

## REQUIREMENTS FOR THE BACHELOR OF ARTS DEGREE

No single course of study can be prescribed as essential for an educated man or woman. But Williams College has two categories of course requirements for all students. The Major Requirement is designed to assure that all Williams undergraduates will have the experience of disciplined and cumulative study, carried on over an extended period of time, in some important field of intellectual inquiry. The Distribution Requirement is intended to foster broadened awareness of some of the most important ways in which man has tried to understand himself, his artistic achievements, his relationships to others, and the nature of the physical world.

### Required Number of Courses

**G** Credit for thirty-two graded semester courses and four passed Winter Study Projects is required for the degree. In addition, four semesters of Physical Education must be completed by the end of the sophomore year.

Freshmen may enroll in only one course in any department during each semester of the first year. Sophomores may register for as many as two courses in any department upon petition to the Committee on Academic Standing.

### The Major

Juniors are required to choose a major field of concentration. The selection is normally made at the time of registration in the spring of the sophomore year.

### Major Fields

Majors are offered in the following fields:

\*American Civilization

Art

\*\*Astronomy and Physics

Biology

Chemistry

Classics

Greek

Latin

History of Ideas

Mathematics

Music

Philosophy

Physics

\*\*\*Political Economy

Political Science

Psychology

\*Offered by the Department of History.

\*\*Offered jointly by the Departments of Astronomy and Physics.

\*\*\*Offered jointly by the Departments of Economics and Political Science.

Economics  
English  
Geology  
German  
History

Religion  
Romanic Languages  
French  
Spanish  
Russian

### General Structure

(1) A student ordinarily must elect at least nine semester courses in his major field. The major may also require a tenth course and/or one Winter Study Project during the junior or senior year. **T**

A student may also fulfill the minimum requirements for a major by taking eight semester courses in his major field and two semester courses, approved by his advisor, in associated fields. In interdepartmental majors, such as Political Economy and American Civilization, a larger number of courses may be required.

(2) A prescribed sequence of courses, supplemented by parallel courses, and ending in a senior major course, is required in some major fields. Other majors ask the student to plan a sequence of elective courses, including advanced work building on elementary courses in the field, and ending in a one or two semester faculty-organized course or project in the senior year. All fields of concentration provide a system of counseling to help students plan programs reflecting individual interests as well as disciplined and cumulative patterns of inquiry.

Courses in many major programs require prerequisite courses in related areas. A full description of the detailed structure of each major is found under the heading of that major in a section of the catalog, "Courses of Instruction."

### Contract Major

A student completing a contract major (p. 76.) is also required to complete nine or ten semester courses, including a senior major course or seminar, and a senior major exercise.

### Double Major

A student with a strong interest in two regular majors may double major with the permission of the major department or program and the Committee on Academic Standing.

*Mathematics*

- Russian 301 Introduction to the Russian Classics in Translation  
Russian 302 Introduction to Soviet Literature in Translation (*Not offered 1975-76.*)  
Russian 303 Tolstoy in Translation  
Russian 307 Dostoevsky in Translation (*Not offered 1975-76; to be offered 1976-77.*)  
Spanish 210 Post-Civil War Spain Through Its Novels

**MATHEMATICS (Div. III)**

DEPARTMENTAL STAFF FOR 1975-76

*Chairman*, Professor G. L. SPENCER, II

Professor SPENCER, Professor OLIVER, Professor JORDAN, Professor KOZELKA, Professor GRABOIS, Associate Professor HILL\*, Assistant Professor ROSENRAAD, Assistant Professor W. GREEN, L. WRIGHT (Director of Computer Services).

MAJOR PROGRAM

*Introductory courses*

- Mathematics 107 Introduction to the Calculus *or*  
Mathematics 109 Elementary Calculus  
Mathematics 110 Infinite Series and Multivariable Calculus

*Sequence courses*

Variation in the sequence courses, adapting the program within the general course requirements to special needs and interests of the individual student, may be arranged in consultation with the department.

