Mathematics and Statistics

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Mathematics and statistics courses provide an opportunity to study mathematics and statistics for its own sake and as a tool for use in the physical, social, and life sciences.

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 128) that are intended for students who wish to take mathematics but are not familiar with calculus.

Learning Goals: Upon completing the degree, a student majoring in Mathematics will:

- Be familiar with examples of the application of mathematics and/or statistics to other fields.
- Be prepared for advanced undergraduate study in mathematics and statistics. In particular:
  - Be able to write correct and coherent mathematical arguments.
  - Understand foundational mathematical ideas related to formal logic, number theory, sets, functions and relations.
- Understand core ideas of advanced undergraduate mathematics, including:
  - Fundamental concepts from abstract algebra (e.g., groups, rings, and fields).
  - Fundamental concepts from real analysis (e.g., continuity, differentiation, and integration).
- Be able to independently investigate an advanced topic in mathematics or statistics and to report the results of that investigation in a clear and organized manner, both orally and in writing.

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 and Statistics.

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

I. 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.

II. 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 and Statistics to determine whether they should enroll in Mathematics 126 or Mathematics 225. Students receive transfer credit for Mathematics 125 only even if they start in Mathematics 225.

III. Students with a 4 or 5 on the statistics test are considered to have completed the equivalent of Mathematics 128 and receive three credits in mathematics. Students should consider taking Mathematics 247 if they have also completed the equivalent of Mathematics 125.

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.

GCE (Cambridge International) A-Level Exam students with an A*, A or B on the A-Level Mathematics Exam are considered to have completed the equivalent of Mathematics 125 and receive 3 credits in Mathematics.

P-D-F policy: The department places no restrictions on the use of the P-D-F option for mathematics courses for majors or non-majors, except that students choosing the Mathematics major must take Mathematics 225, 240, and

260 for grades. 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 and statistics courses.

Distribution: Mathematics 125, 126, 128, 225, and 247 apply to the quantitative analysis distribution area.

Total credit requirements for a Mathematics major: A student who enters Whitman College without a good working knowledge of the material in Mathematics 125 and 126 will have to complete 41 mathematics credits to fulfill the requirements for the Mathematics major (including six credits for Mathematics 125, 126).

The Mathematics major:

- 35 Credits (41 credits if starting with Mathematics 125)
- Required Courses
    - Mathematics 225, 240, 260, 455, 475; 497 or 498
        - 12 additional credits numbered above 200 (excluding 220)
- Other notes
    - An average of the grades received in Mathematics 225, 240, and 260 of 2.5 or better is required
        - All three courses ought to be completed by the end of the sophomore year
        - Grades of B (3.0) or better are strongly recommended if considering Mathematics as a major
        - For students with transfer credit in one or more of these courses, the grade earned at the institution shall be used
    - Students planning graduate study should complete
        - Mathematics 456 and 476
        - Acquire a reading knowledge of either French, German, or Russian
- Senior Requirements
    - Mathematics 497 or 498
    - Written exam in September and oral exam in January
    - Senior assessment consists of the written exam in mathematics and an oral exam over general and advanced topics.
- Honors
    - Students do not apply for admission to candidacy for honors
    - Accumulated at least 87 credits
    - Completed two semesters of residency at Whitman.
    - Cumulative GPA of at least 3.300 on all credits earned at Whitman College
    - Major GPA of at least 3.500
    - Complete a written thesis or research project prepared exclusively for the satisfaction of this program
    - Earn a grade of at least A- on the honors thesis or project and the honors thesis course
    - Pass the senior assessment with distinction
    - Chair of the department will notify the Registrar of students attaining Honors no later than the beginning of week 12 of the semester.
    - An acceptable digital copy of the Honors Thesis must be submitted to Penrose Library no later than Reading Day

The Mathematics minor:

- 15 Credits
    - Courses numbered 200 or above
    - At least three credits must be from a course numbered 300 or above

The Data Science minor:

- 19 Credits
- Required Courses
    - Computer Science 167
    - Mathematics/Computer Science 215
    - Mathematics 240 and 247
- Other minor requirements

    - Two other courses from the following
        - Mathematics 248, 339, 347, 349, 350; Geology 418; Physics 301 ST; Computer Science 301 ST.
- Other notes
    - If also a Mathematics major, Mathematics 240 will satisfy both the Mathematics major and Data Science minor requirements.

