MATHEMATICAL AND COMPUTATIONAL SCIENCE

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Courses offered by the Program in Mathematical and Computational Science have the subject code MCS, and are listed in the "Mathematical and Computational Science (MCS) Courses" section of this bulletin.

This interdepartmental interschool undergraduate program provides a major for students interested in the mathematical and computational sciences, or in the use of mathematical ideas and analysis in problems in the social or management sciences. It provides a core of mathematics basic to all the mathematical sciences and an introduction to concepts and techniques of automatic computation, optimal decision making, probabilistic modeling, and statistical inference. It also provides an opportunity for elective work in any of Stanford's mathematical science disciplines.

The program uses the faculty and courses of the departments of Computer Science, Management Science and Engineering, Mathematics, and Statistics. It prepares students for graduate study or employment in the mathematical and computational sciences or in those areas of applied mathematics which center around the use of computers and are concerned with the problems of the social and management sciences.

A biology option is offered for students interested in applications of mathematics, statistics, and computer science to the biological sciences (bioinformatics, computational biology, statistical genetics, neurosciences); and in a similar spirit, an engineering option.

UNDERGRADUATE PROGRAMS IN MATHEMATICAL AND COMPUTATIONAL SCIENCE

BACHELOR OF SCIENCE IN MATHEMATICAL AND COMPUTATIONAL SCIENCE

The requirement for the bachelor's degree, beyond the University's basic requirements, is an approved course program of 72-77 units, distributed as follows:

Mathematics (MATH): 29-31 units

	Qtr. and Units	
MATH 41. Calculus	A	5
and MATH 42. Calculus	A,W	5
MATH 51. Linear Algebra and Differential Calculus of Several Variables	A,W,S	5
or MATH 51H. Honors Advanced Calculus	A	5
MATH 52. Integral Calculus of Several Variables	A,W,S	5
or MATH 52H. Honors Advanced Calculus	W	5
MATH 53. Ordinary Differential Equations with Linear Algebra	A,W,S	5
or MATH 53H. Honors Advanced Calculus	S	5
MATH 109. Applied Group Theory (WIM)	A	3
or MATH 110. Applied Number Theory and Field Theory (WIM)	S	3
or MATH 120. Modern Algebra (WIM)	A,S	3
MATH 104. Applied Matrix Theory	A,W	3
or MATH 113. Linear Algebra & Matrix Theory	A,W,S	3

Computer Science (CS): 16-18 units

CS 103. Mathematical Foundations of Computing	W	5
or CS 103A. Discrete Mathematics for Computer Science	A	3
and CS 103B. Discrete Structures	W	3
CS 106X. Programming Methodology and Abstractions (Accel.)	A, S	3-5
or CS 106A. Programming Methodology	A,W,S	3-5
and CS 106B. Programming Abstractions	W,S	3-5
And two of the following (CS or CME):		
CME 108. Introduction to Scientific Computing	W	3-4
CS 107. Programming Paradigms	A,S	3-5
CS 154. Introduction to Automata and Complexity Theory	A,S	3-4
CS 161. Design and Analysis of Algorithms	A,W	3-4

Management Science and Engineering (MS&E): 8-9 units

MS&E 111. Introduction to Optimization (same as ENGR 62)	A,S	3-4
and MS&E 121. Introduction to Stochastic Modeling	W	43
or MS&E 221. Stochastic Modeling	W	
or three of the following:		
MS&E 211. Linear and Nonlinear Optimization	A	3-4
MS&E 212. Mathematical Programming and Combinatorial Optimization	W	3
MS&E 221. Stochastic Modeling	W	3
MS&E 251. Stochastic Decision Models	W	3

Statistics (STATS): (11 units)

STATS 116. Theory of Probability	A,S	3-5
STATS 191. Introduction to Applied Statistics	W	3-4
or STATS 203. Introduction to Regression Models and Analysis of Variance	W	3
STATS 200. Introduction to Statistical Inference	W	3

HONORS PROGRAM

The honors program is designed to encourage a more intensive study of mathematical sciences than the B.S. program. In addition to meeting all requirements for the B.S., the student must:

Maintain an average letter grade equivalent in mathematical sciences courses of at least a 3.4.

1. Complete at least 15 units in mathematical sciences in addition to the requirements for the major listed above. These courses should form a sustained effort in one area and constitute a program approved by the committee in charge of the Mathematical and Computational Science Program.
2. Include in the above 15 units at least one of the following:
   a. an approved higher-level graduate course
   b. participation in a small group seminar
   c. at least 3 units of directed reading

Students interested in doing honors work should consult with their advisers by the last quarter of the junior year to prepare a program of study for submission to the committee in charge for approval. Honors work may be concentrated in fields outside the Mathematical and Computational Science programs such as biological sciences, medicine, physics.