- Mathematics 201 Linear Algebra  
Mathematics 301 Real Analysis  
Mathematics 312 (*formerly 311*) Introduction to Abstract Algebra  
Mathematics 406 Senior Major Course

*Elective courses and projects*

Three one-semester courses from among Mathematics 241 and the 300 and 400 level non-sequence courses offered by the department.

Participation on the part of senior majors in the Senior Colloquium.

\*On sabbatical leave second semester 1975-76

Williams

1975

*Mathematics*

In addition it is recommended but not required that one Winter Study Project offered by the department for mathematics majors be taken during the junior or senior year.

The major program emphasizes analysis, provides an introduction to modern algebra, and gives an opportunity for exploration of individual interests in mathematics by choice of elective and Winter Study Project.

THE DEGREE WITH HONORS IN MATHEMATICS

The principal considerations in recommending a student for the degree with Honors will be: mastery of core material and skills; breadth and, particularly, depth of knowledge beyond the core material; ability to pursue independent study of mathematics with a minimum of direction; originality in methods of investigation; and, where appropriate, creativity in research.

When applying for candidacy for the degree with Honors at the beginning of the second semester of his Senior year, a student must present evidence of achievement in these areas. Normally, the minimum achievement would consist of participation in a mathematics seminar and in an independent reading course. The independent reading may be preparatory to writing a thesis.

The Mathematics Department urges all students who plan to be candidates for the degree with Honors to consult with the Department at the beginning of their junior year. At that time, the Department will be prepared to suggest a Faculty Honors Adviser for each student, who will assist in planning the student's program with particular reference to his choice of seminar, independent reading course, and thesis topic (when applicable).

Every candidate for the degree with Honors will take an Honors examination at the end of his senior year. Normally, this will be an oral examination on an assigned topic.

Recommendations for the degree with Honors will be made for outstanding performance in the areas mentioned above; completion of an assigned program will not in itself be sufficient. Students who have, in the opinion of the Department, displayed exceptional ability, achievement, or originality will be recommended for the degree with Highest Honors.

ADVANCED PLACEMENT

The Mathematics Department attempts to place each student who elects a mathematics course in that course best suited to the student's preparation and goals. A freshman enrolling in Williams College is asked to complete a questionnaire with the help of the student's secondary school mathematics teacher, indicating the mathematical material covered by the student and the level of sophistication of the student's previous mathematical experience. The student is placed in the appropriate mathematics course determined by the results of the questionnaire, the results of the Ad-

vanced Placement Examination (AB or BC) if the student took one, and any additional available information. A student who receives a 4 or 5 on the BC examination and elects to continue the calculus is ordinarily placed in Mathematics 110 with credit given for Mathematics 107. A student who receives a 3 on the BC examination or a high grade on the AB examination and whose high school training indicates adequate preparation will receive credit for Mathematics 107 if he or she elects Mathematics 110 and completes it with a grade of C- or better. Students may elect Mathematics 140 in the fall term if they have had the equivalent of Mathematics 107 (or better) in high school. Pre-medical students with adequate background should consider electing Mathematics 110 and Mathematics 140 in either order. In any event, students registering for mathematics courses are urged to consult with members of the department concerning appropriate courses and placement. The department reserves the right to place students in that point of the calculus sequence which is appropriate to their previous preparation.

GENERAL REMARKS

*Divisional Requirements*

All courses listed may be used towards satisfying this requirement.

*Alternate year courses*

Mathematics 231, 241, 304, 306, 313, 315, 321, 324, 325, 330, 351, 352, 360 and 362, as well as Computer Science 331 and 332 are each normally offered once every two years. All other courses listed are normally offered every year.

*Course Numbering*

Courses numbered 200 and above are normally open to all students meeting the prerequisites. Students with questions about the level at which courses are conducted are invited to consult members of the department.

*Courses open on a pass-fail basis*

Students taking a mathematics course on a pass-fail basis must meet all the requirements set for students taking the course on a graded basis.

With the permission of the department, any course offered by the department may be taken on a pass-fail basis. Permission will not be given to mathematics majors to meet any of the requirements of the major or honors degree on this basis. However, with the permission of the department, courses taken in the department beyond those requirements may be taken on a pass-fail basis.