The Economics-Mathematics major:

- 49 (27 credits in Economics and 22 credits in Mathematics)
- Required Courses
    - Economics 100 or 101, 102, 307, 308, 327, 428
    - One additional course in Economics (letter graded)
    - Mathematics 225, 240, 244, 247, 248, 349
    - 3 credits 200 level and above in mathematics
- Other notes
    - For Economics 327, Economics 227 or Mathematics 128 or 247 are a prerequisite
        - Economics 227 and Mathematics 128 do not count toward major requirements
    - Students with a score of 5 on the Principles of Microeconomics AP test will receive four credits for Economics 101
    - Students with a score of 5 on the Principles of Macroeconomics AP test will receive four credits for Economics 102.
    - Students with a score of 6 or higher on the higher level IB Economics test will receive a total of eight credits for Economics 101 and 102.
    - Courses taken PDF (including Economics 493 and 494) and Economics 498 may not be used to meet the credit requirement
- Senior Requirements
    - Senior assessment
        - Written exam in mathematics
        - Major Field Test (MFT; only offered in the spring) in economics
        - Combined oral exam
            - Scheduled by the Economics Department

- Honors
    - Students submit an Honors in Major Study Application to their department
    - Students must submit a proposal for their thesis or project
        - Must be submitted within the first six weeks of the two-semester period in which student is eligible
    - Accumulated at least 87 credits
    - Completed two semesters of residency at Whitman.
    - Cumulative GPA of at least 3.300 on all credits earned at Whitman College
    - Major GPA of at least 3.500
    - Complete a written thesis or research project prepared exclusively for the satisfaction of this program
    - Earn a grade of at least A- on the honors thesis or project and the honors thesis course.
    - Pass the senior assessment with distinction
    - The department will submit the Honors applications to the Registrar's Office of students pursuing Honors by the specified deadline
    - The department submit "Senior Assessment/Major Study Certificate" to the Registrar's Office no later the Reading Day
    - An acceptable digital copy of the Honors Thesis must be submitted to Penrose Library no later than Reading Day
    - For more details
        - https://www.whitman.edu/academics/departments-and-programs/economics/economics-major-programs/department-honors

The Mathematics-Physics combined major:

- 49 credits (24 credits in Physics and 25 credits in Mathematics, if starting with Physics 155 and Mathematics 125)
- Required Mathematics courses
    - Mathematics 225, 240, 244; and either 367 or 368
    - 6 additional credits in Mathematic courses numbered above 200
- Required Physics courses
    - Physics 145 or 155 or 347
    - Physics 156, 245, 255, and 267
    - Three additional courses from among 300 to 480 level physics offerings and the course/lab combination of BBMB 324/334. This category's course selection must include at least two of the following: Physics 325, 339, 347, 357, or 385
        - Physics 347 may not be used to satisfy multiple requirements
- Other notes
    - If students place out of Physics 155 they must take 347
- Senior Requirements
    - Senior assessment
        - Written exam in mathematics
        - Written exam in physics
        - Combined oral exam
            - Scheduled by the physics department
- Honors
    - Students submit an Honors in Major Study Application to their department
    - Students must submit a proposal for their thesis or project
        - Must be submitted within the first six weeks of the two-semester period in which student is eligible
    - Accumulated at least 87 credits
    - Completed two semesters of residency at Whitman.
    - Cumulative GPA of at least 3.300 on all credits earned at Whitman College
    - Major GPA of at least 3.500
    - Complete a written thesis or research project prepared exclusively for the satisfaction of this program
    - Earn a grade of at least A- on the honors thesis or project and the honors thesis course.
    - Pass the senior assessment with distinction
    - The department will submit the Honors applications to the Registrar's Office of students pursuing Honors by the specified deadline
    - The department submit "Senior Assessment/Major Study Certificate" to the Registrar's Office no later the Reading Day
    - An acceptable digital copy of the Honors Thesis must be submitted to Penrose Library no later than Reading Day

125 Calculus I

Fall, Spring **Fall: Hundley, Keef; Spring: R. Gordon** **3 credits**

Topics include limits and continuity. Definition, computation and applications of the derivative. An introduction to integration, including the fundamental theorem of calculus. *Prerequisites:* two years of high school algebra; one year of plane geometry; and knowledge of trigonometry and exponential/logarithmic functions or consent of instructor.

126 Calculus II

Fall, Spring **Fall: R. Gordon; Spring: Balof** **3 credits**

A continuation of Mathematics 125, covering techniques for computing indefinite integrals, applications of the definite integral, infinite sequences and series, Taylor polynomials and power series. *Prerequisite*: Mathematics 125 or equivalent.

