

# FUNDAMENTAL SKILLS

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As part of Pacific's undergraduate and first professional degree graduation requirements, all students must satisfy two fundamental skills: quantitative analysis (math) and writing. These requirements must be met before a student graduates with a bachelor's degree or a first professional degree. Failure to make progress toward fulfilling Pacific's fundamental skills requirements during the first year of study is grounds for being placed on academic probation. Failure to satisfy the fundamental skills requirements by the end of four semesters of full-time study at the University is grounds for academic disqualification.

Students can fulfill the math and writing requirements in one of four ways:

- Completion of Pacific's highest level developmental skills course (e.g., MATH 005 or WRIT 010);
- Completion of an appropriately articulated course at an accredited college or university;
- Satisfactory performance on an approved, nationally administered examination; or
- Satisfactory performance on Pacific's placement examinations.

Students with documented disabilities that directly affect their mastery of these skills or students concurrently enrolled in an approved English-as-a-Second-Language (ESL) Program of instruction in reading and writing may seek a written extension of the deadline for demonstrating competence.

The Developmental Math Program consists of courses designed to help students be successful in all levels of math or quantitative reasoning courses.

University of the Pacific students are required to demonstrate fundamental competency in quantitative analysis (math). The requirement must be met before a student graduates with a bachelor's degree or a first professional degree. Failure to make progress toward fulfilling Pacific's fundamental math skills requirements during the first year of study is grounds for being placed on academic probation. Failure to satisfy the fundamental math skills requirements by the end of four semesters of full-time study at the University is grounds for academic disqualification.

To satisfy the University's quantitative analysis (math) fundamental skills requirement, a student must complete one of the following:

- SAT math score of 570 or above
- ACT math score of 24 or above
- SAT Math Subject Test Level 1 score of 540 or above
- SAT Math Subject Test Level 2 score of 520 or above
- AP Calculus AB score of 3 or higher
- AP Calculus BC score of 3 or higher
- AP Statistics exam score of 3 or higher
- IB Math HL (Higher Level) score of 4 or higher
- Pacific's Intermediate Algebra Math Placement Exam score of 56 or higher
- ALEKS PPL score of 61 or higher
- Successfully complete MATH 005 (Intermediate College Algebra) or MATH 035 (Elementary Statistical Inference) with a grade of C- or higher (or an equivalent course from another college or university with a grade of C or better).

The Developmental Writing Program helps students build the writing skills required for success in college-level writing.

University of the Pacific students are required to demonstrate fundamental competency in writing. The requirement must be met before a student graduates with a bachelor's degree or a first professional degree. Failure to make progress toward fulfilling Pacific's fundamental skills requirements during the first year of study is grounds for being placed on academic probation. Failure to satisfy the fundamental skills requirements by the end of four semesters of full-time study at the University is grounds for academic disqualification.

To satisfy the University's fundamental skills writing requirement, a student must

- Score 550 or higher on the SAT writing exam
- Score 22 or higher on the ACT English/Writing exam
- Score 26 or higher on TOEFL, writing sub-score
- Score 7.5 or higher on IELTS, writing sub-score
- Score 3 or higher on an AP English language or literature exam
- Score 4 or higher on an IB English literature exam
- Complete WRIT 010 with a C- or higher
- Complete a transferable course equivalent to a College Writing Course with a C or higher
- Score 4.5 or higher on Pacific's Writing Diagnostic Exam

## Mathematics Courses

### **MATH 001. Pre-algebra and Lab. 3 Units.**

This course is designed for students whose Mathematics Placement Test score indicates a need to review arithmetic skills and Pre-algebra material. Topics covered include fractions, decimals, percents, basic area and volume formulas, signed numbers, use of variables in mathematical statements, translating statements in English to mathematical equations, solving linear equations and ratio and proportion. The course is taught using a Personalized System of Instruction. Neither the course credit nor course grade applies towards graduation. Prerequisite is an appropriate test score or permission of instructor.

### **MATH 003. Elementary Algebra and Lab. 3 Units.**

Topics covered include signed numbers, linear equations, polynomials, factoring, algebraic fractions, radicals, quadratic equations, inequalities and systems of linear equations. This is an introductory course for students with limited high school background in mathematics. This course is taught using a Personalized System of Instruction. This course is inappropriate for students who have passed the Elementary Algebra placement exam or any higher level placement exam. Neither the course credit nor course grade applies towards graduation. Prerequisite: MATH 001 with a "C" or better or an appropriate test score or permission of instructor.

**MATH 004. Math Literacy for College. 3 Units.**

This course is designed to help students develop mathematical reasoning skills and the foundational algebra skills needed to be successful in an introductory statistics or intermediate algebra course. The topics in the course are selected around the central goals for developing numeracy, proportional reasoning, algebraic reasoning, and an understanding of functions. An emphasis is placed on performing, explaining, and applying relevant skills to new situations. Problems are generally presented in context of real world situations. The course is not appropriate for students who have placed into MATH 005 or above. There is no prerequisite for this course. Students passing this course with a C- or better are eligible to take MATH 005, 005E, 035, or 161.