*Computer Language Instruction*

Because of the increased importance of computers and their applications, all students are urged in their beginning courses in mathematics to learn the Basic programming language. The instruction is provided in a short series of non-credit lectures offered twice each semester, by the Department.

At frequent intervals the Computer Laboratory offers all students a short non-credit lecture series concerning the operation and Fortran programming of the IBM 1130 computer.

1975-1976 Courses Available  
Williams

*Graduate School requirements*

There are an increasing number of graduate and professional schools that require mathematics as a prerequisite to admission or to attaining their degree. Students interested in graduate or professional training in business, medicine, economics, or psychology are advised to find out the requirements in those fields early in their college careers.

107, 107S *Introduction to the Calculus*

Functions, graphs, continuity. Derivatives and applications. Area and integration. Exponential, logarithmic and trigonometric functions.

Hours 107: A, C, D, RW

107S: B

KOZELKA, JORDAN  
JORDAN

109 *Elementary Calculus*

A more advanced treatment of the material of Mathematics 107. Designed for students who have had an introduction to calculus in secondary school.

Hours A, C

OLIVER

110F, 110 *Infinite Series and Multivariable Calculus*

Continuation of Mathematics 107.

Sequences. Infinite Series. Techniques of multivariable calculus including partial derivatives, differentials, multiple integration, maximum and minimum problems and Lagrange multipliers.

Prerequisite, Mathematics 107 or 109.

Hours 110F: A, C, D, E

110: A, E

HILL, W. GREEN  
JORDAN, W. GREEN

111 *Introduction to Linear Algebra*

An introduction to linear algebra recommended for students interested in the social sciences. Topics include matrices, vectors, transformations, linear equations, determinants, and linear programming.

Provides sufficient background for Mathematics 351.

Credit will not be given for both Mathematics 111 and Mathematics 201.

Hour D

GRABOIS

140F, 140 *Calculus and Statistics*

Elementary probability models, including continuous models derived from calculus considerations. Theory of statistical inference by integration and normal curve properties. The relationship between estimation and tests of hypotheses. Elementary bivariate probability: discrete and continuous and random variables.

Prerequisite, Mathematics 107.

Hours 140F: C

140: C, D Mon., Fri, Conferences: C, D, X, Y Wed.

JORDAN  
KOZELKA

1975-76  
Williams152 *Combinatorics*

A study of the properties of patterns and their enumeration. A variety of counting techniques will be developed and applications made to map coloring, network flow, the design of experiments, and problems in the physical and social sciences.

Hour D

GRABOIS

201, 201S *Linear Algebra*

Vector spaces, matrices, transformations.

Prerequisite, Mathematics 107 or 109.

Hours 201: B, E

201S: A

SPENCER  
ROOSENRAAD[203 *Calculus Applications (Not offered 1975-76.)*

Aimed at introducing the interested student in the Social Sciences to various calculus techniques and applications. Topics will include differentiation, integration, series, partial differentiation, differential equations, maxima and minima in several variables, and Lagrange multipliers. Presented as a self paced instructional course.

Open to students who have not had Mathematics 107 or the equivalent.

Hour

SPENCER]

231 (formerly 230) *Algorithms and Computing*

An introduction to computing with emphasis on a systematic approach to the problems normally encountered in computer applications. Intended for students either needing good programming techniques in their own discipline, or wanting a general introduction to computer science. Error analysis, systematic testing and verification of programs, flow charting, methods of searching and sorting, elements of structured programming, and general problem solving methods including simulation and Monte Carlo methods. FORTRAN instruction is an integral part of the course.

Hour L

SPENCER

241 *Intermediate Statistical Inference*

Tests of statistical hypotheses, with emphasis on small-sample tests from normal populations: t-test, F-test, chi-square. Contingency tables and other non-parametric tests. Introduction to utility theory. Applications directed towards the behavioral sciences.

Prerequisite, Mathematics 140.

