputers. Numerical topics include dense and sparse linear algebra, N-body problems, and Fourier transforms. Geometrical topics include partitioning and mesh generation. Other topics include architectures and

software systems with emphasis on understanding the realities and myths of what is possible on the world's fastest machines. Programming languages include MPI and Star-P with MATLAB.
Information: A. Edelman, J. K. White

18.338 Eigenvalues of Random Matrices

Prereq: Permission of instructor
Units: 3-0-9
URL: http://www.mit.edu/%7E18.338/

An introduction to the theory and applications of stochastic eigen-analysis. Theoretical topics include matrix calculus, "free" probability, and stochastic operators. Applications in signal processing, finance, and large stochastic systems are discussed. There is a hands-on emphasis on using the theory to discover new applications.
A. Edelman

18.353J Nonlinear Dynamics I: Chaos

(Same subject as 2.050J, 12.006J)
Prereq: 18.03, 8.02
Units: 3-0-9
URL: http://segovia.mit.edu/12.006/

Introduction to nonlinear dynamics and chaos in dissipative systems. Forced and parametric oscillators. Phase space. Periodic, quasiperiodic, and aperiodic flows. Sensitivity to initial conditions and strange attractors. Lorenz attractor. Period doubling, intermittency, and quasiperiodicity. Scaling and universality. Analysis of experimental data: Fourier transforms, Poincare sections, fractal dimension, and Lyapunov exponents. Applications to mechanical systems, fluid dynamics, physics, geophysics, and chemistry. See 12.207J/18.354J for Nonlinear Dynamics II.
T. Peacock

18.354J Nonlinear Dynamics II: Continuum Systems

(H except 18)
(Same subject as 12.207J)
Prereq: 18.353J/12.006J or permission of instructor
Units: 3-0-9
Lecture: *TR11-12.30* (2-139)

General mathematical principles of continuum systems. (1) From microscopic to macroscopic. Examples range from random walkers, to Newtonian mechanics, to option pricing. (2) Singular Perturbations. Examples include boundary layer theory, snow flakes and geophysical flows. (3) Instability. Generalize ideas from 18.353 to continuum systems. Examples from fluid mechanics, solid mechanics, astrophysics and biology. (4) Pattern formation and turbulence.
M. Hancock

18.355 Fluid Mechanics

Prereq: 18.354J, 12.800, 2.25, or 16.121
Units: 3-0-9

Topics include viscous flows, ideal flows, boundary layers, lubrication theory, Stokes flows, free-surface flows. Fundamental concepts illustrated through problems drawn from a variety of situations including animal locomotion (swimming and flying) and the dynamics of sport (the aerodynamics of sports balls, surfing, skiing). Particular emphasis on the power of dimensional analysis and scaling arguments. Course material supplemented by classroom and laboratory demonstrations.
J. W. Bush

18.358 Nonlinear Fluid Mechanics

Prereq: 18.355 or permission of instructor
Units: 3-0-9

Introduction to the theory of flow stability and the fundamentals of turbulence. Stability of dynamical systems. Stability of static fluids. Instabilities in shear flows. Instabilities at low Reynolds numbers. Nonlinear dynamics. Waves. Vorticity dynamics. Homogeneous turbulence. Kolmogorov's universal equilibrium theory. Mean field theory for convected scalar fields.
E. Lauga

18.361 Introduction to Modeling and Simulation

Engineering School-Wide Elective Subject.
(Offered under: 1.021, 3.021, 10.333, 18.361, 22.00)
Prereq: 18.03 or permission of instructor
Units: 4-0-8
URL: http://stellar.mit.edu/S/course/3/sp08/3.021/
Lecture: *TR3-4.30* (4-231) **Recitation:** *M4* (4-231)

Basic concepts of computer modeling and simulation in science and engineering. Uses techniques and software for simulation, data analysis and visualization. Continuum, mesoscale, atomistic and quantum methods used to study fundamental and applied problems in physics, chemistry, materials science, mechanics, engineering, and biology. Examples drawn from the disciplines above are used to understand or characterize complex structures and materials, and complement experimental observations.
M. Buehler, R. Radovitzky, T. Thonhauser

18.366 Random Walks and Diffusion

Prereq: 18.305 or permission of instructor
Units: 3-0-9
URL: http://math.mit.edu/18.366/

Mathematical modeling of diffusion phenomena: Central limit theorems, the continuum limit, Fokker-

Planck equation, first passage, persistence and self avoidance, continuous-time random walks, Levy flights, random environments, advection-diffusion, diffusion-limited aggregation. Applications include polymers, turbulence, fractal growth, granular flow, and financial derivatives.
M. Z. Bazant

18.369 Mathematical Methods in Nanophotonics

Prereq: 18.305 or permission of instructor
Units: 3-0-9
URL: http://math.mit.edu/~stevenj/18.369
Lecture: *MWF2* (2-146)

High-level approaches to understanding complex optical media, structured on the scale of the wavelength, that are not generally analytically soluable. The basis for understanding optical phenomena such as photonic crystals and band gaps, anomalous diffraction, mechanisms for optical confinement, optical fibers (new and old), nonlinearities, and integrated optical devices. Methods covered include linear algebra and eigensystems for Maxwell's equations, symmetry groups and representation theory, Bloch's theorem, numerical eigensolver methods, time and frequency-domain computation, perturbation theory, and coupled-mode theories.
S. G. Johnson

18.376J Wave Propagation

(Same subject as 1.138J, 2.062J)
Prereq: 2.003J, 18.075
Units: 3-0-9
URL: http://web.mit.edu/2.062j/www/
Lecture: *TR1-2.30* (1-277)

