

The Curriculum

BOWDOIN does not prescribe a pattern of required liberal arts courses for all students. Instead, each student determines, with the help and approval of his academic counselor, what pattern of courses is most liberating for him. This practice is based on the belief that each student has come to Bowdoin to pursue seriously a liberal education. Courses, it is assumed, do not lead simply to other courses in the same subject, but properly taught, they raise questions and evoke a curiosity that other disciplines must satisfy. The College also recognizes through its course offerings the importance of relating a liberal education to a society whose problems and needs are continually changing.

The breadth of a liberal arts education is supposed to distinguish it from professional training, and its depth in one field, from dilettantism, although in fact it shares qualities of both. More specifically, Bowdoin's educational policy invites the student to extend his concerns and awareness beyond the individual at the same time that it helps him to integrate his curricular choices in accordance with his own intellectual needs. Interaction between the student and his academic adviser is a vital part of this educational experience. While there is no tidy progression among subjects outside a given department, and no way of equating a course name with its effect, students are expected to engage academic disciplines outside their chosen major and immediately related fields.

REQUIREMENTS FOR THE DEGREE

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

- a) successfully passed thirty-two courses
- b) completed a single, double, or joint major
- c) spent four semesters in residence, at least two of which will have been during the junior and senior years.

GENERAL REGULATIONS

1. **Course Load:** Students are required to take a minimum of four regular courses each semester. Applied music and ensemble courses are half-credit courses. In order to earn eight course credits for the year, students taking either of these courses are expected to take a fifth course in the fall semester. Students wishing to take more than *five* courses must have permission of the Deans' Office. If desired, a fifth course may be taken on a pass-fail basis.

2. **Course Examinations:** The regular examinations of the College are held at the close of each semester. An absence from an examination entails the mark of zero. In the event of illness or other unavoidable cause of absence from examination, the Deans' Office may authorize makeup of the examination.

3. **Course Grades:** Course grades are High Honors, Honors, Pass, and Fail. A fifth course carried on a pass-fail basis is marked "Sat" (satisfactory) or "Unsat" (unsatisfactory). High Honors indicates a performance of outstanding quality, characterized where appropriate by originality in thought as well as by mastery of the subject at the level studied. Honors indicates a performance which, though short of High Honors, is above the common in insight and understanding. Pass is a satisfactory performance consistent with standards for graduation. Fail indicates unsatisfactory work. In independent study courses that will continue beyond one semester, instructors shall have the option of submitting at the end of each semester except the last a grade of "S" for Satisfactory in place of a regular grade. A regular grade shall be submitted at the end of the final semester and shall become the grade for the previous semesters of independent study. With the approval of the Deans' Office, a grade of Incomplete may be recorded in any course for special reasons, such as illness. If the course is not completed within one year, the Incomplete becomes permanent or changes to Fail.

4. **Grade Reports:** A report of the grades of each student is sent to his parents or guardian at the close of each semester.

5. **The Dean's List:** Students who receive grades of Honors or High Honors in all regularly graded courses and Satisfactory in all other courses for a semester are placed on the Dean's List.

6. **Deficiency in Scholarship:** A student who fails three or more courses at the end of the first semester of the freshman year or who fails two or more courses at the end of any other semester is dropped from college for one semester. A student is dropped permanently from college if he is subject to dismissal a second time for failing two or more courses.

7. **Maximum Residency:** No student shall ordinarily be permitted to remain at Bowdoin for more than nine semesters of full-time work.

8. **Senior Course Selection:** Each student shall take a course in his major department in each semester of his senior year.

9. **Leave of Absence:** A student in good standing may, with the approval of his adviser, apply to the Recording Committee for a leave of absence for a specified number of semesters. The leave must begin at the end of a regular semester. A student on approved leave is eligible for financial aid upon his return. A student wishing to apply for a leave of absence for one or both semesters of an academic year must submit his application by April 1 of the previous academic year. Applications for leave of absence submitted during the fall semester requesting a leave for the next spring semester will be considered only in the most urgent circumstances.

ADVISING SYSTEM

Each student is assigned an academic adviser at the start of his freshman

year. Whenever possible, the adviser is from a field of study in which the student has shown some interest. Advisers and students meet during orientation before the start of fall semester classes and on a systematic basis thereafter.

During orientation, freshmen meet not only with faculty members responsible for premedical and pre dental advising, and for preliminary discussions of law study and engineering, but they also meet for discussions with faculty members representing the humanities, social sciences, and physical sciences. The Student Advisory Board is also available during orientation to meet and talk with freshmen.