128 Introduction to Statistics
Spring **Fall: Staff; Spring: Staff** **3 credits**

This course introduces students to basic tools for describing and summarizing data as well as methods of statistical inference such as confidence intervals and hypothesis tests. The randomization approach used in the course allows students to develop a deeper understanding of the fundamental idea of statistical inference. A web-based statistical applet is used throughout the course. This course does not count toward the Mathematics major or Data Science minor. Students considering these should enroll in Mathematics 247 instead. *Prerequisite:* two years of high school mathematics.

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

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

215 Introduction to Data Science
Fall **Ptukhina** **4 credits**

An introduction to the approaches and tools of exploratory data analysis and visualization. Through a series of projects, we explore large data sets through methods like cleaning, filtering, sorting, boolean selections and merging. As large amounts of data typically are stored in lists, we use algorithmic thinking to transform raw data into usable form. We develop hypotheses and supporting visualizations to tell the story of the data. We learn and practice technical communication in both oral and written form. Through a series of readings and discussions, we learn best practices for the ethical use of data and how to identify problematic uses of data in society. May be elected as Computer Science 215. *Prerequisites*: Mathematics 125 and Computer Science 167.

220 Discrete Mathematics & Functional Programming
Fall **Davis** **3 credits**

Students will practice formal reasoning over discrete structures through two parallel modes: mathematical proofs and computer programs. We will introduce sets and lists, Boolean logic, and proof techniques. We will explore recursive algorithms and data types alongside mathematical and structural induction. We consider relations and functions as mathematical objects built on set theory and develop idioms of higher-order programming. May be elected as Computer Science 220. *Prerequisites:* Computer Science 167 and Mathematics 125.

225 Calculus III
Fall, Spring **Fall: Balof; Spring: Guichard** **4 credits**

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

240 Linear Algebra
Fall, Spring **Fall: Hundley; Spring: Keef** **3 credits**

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 126; Mathematics 225 is highly recommended.

244 Differential Equations
Fall, Spring **Fall: Schueller; Spring: Hundley** **3 credits**

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.

247 Statistics with Applications
Fall, Spring **Fall: Staff; Spring: Ptukhina** **3 credits**

An introduction to statistics for students who have taken at least one course in calculus. This course focuses on

introducing statistical concepts and inference through active learning assignments. Students learn about the process of statistical investigations. This includes data collection and exploration, methods of statistical inference, and the ability to draw appropriate conclusions. The widely-used statistical software R will be used in addition to web-based applets. *Prerequisite:* Mathematics 125 or equivalent.

248 Statistical Modeling

Fall **Ptukhina** **3 credits**

This course follows introductory statistics by investigating more complex statistical models and their application to real data. The topics may include simple linear regression, multiple regression, non-parametric methods, and logistic regression. A statistical software package will be used. *Prerequisite:* Mathematics 128, Mathematics 247, Economics 227, or Environmental Studies 207.

260 An Introduction to Higher Mathematics

Fall, Spring **Fall: Guichard; Spring: Keef** **4 credits**

An introduction to some of the concepts and methodology of advanced mathematics, including a brief introduction to number theory. Emphasis is on the notions of rigor and proof. This course is intended for students interested in majoring in mathematics and statistics; students should plan to complete it no later than the spring semester of the sophomore year. *Prerequisite:* Mathematics 225.

281, 282 Independent Study

Fall, Spring **Staff** **1-3 credits**

A reading project in an area of mathematics and statistics 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 and statistics courses at the 200-level. May be repeated for a maximum of six credits. *Prerequisite:* consent of supervising instructor.

287 Independent Study in Geometry

Not offered 2021-22 **3 credits**

This independent study in geometry will include a review of high school geometry, a few topics in advanced Euclidean geometry, a reading of Books I and II of Euclid's Elements, and an introduction to hyperbolic geometry. The grading for the course will be based on a journal (40%), a two-hour written midterm exam (30%), and a one-hour oral final exam (30%). Since the student will be working independently on the material, a disciplined work ethic is required. *Prerequisite:* Mathematics 225 and consent of instructor.

299 Problem-Solving in Mathematics

Fall **Balof** **1 credit**

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. Graded credit/no credit. May be repeated for a maximum of four credits. *Prerequisite:* Mathematics 260 or consent of instructor.

320 Theory of Computation

Fall **Stratton** **3 credits**

Which problems can be solved computationally? Which cannot? Why? We can prove that computers can perform certain computations and not others. This course will investigate which ones, and why. Topics will include formal models of computation such as finite state automata, push-down automata, and Turing machines, as well as formal languages such as context-free grammars and regular expressions. May be elected as Computer Science 320. *Prerequisite*: Computer Science/Mathematics 220 or Mathematics 260.