Hour T

KOZELKA

301 *Real Analysis*

A systematic development of those aspects of elementary real analysis which form the background for a wide range of mathematical activity. Elementary topology of

the real line, limits, continuity, differentiability, infinite series, uniform convergence, the Riemann and Riemann-Stieltjes integrals.

Prerequisite, Mathematics 110 and 201.

Hour B

W. GREEN

302 *Complex Analysis*

The complex number system, elementary functions and mappings, analytic functions, Cauchy's integral theorem and its consequences, Taylor series and Laurent series. Applications to the calculus of residues, conformal mapping, harmonic functions and boundary value problems. Additional topics in the theory of analytic functions.

Prerequisite, Mathematics 301.

Hour L

W. GREEN

[304 *Integration and Measure Theory (Not offered 1975-76.)*

The Lebesgue integral and Lebesgue measure on the real line. Additional topics chosen from among the following: Lebesgue measure and integration in higher dimensions, general measure theory, the Daniell integral,  $L_p$  spaces, probability theory.

Prerequisite, Mathematics 301.

Hour

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306 *Differential Equations*

An introductory study of both ordinary and partial differential equations. Existence, uniqueness, properties of solutions, as well as consideration of methods of solution.

Prerequisite, Mathematics 301.

Hour C

SPENCER

312 (formerly 311) *Introduction to Abstract Algebra*

Groups, rings and fields.

Prerequisite, Mathematics 201.

Hour B

OLIVER

[313 *Elementary Number Theory (Not offered 1975-76.)*

Divisibility properties of the integers: prime and composite numbers. Congruence modulo  $n$ ; solutions of linear and quadratic congruences and of some Diophantine equations. The distribution of primes. Problems in additive arithmetic and discussion of some famous unsolved problems.

Prerequisite, Mathematics 201.

Hour

GRABOIS]

Mathematics

315 Groups, Representations, and Characters

Group theory with emphasis on topics having applications in the physical sciences and with greater attention to examples than to proofs. Symmetry groups, group structure, representations and characters over the real and complex fields, space groups (chemistry), matrix groups (physics).

Prerequisite, Mathematics 201.

Hour E

HILL

321 Vector Analysis and Differential Geometry

A study of multivariable analysis leading into some elementary questions in differential geometry. Topics to be studied include: Inverse Function Theorem, Implicit Function Theorem, divergence, curl, the theory of curves, the theory of surfaces, differential forms, Stokes' Theorem and Green's Theorem.

Prerequisite, Mathematics 110 and 201.

Hour R

ROOSENRAAD

324 Topology

General spaces and the notions of continuity, connectedness, compactness. Metric spaces. Introduction to homology and homotopy.

Prerequisite, Mathematics 301.

Hour E

SPENCER

[325 Topics in Geometry (Not offered 1975-76.)

Selected topics from projective geometry, geometric algebra, non-Euclidean geometry, Hilbert's axiomatic development of Euclidean geometry.

Prerequisite, Mathematics 201.

Hour

[330 Numerical Analysis (Not offered 1975-76.)

Solution of non-linear equations and linear systems, interpolation and approximation, numerical differentiation and integration, with attention to error analysis and efficiency of algorithms.

Prerequisite, Mathematics 201.

Hour

[Computer Science 331 Programming Languages (Not offered 1975-76.)

A study of the computer languages FORTRAN, BASIC, COBOL, ALGOL, LISP and APL. Concentration will be on the concepts of computer languages and comparisons between them, although students will be expected to write programs in each language studied.

Williams 1975

Mathematics

Prerequisite, Mathematics 230 or equivalent programming experience in FORTRAN or BASIC.

Hour

WRIGHT]

Computer Science 332 Programming Theory

The design and analysis of programs of algorithms. The course will include an introduction to assembly language programming and some material in the mathematical theory of computation.

Prerequisite, Mathematics 231 or equivalent programming experience in FORTRAN or BASIC.

Hour M

WRIGHT

[351 Decision Theory (Not offered 1975-76.)

