Bowdoin [1985]

The Curriculum

BOWDOIN does not prescribe specific liberal arts courses for all students. Instead, each student determines, with the help and approval of an academic adviser, an appropriate pattern of courses. To ensure that students explore the breadth of the curriculum before settling upon a major, they are expected to complete two courses each in natural science and mathematics, social and behavioral science, humanities and fine arts, and foreign studies. Courses, it is assumed, do not lead simply to other courses in the same subject. Properly taught, they should 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. Bowdoin encourages the student to extend his or her concerns and awareness beyond the personal. At the same time the College helps a student to integrate curricular choices in accordance with individual intellectual needs. Interaction between the student and an academic adviser is a vital part of this educational experience.

REQUIREMENTS FOR THE DEGREE

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

1. successfully passed thirty-two courses;
2. completed a departmental major or majors, an interdisciplinary major, or a student-designed major (a departmental minor may be completed with any of the preceding);
3. spent four semesters (passing at least sixteen courses) in residence, at least two of which (eight courses) will have been during the junior and senior years;
4. completed at least two semester courses in each of the following divisions of the curriculum: natural science and mathematics, social and behavioral sciences, humanities and fine arts; and two semester courses in foreign studies.

G

T

GENERAL REGULATIONS

1. Course Load: Students are required to take the equivalent of four full courses each semester. Students wishing to take more than *five* courses must have permission of the Deans' Office. A student may not take five courses in the semester following the receipt of an "F" without the Dean's

Bowdoin 1985

dent has shown some interest. Advisers and students meet during orientation before the start of fall semester classes and on a systematic basis thereafter.

At registration the student chooses courses and asks the 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.

Students elect a major during the second semester of the sophomore year. After registering for a major, a student is advised by a member of his or her major department.

COMPOSITION

The importance of good writing to a student's success in college is obvious. Students are encouraged to enroll in one of the freshman seminars in which composition is taught (**English 1, Seminars 1-6; English 2, Seminars 1-6**). Students with serious writing problems are identified by the Deans' Office and are advised to enter a special tutorial program.

DISTRIBUTION REQUIREMENTS

Students must complete at least two courses in each of the three divisions of the curriculum and two courses in foreign studies, normally by the end of the sophomore year. A course which counts for one distribution area may not count for another. Because these requirements are intended to apply to the college liberal arts experience, they may not be met by advanced placement or international baccalaureate credits but can be met, under the supervision of the Recording Committee, by credits earned while studying away from Bowdoin. Areas of distribution are defined as follows:

Natural Science and Mathematics: Biochemistry, biology, chemistry, computer science and information studies, geology, mathematics, physics, and certain environmental studies courses.

Social and Behavioral Sciences: Afro-American studies, economics, government, psychology, sociology and anthropology, and certain environmental studies courses.

Humanities and Fine Arts: Art, classics, education, English, German, history, music, philosophy, religion, Romance languages, and Russian.

Foreign Studies: Students must take two courses which focus on a culture or society of Asia, Africa, Latin America, or Russia—or on a culture or society with such origins. The requirement is intended to introduce students to cultures fundamentally different from their own to open their minds to different ways in which other people perceive and try to cope with the challenges of life. Though courses treating North American and European topics will not normally count, courses on Afro-American or Native American cultures will meet the requirement when the emphasis is clearly on those cultures and their differences from the predominant culture of the United States. Language

Bowdoin 1985

courses do not normally meet this requirement. Approved courses are indicated by a dagger (†) in the list of "Courses of Instruction" in this catalogue, pages 89-206.

THE MAJOR PROGRAM

Students may choose one of five basic patterns to satisfy the major requirement at Bowdoin: a departmental major, two departmental majors, an interdisciplinary major, a student-designed major; a departmental minor may be completed with any of the preceding. Each student must choose a major by the end of the sophomore year after consultation with the department or departments involved. No student may major in a department unless the department is satisfied that the student is able to do work of at least passing quality in its courses. Seniors may add or change majors and/or minors until the end of the first semester of their senior year. Changes by seniors in interdisciplinary or self-designed majors require the approval of the Recording Committee. A student who has not been accepted in a major department cannot continue registration.

Options for major programs are described below.

Departmental Majors

All departments authorized by the faculty to offer majors specify the requirements for the major in the catalogue. A student may choose to satisfy the requirements of one department (single major) or to satisfy all of the requirements set by two departments (double major). A student may drop a second departmental major by notifying both the registrar and the department concerned at any time.

Interdisciplinary Major

As the intellectual interests of students and faculty alike have reached across departmental lines, there has been a growing tendency to develop interdisciplinary majors. Interdisciplinary majors are designed to tie together the offerings and major requirements of two separate departments by focusing on a theme which integrates the interests of those two departments. Such majors usually fulfill most or all of the requirements of two separate departments and usually entail a special project to achieve a synthesis of the disciplines involved.