At registration the student makes his choice of courses and asks his adviser to approve the selection by signing the registration card. Should a student and adviser find themselves in disagreement over the wisdom of the selection, a subcommittee of the Recording Committee acts as arbiter.

Although students do not register as majors until the end of their sophomore year, they are invited to talk with prospective major departments at the end of their freshman year during the period major departments have posted office hours for such discussions. The student's regular adviser, however, continues to work out programs with him and approves them through the sophomore year. After the sophomore year, a member of the student's major department serves as his adviser.

Following registration in the spring, the Recording Committee reviews the program of each student for the past year, not with the intent of correcting individual excesses but for the purpose of determining whether, under this system, the course selections of individual students reflect patterns of liberal studies consistent with the aims of the College. The committee is expected to discuss this concern in its annual report to the faculty.

COMPOSITION

The importance of good writing to a student's success in college is obvious. Students with serious writing problems will be identified by the Deans' Office in cooperation with advisers. The Deans' Office will be responsible for working out the details of this cooperative arrangement. Students identified as having serious writing problems will be advised to enter a special, noncredit tutorial program, with a reduced course load if necessary. Students who can profit from further writing experience should be encouraged to enroll in one of the Freshman-Sophomore English Seminars, in all of which composition is taught.

THE MAJOR PROGRAM

A major program is offered by every department which has been authorized by the faculty to do so. The departmental requirements for each major are listed in Courses of Instruction on pages 94-179. Students may elect one or two majors.

Interdepartmental major programs, designed to meet an individual, cultural, or professional objective, may be offered if approved by the departments concerned and the Recording Committee.

Each student must choose a major by the end of his sophomore year after consultation with the department concerned. During the week preceding the spring vacation, the registrar shall post hours for faculty conferences with sophomores regarding choice of a major. No student may major in a department unless he has satisfied the department that he is able to do work of at least passing quality in its courses. Changes in major programs may take place only with the permission of the Recording Committee following the submission of a written request stating the reason for the change. Such request must also be approved by the departments concerned. A student who has not been accepted in a major department cannot continue his registration.

INDEPENDENT STUDY

With departmental approval, a student may elect a course of independent study under tutorial supervision. (Freshmen and sophomores require the approval of the Recording Committee as well.) In most departments the project will consist of a written dissertation or an appropriate account of an original investigation, but projects in music, the fine arts, and letters are also encouraged. *Students who seek departmental honors are expected to register for at least one course in independent study and to achieve an honor grade in it.*

A department will ordinarily approve one or two semesters of independent study for which regular course credit will be given. A definite plan for the project must be presented by the student, approved by the department, and filed in the Dean of the College's Office. The plan for a fall semester must be on file on or before the first day of classes; the plan for a spring semester must be submitted on or before the first day of the fall semester examination period. Where more than one semester's credit is sought, the project will be subject to review by the department at the end of the first semester. In special cases the Recording Committee, upon recommendation of the department, may extend credit for additional semester courses beyond two. In independent study courses that will continue beyond one semester, instructors shall have the option of submitting at the end of each semester except the last a grade of "S" for Satisfactory in place of a regular grade. A regular grade shall be submitted at the end of the final semester and shall become the grade for the previous semesters of independent study. The final corrected copy of the project must be submitted to the department before the last day of classes of the final semester of the work. Normally, the evaluation of an independent study project should be made by two faculty members. *For administrative purposes this independent study will bear one or more of the course numbers 201, 202, 203, 204, depending upon the number of course credits allowed.*

Mathematics

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- 11-12. Elementary Chinese.
 *13-14. Intermediate Chinese.
 36. Elementary Japanese.
 *45-46. Elementary Portuguese.

Mathematics

PROFESSOR GROBE, *Chairman*; PROFESSORS CHITTIM, CHRISTIE, AND JOHNSON;
 ASSOCIATE PROFESSOR WARD; ASSISTANT PROFESSORS BARKER, FAY,
 RASMUSSEN, AND SILVER; LECTURER CURTIS

Requirements for the Major in Mathematics: The major consists of a coherent program of courses, reviewed and approved by the department on an individual basis. Such a program must include at least seven courses numbered above 20, except that a quantitative course from another department (e.g., Chemistry 32, Economics 16, or Physics 37) may be substituted for one of these. Basic courses in both algebra (e.g., Mathematics 21) and analysis (e.g., Mathematics 13 or 22) are strongly recommended for all mathematics majors. A major program should include a selection of some courses in which the emphasis is primarily theoretical, as well as courses which are useful for applications. An exceptional major who demonstrates that he is capable of intensive advanced work is encouraged to undertake an independent study project in a topic which is of personal interest or importance to him. Such an independent study receives course credit and with departmental approval may also help satisfy the major requirement.

