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The Curriculum

BOWDOIN RECOGNIZES through its course offerings and requirements the importance of relating a liberal education to a world whose problems and needs are continually changing. The College does not prescribe specific courses for all students. Rather, each student determines an appropriate program of liberal arts courses within the framework of the College's academic standards and in consultation with an academic advisor.

Bowdoin offers a course of study leading to the degree of Bachelor of Arts. The requirements for the degree include completion of a minimum number of courses, residence at the College for a minimum time, fulfillment of the distribution requirements, and completion of a major. A student must achieve minimum grades in order to remain enrolled at Bowdoin.

A vital part of the educational experience takes place in the interaction between students and their academic advisors. Each student is assigned a pre-major academic advisor at the start of the first year. The pre-major academic advising system is intended to help students take full advantage of the first two years of Bowdoin and begin to plan the remaining years. It provides a framework within which a student can work with a faculty member to make informed academic decisions. Such a partnership is particularly important during the period of transition and adjustment of the first year. Faculty members may make recommendations about courses, combinations of courses, or direct students towards other resources of the College. They may also play a role at moments of academic difficulty. The effectiveness of the system depends on the commitment of the student and the advisor. Students declare their majors during the second semester of the sophomore year, and afterwards are advised by members of their major departments.

ACADEMIC REQUIREMENTS FOR THE DEGREE

To qualify for the bachelor of arts degree, a student must have:

1. Successfully passed thirty-two full-credit courses or the equivalent;
2. Spent four semesters (successfully passed sixteen credits) in residence, at least two semesters of which have been during the junior and senior years;
3. Completed at least two courses in each of the following divisions of the curriculum—natural science and mathematics, social and behavioral sciences, and humanities and fine arts—and two courses in non-Eurocentric studies; and
4. Completed a major, either a departmental major, two departmental majors, a coordinate major, an interdisciplinary major, or a student-designed major (a departmental minor may be completed with any of the preceding).
5. In addition, all students beginning with the Class of 2009 must have completed a first-year seminar.

No student will ordinarily be permitted to remain at Bowdoin for more than nine semesters of full-time work.

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DISTRIBUTION REQUIREMENTS

Students must take two courses from each of the three divisions of the curriculum—natural science and mathematics, social and behavioral sciences, and humanities and fine arts. Students must also take two courses in non-Eurocentric studies; a course that satisfies the non-Eurocentric studies requirement may also count for its division. In addition, all students beginning with the Class of 2009 must take a first-year seminar. These requirements may not be met by Advanced Placement or International Baccalaureate credits, but may be met by credits earned while studying away from Bowdoin. Distribution requirements should normally be completed by the end of the sophomore year. Areas of distribution are defined as follows:

Natural Science and Mathematics: Biochemistry, biology, chemistry, computer science, geology, mathematics, neuroscience, physics, and certain environmental studies and psychology courses. (Designated by the letter *a* following a course number in the course descriptions.)

Social and Behavioral Sciences: Africana studies, economics, government, psychology, sociology and anthropology, and certain Asian studies, environmental studies, history, and gender and women's studies courses. (Designated by the letter *b* following a course number in the course descriptions.)

Humanities and Fine Arts: Art, Chinese, classics, dance, education, English, film, German, Japanese, music, philosophy, religion, Romance languages, Russian, theater, most history courses, and certain Asian studies and gender and women's studies courses. (Designated by the letter *c* following a course number in the course descriptions.)

Non-Eurocentric Studies: Students must take two courses that focus on a non-Eurocentric culture or society, exclusive of Europe and European Russia and their literary, artistic, musical, religious, and political traditions. The requirement is intended to introduce students to the variety of cultures and to open their minds to the different ways in which people perceive and cope with the challenges of life. Though courses primarily emphasizing North American and European topics will not count toward this requirement, courses focusing on African American, Native American, or Latin American cultures will meet the requirement. Language courses do not meet this requirement. (Designated by the letter *d* following a course number in the course descriptions.)

THE MAJOR PROGRAM

Students may choose one of six basic patterns to satisfy the major requirement at Bowdoin: a departmental major, two departmental majors (a double major), a coordinate major, an interdisciplinary major, a student-designed major, or any of the preceding with a departmental minor. The requirements for completing specific majors and minors are presented in detail in the section describing the courses offered by each department, beginning on page 46. Interdisciplinary majors are described beginning on page 189.