Anticipating that many students will be interested in certain patterns of interdisciplinary majors, several departments have specified standard requirements for interdisciplinary majors. For descriptions of these interdisciplinary majors see pages 155-156.

A student may take the initiative to develop an interdisciplinary major by consulting with the chairmen of the two major departments. A stu-

Bowdoin 1985

7. **Composer as Reader, and Reader as Composer.** Fall 1985. Mr. Greenlee (Music) and Mr. Long (Religion).

Explores musical and literary compositions which are based on the Bible to discover how composer and author achieved their particular renderings of Biblical narrative or poetry. Listening, reading, discussion, and inquiry into the intricacies of artistic creation. Includes analysis of cultural situations and basic concepts which produced a unified interpretation of Biblical texts. Works to be considered include Handel, *Messiah;* Bach, *Saint Matthew Passion;* Honegger, *LeRoi David;* and literary works by Milton, D. H. Lawrence, Byron, Browning, and Michel de Ghelderorde.

8. **The Music Dramas of Richard Wagner.** Spring 1986. Mr. Beckwith (Music) and Mr. Cerf (German).

Traces the artistic development of Richard Wagner by studying closely four of his operas. Starts with Wagner's beginnings as a composer rooted in the German Romantic tradition and follows his emergence as a seminal operatic composer, the focus shifting to his uniqueness as one who wrote his own texts and designed the auditorium in which his festival dramas were to be performed. The mythological elements of Wagner's libretti are analyzed for their dramaturgical importance and his music theories are examined as a link in the development of nineteenth-century European music. Ability to read music and/or German not required.

Mathematics

Professor Grobe, *Chairman;* Professors Chittim, Johnson, and Ward; Associate Professors Barker and Fisk; Assistant Professors Ong and Roberts

M

Requirements for the Major in Mathematics: A major consists of at least eight courses numbered 20 or above, including at least one of the following: **Mathematics 32, 35, 39,** or a course numbered in the 40s.

A student must submit a major program to the department at the time that he or she declares a major. That program should include courses in which the emphasis is primarily theoretical and courses in which applications are stressed. A student's major program may be changed later with the approval of the departmental advisor.

All majors should take basic courses in algebra (e.g., **Mathematics 21** or **35**) and in analysis (e.g., **Mathematics 22** or **32**). The department also encourages all majors to complete at least one sequence in a specific area of mathematics. Those areas are: algebra (**Mathematics 21, 35,** and **42**); analysis (**Mathematics**

Bowdoin 1985

32, 34, and 45); applied mathematics (**Mathematics** 28, 29, and 41); probability and statistics (**Mathematics** 27, 37, and 47); topology (**Mathematics** 32, 39, and 40). In exceptional circumstances, a student may substitute a quantitative course from another department for one of the eight mathematics courses required for the major. Such a substitution must be approved in advance by the department.

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, in exceptional cases, 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 21 or above, at least one of which must be **Mathematics 29** or any course numbered 31 or above.

Interdisciplinary Major: The department participates in an interdisciplinary program in mathematics and economics. See page 156.

Listed below are some of the courses recommended to students contemplating various options in mathematics.

For secondary-school teaching: **Computer Science 5, Mathematics 21, 25, 27, 31, 32, 33, 35, 36.**

For graduate study: **Mathematics 21, 22, 32, 34, 35, 39,** and at least one course numbered in the 40s.

For engineering, operations research, and applied mathematics: **Mathematics 22, 24, 26, 27, 28, 29, 30, 31, 34, 37, 41, 47.**

For mathematical economics and econometrics: **Mathematics 21, 22** or **32, 24, 26, 27, 30, 31, 37, 47,** and **Economics 16.**

For computer science: **Computer Science 5, Mathematics 20, 21, 24, 26, 27, 30, 31, 35, 36, 37.**

C

2. Topics in Mathematics. Spring 1986.

This course is designed for students who wish to learn something about the spirit of modern mathematics and who do not plan to take other mathematics courses. The emphasis is on the history and origins of mathematical problems; the development of the ideas, language, and symbolism needed to deal with those problems; and the ramifications and applications of the theory to current quantitative problems in a variety of disciplines. Topics are chosen from geometry, number theory, probability, game theory and optimization, graph theory, topology, and computing.

10. Introduction to College Mathematics. Every fall. Mr. Johnson.

Material selected from the following topics: combinatorics, probability, modern algebra, logic, linear programming, and computer programming. This course, followed by **Mathematics 11,** is intended as a

Bowdoin 1985

one-year introduction to mathematics and is recommended for those students who intend to take only one year of college mathematics.

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.