Theoretical concepts and analysis of wave problems in science and engineering with examples chosen from elasticity, acoustics, geophysics, hydrodynamics, blood flow, nondestructive evaluation, and other applications. Progressive waves, group velocity and dispersion, energy density and transport. Reflection, refraction and transmission of plane waves by an interface. Mode conversion in elastic waves. Rayleigh waves. Waves due to a moving load. Scattering by a two dimensional obstacle. Reciprocity theorems. Parabolic approximation. Waves on the sea surface. Capillary-gravity waves. Wave resistance. Radiation of surface waves. Internal waves in stratified fluids. Waves in rotating media. Waves in random media.
T. R. Akylas, C. C. Mei, R. R. Rosales

18.377J Nonlinear Dynamics and Waves

(Same subject as 1.685J, 2.034J)
Prereq: Permission of instructor
Units: 3-0-9

A unified treatment of nonlinear oscillations and wave phenomena with applications to mechanical, optical,

geophysical, fluid, electrical and flow-structure interaction problems. Nonlinear free and forced vibrations; nonlinear resonances; self-excited oscillations; lock-in phenomena. Nonlinear dispersive and nondispersive waves; resonant wave interactions; propagation of wave pulses and nonlinear Schrodinger equation. Nonlinear long waves and breaking; theory of characteristics; the Korteweg-de Vries equation; solitons and solitary wave interactions. Stability of shear flows. Some topics and applications may vary from year to year.
T. R. Akylas, C. C. Mei, R. R. Rosales

18.384 Undergraduate Seminar in Physical Mathematics (New)

U ( )
Prereq: 18.311, 18.354, or permission of instructor
Units: 3-0-9
Lecture: *MWF10* (2-146)

The applied mathematics of continuous media and classical physics. Reading and presentation of papers from recent applied mathematics and physics literature. Topics and papers include fluid mechanics, solid mechanics, and biophysics. Enrollment limited.
J. W. Bush

18.385J Nonlinear Dynamics and Chaos

G ( ) H
(Same subject as 2.036J)
Prereq: 18.03 or 18.034
Units: 3-0-9
URL: http://web.mit.edu/2.036j/www/index.html

Introduction to the modern theory of nonlinear dynamical systems with an emphasis on applications in science and engineering. Local and global existence of solutions to nonlinear dynamical systems, their dependence on initial data and parameters. Phase plane, limit cycles, Poincare-Bendixson theory. Time-dependent systems, Floquet theory, Poincare maps, averaging. Stability of equilibria, near-equilibrium dynamics. Center manifolds, elementary bifurcations, normal forms. Introduction to chaos. Physical applications.
R. R. Rosales

18.386J Advanced Nonlinear Dynamics and Chaos

⊘ G ( ) H
(Same subject as 2.037J)
Prereq: 18.385/2.036 or permission of instructor
Units: 3-0-9
URL: http://web.mit.edu/2.037j/www/

Advanced subject on the modern theory of nonlinear dynamical systems with an emphasis on applications in science and engineering. Invariant manifolds, homoclinic orbits, global bifurcations. Hamiltonian systems, completely integrable systems, KAM theory. Different mechanisms for chaotic dynamics,

Shilnikov-type orbits, attractors, horseshoes, symbolic dynamics. Geometric singular perturbation theory. Physical applications.
R. R. Rosales

18.395 Group Theory with Applications to Physics

Prereq: 8.321
Units: 3-0-9

Selection of topics from the theory of finite groups, Lie groups, and group representations, motivated by quantum mechanics and particle physics. 8.322 and 8.323 helpful.
Information: D. Z. Freedman

18.396J Supersymmetric Quantum Field Theories

(Same subject as 8.831J)
Prereq: Permission of instructor
Units: 3-0-9

Topics selected from the following: SUSY algebras and their particle representations; Weyl and Majorana spinors; Lagrangians of basic four-dimensional SUSY theories, both rigid SUSY and supergravity; supermultiplets of fields and superspace methods; renormalization properties, and the non-renormalization theorem; sponteneous breakdown of SUSY; and phenomenological SUSY theories. Some prior knowledge of Noether's theorem, derivation and use of Feynman rules, l-loop renormalization, and gauge theories is essential.
Information: D. Z. Freedman

18.398 Quantum Field Theories

Prereq: Permission of instructor
Units: 3-0-9
Lecture: *TR2.30-4* (2-146)

For students who want to have a clear understanding of quantum field theories. Appropriate for students who have not taken such a subject as well as students who have but are not entirely comfortable with the basic concepts and techniques. The topics begin with classical mechanics and end with gauge field theories and the renormalization of the standard model.
H. Cheng

Theoretical Computer Science

18.400J Automata, Computability, and Complexity

(Same subject as 6.045J)

Prereq: 6.042J
Units: 4-0-8
URL: http://theory.lcs.mit.edu/classes/6.045/
Subject Cancelled

Slower paced than 6.840J/18.404J. Introduces basic mathematical models of computation and the finite representation of infinite objects. Context-free languages. Turing machines. Partial recursive functions. Church's Thesis. Undecidability. Reducibility and completeness. Time complexity and NP-completeness. Probabilistic computation. Interactive proof systems.
S. Micali

18.404J Theory of Computation

(H except 18)
(Same subject as 6.840J)
Prereq: 18.310 or 18.062J
Units: 4-0-8
URL: http://www-math.mit.edu/~sipser/18404/18.404.html

A more extensive and theoretical treatment of the material in 6.045J/18.400J, emphasizing computability and computational complexity theory. Regular and context-free languages. Decidable and undecidable problems, reducibility, recursive function theory. Time and space measures on computation, completeness, hierarchy theorems, inherently complex problems, oracles, probabilistic computation, and interactive proof systems.
M. Sipser

18.405J Advanced Complexity Theory

(Same subject as 6.841J)
Prereq: 6.840J/18.404J
Units: 3-0-9
URL: http://theory.csail.mit.edu/~madhu/ST07/
Subject Cancelled

