Mathematics and Computer Science

Douglas Hundley, *Chair*
Barry Balof
Robert A. Fontenot
Russell A. Gordon
David Guichard
Patrick W. Keef
Albert W. Schueller
Laura M. Schueller

Mathematics courses provide an opportunity to study mathematics for its own sake and as a tool for the physical, social, and life sciences (applied mathematics). Most courses mix the two points of view to some extent, though some deal almost exclusively with one or the other. The department offers two separate major programs corresponding to these two areas.

All or part of the calculus sequence is required or recommended by several majors at Whitman and calculus is the most common mathematics course taken by students. However, the department offers other courses (Mathematics 108, 128, 167) that are intended for students who wish to take mathematics but are not interested in or not prepared for calculus. Courses in computer science, or with an emphasis on computing, are 167, 235, 236, 270, 350, 467.

P-D-F policy: The department places no restrictions on the use of the P-D-F option for mathematics courses for majors or nonmajors, except that students choosing the mathematics major must take Mathematics 260 for a grade. The department strongly recommends that students majoring in mathematics or completing a joint major with mathematics not use the P-D-F option in mathematics courses.

The senior assessment in mathematics consists of a comprehensive examination in two parts: a four-hour written examination and a one-hour oral examination. The written examination covers three semesters of calculus and one of linear algebra — roughly the first two years of the program. The oral examination covers advanced topics.

Courses in mathematics apply to the quantitative analysis distribution area.

The Mathematics major: 225, 235, 236, 260, 300; any two of 385, 386, 455, 456; 495 and 496; 12 additional credits in mathematics courses numbered above 200, for a total of 36 credits. A grade of C (2.0) or better in Mathematics 260 is required and grades of B (3.0) or better in Mathematics 225 and 260 are strongly recommended for any student considering mathematics as a major. The following are strongly recommended: computer programming experience and the use of a variety of technical software packages; applied mathematics courses, such as Mathematics 338, 339, 350 and 467; and a minor in a subject which makes substantial use of mathematics; for example, a physical science or economics. Students planning graduate study should take Mathematics 386 and 456 and should acquire a reading knowledge of at least one of French, German, and Russian.

The Applied Mathematics major: 167, 225, 235, 236, 244, 300, 338, 467, 495 and 496; nine additional credits in mathematics courses numbered above 200 (270, 339, 350, 367, 368 are good options) for a total of 34 credits; a minor (or major) in a related discipline, approved by the department. Students planning graduate study should acquire a reading knowledge of at least one of French, German, and Russian.

A student who enters Whitman College without a good working knowledge of the material in Mathematics 125 and 126 will have to complete 42 mathematics credits to fulfill the requirements for the mathematics major, 40 credits for the applied mathematics major; both totals include six credits for Mathematics 125, 126.

Twenty-seven mathematics credits are required for the mathematics-physics major, 31 mathematics credits for the economics-mathematics major, and 27 mathematics credits for the 3-2 mathematics-computer science major. Students may not declare both a mathematics and applied mathematics major.

The Mathematics minor: Fifteen credits or more in mathematics courses numbered 200 or above.

The Computer Science minor: A minimum of 15 credits including: 167, 270, and three courses chosen from 339, 350, 358, and 467.

The Economics-Mathematics combined major: Mathematics 167, 225, 235, 236, 244, 300, 338, either 339 or 350, and three additional credits chosen from mathematics courses

numbered above 200. Economics 101 or 177, 102, 307, 308, 327, 428 plus two additional courses in economics, at least one of which is numbered 310 through 490. For economics-mathematics majors, Economics 101 or 177, 102 and Mathematics 338 are the prerequisites for Economics 327, and Economics 227 does not apply toward the minimum major requirements. Courses completed in this major apply to the social science, science and quantitative analysis distribution areas.

The Mathematics-Physics combined major: Mathematics 225, 235, 236, 244, 300, and nine additional credits in mathematics courses numbered above 200; Physics 155 or 165, 156 or 166, 245, 246, 255, 256, 335, either 325 or 347, and five credits from physics courses numbered from 300-480, or from BBMB 324 and BBMB 334. Courses completed in this major apply to the science and quantitative analysis distribution areas.