Students should have ample time to be exposed to a broad range of courses and experiences before focusing their educational interests and so do not declare their majors until spring of the sophomore year. Students are required to declare their majors before registering for courses for the junior year or applying to participate in off-campus study programs. Students declare their majors only after consultation with a major academic advisor(s). Since some departments have courses that must be passed or criteria that must be met before a student will be accepted as a major, students are encouraged to think well in advance about possible majors and to speak with faculty about their educational interests. Students may change their majors after consultation with the relevant departments, but they may not declare a new major after

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Mathematics

Professors: William H. Barker, Stephen T. Fisk†, Rosemary A. Roberts, *Chair*; James E. Ward
Associate Professor: Adam B. Levy
Assistant Professors: Matthew G. Killough, Thomas Pietraho†, Jennifer Taback**
Visiting Assistant Professors: Rebecca E. Field, Mark J. Rhodes, Mohammad Tajdari
Laboratory Instructor and Tutor: Raymond E. Fisher
Department Coordinator: Suzanne M. Theberge

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Requirements for the Major in Mathematics

A major consists of at least eight courses numbered 200 or above, including at least one of the following—**Mathematics 262, 263,** or a course numbered in the 300s.

A student must submit a planned program of courses to the department when he or she declares a major. That program should include both theoretical and applied mathematics courses, and it may be changed later with the approval of the departmental advisor.

All majors should take basic courses in algebra (e.g., **Mathematics 222** or **262**) and in analysis (e.g., **Mathematics 223** or **263**), and they are strongly encouraged to complete at least one sequence in a specific area of mathematics. Those areas are algebra (**Mathematics 222, 262,** and **302**); analysis (**Mathematics 243, 263,** and **303**); applied mathematics (**Mathematics 224, 264,** and **304**); probability and statistics (**Mathematics 225, 265,** and **305**); and geometry (**Mathematics 247** and **307**). In exceptional circumstances, a student may substitute a quantitative course from another department for one of the eight mathematics courses required for the major, but such a substitution must be approved in advance by the department. Without specific departmental approval, no course that counts toward another department's major or minor may be counted toward a mathematics major or minor.

Majors who have demonstrated that they are capable of intensive advanced work are encouraged to undertake independent study projects. With the prior approval of the department, such a project counts toward the major requirement and may lead to graduation with honors in mathematics.

Requirements for the Minor in Mathematics

A minor in mathematics consists of a minimum of four courses numbered 200 or above.

Interdisciplinary Majors

The department participates in interdisciplinary programs in computer science and mathematics and mathematics and economics. See pages 190 and 192.

Recommended Courses

Listed below are some of the courses recommended to students with the indicated interests.

For secondary school teaching:
Computer Science 107, Mathematics 222, 225, 242, 247, 262, 263, 265, 288.

For graduate study:
Mathematics 222, 243, 262, 263, and at least one course numbered in the 300s.

For engineering and applied mathematics:
Mathematics 223, 224, 225, 243, 244, 264, 265, 288, 304.

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For mathematical economics and econometrics:
Mathematics 222 or **263, 225, 244, 249, 265, 288, 304, 305,** and **Economics 316.**

For statistics and other interdisciplinary areas:
Mathematics 222, 224, 225, 243, 244, 255, 265, 305.

For computer science:
Computer Science 231; Mathematics 200, 222, 225, 244, 249, 262, 265, 288, 289.

For operations research and management science:
Mathematics 200, 222, 225, 249, 265, 288, 305, and **Economics 316.**

Introductory, Intermediate, and Advanced Courses

55a. Statistical Reasoning (formerly Mathematics 65). Every spring. THE DEPARTMENT.

An introduction to the ideas of statistics. Students learn how to reason statistically and how to interpret and draw conclusions from data. Designed for students who want to understand the nature of statistical information. Open to first-year students and sophomores who want to improve their quantitative skills. It is recommended that students with a background in calculus enroll in **Mathematics 155** or **165.** Not open to students who have credit for **Mathematics 65**.

Prerequisite: Recommendation of the director of the Quantitative Skills Program and permission of the instructor.

60a. Introduction to College Mathematics. Fall 2005. JAMES WARD.