Current research topics in computational complexity theory. Nondeterministic, alternating, probabilistic, and parallel computation models. Boolean circuits. Complexity classes and complete sets. The polynomial-time hierarchy. Interactive proof systems. Relativization. Definitions of randomness. Pseudo-randomness and derandomizations. Interactive proof systems and probabilistically checkable proofs.
Information: M. Sudan, M. X. Goemans

18.409 Topics in Theoretical Computer Science

Prereq: Permission of instructor
Units: 3-0-9
Lecture: *TR11-12.30* (36-153)

Study of areas of current interest in theoretical computer science. Topics vary from term to term. Topic for fall 2007: An algorithmist's toolkit. Topic for spring 2008: Aspects of quantum information and quantum computation. 18.435 or equivalent helpful.
Fall: *J. Kelner*
Spring: *P.W. Shor*

18.410J Design and Analysis of Algorithms

(Same subject as 6.046J)
Prereq: 6.006 (alternatively: 6.001; 6.042/18.062 or 18.310)
Units: 4-0-8
URL: http://theory.lcs.mit.edu/classes/6.046/
Lecture: *TR11-12.30* (2-190) **Recitation:** *F10* (2-136) or *F11* (2-136) or *F12* (2-136) or *F1* (2-135) or *F2* (2-135) or *F9.30* (2-147) or *F11* (2-147) or *F12* (2-147) or *F1* (2-147, 2-131) or *F2* (2-147) ***+final***

Techniques for the design and analysis of efficient algorithms, emphasizing methods useful in practice. Topics include sorting; search trees, heaps, and hashing; divide-and-conquer; dynamic programming; greedy algorithms; amortized analysis; graph algorithms; and shortest paths. Advanced topics include network flow; computational geometry; number-theoretic algorithms; polynomial and matrix calculations; caching; and parallel computing.
C. E. Leiserson, M. Goemans

18.415J Advanced Algorithms

(Same subject as 6.854J)
Prereq: 6.041 or 6.042J; 6.046J
Units: 5-0-7
URL: http://theory.lcs.mit.edu/classes/6.854/

First-year graduate subject in algorithms. Emphasizes fundamental algorithms and advanced methods of algorithmic design, analysis, and implementation. Surveys a variety of computational models and the algorithms for them. Data structures, network flows, linear programming, computational geometry, approximation algorithms, online algorithms, parallel algorithms, external memory, streaming algorithms.
D. R. Karger

18.416J Randomized Algorithms

(Same subject as 6.856J)
Prereq: 6.854J, 6.041 or 6.042J
Units: 5-0-7

Studies how randomization can be used to make algorithms simpler and more efficient via random sampling, random selection of witnesses, symmetry breaking, and Markov chains. Models of randomized computation. Data structures: hash tables, and skip lists. Graph algorithms: minimum spanning trees, shortest paths, and minimum cuts. Geometric algorithms: convex hulls, linear programming in fixed or

arbitrary dimension. Approximate counting; parallel algorithms; online algorithms; derandomization techniques; and tools for probabilistic analysis of algorithms. Alternate years.
D. R. Karger

18.417 Introduction to Computational Molecular Biology

Prereq: 6.001; 18.410J/6.046J, or permission of instructor
Units: 3-0-9
URL: http://www-math.mit.edu/18.417/
Lecture: *TR9.30-11* (2-135)

Introduces the basic computational methods used to model and predict the structure of biomolecules (proteins, DNA, RNA). Covers classical techniques in the field (molecular dynamics, Monte Carlo, dynamic programming) to more recent advances in analyzing and predicting RNA and protein structure, ranging from Hidden Markov Models and 3D lattice models to attribute Grammars and tree Grammars.
J. Waldispühl

18.418 Topics in Computational Molecular Biology

Prereq: 18.417 or permission of instructor
Units: 3-0-9
URL: http://people.csail.mit.edu/bab/class/08-18.418-home.html
Lecture: *MW11.30-1* (32-G575)

Covers current research topics in computational molecular biology. Recent research papers presented from leading conferences such as the SIGACT International Conference on Computational Molecular Biology (RECOMB). Topics include original research (both theoretical and experimental) in comparative genomics, sequence and structure analysis, molecular evolution, proteomics, gene expression, transcriptional regulation, and biological networks. Recent research by course participants also covered. Participants will be expected to present either group or individual projects to the class.
B. Berger

18.419 Seminar in Theoretical Computer Science

Prereq: Permission of instructor
Units: 3-0-9
URL: http://www-math.mit.edu/%7Evempala/spectral/course.html

Advanced topics in theoretical computer science. Current literature presented by students and instructors with a view toward preparing students for research in theoretical computer science, and for developing the skills needed to present such results effectively.
Information: A. Toomre

18.424 Seminar in Information Theory

Prereq: 18.05, 18.440 or 6.041; 18.06, 18.700, or 18.701
Units: 3-0-9
Lecture: *MWF1* (2-142)

Considers various topics in information theory, including data compression, Shannon's Theorems, and error-correcting codes. Students present and discuss the subject matter. Instruction and practice in written and oral communication provided. Enrollment limited.
P.W. Shor

18.425J Cryptography and Cryptanalysis

G ( ) H
(Same subject as 6.875J)
Prereq: 6.046J
Units: 3-0-9
Lecture: *TR2.30-4* (32-141)

A rigorous introduction to modern cryptography. Emphasis on the fundamental cryptographic primitives of public-key encryption, digital signatures, pseudo-random number generation, and basic protocols and their computational complexity requirements.
S. Goldwasser