By the beginning of his junior year, each major will submit a proposed major program for departmental approval. This program may undergo changes during the junior and senior years, but departmental approval is required for any such changes. A revised major program should maintain the required coherence.

Below are listed some of the courses recommended to students contemplating various careers in mathematics.

- For secondary-school teaching: Mathematics 17, 25, 5 or 26, 27, 33, 35, 36.
 For graduate study: Mathematics 32, 35, 39, and at least one 40-level course.
 For engineering and applied mathematics: Mathematics 22, 26, 27, 28, 29, 31, 34, 37, 38.
 For operations research, management science, and econometrics: Mathematics 26, 27, 29, 30, 37, 38, and Economics 16.
 For computer science: Mathematics 5, 26, 30, 35, 36.

2. **Topics in Mathematics.** Every spring. MR. CHRISTIE.

Elementary topics are presented to demonstrate the origins of mathematical problems, the nature of mathematical language and proof, and the purpose and applicability of abstract mathematics. One or more

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themes developed each semester. Recent topics have been the unity of mathematics, the theory of numbers, basic algebraic structures, topological models and graph theory, and algorithmic mathematics.

5. Introduction to Computer Programming. Every fall. THE COMPUTING CENTER STAFF.

An introduction to programming and using a modern time-sharing computer system (DEC System-10). Focus is on the techniques and algorithms that are fundamental in information storage and retrieval. The primary language to be studied will alternate between FORTRAN IV (1975-1976) and BASIC (1976-1977). There will also be a brief introduction to COBOL and MACRO-10.

10. Introduction to College Mathematics. Every fall.

An introduction to combinatorics, probability theory, linear algebra, linear programming, and computer programming for the PDP-10. This course, followed by **Mathematics 11** in the spring, is intended as a one-year introduction to mathematics and, as such, is recommended for those students who intend to take only one year of college mathematics. **Mathematics 10** may also be used to satisfy the prerequisites for **Mathematics 30**.

11. Differential and Integral Calculus I. Every semester. THE DEPARTMENT.

An introduction to limits; the derivatives of rational functions and roots of rational functions; the chain rule; the derivatives of the trigonometric functions; applications of the derivative to curve sketching; the Mean Value Theorem; integration of algebraic functions; areas between curves. The spring semester version includes additional topics and examples relevant to the social and life sciences.

Open to students whose secondary school background has included at least three years of mathematics.

12. Differential and Integral Calculus II. Every semester. THE DEPARTMENT.

Techniques of integration; the logarithm and exponential functions; the inverse trigonometric functions; applications of the integral; improper integrals; series, including Taylor's theorem and differentiation and integration of power series.

Prerequisite: **Mathematics 11**.

13. Differential Equations and Intermediate Calculus. Every semester. THE DEPARTMENT.

Differential equations, functions of two or three variables, and geometry in three dimensions, using vectors, matrices, and complex numbers. Partial differentiation and multiple integration.

Prerequisite: **Mathematics 12** or equivalent.

14. **Elementary Probability and Statistics.** Every spring. MESSRS. FAY OR SILVER.

Course material is equally divided between probability and statistics. Probability topics include basic axioms, combinatorics, conditional probability, independence, discrete and continuous random variables, mean, variance and expected values. Topics in statistics include descriptive statistics, random sample, sample mean, sample variance, point estimates, confidence intervals, and hypothesis testing. Additional topics, as time allows, are chosen from regression, correlation, analysis of variance, and decision theory.

Prerequisite: **Mathematics 11** or a good high school course in calculus or consent of the instructor.

17. **Elementary Topics in Algebra.** Spring 1977. MR. SILVER.

Real and complex numbers, determinants and matrices, theory of equations, divisors and prime numbers, congruences, quadratic residues, continued fractions.

Prerequisite: Two semesters of college mathematics or consent of the instructor.

21. **Vector Geometry and Linear Algebra.** Every semester. THE DEPARTMENT.

Vectors, matrices, vector spaces, linear transformations, inner and cross products, eigenvalues, applications to systems of linear equations.