Majoring in Computer Science. Please see the *Combined Plans* section of this catalog.

Choosing a Calculus Course

Students who wish to take calculus should note the following: Students with a strong background in high school mathematics not including calculus start with Mathematics 125. Students who have taken a high school course in calculus, but who have not taken the BC calculus Advanced Placement Test (see the statement below regarding college credit for the Advanced Placement Test) should take the Advisory Calculus Placement exam offered by the department of mathematics.

Students should note that several programs require the calculus labs, Mathematics 235 and 236, in addition to Mathematics 225. Because the lab courses teach skills that are useful in other mathematics and science courses, it is strongly recommended that students take Mathematics 235 and 236 as early as possible in their programs. Programs that require the calculus labs are the mathematics major, the economics-mathematics major, the mathematics-physics major, the physics major, the 3-2 engineering program, and the 3-2 mathematics-computer science major.

Advanced Placement

The policy for advanced standing and credit for the College Board Advanced Placement program is as follows:

1. Students with a 4 or 5 on the BC calculus test are considered to have completed the equivalent of Mathematics 125 and 126 and receive six credits in mathematics.
2. Students with a 4 or 5 on the AB calculus test (or on the AB subtest of the BC test) are considered to have completed the equivalent of Mathematics 125 and receive three credits in mathematics. These students should take the placement test offered by the department of mathematics to determine whether they should enroll in Mathematics 126 or Mathematics 225.
3. Students with a 4 or 5 on the computer science (A) test are considered to have completed the equivalent of Mathematics 167 and receive three credits in mathematics. Students with a 4 or 5 on the computer science (AB) test are considered to have completed the equivalent of Mathematics 167 and 270 and receive six credits in mathematics.

A student has the option of repeating a course for which AP credit has been granted, but with a commensurate reduction in advanced placement credit.

108 Introduction to Mathematical Thinking
x, 3 **Keef**

This course will introduce students to mathematical thinking by studying a variety of mathematical topics. Topics may include problem solving strategies, recreational mathematics and puzzles, mathematics of finance, voting power, and game theory. This course is not designed to prepare students for calculus and is intended primarily for the nonmath major. *Prerequisite*: two years of high school mathematics.

125 Calculus I
3, 3 **Fall: Keef, Gordon, Guichard**
Spring: Fontenot

A brief review of some precalculus topics followed by limits, continuity, a discussion of derivatives, and applications of the derivative. *Prerequisites*: two years of high school algebra; one year of plane geometry; and knowledge of trigonometry and conic sections or consent of the instructor.

126 Calculus II
3, 3 **Fall: Fontenot, Guichard**
Spring: Guichard, Fontenot

A continuation of Mathematics 125, covering integration, techniques for computing antiderivatives, applications of the definite integral, and infinite series.

128 Elementary Statistics
x, 3 **Keef**

Probability and statistics including methods for exploring data and relationships in data, methods for producing data, an introduction to probability and distributions, confidence intervals, and hypothesis testing. *Prerequisite*: two years of high school mathematics.

167 Programming in C++
x, 3 **Guichard**

An introduction to programming techniques applicable to most languages. Emphasis is placed on

the C++ language; frequent programming projects are required.

203, 204 Special Topics in Introductory Level Mathematics
1-3

On occasion, the mathematics department will offer courses on introductory topics in mathematics that are not generally covered in other introductory courses. Possible topics include Introduction to Number Theory, Chaos and Applied Discrete Probability.

203A ST: Chaos Theory
3, x **Hundley**

This course is an introduction to chaotic dynamical systems through theory and computer experimentation. We begin by examining discrete dynamical systems, bifurcations, and transitions to chaos. We will build up analytic tools, including fractal geometry and a little complex analysis to end the course with dynamics in the complex plane, Julia sets and the Mandelbrot set. *Prerequisites*: Mathematics 126.