18.426J Advanced Topics in Cryptography

G ( ) H
(Same subject as 6.876J)
Prereq: 6.875J/18.425J
Units: 3-0-9

Recent results in cryptography and interactive proofs. Lectures by instructor, invited speakers, and students. Alternate years.
S. Goldwasser

18.433 Combinatorial Optimization

U ( ) H except 18
Prereq: 18.06 or 18.700
Units: 3-0-9
URL: http://math.mit.edu/%7Egoemans/18433.html

Thorough treatment of linear programming and combinatorial optimization. Topics include matching theory, network flow, matroid optimization, and how to deal with NP-hard optimization problems. Prior exposure to discrete mathematics (such as 18.310) helpful.
Information: P.W. Shor

18.434 Seminar in Theoretical Computer Science

U ( )
Prereq: 18.404, 18.410

Units: 3-0-9
URL: http://www-math.mit.edu/~goemans/18434.html

Topics vary from year to year. Students present and discuss the subject matter. Instruction and practice in written and oral communication provided. Enrollment limited.
Information: M. X. Goemans

18.435J Quantum Computation

(Same subject as 2.111J, ESD.79J)
Prereq: Permission of instructor
Units: 3-0-9

Provides an introduction to the theory and practice of quantum computation. Topics covered: physics of information processing; quantum algorithms including the factoring algorithm and Grover's search algorithm; quantum error correction; quantum communication and cryptography. Knowledge of quantum mechanics helpful but not required.
E. Farhi, S. Lloyd, P. Shor

18.437J Distributed Algorithms

(Same subject as 6.852J)
Prereq: 6.046J
Units: 3-0-9
URL: http://theory.csail.mit.edu/classes/6.852/
Lecture: *TR11-12.30* (4-149)

Design and analysis of concurrent algorithms, emphasizing those suitable for use in distributed networks. Process synchronization, allocation of computational resources, distributed consensus, distributed graph algorithms, election of a leader in a network, distributed termination, deadlock detection, concurrency control, communication, and clock synchronization. Special consideration given to issues of efficiency and fault tolerance. Formal models and proof methods for distributed computation. Alternate years.
N. A. Lynch

Applied Mathematics:Statistics

18.440 Probability and Random Variables

Prereq: 18.02
Units: 3-0-9
URL: http://www-math.mit.edu/~danny/courses/probability.html
Lecture: *MWF1* (2-190) ***+final***

Probability spaces, random variables, distribution functions. Binomial, geometric, hypergeometric, Poisson

distributions. Uniform, exponential, normal, gamma and beta distributions. Conditional probability, Bayes theorem, joint distributions. Chebyshev inequality, law of large numbers, and central limit theorem.
Fall: *D. Gutfreund*
Spring: *J. Kelner*

18.443 Statistics for Applications

U (,) H except 18
Prereq: 18.440 or 6.041
Units: 3-0-9
URL: http://math.mit.edu/%7Epanchenk/class443/class18_443.html
Lecture: *MWF10* (4-370)

A broad treatment of statistics, concentrating on specific statistical techniques used in science and industry. Topics: hypothesis testing and estimation. Confidence intervals, chi-square tests, nonparametric statistics, analysis of variance, regression, correlation, decision theory, and Bayesian statistics.
R. M. Dudley

18.445 Introduction to Stochastic Processes

G () H
Prereq: 18.100; 18.440 or 6.041
Units: 3-0-9
URL: http://www-math.mit.edu/~dws
Lecture: *MWF1* (2-143)

Introduces the theory and application of stochastic processes. Emphasis on Markov chains, Markov processes, and their ergotic theory.
D.W. Stroock

18.447 Probabilistic Methods in Combinatorics and Algorithms

G () H
Prereq: 18.310 or permission of instructor
Units: 3-0-9

Probabilistic methods are used extensively in combinatorics and in the study of algorithms in computer science. This course develops some of the basic tools and illustrates their use via examples. Topics include the probabilistic method of Erdös and the theory of random graphs.
Information: C. D. Smyth

18.465 Topics in Statistics

G () H
Prereq: Permission of instructor
Units: 3-0-9
URL: http://www-math.mit.edu/~panchenk/class.htm

Topics vary from year to year.

R. M. Dudley

18.466 Mathematical Statistics

( )

Prereq: Permission of instructor
Units: 3-0-9

Decision theory, estimation, confidence intervals, hypothesis testing. Introduces large sample theory. Asymptotic efficiency of estimates. Exponential families. Sequential analysis.
Information: R. M. Dudley

For additional related subjects in Statistics, see:

Civil and Environmental Engineering: 1.151, 1.155,1.202J, 1.203J, 1.205J

Electrical Engineering and Computer Science: 6.041,6.231, 6.245, 6.262, 6.431, 6.432, and 6.435

Management: 15.034, 15.061, 15.065, 15.070, 15.075,15.076, 15.098, and 15.306

Mathematics: 18.05, 18.175, 18.177, 18.440, 18.441,18.443, 18.445, 18.458, and 18.465

See also: 2.061, 2.830, 5.70, 5.72, 7.02, 8.044, 8.08,10.816, 11.220, 11.221, 16.322, 17.872, 17.874, 22.38, HST.191, and MAS.622J.

