APPLIED MATHEMATICS

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Mathematical models are widely used throughout science and engineering in fields as diverse as physics, bioinformatics, robotics, image processing, and economics. Despite the broad range of mathematical settings and applications, there is a core of essential concepts and techniques used in addressing most problems. The Applied Mathematics major provides a foundation in these mathematical techniques and trains the student to use them in a substantive field of application.

The interdisciplinary major permits a great deal of flexibility in design. It is intended to appeal to students who wish to study the more mathematical aspects of science or engineering, as well as those whose primary interest is in mathematics and statistics and who wish to become acquainted with applications. Core courses are drawn from Computer Science, Mathematics, Statistics and Data Science, and Engineering and Applied Science. Courses applying mathematics may be drawn from participating programs in Applied Physics; Astronomy; the biological sciences, including Ecology and Evolutionary Biology, Molecular Biophysics and Biochemistry, and Molecular, Cellular, and Developmental Biology; Chemistry; Economics; the various programs in engineering, including Biomedical, Chemical, Electrical, Environmental, and Mechanical Engineering and Materials Science; Earth and Planetary Sciences; Physics; and even Linguistics and Political Science. The Applied Mathematics degree program requires a three-course concentration in a field in which mathematics is used.

Students in the major are often sought after by graduate programs in either Applied Mathematics or in the disciplines in which they choose their concentration, as well as by industries and startup companies in which their breadth of quantitative skills are essential.

Students may pursue a major in Applied Mathematics as one of two majors and can thereby equip themselves with mathematical modeling skills while being fully engaged in a field of application. In this case, the concentration requirement of the Applied Mathematics program is flexible in order to recognize the contribution of the other major. A two-course overlap is permitted in satisfying the requirements of the two majors.

Frequently Asked Questions Students are encouraged to consult the Applied Mathematics FAQ for more detail about courses and policies in the major.

PREREQUISITE AND INTRODUCTORY COURSES

Multivariable calculus and linear algebra are required and should be taken before or during the sophomore year. This requirement may be satisfied by MATH 120 or ENAS 151, and MATH 222 or 225 or equivalents. It may also be satisfied by MATH 230, 231. Computer programming skills are also required and may be acquired by taking ENAS 130, CPSC 100, or 112. Details of individual programs must be worked out in consultation with the director of undergraduate studies (DUS), whose signed permission is required.

REQUIREMENTS OF THE MAJOR

The B.A. degree program The program requires eleven term courses beyond the prerequisites, including the senior project, comprising a coherent program:

1. A course in differential equations (ENAS 194 or MATH 246).
2. A course in probability (S&DS 241 or S&DS 238).
3. A course in data analysis (S&DS 361 or S&DS 230).
4. A course in discrete mathematics (AMTH 244 or CPSC 202).
5. Courses in at least three of the following areas including, but not limited to:
   (a) optimization: AMTH 437, EENG 400;
   (b) probability and statistics: S&DS 242, 312, 351, 364, 400, 410, 411, 425, ECON 136, APHY 470;
   (c) partial differential equations and analysis: MATH 247, 250, 260, 300, 301, 305, 310, AMTH 428;
   (d) algorithms and numerical methods: CPSC 365, 366, 424, 440, 465, 467, 468, 469, ENAS 440, 441;
   (e) graph theory: AMTH 462, CPSC 662, ENAS 962;
   (f) mathematical economics: ECON 125, 126, 350, 351, 353, 417, 433, 460, 471;
   (g) electrical engineering: EENG 397, 436, EENG 442, 455, S&DS 364;
   (h) data mining and machine learning: S&DS 262, 365, 669, 671, CPSC 445, 453, 470, 474, 477, CPSC 663, 745;
   (i) biological modeling and computation: CPSC 453, 475, 476, BENG 352, 445, 458, ENAS 559;
(j) physical sciences: ASTR 320, 420, CHEM 333*, EPS 322, 323, 421, 428, 456, PHYS 342, 343, 344, 401, 402, 410, 420, 430, 440, 442, 460, APHY 439, 448;

(k) engineering: MENG 280, 285, 361, 365, 383, 463, 469, CENG 301, 315;

(l) linguistics: LING 277, LING 380.

*CHEM courses with number 410 and above may count as a breadth requirement with permission of the DUS.

Because departmental curricula from which the program draws regularly change, the DUS maintains a more exhaustive list of courses satisfying this particular requirement.

6. At least three advanced courses in a field of concentration involving the application of mathematics to that field. Programs in science, engineering, computer science, statistics, and economics are natural sources of concentration. Alternatively, when two majors are undertaken, if the second major is in a participating program, then, recognizing that there can be an overlap of two courses, the student may take for the remaining course an additional choice relevant to the Applied Mathematics major such as listed in point 5 above or for the B.S. below. Details of a student’s program to satisfy the concentration requirement must be worked out in consultation with, and approved by, the DUS.