204A ST: Programming with Robots
x, 3 **A. Schueller**

An introduction to programming techniques applicable to most languages using personal robotics kits (Lego Mindstorm NXT's provided). The programming language used is most similar to the C programming language. Frequent programming projects are required in both independent and group settings. Along with traditional computer science topics like logic and algorithms, simple networking and threading will also be explored. *Prerequisite*: open to first year students only.

225 Calculus III
4, 4 **Fall: Balof; Spring: Hundley**

Topics include partial derivatives, gradients, extreme value theory for functions of more than one variable, multiple integration, line integrals and various topics in vector analysis.

235, 236 Calculus Laboratory
1, 1 **Fall: Hundley; Spring: Balof**

A laboratory to investigate ways in which the computer can help in understanding the calculus and in dealing with problems whose solutions involve calculus. No programming required; a variety of existing programs will be used. *Prerequisite or corequisite* for Mathematics 235: Mathematics 225; *Prerequisite* for Mathematics 236: Mathematics 235.

244 Differential Equations
3, 3 **Fontenot**

This course includes first and second order linear differential equations and applications. Other topics may include systems of differential equations and series solutions of differential equations. *Prerequisite:* Mathematics 225.

260 An Introduction to Higher Mathematics
x, 3 **Gordon**

An introduction to some of the concepts and methodology of advanced mathematics. Emphasis is on the notions of rigor and proof. This course is intended for students interested in majoring in mathematics; students should plan to complete it not later than the spring semester of the sophomore year. *Prerequisite*: Mathematics 225.

270 Data Structures with C++
3, x **A. Schueller**

We study fundamental methods used to store, access, and manipulate data in computers. Storage structures to be covered include files, lists, tables, graphs, and trees. We will discuss and analyze methods of searching for and sorting data in these structures. *Prerequisite*: Mathematics 167 or consent of instructor.

281, 282 Independent Study
1-3, 1-3 **Staff**

A reading project in an area of mathematics not covered in regular courses or that is a proper subset of an existing course. The topic, selected by the student in consultation with the staff, is deemed to be introductory in nature with a level of difficulty comparable to other mathematics courses at the 200-level. May be repeated for a maximum of six credits. *Prerequisite:* consent of supervising instructor.

299 Problem Solving in Mathematics
1, x **Balof**

Students will meet weekly to discuss problem solving techniques. Each week a different type of problem will be discussed. Topics covered will include polynomials, combinatorics, geometry, probability, proofs involving induction, parity arguments and divisibility arguments. The main focus of the course will be to prepare students for the William Lowell Putnam Mathematics Competition, a national examination held the first Saturday in December. Students who place in the top 500 on this exam nationwide have their names listed for consideration to mathematics graduate programs. May be repeated for a maximum of four credits. *Prerequisite*: Consent of Instructor.

300 Linear Algebra
3, 3 **Fall: Balof; Spring: Gordon**

This course first considers the solution set of a system of linear equations. The ideas generated from systems of equations are then generalized and studied in a more abstract setting, which considers topics such as matrices, determinants, vector spaces, inner products, linear transformations, and eigenvalues. *Prerequisite:* Mathematics 225.

337 Geometry
3, x **Gordon**

Essential for prospective high school mathematics teachers, this course includes a study of Euclidean geometry, a discussion of the flaws in Euclidean geometry as seen from the point of view of modern axiomatics, a consideration of the parallel postulate and attempts to prove it, and a discussion of the discovery of non-Euclidean geometry and its philo-

sophical implications. *Prerequisite*: Mathematics 126.

338 Probability and Statistics
4, x **Hundley**

Topics include discrete and continuous probability spaces, distribution functions, the central limit theorem, estimation, tests of hypothesis, regression, and correlation. *Prerequisite*: Mathematics 225.

339 Operations Research
x, 3 **Fontenot**

Operations research is a scientific approach to determining how best to operate a system, usually under conditions requiring the allocation of scarce resources. This course will consider deterministic models, including those in linear programming (optimization) and related subfields of operations research. *Prerequisite:* Mathematics 300.