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MIT 2007-08

18.725 Algebraic Geometry
Prereq: 18.705
G (Fall)
3-0-9 H-LEVEL Grad Credit

18.726 Algebraic Geometry
Prereq: 18.725
G (Spring)
3-0-9 H-LEVEL Grad Credit

Introduces the basic notions and techniques of modern algebraic geometry. 18.725: Fundamental notions and results about algebraic varieties over an algebraically closed field; relations between complex algebraic varieties and complex analytic varieties; examples with emphasis on algebraic curves and surfaces. May be taken concurrently with 18.705. Knowledge of elementary algebraic topology, elementary differential geometry recommended, but not required. 18.726: Introduction to the language of schemes, properties of morphisms, and sheaf cohomology.
Fall: I. Tyomkin
Spring: J. McKernan

18.727 Topics in Algebraic Geometry
Prereq: 18.725
G (Fall, Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Topics vary from year to year. Topic for fall 2007: algebraic cycles and homotopy theory. Topic for spring 2008: algebraic surfaces. Classification, geometry and arithmetic of projective algebraic surfaces. Knowledge of algebraic curves and sheaf cohomology expected.
Fall: W. Hu
Spring: A. Kumar

18.735 Topics in Algebra
Prereq: 18.702, 18.703, or permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Topics vary from year to year.
J. McKernan

18.737 Algebraic Groups
Prereq: 18.705
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Fall)
3-0-9 H-LEVEL Grad Credit

Structure of linear algebraic groups over an algebraically closed field, with emphasis on reductive groups. Representations of groups over a finite field using methods from etale cohomology. Some results from algebraic geometry are stated without proof.
Information: G. Lusztig

18.745 Introduction to Lie Algebras
Prereq: 18.701 or 18.703
G (Fall)
3-0-9 H-LEVEL Grad Credit

Structure of finite-dimensional Lie algebras. Theorems of Engel and Lie. Cartan subalgebras. Trace form and Cartan's criterion. Classification and construction of semisimple Lie algebras. Weyl group. Finite-dimensional representations of semisimple Lie algebras.
G. Lusztig

18.747 Infinite-dimensional Lie Algebras
Prereq: 18.745
G (Spring)
3-0-9 H-LEVEL Grad Credit

Topics vary from year to year. Topics for spring 2008: Representations of the Virasoro and Kac-Moody Lie algebras, vertex operators, relation to integrable systems, The Weyl-Kac denominator and character formulas, Knizhnik-Zamolodchikov equations.
P. I. Etingof

18.755 Introduction to Lie Groups
Prereq: 18.100B; 18.700 or 18.701
G (Fall)
3-0-9 H-LEVEL Grad Credit

A general introduction to manifolds and Lie groups. The role of Lie groups in mathematics and physics. Exponential mapping. Correspondence with Lie algebras. Homogeneous spaces and transformation groups. Adjoint representation. Covering groups. Automorphism groups. Invariant differential forms and cohomology of Lie groups and homogeneous spaces. 18.101 recommended but not required.
S. Helgason

18.757 Representations of Lie Groups
Prereq: 18.745
G (Spring)
3-0-9 H-LEVEL Grad Credit

Representations of locally compact groups, with emphasis on compact groups and abelian groups. Peter-Weyl theorem and Cartan-Weyl highest weight theory for compact Lie groups.
D. A. Vogan

18.758 Representations of Lie Groups
Prereq: 18.757
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Fall)
3-0-9 H-LEVEL Grad Credit

Introduction to unitary representations of semisimple Lie groups: compact groups and the Borel-Weil theorem; parabolic induction; Zuckerman construction; unipotent representations.
Information: D. A. Vogan

18.769 Topics in Lie Theory
Prereq: Permission of instructor
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Topics vary from year to year.
Information: M. Artin

18.781 Theory of Numbers
Prereq: —
U (Fall)
3-0-9

An elementary introduction to number theory with no algebraic prerequisites. Primes, congruences, quadratic reciprocity, diophantine equations, irrational numbers, continued fractions, partitions.
B. Brubaker

18.784 Seminar in Number Theory (New)
Prereq: 18.06 and 18.100; or 18.700 or 18.701
U (Fall, Spring)
3-0-9

Topics vary from year to year. Students present and discuss the subject matter. Instruction and practice in written and oral communication provided. Topic for fall 2007: Quantum calculus and its applications to number theory. Topic for spring 2008: Modular forms in number theory and the work of Ramanujan. Enrollment limited.
Fall: V. G. Kac
Spring: B. Brubaker

18.785 Analytic Number Theory
Prereq: 18.112
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Spring)
3-0-9 H-LEVEL Grad Credit

An introduction to analytic number theory. Riemann zeta function, L-functions, prime number theorem, Dirichlet's theorem, Riemann Hypothesis and related conjectures. Sieving methods, Linnik's large sieve, Selberg's sieve. Applications to distribution of prime numbers. Other topics if time permits. Background in elementary number theory (e.g., 18.781) strongly recommended.
Information: K. S. Kedlaya

18.786 Algebraic Number Theory
Prereq: 18.100B or 18.100C; 18.702
G (Spring)
3-0-9 H-LEVEL Grad Credit

An introduction to algebraic number theory. Dedekind domains, unique factorization of prime ideals. Number fields, splitting of primes, class group. Lattice methods, finiteness of the class

MIT 2007-08

18.510 Introduction to Mathematical Logic and Set Theory
Prereq: —
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: U (Fall)
3-0-9
Credit cannot also be received for 18.511

Zermelo-Fraenkel set theory. Ordinals and cardinals. Axiom of choice and transfinite induction. Propositional and predicate logic. Elementary model theory: completeness, compactness, and Lowenheim-Skolem theorems. Gödel incompleteness theorem. 18.510 and 18.511 are offered in alternate years; they may not both be taken for credit.
Information: H. Rogers

18.511 Introduction to Mathematical Logic and Recursion Theory
Prereq: —
Acad Year 2007–2008: U (Fall)
Acad Year 2008–2009: Not offered
3-0-9
Credit cannot also be received for 18.510

Propositional and predicate logic. Elementary model theory: completeness, compactness, and Lowenheim-Skolem theorems. Elementary recursion theory: enumeration and recursion theorems. Post's Problem. Gödel incompleteness theorem. 18.511 and 18.510 are offered in alternate years; they may not both be taken for credit.
E. Rosen