Material selected from the following topics: combinatorics, probability, modern algebra, logic, linear programming, and computer programming. This course, in conjunction with **Mathematics 155** or **161,** is intended as a one-year introduction to mathematics and is recommended for those students who intend to take only one year of college mathematics.

155a. Introduction to Statistics and Data Analysis. Fall 2005. MATTHEW KILLOUGH. Spring 2006. THE DEPARTMENT.

A general introduction to statistics in which students learn to draw conclusions from data using statistical techniques. Examples are drawn from many different areas of application. The computer is used extensively. Topics include exploratory data analysis, planning and design of experiments, probability, one and two sample t-procedures, and simple linear regression. Not open to students who have credit for **Mathematics 165, Psychology 252, Economics 257**, or AP Statistics.

161a. Differential Calculus. Every semester. THE DEPARTMENT.

Functions, including the trigonometric, exponential, and logarithmic functions; the derivative and the rules for differentiation; the anti-derivative; applications of the derivative and the anti-derivative. Four to five hours of class meetings and computer laboratory sessions per week, on average. Open to students who have taken at least three years of mathematics in secondary school.

165a. Biostatistics. Every fall. ROSEMARY ROBERTS.

An introduction to the statistical methods used in the life sciences. Emphasizes conceptual understanding and includes topics from exploratory data analysis, the planning and design of experiments, probability, and statistical inference. One and two sample t-procedures and their non-parametric analogs, one-way ANOVA, simple linear regression, goodness of fit tests, and the chi-square test for independence are discussed. Four to five hours of class meetings and computer laboratory sessions per week, on average. Not open to students who have credit for **Mathematics 155, Psychology 252, Economics 257**, or AP Statistics.

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171a. Integral Calculus. Every semester. THE DEPARTMENT.

The definite integral; the Fundamental theorems; improper integrals; applications of the definite integral; differential equations; and approximations including Taylor polynomials and Fourier series. Four to five hours of class meetings and computer laboratory sessions per week, on average.

Prerequisite: **Mathematics 161** or equivalent.

172a. Integral Calculus, Advanced Section. Every fall. THE DEPARTMENT.

A review of the exponential and logarithmic functions, techniques of integration, and numerical integration. Improper integrals. Approximations using Taylor polynomials and infinite series. Emphasis on differential equation models and their solutions. Four to five hours of class meetings and computer laboratory sessions per week, on average. Open to students whose backgrounds include the equivalent of **Mathematics 161** and the first half of **Mathematics 171.** Designed for first-year students who have completed an AB Advanced Placement calculus course in their secondary schools.

181a. Multivariate Calculus. Every semester. THE DEPARTMENT.

Multivariate calculus in two and three dimensions. Vectors and curves in two and three dimensions; partial and directional derivatives; the gradient; the chain rule in higher dimensions; double and triple integration; polar, cylindrical, and spherical coordinates; line integration; conservative vector fields; and Green's theorem. Four to five hours of class meetings and computer laboratory sessions per week, on average.

Prerequisite: **Mathematics 171** or equivalent.

200a. Introduction to Mathematical Reasoning. Fall 2005. JENNIFER TABACK. Spring 2006. THE DEPARTMENT.

An introduction to logical deductive reasoning, mathematical proof, and the fundamental concepts of higher mathematics. Specific topics include set theory, induction, infinite sets, permutations, and combinations. An active, guided discovery classroom format.

Prerequisite: **Mathematics 161.**

207a. Elementary Topics in Topology. Every two years. Spring 2007. THE DEPARTMENT.

Topology studies properties of geometric objects that do not change when the object is deformed. The course covers knot theory, surfaces, and other elementary areas of topology.

Prerequisite: **Mathematics 181.**

222a. Linear Algebra. Every spring. THE DEPARTMENT.

Topics include vectors, matrices, vector spaces, inner product spaces, linear transformations, eigenvalues and eigenvectors, and quadratic forms. Applications to linear equations, discrete dynamical systems, Markov chains, least-squares approximation, and Fourier series.

Prerequisite: **Mathematics 181** or permission of the instructor.

224a. Applied Mathematics: Ordinary Differential Equations. Every fall. MOHAMMAD TAJDARI.

A study of some of the ordinary differential equations that model a variety of systems in the natural and social sciences. Classical methods for solving differential equations with an emphasis on modern, qualitative techniques for studying the behavior of solutions to differential equations. Applications to the analysis of a broad set of topics, including population dynamics, competitive economic markets, and design flaws. Computer software is used as an important tool, but no prior programming background is assumed.