Mathematical rules for and consequences of making decisions under various conditions: certainty, risk (known probabilities of outcomes), uncertainty (unspecified probabilities of outcomes). Linear programming and game theory, principally in matrix form, as examples of the first situation; duality between them. Utility theory of von Neumann as an example of the second; quantification of non-numeric prospects. Prior probabilities as an example of the third; how to modify guesses on the basis of data. Emphasis on discrete problems.

Prerequisite, Mathematics 111 or equivalent.

Hour

KOZELKA]

[352 Graph Theory (Not offered 1975-76.)

A study of the properties and characterizations of configurations of points and lines. Graphs, trees, criteria for planarity and map coloring will be considered, as well as applications in the physical and social sciences. The theory will be developed with an emphasis on independent work and problem solving.

Prerequisite, permission of the instructor.

Hour

GRABOIS]

[360 Metamathematics (Not offered 1975-76.)

Intuitionism as a reaction to non-Euclidean geometry and transfinite arithmetic. Formalism: statement calculus, natural numbers, completeness, consistency. Primitive recursive functions. Gödel's Incompleteness Theorem.

Prerequisite, none.

Hour

HILL]

362F Foundations of Set Theory

Zermelo-Fraenkel axiomatic set theory, ordinals, cardinals, the axiom of choice and its equivalents, recent work of Cohen and Solovay.

Prerequisite, none.

Hour T

HILL

## Mathematics

### 371, 372, 471, 472 Topics in Actuarial Science

Directed independent study of topics in Actuarial Science aimed at preparing students for the examinations of the Society of Actuaries.

Prerequisite, permission of the instructor.

Hour

JORDAN

### 397, 398 Reading

Directed independent reading in Mathematics.

Prerequisite, permission of the department.

Hour

MEMBERS OF THE DEPARTMENT

### 403 Linear Analysis

Euclidean spaces and Fourier series; ordinary and partial differential operators; integral operators; boundary value problems.

Prerequisite, Mathematics 301.

Hour N

OLIVER

### 406 Senior Major Course

The purpose of the course is to emphasize the unity and power of mathematics by studying in depth a particular area of mathematics. The content will be chosen to draw as widely as possible upon the backgrounds of the participants and to illustrate a variety of applications. The exact topics to be covered will be decided by consultation among staff and students.

Senior course. Required of senior mathematics majors.

Prerequisite, permission of the department.

Hour S

OLIVER

### 407 Fall Seminar

Joint Faculty-student seminar. Topics selected in accordance with interests of the participants.

Prerequisite, permission of the department.

Hour M

OLIVER

### 491-492 Senior Thesis

### 497, 498 Reading

Directed independent reading in Mathematics.

Prerequisite, permission of the department.

Hour

MEMBERS OF THE DEPARTMENT

## Senior Colloquium

Required of senior majors. Meets every one or two weeks for one hour both fall and spring.

Hour U Tu.

MEMBERS OF THE DEPARTMENT

## MUSIC (Div. I)

DEPARTMENTAL STAFF FOR 1975-76

Chairman, Professor I. SHAINMAN

Professor BARROW, Professor SHAINMAN, Professor ROBERTS, Assistant Professor MOORE\*, Assistant Professor DANKNER, Lecturer HEGYI, Lecturer BEARDSLEY\*\*.

## MAJOR PROGRAM

### Sequence courses

Music 103 Introduction to Music, and any one of the following musical literature courses: Music 104F through 117.

Music 201-202 Elementary Harmony

Music 301-302 Music in History (Medieval and Renaissance Music in the first semester, plus a second semester of independent study as part of a "period" course, Music 210, 211, 212.)

Music 401-402 Twentieth Century Music

### Parallel courses

An additional year course or two semester courses in Music. The student is especially encouraged to enroll in those courses which will develop his critical skills in analysis and creative work in music, including independent study with one or more members of the faculty (i.e., Music 303-304, 325, 326, 403-404 and 425, 426). It is expected that music majors will participate in at least one department sponsored performance group during their junior and senior years.

## THE DEGREE WITH HONORS IN MUSIC

The degree with Honors in Music may be awarded to a student who has exhibited outstanding work in any one or more of the following areas:

\*On leave second semester 1975-76

\*\*Second semester 1975-76