Mathematics

See also Applied Mathematics

Directors of undergraduate studies: Richard Kenyon [spring 2025], Sebastian Hurtado-Salazar [fall 2025 and spring 2026], Miki Havlickova [all semesters]; contact email: math.dus@yale.edu; Math DUS website; Math department website

Mathematics has many aspects: it is the language and tool of the sciences, a cultural phenomenon with a rich historical tradition, and a model of abstract reasoning. The course offerings and the major in Mathematics reflect these multiple facets. The Mathematics major provides a broad education in various areas of mathematics in a program flexible enough to accommodate many ranges of interest. Incoming students are encouraged to visit the Math first-year student resources website for advice about choosing their mathematics courses.

PREREQUISITE

The prerequisite for both the B.A and B.S. degree programs is single variable calculus, through the level of MATH 1150 or equivalent (such as a score of 4 or 5 on the AP Calculus BC exam).

CALCULUS PLACEMENT PROCEDURES

The department offers a three-term sequence in calculus, MATH 1120, 1150, and 1200. Students who have not taken calculus at Yale and wish to enroll in calculus must take the mathematics online placement examination. Detailed information is available on the Math first-year student resources website. A calculus advising session will be held prior to registration to answer student questions about placement.

MATH 1120 covers differential calculus and assumes mastery of high school algebra, geometry, and trigonometry. Enrolling students are expected to know the basic definitions of trigonometric functions, inverse functions, factoring quadratic polynomials, and elementary area and volume formulas of plane and solid geometry. Students who could benefit from a review of precalculus are encouraged to consider MATH 1100 and 1110 in place of MATH 1120.

The next course in the calculus sequence is MATH 1150, which covers integral calculus, including sequences and series. It assumes mastery of the content of MATH 1120 or equivalent (AP Calculus AB exam).

MATH 1200 covers multivariable calculus and assumes mastery of the material in MATH 1150 or equivalent (AP Calculus BC exam).

REQUIREMENTS OF THE MAJOR

See Links to the attributes indicating courses approved for Math major requirements.

Students are held to the requirements that were in place when they declared their major. However, with approval from the director of undergraduate studies (DUS), the following requirements, updated for the academic year 2024-2025, may be fulfilled by students who declared the major in a prior term.

Introductory sequence requirement Each student is expected to complete Linear algebra with proofs (MATH 2250 or 2260), Real analysis (MATH 2550 or 2560), and Vector analysis or Multivariable calculus (MATH 3020 or 1200).

B.A. degree program The B.A. degree program consists of ten term courses in Mathematics numbered 2250 or higher, including the senior requirement, but excluding MATH 4700. To acquire both depth and breadth in the field, students are required to take at least three courses that carry the "math distribution" attribute (YC MATH Distribution), searchable in Yale Course Search (YCS). Students are also required to complete MATH 3500 (algebra), and at least one of MATH 3050 (real analysis) or MATH 3100 (complex analysis). Taking all three is recommended. With prior written permission from the DUS, students familiar with the material may substitute a higher-level course in the same area (typically MATH 3700, 3200, 3150 respectively.)

B.S. degree program The B.S. degree program consists of twelve term courses and follows the same requirements as for the B.A. degree, with the addition of at least two advanced term courses in the physical sciences, such as ASTR 4180, ASTR 4300, CHEM 3330, 4700, PHYS 4010 or PHYS 4100, PHYS 4020 or PHYS 4300, PHYS 4400, PHYS 4410, PHYS 4500. Other such courses require the approval of the director of undergraduate studies (DUS); written approval is advised.

Distinction in the major To be eligible for Distinction in the Major, a student must have completed MATH 3050 (real analysis), MATH 3100 (complex analysis), and MATH 3500 (algebra).

The intensive major Candidates for a degree with an intensive major in Mathematics must take MATH 3050, 3100, and 3500. Intensive majors are also expected to include at least two graduate courses level 5000 or above in the Mathematics department, or equivalent independent study, among their required ten mathematics courses. Familiarity with the material of the following courses is prerequisite to graduate courses in each category: *algebra:* MATH 3500 and MATH 3700; *analysis:* MATH 3050, 3100; *algebraic topology:* MATH 3500, 4300.

Credit/D/Fail No course taken Credit/D/Fail may be applied toward the requirements of the major.

Outside credit Courses taken after matriculation at Yale at another institution or during an approved summer or term-time study abroad program may count toward the major requirements with DUS approval.

SENIOR REQUIREMENT

During the senior year, students majoring in Mathematics fulfill the senior requirement by taking any Math course numbered MATH 4800 through MATH 4890. Alternatively, with the consent of the DUS, students may write a senior essay in MATH 4750 under the guidance of a faculty member, which includes both a written and an oral report. Students wishing to write a senior essay should consult the DUS at least six weeks before enrolling in MATH 4750, and are encouraged to pursue independent study opportunities prior to their senior year, for example through the Mathematics directed reading program or through summer research programs.