18.515 Mathematical Logic
Prereq: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit

More rigorous treatment of basic mathematical logic, Gödel's theorems, and Zermelo-Fraenkel set theory. First-order logic. Models and satisfaction. Deduction and proof. Soundness and completeness. Compactness and its consequences. Quantifier elimination. Recursive sets and functions. Incompleteness and undecidability. Ordinals and cardinals. Set-theoretic formalization of mathematics.
H. Rogers

18.565 Recursion Theory
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit

Topics in recursion theory chosen from priority arguments, hyperarithmetic theory, ordinal recursion, E-recursion, theory of projective sets. A previous subject in logic recommended but not required.
R. Shore

18.575 Model Theory
Prereq: 18.510, 18.511, or 18.515
G (Spring)
3-0-9 H-LEVEL Grad Credit

Compactness theorem, ultraproducts, quantifier elimination, model completeness, Lowenheim-Skolem theorem, omitting types theorem, atomic and prime models, saturated and homogeneous models, indiscernibles, countable models, Morley's theorem, Baldwin-Lachlan theorem, omega-stability, forking and independence, model theory of algebraically closed and real closed fields, applications to algebra.
E. Rosen

18.585 Set Theory
Prereq: Permission of instructor
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Fall)
3-0-9 H-LEVEL Grad Credit

Topics in set theory chosen from large cardinals, combinatorial set theory, forcing, descriptive set theory, fine structure theory.
Information: H. Rogers

ALGEBRA AND NUMBER THEORY

18.700 Linear Algebra
Prereq: 18.02
U (Fall)
3-0-9 REST
Credit cannot also be received for 18.06

A rigorous treatment of linear algebra, including vector spaces, systems of linear equations, bases, linear independence, matrices, determinants, eigenvalues, inner products, quadratic forms, and canonical forms of matrices. Compared with 18.06, more emphasis on theory and proofs.
J. L. Kim

18.701 Algebra I
Prereq: 18.700, 18.100B, 18.100C or permission of instructor
U (Fall)
3-0-9

18.702 Algebra II
Prereq: 18.701
U (Spring)
3-0-9

More extensive and theoretical than the 18.700-18.703 sequence. Experience with proofs helpful. First term: group theory, geometry, and linear algebra. Second term: group representations, rings, ideals, fields, polynomial rings, modules, factorization, integers in quadratic number fields, field extensions, Galois theory.
M. Artin

18.703 Modern Algebra
Prereq: 18.02
U (Spring)
3-0-9

A one-term treatment, covering the traditional algebra topics that have found greatest application in science and engineering as well as in mathematics: group theory, emphasizing finite groups; ring theory, including ideals and unique factorization in polynomial and Euclidean rings; field theory, including properties and applications of finite fields. 18.700 and 18.703 together form a standard algebra sequence.
V. G. Kac

18.704 Seminar in Algebra
Prereq: 18.06, 18.700, or 18.701
U (Fall, Spring)
3-0-9

Topics vary from year to year. Students present and discuss the subject matter. Instruction and practice in written and oral communication provided. Some experience with proofs required. Topic for fall 2007: Computational algebra and algebraic geometry. Enrollment limited.
Fall: S. Kleiman
Spring: J. L. Kim

18.705 Commutative Algebra
Prereq: 18.702 or 18.703
G (Fall)
3-0-9 H-LEVEL Grad Credit

Basic topics in commutative algebra: Noetherian rings and modules, Hilbert basis theorem, Cayley-Hamilton theorem, integral dependence, Noether normalization, the Nullstellensatz, localization, primary decomposition, DVRs, filtrations, length, Artin rings, Hilbert polynomials, tensor products, and dimension theory.
S. Kleiman

18.706 Noncommutative Algebra
Prereq: 18.705
G (Spring)
3-0-9 H-LEVEL Grad Credit

Wedderburn theory, Morita equivalence, localization and Goldie's theorem central simple algebras and the Brauer group, maximal orders, representations, polynomial identity rings, invariant theory growth of algebras, Gelfand-Kirillov dimension.
P. I. Etingof

18.725 Algebraic Geometry
Prereq: 18.705
G (Fall)
3-0-9 H-LEVEL Grad Credit
18.726 Algebraic Geometry
Prereq: 18.725
G (Spring)
3-0-9 H-LEVEL Grad Credit

Introduces the basic notions and techniques of modern algebraic geometry. 18.725: Fundamental notions and results about algebraic varieties over an algebraically closed field; relations between complex algebraic varieties and complex analytic varieties; examples with emphasis on algebraic curves and surfaces. May be taken concurrently with 18.705. Knowledge of elementary algebraic topology, elementary differential geometry recommended, but not required. 18.726: Introduction to the language of schemes, properties of morphisms, and sheaf cohomology.
Fall: I. Tyomkin
Spring: J. McKernan

18.727 Topics in Algebraic Geometry
Prereq: 18.725
G (Fall, Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Topics vary from year to year. Topic for fall 2007: algebraic cycles and homotopy theory. Topic for spring 2008: algebraic surfaces. Classification, geometry and arithmetic of projective algebraic surfaces. Knowledge of algebraic curves and sheaf cohomology expected.
Fall: W. Hu
Spring: A. Kumar

18.735 Topics in Algebra
Prereq: 18.702, 18.703, or permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Topics vary from year to year.
J. McKernan

18.737 Algebraic Groups
Prereq: 18.705
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Fall)
3-0-9 H-LEVEL Grad Credit

Structure of linear algebraic groups over an algebraically closed field, with emphasis on reductive groups. Representations of groups over a finite field using methods from etale cohomology. Some results from algebraic geometry are stated without proof.
Information: G. Lusztig