Prerequisite: A year of college mathematics or equivalent.

22. **Calculus of Vector Functions.** Every spring. MR. FAY.

The differential and integral calculus of more than one variable. Vector fields; gradient, curl, and divergence; theorems of Green, Gauss, and Stokes. Applications.

Prerequisite: **Mathematics 12** and **21**, or **Mathematics 13**, or consent of the instructor.

25. **Number Theory.** Spring 1977.

An introduction to elementary number theory. Factorization and the notion of primes and irreducible elements in various number systems, together with the problems of unique factorization and of finding integer solutions for certain equations. Congruences and the law of quadratic reciprocity. A brief look at various number theoretic functions. Rational approximation of irrational numbers, a criterion for transcendence, and continued fractions.

6. **Numerical Analysis.** Every spring. MR. CURTIS.

BASIC and FORTRAN programming, solutions of systems of linear and nonlinear simultaneous equations, polynomial approximation, numeri-

cal differentiation and integration, solutions of systems of first-order differential equations. The PDP-10 time-sharing system is used extensively.

Prerequisite: Mathematics 13 or 21 or consent of the instructor.

27. **Probability.** Fall 1975.

A detailed course in basic probability. Topics include probability spaces, combinatorial models, conditional probability, independent and dependent events, random variables, binomial distribution, poisson distribution, and normal distribution. Finite Markov chains are studied in detail. The main emphasis is on probabilistic models from several areas, including medicine, genetics, psychology, physics, and games of chance.

Prerequisite: Mathematics 12 or consent of the instructor.

28. **Mathematical Models in Science.** Spring 1976. MR. CHRISTIE.

How elementary models from analysis, algebra, geometry, topology, and probability arise naturally in science. The scientific focus of the course varies according to the interests of the instructor and students.

Prerequisite: Mathematics 13 or 22.

29. **Graph Theory and Combinatorics.** Fall 1976. MR. CHRISTIE.

An introduction to combinatorics with emphasis on graph theory and its applications: trees, blocks, coloring, matching, digraphs, duality, and networks.

Prerequisite: One year of college mathematics or consent of the instructor.

30. **Linear Models.** Every spring. MR. JOHNSON.

Techniques for solving maximization and minimization problems including linear programming and its applications to resource allocation problems, transportation problems, and the solution of 2-person zero-sum games.

Prerequisite: Mathematics 10 or 12 or 21 or consent of the instructor.

31. **Applied Analysis.** Every spring. MR. GROBE.

The material for this course is selected from the following list of topics: the Taylor expansion, uniform convergence, Fourier series, the Laplace transform, general methods in ordinary linear differential equations, boundary value problems including the Sturm-Liouville equation and an introduction to partial differentiation equations.

Prerequisite: Mathematics 13 or 22.

32. **Advanced Calculus.** Every spring. MR. FAY.

An introduction to the theory of functions of one real variable. Topics include definition, completeness, and topological properties of the real

numbers, sequences and series of both numbers and functions, continuity, uniform continuity, differentiability, the Riemann integral, the Riemann-Stieltjes integral, and properties of some transcendental functions.

Prerequisite: Consent of the instructor.

33. **Foundations of Geometry.** Spring 1976. MR. SILVER.

Euclidean and non-Euclidean geometries will be treated in the framework of Klein's Erlangen program. Topics are drawn from transformation groups and invariants, coordinatization and models, one- and two-dimensional projective geometry and subgeometries such as affine, Euclidean metric, hyperbolic, and elliptic.

Prerequisite: **Mathematics 12.**

34. **Complex Variable.** Every fall. MR. BARKER.

Analytic functions of a complex variable, differentiation and integration in the complex plane, theory of residues, conformal mapping.

Prerequisite: **Mathematics 13 or 22 or consent of the instructor.**

35. **Introduction to Algebraic Structures.** Every fall. MR. 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 into general, abstract systems which satisfy certain arithmetic axioms. Properties of mappings which preserve algebraic structure.

Prerequisite: **Mathematics 21.**

36. **Topics in Set Theory and Foundations.** Fall 1975. MR. JOHNSON.

Selected topics from set theory, logic, and the foundations of mathematics.

The fall 1975 course is an introduction to logic and computability theory. The predicate calculus and digital computers will be introduced as sources of the basic idea of recursiveness. Recursive function theory, Turing machines, and effectively computable functions. Undecidability and unsolvability, with applications to the completeness of axiomatic systems (Gödel's theorem) and the theory of numbers (Hilbert's tenth problem).