Mathematics 11 may be taken as either a lecture or a self-paced course in the fall semester, but only as a self-paced course in the spring semester.

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 logarithmic 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.

Mathematics 12 may be taken as either a lecture or a self-paced course.

Prerequisite: **Mathematics 11** or equivalent.

13. **Multivariate Calculus with Linear Algebra.** Every semester. THE DEPARTMENT.

Multivariate calculus in two and three dimensions, and an introduction to linear algebra. The calculus topics include: vector geometry and the calculus of curves; differentiation; the partial derivatives of real-valued functions, the gradient, directional derivatives, approximations using the tangent plane, and applications to extremal problems; multiple integration in two and three dimensions. The linear algebra topics include: an introduction to vector spaces, with an emphasis on R^n, and the concept of dimension. Matrix algebra and Gaussian elimination are covered as time permits. Applications from the physical and the social sciences are discussed as time permits.

Mathematics 13 may be taken as either a lecture or a self-paced course.

Prerequisite: **Mathematics 12** or equivalent.

14. **Elementary Probability and Statistics.** Every spring.

Course material is divided between probability and statistics. Probability topics may include basic axioms, combinatorics, conditional probability, independence, discrete and continuous random variables, mean, variance, and expected value. Topics in statistics may include de-

Bowdoin 1985

scriptive statistics, random samples, sample mean, sample variance, point estimates, confidence intervals, and hypothesis testing.

Prerequisite: **Mathematics 11.**

20. Discrete Mathematical Structures. Every spring. MR. GROBE.

An introduction to logic, reasoning, and the discrete mathematical structures which are important in computer science. Topics include propositional logic, types of proof, induction and recursion, sets, counting, functions and relations, graphs, and program correctness.

Prerequisite: Any mathematics course numbered 10 or above, or consent of the instructor.

21. Vector Geometry and Linear Algebra. Every fall. Fall 1985. MR. CHITTIM.

Topics include vectors, matrices, determinants, vector spaces, inner product spaces, linear transformations, eigenvalues and eigenvectors, and quadratic forms. Applications to linear equations, conics, quadric surfaces, and n-dimensional geometry.

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

22. Calculus of Vector Functions. Every fall. Fall 1985. MR. JOHNSON.

The basic concepts of multivariate and vector calculus. Topics include continuity; the derivative as best affine approximation; the chain rule; Taylor's theorem and applications to optimization; Lagrange multipliers; multiple integration and change of variables; line and surface integration; gradient, divergence, and curl; conservative and solenoidal vector fields; theorems of Green, Gauss, and Stokes. Applications from economics and the physical sciences are discussed as time permits.

Prerequisite: **Mathematics 13.**

24. Nonnumeric Algorithms. Every other fall. Fall 1986.

The mathematical theory of nonnumeric algorithms. Sorting and searching, expected time and storage of algorithms, graph theory algorithms, and combinatorial algorithms. Students are required to program and run short computer programs.

Prerequisite: **Mathematics 13, Computer Science 5,** or consent of the instructor.

25. Number Theory. Every other spring. Spring 1986. MR. FISK.

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

Bowdoin 1985

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.

26. **Numerical Analysis.** Fall 1985. MR. BARKER.

An introduction to the numerical solutions of mathematical problems. Topics include computational aspects of linear algebra, approximation theory, numerical differentiation and integration, and numerical methods for differential equations. Students are required to develop computer software for the topics covered; therefore, previous exposure to computer programming is useful. An extra hour of instruction in FORTRAN will be scheduled each week for students without prior exposure to this programming language.

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

27. **Probability.** Every fall. Fall 1985. MRS. ROBERTS.

A study of the mathematical models used to formalize non-deterministic 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 will be discussed in depth.

Prerequisite: **Mathematics 13.**

28. **Methods of Applied Mathematics I.** Every year in alternate semesters. Fall 1985. MR. ONG.

An introduction to the theory of ordinary differential equations with diverse applications to problems arising in the natural and social sciences. Emphasis is placed upon the rigorous development of the different methods of solution. Topics include first-, second-, and higher-order equations with applications in qualitative stability and oscillation theory, Laplace transforms, series solutions, and the existence and uniqueness theorems. A few numerical methods sporadically introduced during the course. Knowledge of BASIC, FORTRAN, or PASCAL is helpful.

Prerequisite: **Mathematics 13**, or concurrent registration in **13.**

29. **Methods of Applied Mathematics II.** Every other spring. Spring 1986. MR. ONG.