MATHEMATICAL AND COMPUTATIONAL SCIENCE ELECTIVES (9 UNITS)

Three courses in mathematical and computational science, 100-level or above, at least 3 units each. At least one must be chosen from the following:

	Qtr. and Units	
ECON 102C. Advanced Topics in Econometrics	S	5
ECON 140. Introduction to Financial Economics	S	5
ECON 160. Game Theory and Economic Applications (prerequisite ECON 51)	W	5
ECON 179. Experimental Economics	W	5
EE 261. The Fourier Transform and its Applications	A,W	3

MS&E 211. Linear and Nonlinear Optimization	A	3-4
MS&E 212. Mathematical Programming and Combinatorial Optimization	W	3
MS&E 221. Stochastic Modeling	W	3
MS&E 251. Stochastic Decision Models	W	3
MCS 100. Mathematics of Sports (same as STATS 50) (not given 2008-09)		3
MATH 104. Applied Matrix Theory	A, W	3
MATH 106. Functions of a Complex Variable	W	3
MATH 108. Introduction to Combinatorics and its Applications	S	3
MATH 111. Computational Commutative Algebra (not given 2008-09)		3
MATH 113. Linear Algebra & Matrix Theory	A,W,S	3
MATH 115. Functions of a Real Variable	A,W	3
MATH 116. Complex Analysis	W	3
MATH 118. Mathematics of Computation	W	3
MATH 131. Partial Differential Equations I	A,W	3
MATH 132. Partial Differential Equations II	S	3
MATH 135. Nonlinear Dynamics and Chaos (not given 2008-09)		3
MATH 136. Stochastic Processes	A	3
PHIL 151. First-Order Logic	W	4
STATS 202. Data Analysis	A	3
STATS 215. Statistical Models in Biology	W	3
STATS 217. Introduction to Stochastic Processes	W	3

For Computer Science (CS), electives can include courses not taken as units under the CS list above and the following:

CME 302. Numerical Linear Algebra	A	3
CS 108. Object-Oriented Systems Design	A,W	3-4
CS 110. Principles of Computer Systems	S	5
CS 140. Operating Systems and Systems Programming	A,W	3-4
CS 143. Compilers	A	3-4
CS 157. Logic and Automated Reasoning	A	3-4
CS 161. Design and Analysis of Algorithms	A,W	3-4
CS 194. Software Project (prerequisite CS 108)	S	3
CS 221. Artificial Intelligence: Principles and Techniques	W	3-4
CS 223A. Introduction to Robotics	W	3
CS 223B. Introduction to Computer Vision	W	3
CS 225A. Experimental Robotics (not given 2008-09)		3
CS 228. Probabilistic Models in Artificial Intelligence	W	3
CS 229. Machine Learning	A	3
CS 243. Advanced Compiling Techniques	W	3-4
EE 282. Computer Systems Architecture	A	3

With the adviser's approval, courses other than those offered by the sponsoring departments may be used to fulfill part of the elective requirement. These may be in fields such as biology, economics, electrical engineering, industrial engineering, and medicine, that might be relevant to a mathematical sciences major, depending on a student's interests.

At least three quarters before graduation, majors must file with their advisers a plan for completing degree requirements.

3. All courses used to fulfill major requirements must be taken for a letter grade with the exception of courses offered satisfactory/no credit only.
4. A course used to fulfill the requirements of one section of the program may not be applied toward the fulfillment of the requirements of another section.
5. The student must have a grade point average (GPA) of 2.0 or better in all course work used to fulfill the major requirement.

MATHEMATICAL AND COMPUTATIONAL SCIENCE BIOLOGY OPTION

Replace MATH 109/110 with:

	Qtr. and Units
MATH 135. Nonlinear Dynamic Systems (not given 2008-09)	3

Replace STATS 191/203 by

STATS/BIO 141. Biostatistics	A	3-5

Take at least 2 courses from the Biology core:

BIO 41. Genetics and Biochemistry	A	5
BIO 42. Cell Biology and Animal Physiology	W	5
BIO 43. Plant Biology, Evolution, and Ecology	S	5

Take a third course either from the core or

STATS 166. Statistical Methods in Computational Genetics (WIM)	S	3
BIO 133. Genetics of Prokaryotes	A	3
BIO 134. Replication of DNA	W	3
BIO 135. Biological Clocks (not given 2008-09)		3
BIO 136. Evolutionary Paleobiology (not given 2008-09)		4
BIO 143/243. Evolution	A	4
BIO 144. Conservation Biology	W	3-4
BIO 160A. Developmental Biology I	W	4
BIO 160B. Developmental Biology II	S	4
BIO 203. Advanced Genetics	A	4
BIO 230. Molecular and Cellular Immunology	A	4-5

Honors students should take 3 of the following:

STATS 166. Statistical Methods in Computational Genetics (WIM)	S	3
ANTHRO 180. Introduction to Anthropological Genetics	S	5
ANTHRO 187. The Genetic Structure of Populations (not given 2008-09)		5
ANTHRO 188. Research in Anthropological Genetics (not given 2008-09)		5
BIO 113. Fundamentals of Molecular Evolution (not given 2008-09)		4
BIO 146. Population Studies	W	1

MATHEMATICAL AND COMPUTATIONAL SCIENCE ENGINEERING OPTION

Students in the Engineering option take the introductory courses for the Mathematics and Computational Sciences major with the following allowable substitutions.