Prerequisite: **Mathematics 181** or permission of the instructor.

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225a. Probability. Every fall. ROSEMARY ROBERTS.

A study of the mathematical models used to formalize nondeterministic or "chance" phenomena. General topics include combinatorial models, probability spaces, conditional probability, discrete and continuous random variables, independence and expected values. Specific probability densities, such as the binomial, Poisson, exponential, and normal, are discussed in depth.

Prerequisite: **Mathematics 181.**

242a. Number Theory. Every other year. Fall 2006. THE DEPARTMENT.

A standard course in elementary number theory which traces the historical development and includes the major contributions of Euclid, Fermat, Euler, Gauss, and Dirichlet. Prime numbers, factorization, and number-theoretic functions. Perfect numbers and Mersenne primes. Fermat's theorem and its consequences. Congruences and the law of quadratic reciprocity. The problem of unique factorization in various number systems. Integer solutions to algebraic equations. Primes in arithmetic progressions. An effort is made to collect along the way a list of unsolved problems.

243a. Functions of a Complex Variable. Every other fall. Fall 2005. MARK RHODES.

The differential and integral calculus of functions of a complex variable. Cauchy's theorem and Cauchy's integral formula, power series, singularities, Taylor's theorem, Laurent's theorem, the residue calculus, harmonic functions, and conformal mapping.

Prerequisite: **Mathematics 171.**

244a. Numerical Methods. Every other fall. Fall 2005. MATTHEW KILLOUGH.

An introduction to the theory and application of numerical analysis. Topics include approximation theory, numerical integration and differentiation, iterative methods for solving equations, and numerical analysis of differential equations.

Prerequisite: **Mathematics 222** or permission of the instructor.

247a. Geometry. Every other fall. Fall 2005. WILLIAM BARKER.

A survey of modern approaches to Euclidean geometry in two and three dimensions. Axiomatic foundations of metric geometry. Transformational geometry: isometries and similarities. Klein's Erlangen Program. Symmetric figures. Scaling, measurement, and dimension.

Prerequisite: **Mathematics 171** or permission of the instructor.

249a. Optimization. Every other fall. Fall 2006. ADAM LEVY.

A study of optimization problems arising in a variety of situations in the social and natural sciences. Analytic and numerical methods are used to study problems in mathematical programming, including linear models, but with an emphasis on modern nonlinear models. Issues of duality and sensitivity to data perturbations are covered, and there are extensive applications to real-world problems.

Prerequisite: **Mathematics 181.**

255a. Applied Statistical Methods. Every other spring. Spring 2006. MATTHEW KILLOUGH.

An introduction to statistical modeling techniques with an emphasis on applications. Deals first with regression analysis: least square estimates of parameters; single and multiple linear regression; hypothesis testing and confidence intervals in linear regression models; and testing of models, data analysis, and appropriateness of models. Follows with a focus on time series: linear time series models; moving average, autoregressive, and ARIMA models; estimation, data analysis, and forecasting with time series models; and forecast errors and confidence intervals.

Prerequisite: **Mathematics 155** or **165** or permission of the instructor.

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262a. Introduction to Algebraic Structures. Every year. Fall 2005. JAMES WARD.

A study of the basic arithmetic and algebraic structure of the common number systems, polynomials, and matrices. Axioms for groups, rings, and fields, and an investigation of general abstract systems that satisfy certain arithmetic axioms. Properties of mappings that preserve algebraic structure.

Prerequisite: **Mathematics 222**.

263a. Introduction to Analysis. Spring 2006. THE DEPARTMENT.

Emphasizes proof and develops the rudiments of mathematical analysis. Topics include an introduction to the theory of sets and topology of metric spaces, sequences and series, continuity, differentiability, and the theory of Riemann integration. Additional topics may be chosen as time permits.

Prerequisite: **Mathematics 181.**

264a. Applied Mathematics: Partial Differential Equations. Every other spring. Spring 2006. ADAM LEVY.

A study of some of the partial differential equations that model a variety of systems in the natural and social sciences. Classical methods for solving partial differential equations, with an emphasis where appropriate on modern, qualitative techniques for studying the behavior of solutions. Applications to the analysis of a broad set of topics, including air quality, traffic flow, and imaging. Computer software is used as an important tool, but no prior programming background is assumed.