327 Algorithm Design & Analysis

Spring **Stratton** **3 credits**

How can we be confident that an algorithm is correct before we implement it? How can we compare the efficiency of different algorithms? We present rigorous techniques for design and analysis of efficient algorithms. We consider problems such as sorting, searching, graph algorithms, and string processing. Students will learn design techniques such as linear programming, dynamic programming, and the greedy method, as well as asymptotic, worst-case, average-case and amortized runtime analyses. Data structures will be further developed and analyzed. We consider the limits of what can be efficiently computed. May be elected as Computer Science 327. *Prerequisites:* Computer Science 270; Computer Science/Mathematics 220 or Mathematics 260.

337 Geometry

Not offered 2021-22 **3 credits**

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 philosophical implications. *Prerequisite:* Mathematics 126.

339 Operations Research

Spring **Hundley** **3 credits**

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. May be elected as Computer Science 339. *Prerequisites:* Mathematics 240 and Computer Science 167.

347 Design and Analysis of Research Studies

Spring **Ptukhina** **4 credits**

Statistical concepts and statistical methodology useful in descriptive, experimental, and analytical study of biological and other natural phenomena. Course covers major design structures, including blocking, nesting and repeated measures (longitudinal data), and statistical analysis associated with these structures. *Prerequisite*: Mathematics 247.

349 Probability Theory

Spring **Staff** **3 credits**

A formal introduction to probability and randomness. The topics of the course include but are not limited to conditional probability, Bayes' Theorem, random variables, the Central Limit Theorem, expectation and variance. Both discrete and continuous probability distribution functions and cumulative distribution functions are studied. *Prerequisite:* Mathematics 225.

350 Mathematical Modeling and Numerical Methods

Not offered 2021-22 **3 credits**

This course explores the process of building, analyzing and interpreting mathematical descriptions of physical processes. This may include theoretical models using statistics and differential equations, simulation modeling, and empirical modeling (meaning model building from data). The course will involve some computer programming, so previous programming experience is helpful. May be elected as Computer Science 350. *Prerequisites:* Mathematics 240 and 244.

358 Combinatorics and Graph Theory

Spring **Guichard** **3 credits**

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

367 Engineering Mathematics
Not offered 2021-22 **3 credits**

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
Spring **Schueller** **3 credits**

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.

371- 373 Special Topics
1-3 credits

Any current offerings follow.

438 Statistical Theory
Not offered 2021-22 **4 credits**

This course studies the mathematical theory of statistics with a focus on the theory of estimation and hypothesis tests. Topics may include properties of estimators, maximum likelihood estimation, convergence in probability, the central limit theorem, order statistics, moment generating functions, and likelihood ratio tests. A statistical software package will be used. *Prerequisites:* Mathematics 349 and one of the following: Mathematics 128, Mathematics 247, Economics 227, or Environmental Studies 207.

455, 456 Real Analysis
Fall, Spring **R. Gordon** **4 credits**

The first semester provides 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, and infinite series. The content for the second semester varies from instructor to instructor with typical topics chosen from series of functions, topology of the real line, basic concepts of metric spaces, the calculus of vector-valued functions, and more advanced integration theory. *Prerequisit*e: Mathematics 260.

467 Numerical Analysis
Not offered 2021-22 **3 credits**

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. May be elected as Computer Science 467. *Prerequisite:* Computer Science 167. *Pre-* or *corequisite:* Mathematics 240.

471- 473 Special Topics
1-3 credits

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

475, 476 Abstract Algebra
Fall-475 **Guichard** **4 credits**

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.

481, 482 Independent Study
Fall, Spring **Staff** **1-3 credits**
A reading or research project in an area of mathematics and statistics 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.

497 Senior Project
Spring **Keef** **4 credits**
Preparation of the senior project required of all graduating mathematics majors. Each student will be matched with a faculty member from the mathematics and statistics department who will help supervise the project. Course objectives include developing students' abilities to independently read, develop, organize, and communicate mathematical ideas, both orally and in writing. A final written and oral report on the project is completed.

498 Honors Thesis
Fall, Spring **Staff** **4 credits**
Preparation of an honors thesis. Required of and limited to senior honors candidates in mathematics. Students will be a part of the Mathematics 497 *Senior Project* class (described above), but their work will be held to a higher standard. P*rerequisite:* admission to honors candidacy.