No formal prerequisite, but at least one year's experience in college mathematics is expected. Appropriate for students interested in logic, philosophy, and computer science, as well as for those intending to complete a major in mathematics.

37. **Statistics.** Fall 1976.

An introduction to the fundamentals of mathematical statistics. The theory of random variables, including density functions, distribution

functions, and moment generating functions. The standard distributions: binomial, poisson, normal, gamma, χ^2 , t, and F. Point estimates, confidence intervals, and hypothesis testing. Additional topics, as time allows, are chosen from regression analysis, nonparametric techniques, and analysis of variance.

Prerequisite: At least one year of calculus. **Mathematics 27** and either **13** or **22** are a natural prelude to **Mathematics 37**, but other routes are possible; instructor should be consulted.

38. Topics in Probability and Statistics. Spring 1977.

One or more specialized topics from probability and statistics. Topics from probability include stochastic processes and measure theoretic aspects of probability. Topics in statistics could include statistical decision theory, sampling theory, and experimental design. Topics in applied probability theory that might be covered include queuing and inventory theory, reliability mathematics, and Monte Carlo techniques. The topics for spring 1977 will depend on the amount of material covered in **Mathematics 27** and **37** and the interests and preparation of the student.

Prerequisite: **Mathematics 27** or **37**.

39. Introduction to Topology. Every fall. MR. CHRISTIE.

Fundamental concepts of general topology: topological spaces, continuity, separation and countability axioms, connectedness, and compactness. The geometric emphasis is made more explicit, as time permits, by a consideration of mappings, fixed points, vector fields, networks and polyhedra, curves, and surfaces.

Prerequisite: **Mathematics 13** or **21** or **22** or consent of the instructor.

40. Topics in Topology. Spring 1977. MR. CHRISTIE.

One or two directions in topology are pursued with a fair degree of thoroughness, e.g., combinatorial topology, homology theory, homotopy theory, topological groups, knot theory, differential topology, additional general topology, or applications of topology.

Prerequisite: **Mathematics 39** or consent of the instructor.

42. Advanced Topics in Algebra. Spring 1976.

One or more specialized topics from abstract algebra and its applications. Topics in the last few years have included Galois theory, algebraic number theory, the character theory of finite groups, and algebraic coding theory.

The spring 1976 course is a study of finite reflection groups. This study involves an elegant interplay of geometry, graph theory, group theory, and linear algebra. Reflection groups play an important role in

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the theory of molecular structure in chemistry, as well as in modern algebra and in other areas of advanced mathematics.

Prerequisite: Mathematics 35, or Mathematics 21 and consent of the instructor.

44. **Advanced Topics in Geometry.** Fall 1976.

Content of the course varies, so as to provide the student with advanced geometrical experience from the areas of algebraic geometry, classical differential geometry, or projective and metric geometry.

Prerequisite: Mathematics 13 or 22 or consent of the instructor.

45. **Advanced Topics in Analysis.** Fall 1975. MR. FAY.

Selected topics in advanced calculus and analysis, often including Lebesgue integration, an introduction to Hilbert spaces, harmonic analysis, and advanced complex analysis.

The fall 1975 course is an introduction to differential equations with particular emphasis on applications in the natural sciences. Second-order differential equations with applications to celestial mechanics, oscillation theory, stability theory, and topics from the calculus of variations.

Prerequisite: Mathematics 13 or 22.

200. **Independent Study.** THE DEPARTMENT.

Music

PROFESSOR SCHWARTZ, *Chairman*; PROFESSOR BECKWITH; VISITING ASSOCIATE PROFESSOR DUNSCOMBE; ASSISTANT PROFESSOR CALDWELL; VISITING INSTRUCTOR PALMER

Requirements for the Major in Music: Music 1 and Music 10, or their equivalents, are prerequisites for the major but do not count in the nine courses required for the major. Prospective majors who cannot waive Music 1 and/or Music 10 by examination are urged to take these courses in their freshman year.

The required courses are Music 11, 12; 21-22; 31-32; and three semester courses chosen with the approval of the department. Either Music 2 or Music 5 but not both may be included. Students planning to take graduate degrees in music should complete the theory sequence through Music 14 and demonstrate facility at the keyboard. Any student planning to major in music should take Music 11, 12 by the sophomore year if possible.

The departmental offerings and the requirements for the major in music are so designed that a very broad course of study is possible, well within the