Prerequisite: **Mathematics 224** or permission of the instructor.

265a. Statistics. Every spring. ROSEMARY ROBERTS.

An introduction to the fundamentals of mathematical statistics. General topics include likelihood methods, point and interval estimation, and tests of significance. Applications include inference about binomial, Poisson, and exponential models, frequency data, and analysis of normal measurements.

Prerequisite: **Mathematics 225.**

288a. Combinatorics and Graph Theory. Every other spring. Spring 2007. STEPHEN FISK.

An introduction to combinatorics and graph theory. Topics to be covered may include enumeration, matching theory, generating functions, partially ordered sets, Latin squares, designs, and graph algorithms.

Prerequisite: **Mathematics 200, 262** or **263,** or permission of the instructor.

302a. Advanced Topics in Algebra. Every other spring. Spring 2006. JAMES WARD.

One or more specialized topics from abstract algebra and its applications. Topics may include group representation theory, coding theory, symmetries, ring theory, finite fields and field theory, algebraic numbers, and Diophantine equations.

Prerequisite: **Mathematics 262.**

303a. Advanced Topics in Analysis. Every other spring. Spring 2007. THOMAS PIETRAHO.

One or more selected topics from analysis. Possible topics include geometric measure theory, Lebesque general measure and integration theory, Fourier analysis, Hilbert and Banach space theory, and spectral theory.

Prerequisite: **Mathematics 263.**

304a. Advanced Topics in Applied Mathematics. Every other spring. Spring 2007. MATTHEW KILLOUGH.

One or more selected topics in applied mathematics. Material selected from the following: Fourier series, partial differential equations, integral equations, optimal control, bifurcation theory, asymptotic analysis, applied functional analysis, and topics in mathematical physics.

Prerequisite: **Mathematics 224** or **264**.

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305a. Advanced Topics in Probability and Statistics. Every other fall. Fall 2006. ROSEMARY ROBERTS.

One or more specialized topics in probability and statistics. Possible topics include regression analysis, nonparametric statistics, logistic regression, and other linear and nonlinear approaches to modeling data. Emphasis is on the mathematical derivation of the statistical procedures and on the application of the statistical theory to real-life problems.

Prerequisite: **Mathematics 265** or permission of the instructor.

307a. Advanced Topics in Geometry. Every other spring. Spring 2006. WILLIAM BARKER.

A survey of analytic geometry, affine geometric, projective geometry, and the non-Euclidean geometries. Culminates in a rigorous development of the geometry of four-dimensional space-time in special relativity. The unifying theme is the transformational viewpoint of Klein's Erlangen Program.

Prerequisite: **Mathematics 247.**

291a–294a. Intermediate Independent Study. THE DEPARTMENT.

401a–404a. Advanced Independent Study and Honors. THE DEPARTMENT.

Music

Professors: Mary Hunter, Elliott S. Schwartz
Associate Professors: Robert K. Greenlee, *Chair;* James W. McCalla
Assistant Professors: Joanna Bosse†, Vineet Shende
Director of the Bowdoin Chorus: Anthony F. Antolini
Director of the Bowdoin Concert Band: John Morneau
Director of Chamber Ensembles: Roland Vazquez
Acting Director of Jazz Ensembles: Steve Grover
Concert, Budget, and Equipment Manager: Delmar Small
Department Coordinator: Linda Marquis

Requirements for the Major in Music

The music major consists of ten academic courses and two performance credits. Most majors follow one of the tracks indicated in the "Sample Majors" listed below, but students are also invited to design a major to suit their own needs. Required of all majors are: **Music 131** and **151**; two credits of performance; at least two 300-level courses; and **Music 451**, Senior Project, to be completed in the spring semester of the senior year. No more than two 100-level courses in addition to **Music 131** and **151** may be counted toward the major. **Music 101** does not count toward the major, and students are not normally permitted to count more than three independent studies courses toward the major. Honors work normally adds one extra course to the standard ten, and its second semester counts as the senior independent study.

The process for declaring the major is as follows: 1) The student consults with a member of the music faculty as early in the individual's college career as possible. 2) Before declaring major, the student proposes a list of courses that fulfill the major, or identifies a sample major to follow by submitting a list or sample major announcement to the music department chair or another member of the department. 3) Upon departmental approval of the list of courses