The MATH 51-53 series may be replaced by:

	Qtr. and Units	
CME 100/ENGR 154. Vector Calculus for Engineers	A	5
CME 102/ENGR 155A. Ordinary Differential Equations for Engineers	W	5
CME 104/ENGR 155B. Linear Algebra and Partial Differential Equations for Engineers	S	5
MATH 115. Functions of a Real Variable	A,W	3

STATS 116 may be replaced by either one of the following:

STATS 110. Statistical Methods in Engineering and Physical Sciences	A	4-5
or CME 106/ENGR 155C. Introduction to Probability and Statistics for Engineers	W	3-4

STATS 191/STATS 203 may be replaced by:

STATS 202. Data Analysis	A	3

Electives; take at least one course from the following list:

MATH 106. Introduction to Theory of Functions of a Complex Variable	W	3
MATH 108. Introduction to Combinatorics Applications	S	3
MATH 116. Complex Analysis	W	3
MATH 118. Mathematics of Computation	W	3
MATH 132. Partial Differential Equations II	S	3
MATH 135. Nonlinear Dynamics and Chaos (not given 2008-09)		3
PHIL 151. First-Order Logic	W	4

Take at least two courses from the following list:

ENGR 15. Dynamics	A,S	3
ENGR 20. Introduction to Chemical Engineering	S	3
ENGR 25. Biotechnology	S	3
ENGR 30. Engineering Thermodynamics	A,W	3
ENGR 40. Introductory Electronics	A, S	5
ENGR 50. Introductory Science Materials	A,W, S	4
ENGR 105. Feedback Control Design	W	3

Take three additional courses from a single engineering department, and two additional courses from any engineering department(s).

MINOR IN MATHEMATICAL AND COMPUTATIONAL SCIENCE

The minor in Mathematical and Computational Science is intended to provide an experience of the four constituent areas: Computer Science, Mathematics, Management Science and Engineering, and Statistics. Four basic courses are required:

CS 106X. Programming Methodology and Abstractions (Accelerated)
or CS 106A,B. Programming Methodology

MATH 51. Linear Algebra and Differential Calculus of Several Variables
or MATH 104. Applied Matrix Theory

ENGR 62/MS&E 111. Introduction to Optimization
or MS&E 121. Introduction to Stochastic Modeling

STATS 116. Theory of Probability and either
STATS 191. Introduction to Applied Statistics
or STATS 200. Introduction to Statistical Inference

In addition to the above, the minor requires three courses from the following, two of which must be in different departments:

CME 108. Introduction to Scientific Computing
CS 103. Mathematical Foundations of Computing
CS 107. Programming Paradigms
CS 154. Introduction to Automata and Complexity Theory
CS 161. Design and Analysis of Algorithms
EE 261. The Fourier Transform and its Applications
ECON 102C. Advanced Topics in Econometrics
ECON 160. Game Theory and Economic Applications (prerequisite ECON 51)
ECON 181. Optimization and Economic Analysis
MS&E 121. Introduction to Stochastic Modeling
MS&E 211. Linear and Nonlinear Optimization
MS&E 212. Mathematical Programming and Combinatorial Optimization
MS&E 221. Stochastic Modeling
MS&E 251. Stochastic Decision Models
MATH 104. Applied Matrix Theory
MATH 106. Functions of a Complex Variable
MATH 108. Introduction to Combinatorics and its Applications
MATH 109. Applied Group Theory
MATH 110. Applied Number Theory and Field Theory
MATH 115. Functions of a Real Variable
MATH 118. Mathematics of Computation
MATH 131. Partial Differential Equations I
MATH 132. Partial Differential Equations II
MATH 135. Nonlinear Dynamics and Chaos
MATH 171. Fundamental Concepts of Analysis
PHIL 151. First-Order Logic
STATS 191. Introduction to Applied Statistics
STATS 200. Introduction to Statistical Inference
STATS 202. Data Analysis
STATS 203. Introduction to Regression Models and Analysis of Variance
STATS 217. Introduction to Stochastic Processes

Other upper-division courses appropriate to the program major may be substituted with consent of the program director. Undergraduate majors in the constituent programs may not count courses in their own departments.

MATHEMATICAL AND COMPUTATIONAL SCIENCE (MCS) COURSES

For information on undergraduate programs in Mathematical and Computational Science, including lists of courses applicable to the major, see the "Mathematical and Computational Science" section of this bulletin.

UNDERGRADUATE COURSES IN MATHEMATICAL AND COMPUTATIONAL SCIENCE

MCS 100. Mathematics of Sports
(Same as STATS 50.) The use of mathematics, statistics, and probability in the analysis of sports performance, sports records, and strategy. Topics include mathematical analysis of the physics of sports and the determinations of optimal strategies. New diagnostic statistics and strategies for each sport. Corequisite: STATS 116. GER:DB-Math
3 units, not given this year