A continuation of **Mathematics 28.** Topics include the applications of linear algebra and vector analysis to the solutions of systems of first-order linear differential equations, stability of linear systems, Green's functions and inhomogeneous equations, non-linear equations with emphasis on stability of equilibria, perturbation theory, and a few

Bowdoin 1985

numerical methods. Knowledge of a programming language is helpful.
Prerequisite: **Mathematics 28.**

30. Linear Programming and Optimization. Every other fall. Fall 1986.
A survey of some of the mathematical techniques for optimizing various quantities, many of which arise naturally in economics and, more generally, in competitive situations. Production problems, resource allocation problems, transportation problems, and the theory of network flows. Game theory and strategies for matrix games. The emphasis is on convex and linear programming methods, but other nonlinear optimization techniques are presented. The course includes computer demonstrations of many of the techniques that are discussed.
Prerequisite: **Mathematics 13.**

31. Combinatorics and Graph Theory. Spring 1987.
An introduction to combinatorics and graph theory. Topics to be covered may include enumeration, matching theory, generating functions, and partially ordered sets. Applications cover Latin squares, designs, computer science, and graph algorithms.
Prerequisite: **Mathematics 12.**

32. Introduction to Analysis. Every year in alternate semesters. Spring 1986. Mr. Johnson.
An introduction to the theory of functions of one real variable. A major goal is the rigorous development of the foundations of calculus. Topics include the completeness and topological properties of the real numbers, metric spaces, sequences, continuity, uniform continuity, differentiability, and Riemann integration. Additional topics may be chosen from the following: series convergence, uniform convergence, Taylor series, and properties of transcendental functions. The course also serves as an introduction to rigorous mathematical proof.
Prerequisite: **Mathematics 12.**

33. Geometry. Spring 1986. Mr. Chittim.
Primarily a course in advanced analytic geometry of two and three dimensions. Analysis of plane curves. Cross-ratio; poles, polars, and diameters of conics. Formal reduction of the second-degree equations of curves and surfaces using matrix algebra. Homothetic and Moebius transformations; the Euler Line and related triangle properties. Theorems of Menelaus, Ceva, Desargues, and Pascal.
Prerequisite: **Mathematics 13** or **21.**

34. Functions of a Complex Variable. Every other spring. Spring 1987.
The differential and integral calculus of functions of a complex variable. Cauchy's theorem and Cauchy's integral formula, power series,

Bowdoin 1985

singularities, Taylor's theorem, Laurent's theorem, and the residue calculus, harmonic functions, and conformal mapping.

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

35. **Introduction to Algebraic Structures.** Every year in alternate semesters. Fall 1985. 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 the Foundations of Mathematics.** Every other fall. Fall 1985. Mr. Fisk.

One or more topics selected from the general area of set theory, logic, and the foundations of mathematics. Recent courses have dealt with logic and computability theory, countability and diagonalization, Turing machines and various kinds of computability, recursive functions, Hilbert's Tenth Problem, undecidability and incompleteness.

Prerequisite: At least two years of college mathematics or consent of instructor.

37. **Statistics.** Every spring. Spring 1986. Mrs. Roberts.

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: **Mathematics 13** and **27.**

[38. **History of Modern Mathematics.**]

39. **Topology.** Spring 1986. Mr. Barker.

An introduction to both point-set and geometric topology centered on the fundamental notion of topological space and continuous function. Topics include fundamentals of point-set topology with special emphasis on homeomorphisms, compactness, connectedness, and separation. Geometric applications include fixed point theorems, surfaces, covering spaces, the Jordan curve theorem, and an introduction to knots and links.

Prerequisite: **Mathematics 32,** or consent of the instructor.

Bowdoin 1985

[40. **Topics in Topology.**]

41. **Methods of Applied Mathematics III.** Every other fall. Fall 1986. Mr. Ong.

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

Prerequisite: **Mathematics 29.**

42. **Advanced Topics in Algebra.** Every other spring. Spring 1986. Mr. Ward.

One or more specialized topics from abstract algebra and its applications.

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

44. **Advanced Topics in Geometry.** Spring 1987.

One or more selected topics from differential geometry, algebraic geometry, or projective and metric geometry. The topic is usually differential geometry with an emphasis on those geometric properties of curves and surfaces which can be investigated using the techniques of calculus.

Prerequisite: **Mathematics 22.**

45. **Advanced Topics in Analysis.** Every other spring. Spring 1987.

One or more selected topics from analysis. Topics may be chosen from Lebesgue integration, general measure and integration theory, Fourier analysis, Hilbert and Banach space theory, and spectral theory.

Prerequisite: **Mathematics 32.**

47. **Topics in Probability and Statistics.** Spring 1986. Mrs. Roberts.

One or more specialized topics from probability and statistics. Topics in statistics may include multivariate analysis, nonparametric statistics, sampling theory, and experimental design. Topics in applied probability theory may include queuing and inventory theory, reliability mathematics, Monte Carlo techniques, and linear models.

Prerequisite: **Mathematics 37** or consent of the instructor.

200. **Independent Study.** The Department.