350 Mathematical Modeling and Numerical Methods
3; not offered 2008-09

This course explores the process of building, analyzing, and interpreting mathematical descriptions of physical processes. Topics may include feature extraction, partial differential equations, neural networks, statistical models. The course will involve some computer programming, so previous programming experience is helpful, but not required. *Prerequisite:* Mathematics 300.

358 Combinatorics and Graph Theory
x, 3 **Balof**

Topics in elementary combinatorics, including: permutations, combinations, generating functions, the inclusion-exclusion principle, and other counting techniques; graph theory; and recurrence relations. *Prerequisites*: Mathematics 260 or consent of instructor.

367 Engineering Mathematics
3, x **A. Schueller**

An introduction to mathematics commonly used in engineering and physics applications. Topics may include: vector analysis and applications; matrices, eigenvalues, and eigenfunctions; boundary value problems and spectral representations; Fourier series and Fourier integrals; solution of partial differential equations of mathematical physics; differentiation and integration of complex functions, residue calculus, conformal mapping. *Prerequisite:* Mathematics 244.

368 Complex Variables
3; not offered 2008-09

Complex analysis is the study of functions defined on the set of complex numbers. This introductory course covers limits and continuity, analytic functions, the Cauchy-Riemann equations, Taylor and Laurent series, contour integration and integration theorems, and residue theory. *Prerequisite*: Mathematics 225.

385, 386 Abstract Algebra
4, 4 **Fall: Guichard; Spring: Balof**

The first semester is an introduction to groups and rings, including subgroups and quotient groups, homomorphisms and isomorphisms, subrings and ideals. Topics for the second semester may include fields, simple groups, Sylow theorems, Galois theory, and modules. *Prerequisite*: Mathematics 260.

455, 456 Real Analysis
4; not offered 2008-09

First semester: a rigorous study of the basic concepts of real analysis, with emphasis on real-valued functions defined on intervals of real numbers. Topics include sequences, continuity, differentiation, integration, infinite series, and series of functions. Second semester: content varies from instructor to instructor but includes topics from metric spaces, the calculus of vector-valued functions, and more advanced integration theory. *Prerequisite*: Mathematics 260.

467 Numerical Analysis
x, 3 **Hundley**

An introduction to numerical approximation of algebraic and analytic processes. Topics include numerical methods of solution of equations, systems of equations and differential equations, and error analysis of approximations. *Prerequisite*: Mathematics 167; *pre- or corequisite*: Mathematics 300.

471, 472 Special Topics
1-3

On occasion, the mathematics department will offer courses on advanced topics in mathematics that are not found in other course offerings. Possible topics include topology, number theory, and problem solving.

472A ST: Cryptography
x, 3 **L. Schueller**

In this course, we will study public key cryptosystems. This is a mathematics course and the emphasis will be placed on cryptosystems with interesting mathematical structure. For this reason, we will sometimes study systems that are not ideal from a practical standpoint. We will concern ourselves primarily with the structure of the systems and limit our study of their actual implementation and security. *Prerequisite*: Math 300.

481, 482 Independent Study
1-3, 1-3 **Staff**

A reading or research project in an area of mathematics not covered in regular courses. The topic is to be selected by the student in consultation with the staff. Maximum of six credits. *Prerequisite*: consent of supervising instructor.

495 Senior Project I
3, x **L. Schueller**

Preparation of the senior project required of all

graduating mathematics majors. Aid will be given in choosing a senior project during the first two weeks. Once a project is defined, each student will be matched with a faculty mentor from the math department. Short oral reports will be given weekly for the remainder of the semester on the progress of the senior project.

496 Senior Project II

x, 1 **L. Schueller**

Finalization of the senior project for mathematics majors. A final written and oral report on the senior project is completed and submitted. During the semester drafts of the senior report are submitted regularly and evaluated for content and style. Proper mathematical writing will be emphasized.

498 Honors Thesis

3, 3 **Staff**

Preparation of an honors thesis. Required of and limited to senior honors candidates in mathematics. *Prerequisite*: admission to honors candidacy.