18.745 Introduction to Lie Algebras
Prereq: 18.701 or 18.703
G (Fall)
3-0-9 H-LEVEL Grad Credit

Structure of finite-dimensional Lie algebras. Theorems of Engel and Lie. Cartan subalgebras. Trace form and Cartan's criterion. Classification and construction of semisimple Lie algebras. Weyl group. Finite-dimensional representations of semisimple Lie algebras.
G. Lusztig

18.747 Infinite-dimensional Lie Algebras
Prereq: 18.745
G (Spring)
3-0-9 H-LEVEL Grad Credit

Topics vary from year to year. Topics for spring 2008: Representations of the Virasoro and Kac-Moody Lie algebras, vertex operators, relation to integrable systems, The Weyl-Kac denominator and character formulas, Knizhnik-Zamolodchikov equations.
P. I. Etingof

18.755 Introduction to Lie Groups
Prereq: 18.100B; 18.700 or 18.701
G (Fall)
3-0-9 H-LEVEL Grad Credit

A general introduction to manifolds and Lie groups. The role of Lie groups in mathematics and physics. Exponential mapping. Correspondence with Lie algebras. Homogeneous spaces and transformation groups. Adjoint representation. Covering groups. Automorphism groups. Invariant differential forms and cohomology of Lie groups and homogeneous spaces. 18.101 recommended but not required.
S. Helgason

18.757 Representations of Lie Groups
Prereq: 18.745
G (Spring)
3-0-9 H-LEVEL Grad Credit

Representations of locally compact groups, with emphasis on compact groups and abelian groups. Peter-Weyl theorem and Cartan-Weyl highest weight theory for compact Lie groups.
D. A. Vogan

18.758 Representations of Lie Groups
Prereq: 18.757
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Fall)
3-0-9 H-LEVEL Grad Credit

Introduction to unitary representations of semisimple Lie groups: compact groups and the Borel-Weil theorem; parabolic induction; Zuckerman construction; unipotent representations.
Information: D. A. Vogan

18.769 Topics in Lie Theory
Prereq: Permission of instructor
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Topics vary from year to year.
Information: M. Artin

18.781 Theory of Numbers
Prereq: —
U (Fall)
3-0-9

An elementary introduction to number theory with no algebraic prerequisites. Primes, congruences, quadratic reciprocity, diophantine equations, irrational numbers, continued fractions, partitions.
B. Brubaker

18.784 Seminar in Number Theory (New)
Prereq: 18.06 and 18.100; or 18.700 or 18.701
U (Fall, Spring)
3-0-9

Topics vary from year to year. Students present and discuss the subject matter. Instruction and practice in written and oral communication provided. Topic for fall 2007: Quantum calculus and its applications to number theory. Topic for spring 2008: Modular forms in number theory and the work of Ramanujan. Enrollment limited.
Fall: V. G. Kac
Spring: B. Brubaker

18.785 Analytic Number Theory
Prereq: 18.112
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Spring)
3-0-9 H-LEVEL Grad Credit

An introduction to analytic number theory. Riemann zeta function, L-functions, prime number theorem, Dirichlet's theorem, Riemann Hypothesis and related conjectures. Sieving methods, Linnik's large sieve, Selberg's sieve. Applications to distribution of prime numbers. Other topics if time permits. Background in elementary number theory (e.g., 18.781) strongly recommended.
Information: K. S. Kedlaya

18.786 Algebraic Number Theory
Prereq: 18.100B or 18.100C; 18.702
G (Spring)
3-0-9 H-LEVEL Grad Credit

An introduction to algebraic number theory. Dedekind domains, unique factorization of prime ideals. Number fields, splitting of primes, class group. Lattice methods, finiteness of the class

number, Dirichlet's units theorem. Local fields, ramification, discriminants. Background in elementary number theory (e.g., 18.781) strongly recommended.
K. E. Mahlburg

18.787 Topics in Number Theory (New)
Prereq: Permission of instructor
G (Fall)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Content varies from year to year. Topic for fall 2007: theory of p-adic ordinary differential equations; applications to p-adic Hodge theory, zeta functions of algebraic varieties.
K. S. Kedlaya

18.821 Project Laboratory in Mathematics
Prereq: Two mathematics subjects numbered 18.100 or above
U (Fall, Spring)
0-6-6 Institute LAB

Guided research in mathematics, employing the scientific method. Students confront puzzling and complex mathematical situations, through the acquisition of data by computer, pencil and paper, or physical experimentation, and attempt to explain them mathematically. Students choose three projects from a large collection of options. Each project results in a laboratory report subject to revision; oral presentation on one report in a course conference. Projects drawn from many areas, including dynamical systems, number theory, algebra, fluid mechanics, asymptotic analysis, knot theory, and probability. Limited enrollment.
Fall: D. A. Vogan
Spring: P. Seidel

TOPOLOGY AND GEOMETRY

18.901 Introduction to Topology
Prereq: 18.100B, 18.100C, or permission of instructor
U (Fall, Spring)
3-0-9 H (except for Course 18 students)

Introduces topology, covering topics fundamental to modern analysis and geometry. Topological spaces and continuous functions, connectedness, compactness, separation axioms, and selected further topics such as function spaces, metrization theorems, embedding theorems, dimension theory.
Fall: J. R. Munkres
Spring: Staff

18.904 Seminar in Topology
Prereq: 18.901
U (Fall)
3-0-9

Students present and discuss the subject matter with faculty guidance. Topics include the fundamental group and covering spaces. Instruction and practice in written and oral communication provided. Enrollment limited.
P. Cheung

18.905 Algebraic Topology I
Prereq: 18.701 or 18.703; 18.901
G (Fall)
3-0-9 H-LEVEL Grad Credit

Review of fundamental group and covering spaces; simplicial, cellular, and singular homology; universal coefficient and Künneth theorems; cohomology, cup product; Poincaré duality.
M. J. Behrens