The B.S. degree program In addition to the courses indicated for the B.A. degree, the B.S. degree, which totals fourteen term courses beyond the prerequisites, must also include:

1. Topics in analysis (MATH 300) or introduction to analysis (MATH 301); the course selected may not be counted toward the area requirement for the major (see item 5 above). (MATH 350 and MATH 440 can in specific cases be considered in consultation with the DUS.)

2. An additional course selected from the list in item 5 above.

3. Another course numbered 300 or higher from the list above, or a course numbered 300 or higher in mathematics, applied mathematics, statistics, or quantitative computer science or engineering, subject to the approval of the DUS.

Alternatively, students may petition to receive a B.S. in Applied Mathematics by fulfilling the B.A. requirements in Applied Mathematics and the B.S. requirements in another program.

Credit/D/Fail A maximum of one course credit taken Credit/D/Fail may be counted toward the requirements of the major.

SENIOR REQUIREMENT

Both the B.A. and B.S. degree programs require a senior seminar and project (AMTH 490), or a special project completed during senior year (AMTH 491).

REQUIREMENTS OF THE MAJOR

Prerequisites MATH 120 or ENAS 151, and MATH 222 or 225, or equivalents; ENAS 130, CPSC 100, or 112

Number of courses B.A. – 11 term courses beyond prereqs (incl senior req); B.S. – 14 term courses beyond prereqs (incl senior req)

Specific courses required B.A. – ENAS 194 or MATH 246; S&DS 241 or S&DS 238; S&DS 361 or S&DS 230; AMTH 244 or CPSC 202; B.S. – same, plus MATH 300 or 301 (in specific cases, MATH 350 and 440, with DUS approval)

Distribution of courses B.A. – at least 3 advanced courses in a field of concentration concerning the application of math to that field; 3 addtl courses as specified; B.S. – same, with 2 addtl courses as specified

Substitution permitted MATH 230, 231 for mathematics prerequisites

Senior requirement Senior sem (AMTH 490) or special project (AMTH 491)

Mathematical models are used to study a multitude of problems in fields as diverse as bioinformatics, systems engineering, and business management. Despite the wide range of the applications, relatively few essential mathematical techniques and concepts are used in addressing most problems. The Applied Mathematics major is designed to provide a foundation in these common mathematical techniques and to train students to use them to solve problems in one or two fields of application.

The major is intended for students interested in theoretical and quantitative aspects of the natural and social sciences. Students currently combine applied mathematics with astronomy, chemistry, computer science, economics, engineering, geophysics, physics, and statistics and data science, but any other discipline with enough quantitative courses may serve as the area of specialization.

Prerequisites for the major include courses in computer programming, multivariable calculus, and linear algebra. Students who want to keep their options open should take, in addition to the prerequisites, an introductory sequence in physics or chemistry (for those interested in the natural sciences) or a year of introductory economics (for those who wish to concentrate in the social or management sciences).

The director of undergraduate studies (DUS) may be contacted in the fall for a more detailed description of the Applied Mathematics program, including a sample curriculum and a list of appropriate upper-level courses.
FACULTY ASSOCIATED WITH THE PROGRAM OF APPLIED MATHEMATICS

**Professors** Andrew Barron (Statistics & Data Science), David Bercovici (Geology & Geophysics), Donald Brown (Emeritus) (Economics, Mathematics), Joseph Chang (Statistics & Data Science), Ronald Coifman (Mathematics), Stanley Eisenstat (Computer Science), Michael Fischer (Computer Science), Igor Frenkel (Mathematics), Roger Howe (Emeritus) (Mathematics), Peter Jones (Mathematics), John Laflerty (Statistics & Data Science), A. Stephen Morse (Electrical Engineering), David Pollard (Statistics & Data Science), Nicholas Read (Physics, Applied Physics), Vladimir Rokhlin (Computer Science, Mathematics), Peter Schultheiss (Emeritus) (Electrical Engineering), Martin Schultz (Emeritus) (Computer Science), Mitchell Smooke (Mechanical Engineering, Applied Physics), Daniel Spielman (Computer Science, Statistics & Data Science), Mary-Louise Timmermans (Geology & Geophysics), Van Vu (Mathematics), Günter Wagner (Ecology & Evolutionary Biology), John Wettlaufer (Geology & Geophysics, Mathematics, Physics), Huibin Zhou (Statistics & Data Science), Steven Zucker (Computer Science, Biomedical Engineering)

**Associate Professors** John Emerson (Statistics & Data Science), Thierry Emonet (Molecular, Cellular, & Developmental Biology, Physics), Josephine Hoh (Epidemiology & Public Health), Yuval Kluger (Pathology), Michael Krauthammer (Pathology), Sekhar Tatikonda (Electrical Engineering, Statistics & Data Science)

**J. W. Gibbs Assistant Professors** Asher Auel, Ross Berkowitz, Ariel Jaffe, Gal Mishne

View Courses