ADVISING

Students interested in pursuing further study in pure mathematics should include MATH 3020, 3050, 3100, 3500, 3700, and 4300 in their programs, and should consider taking one or more graduate-level courses. Students interested in applications of mathematics should include MATH 3020, 3100, 3500, and a selection of courses from MATH 2410, 2420, 2440, 2460, 2470, 2510, 2600.

Courses related to mathematics Each Mathematics major is urged to acquire additional familiarity with the uses of mathematics by taking courses in Applied Mathematics, Computer Science, Engineering and Applied Science, Economics, Philosophy, Physics, Statistics and Data Science, or other departments. With approval from the DUS, up to two math-intensive courses from other departments may be counted among the ten courses required for the major in Mathematics.

Graduate work Each year the Mathematics department offers a large number of graduate courses, some of which are accessible to undergraduates with advanced preparation in mathematics. Graduate courses numbered 5000–5999 may be counted toward the requirements of the major.

Combined B.S./M.S. degree program Students who, by the end of their senior year, complete the requirements of the department for the M.S. in Mathematics are eligible to receive this degree at their Senior Commencement. Required are: (1) eight additional term courses numbered 5000–9999, most of which must be completed with grades of B or better; (2) passing a written qualifying examination of the student's choice from analysis, algebra, or topology.

The master's program is in no sense a substitute for the B.S. program; rather, it is designed to accommodate exceptional students who, by means of accelerated or independent study, can satisfy the department as to their command of the content of the normal undergraduate program by the end of the junior year. Candidates must contact the Mathematics DUS at least two weeks prior to the last day of classes of their fifth term at Yale College. Minimum eligibility criteria include at least seventy-five percent of A/A– grades within mathematics as well as seventy-five percent of A/A– grades overall. For more information on mathematics requirements, please see the B.S./M.S. section of the Math major FAQ. For more information on Yale College requirements for the program, see Academic Regulations, Section L, Special Academic Arrangements, "Simultaneous Award of the Bachelor's and Master's Degrees."

Graduate classes: Undergraduate students are welcome to enroll in courses level 5000 and above, after completing the relevant pre-requisites. We recommend that students wishing to take graduate classes begin with courses level 5000–5999, which are designed to be accessible to advanced undergraduates, and can be counted toward undergraduate requirements of the major. Courses level 6000 and above cannot be counted toward undergraduate requirements of the major, but they can earn graduation credit, and be applied toward the graduate requirement of the intensive mathematics major as well as toward the graduate requirement of the combined B.S./M.S. degree.

SUMMARY OF MAJOR REQUIREMENTS

Prerequisite Single-variable calculus through MATH 1150 or equivalent

Introductory sequence Linear algebra with proofs (MATH 2250 or MATH 2260), Real analysis (MATH 2550 or MATH 2560), and Vector analysis or Multivariable calculus (MATH 3020 or MATH 1200).

Number of courses *B.A.*—10 term courses numbered 2250 or higher (incl senior req), excludes MATH 4700; *B.S.*—12 term courses numbered 2250 or higher (incl senior req), excludes MATH 4700

Specific courses required *B.A. and B.S.*—MATH 3500; MATH 3050 or MATH 3100

Distribution of courses *B.A. and B.S.*— 3 courses in the Math distribution category; *B.S.*—at least two adv term courses in the physical sciences as approved by DUS

Substitution permitted With DUS permission, up to 2 math-intensive courses from other depts

Intensive major All three of MATH 3050, 3100, 3500; 2 math grad courses level 5000 through 5999 or equivalent independent study counted among the required courses

Senior requirement Senior seminar numbered MATH 4800 through 4890, or MATH 4750 with DUS permission

FACULTY OF THE DEPARTMENT OF MATHEMATICS

Professors Richard Beals (*Emeritus*), Jeffrey Brock, Andrew Casson (*Emeritus*), Ronald Coifman, Igor Frenkel, Howard Garland (*Emeritus*), Anna Gilbert, Alexander Goncharov, Roger Howe (*Emeritus*), Peter Jones, Richard Kenyon, Ivan Losev, Gregory Margulis, Yair Minsky, Vincent Moncrief, Andrew Neitzke, Hee Oh, †Nicholas Read, Vladimir Rokhlin, Wilhelm Schlag, George Seligman (*Emeritus*), †Daniel Spielman, Van Vu, Lu Wang, †John S. Wettlaufer, Gregg Zuckerman (*Emeritus*)

J. W. Gibbs Assistant Professors Yariv Aizenbud, Pablo Boixeda Alvarez, Subhadip Dey, Gurbir Dhillon, Daniel Douglas, James Farre, Abinand Gopal, Erik Orvehed Hiltunen, Yakov Kononov, Boris Landa, Or Landesberg, Kevin O'Neill, Cosmin Pohoata, Congling Qiu, Ebru Toprak, Franco Vargas Pallete

Adjunct Professors Gil Kalai, Alex Lubotzky, Jacques Peyriere, Mathias Schacht

Senior Lecturers John Hall, Miki Havlickova

Lecturers Ian Adelstein, Mihai Alboiu, James Barnes, Rachel Diethorn, Eric Geiger, Su Ji Hong, Robert McDonald, Brett Smith

†A joint appointment with primary affiliation in another department.