18.906 Algebraic Topology II
Prereq: 18.905
G (Spring)
3-0-9 H-LEVEL Grad Credit

Continues the introduction to algebraic topology from 18.905. Topics include basic homotopy theory, spectral sequences, characteristic classes, and cohomology operations.
L. Hesselholt

18.915 Graduate Topology Seminar
Prereq: 18.906
G (Fall)
3-0-9 H-LEVEL Grad Credit

Study and discussion of important original papers in the various parts of algebraic topology. Open to all students who have taken 18.906 or the equivalent, not only prospective topologists.
H. R. Miller

18.917 Topics in Algebraic Topology
Prereq: 18.906
G (Fall, Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Content varies from year to year. Introduces new and significant developments in algebraic topology with the focus on homotopy theory and related areas.
Fall: J. Lurie
Spring: M. J. Behrens

18.937 Topics in Geometric Topology
Prereq: Permission of instructor
Acad Year 2007–2008: Not offered
Acad Year 2008–2009: G (Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Content varies from year to year. Introduces new and significant developments in geometric topology.
Information: T. S. Mrowka

18.950 Differential Geometry
Prereq: 18.100; 18.101 or 18.901
U (Fall)
3-0-9 H (except for Course 18 students)

An introduction to differential geometry. Metrics, Lie bracket, connections, geodesics, tensors, intrinsic and extrinsic curvature are studied on abstractly defined manifolds using coordinate charts. Curves and surfaces in three dimensions are studied as important special cases. Gauss-Bonnet theorem for surfaces and selected introductory topics in special and general relativity are also studied. 18.100 is required, 18.101 is strongly recommended, and 18.901 would be helpful.
P. Seidel

18.952 Theory of Differential Forms
Prereq: 18.101; 18.700 or 18.701
U (Spring)
3-0-9

Multilinear algebra: tensors and exterior forms. Differential forms on R^n: exterior differentiation, the pull-back operation and the Poincaré lemma. Applications to physics: Maxwell's equations from the differential form perspective. Integration of forms on open sets of R^n. The change of variables formula revisited. The degree of a differentiable mapping. Differential forms on manifolds and De Rham theory. Integration of forms on manifolds and Stokes' theorem. The push-forward operation for forms. Thom forms and intersection theory. Applications to differential topology.
B. D. Parker

18.965 Geometry of Manifolds
Prereq: 18.101, *18.905*
G (Fall)
3-0-9 H-LEVEL Grad Credit
18.966 Geometry of Manifolds
Prereq: 18.965, *18.906*
G (Spring)
3-0-9 H-LEVEL Grad Credit

Differential forms, introduction to Lie groups, the DeRham theorem, Riemannian manifolds, curvature, the Hodge theory. 18.966 is a con-

tinuation of 18.965 and focuses more deeply on various aspects of the geometry of manifolds. Contents vary from year to year, and can range from Riemannian geometry (curvature, holonomy) to symplectic geometry, complex geometry and Hodge-Kahler theory, or smooth manifold topology.
Fall: M. E. Gualtieri
Spring: D. S. Auroux

18.969 Topics in Geometry
Prereq: 18.965
G (Fall)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Content varies from year to year. Topics for fall 2007: Introduction to Ozsvath-Szabo (Heegaard) Floer homology. Topics will include a brief introduction to Lagrangian Floer homology, construction of three and four-manifold invariants introduced by Ozsvath and Szabo as a special case of Lagrangian Floer homology, knot and link Floer homology invariants and their relationship to the three and four-manifold invariants, and applications of these invariants to contact geometry, knot theory, and three-manifold topology and geometry.
M. E. Hedden

18.979 Graduate Geometry Seminar
Prereq: Permission of instructor
G (Spring)
3-0-9 H-LEVEL Grad Credit
Can be repeated for credit

Content varies from year to year. Fall 2007: Symplectic Topology. Topic is either generalized Lagrangian Floer theory (as A_\infty algebras) or Lagrangian correspondences and pseudoholomorphic quilts.
K. Wehrheim

18.994 Seminar in Geometry
Prereq: 18.101
U (Spring)
3-0-9

Students present and discuss subject matter taken from current journals or books. Topics vary from year to year. Instruction and practice in written and oral communication provided. Enrollment limited.
V. W. Guillemin

18.995–18.998 Special Topics in Mathematics
Prereq: Permission of instructor
G (Fall, IAP, Spring)
Units arranged H-LEVEL Grad Credit
Can be repeated for credit

Opportunity for group study of advanced subjects in mathematics not otherwise included in the curriculum. Offerings are initiated by members of the Mathematics faculty on an ad hoc basis, subject to departmental approval.
Information: H. R. Miller

18.999 Research in Mathematics
Prereq: —
G (Fall, Spring, Summer)
Units arranged
Can be repeated for credit

Opportunity for study of graduate-level topics in mathematics under the supervision of a member of the department. For graduate students desiring advanced work not provided in regular subjects.
Information: D. S. Jerison, G. Staffilani

18.UR Undergraduate Research
Prereq: —
U (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit

Undergraduate research opportunities in mathematics. Permission required in advance to register for this subject. For further information, consult the departmental coordinator.
Information: H. R. Miller

18.ThG Graduate Thesis
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged H-LEVEL Grad Credit
Can be repeated for credit

Program of research leading to the writing of a PhD thesis; to be arranged by the student and an appropriate MIT faculty member.
Information: D.S. Jerison, G. Staffilani

18.CME Study at Cambridge University
Prereq: —
U (Fall, Spring)
Units arranged
Can be repeated for credit

Provides credit for students studying at Cambridge University under the Undergraduate Student Exchange Program of the Cambridge-MIT Institute. Credit may be used to satisfy specific SB degree requirements. Consult with department and CME office.
H. R. Miller