**MATH 005. Intermediate College Algebra. 3 Units.**

This course is taught in a traditional lecture format. Topics covered in this course include the real number system, solution of linear equations and inequalities, word problems, factoring, algebraic equations, exponents and radicals, quadratic equations, relations, functions, graphs, systems of equations and logarithmic and exponential functions. This course is not appropriate for students who have passed the Intermediate Algebra placement test of any higher level test. Pass/No Credit (P/NC) grading option is not allowed for this course. A grade of C- or better is required to satisfy the University's Fundamental Skills requirement in quantitative analysis/math. Prerequisite: MATH 003 with a "C-" or better or an appropriate test score or permission of instructor. (MATH)

**MATH 005E. Intermediate College Algebra and Lab. 3 Units.**

This course is taught using the emporium model in which students use technology to drive their learning in a lab setting with on-demand support from the instructor and tutors. Topics covered in this course include the real number system, solution of linear equations and inequalities, word problems, factoring, algebraic equations, exponents and radicals, quadratic equations, relations, functions, graphs, systems of equations and logarithmic and exponential functions. This course is not appropriate for students who have passed the Intermediate Algebra placement test of any higher level test. Pass/No Credit (P/NC) grading option is not allowed for this course. A grade of C- or better is required to satisfy the University's Fundamental Skills requirement in quantitative analysis/math. Prerequisite: MATH 003 with a "C-" or better or an appropriate test score or permission of instructor. (MATH)

**MATH 007. Trigonometry and Lab. 2 Units.**

Topics in this course include angle measure, trigonometric functions, applications of trigonometry, graphs of trigonometric functions, trigonometric identities, inverse functions and complex numbers. This course is designed for students who have not studied trigonometry in high school. Prerequisites include a satisfactory score on the Intermediate Algebra placement test. This course is taught using a Personalized System of Instruction and meets three hours per week. Pass/No credit (P/NC) grading option is not allowed for this course. Students who complete MATH 005 and MATH 007 with a C- or better may enroll in MATH 051. Prerequisite: MATH 005 with a "C-" or better, an appropriate test score, or permission of instructor. (MATH)

**MATH 011. Chair's Seminar. 1 Unit.**

The learning objective of this course is for students to gain insight into the Math department and university resources. Throughout the semester students will be exposed to various facets of the Math department and the university. Math professors will make presentations, introducing students to their research areas and upper division math courses they teach. Some of these presentations will introduce students to opportunities to get involved in undergraduate research. Students will also be exposed to university resources including, but not limited to, the Math Tutoring Center, Career Resource Center, Counselling and Psychological Services.

**MATH 033. Elements of Calculus. 4 Units.**

This course covers polynomial, rational, exponential and logarithmic functions as well as differentiation, integration and maxima/minima of functions of several variables. Elementary differential equations are studied and applications to natural sciences, social sciences and other fields are covered. Credit is not given for this course if a student has received credit for MATH 051 or AP credit in Calculus. Prerequisites: Two years of high school algebra and an appropriate score on either the Intermediate Algebra placement test or the Pre-Calculus placement test; or MATH 005 or MATH 041 with a "C-" or better. (GE3B, GEQR, MATH)

**MATH 035. Elementary Statistical Inference. 3 Units.**

Sampling, simple experimental designs, descriptive statistics, confidence intervals & hypothesis tests for means and proportions, Chi-square tests, linear & multiple regression, analysis of variance. Use of statistical software and/or online statistical calculators. Credit is not given for this course if a student has received credit for MATH 037 or MATH 131 or has AP credit in statistics. Prerequisite: MATH 004 or exemption by placement. GE IIIB. (GE3B, GEQR, MATH, PLAW)

**MATH 037. Introduction to Statistics and Probability. 4 Units.**

Students will develop mathematical tools for collecting, summarizing, analyzing, and drawing inferences from data. Topics covered include elements of descriptive statistics, such as graphs, tables, measures of central tendency and dispersion; discrete and continuous probability models for experiments and sampling distributions including the normal,  $t$ -, and chi-square distributions; and basic concepts of inferential statistics including confidence intervals,  $p$ -values, hypothesis tests for both one- and two-sample problems, ANOVA, and linear regression. The use of statistical software is required. This course is not recommended for first semester freshmen. Credit will not be given for this course if a student has received credit for MATH 035 or has AP credit in Statistics. Prerequisites: MATH 033 or MATH 041 or MATH 045 or MATH 051 or MATH 053 with a "C-" or better or appropriate score on the calculus placement test. (GE3B, GEQR, MATH, PLAW)

**MATH 039. Probability with Applications to Statistics. 4 Units.**

Probability concepts in discrete and continuous spaces is explored in some depth as well as important probability models (e.g., binomial, Poisson, exponential, normal, etc.), mathematical expectation and generating functions. Applications to statistical inference includes maximum likelihood, moment and least squares estimation. Confidence intervals and hypothesis testing is also covered. Credit is not given for both MATH 039 and MATH 131. Prerequisite: MATH 053 with a "C-" or better. (GE3B)

**MATH 041. Pre-calculus. 4 Units.**

The algebraic and trigonometric concepts which are necessary preparation for Calculus I are studied. Topics include the real number system, algebraic, trigonometric, exponential and logarithmic functions. Emphasis is on the function concept; graphing functions; solving equations, inequalities and linear systems; and applied problems. Credit for this course is not given if a student has AP Calculus credit. Prerequisite: MATH 005 with a "C-" or better or an appropriate score on either the Intermediate Algebra placement test, the Pre-calculus placement test or the calculus placement test. (GE3B, GEQR, MATH)

**MATH 045. Introduction to Finite Mathematics and Calculus. 3 Units.**

Applications of finite math & calculus to problems in business, economics, and related fields through the study of systems of equations, elementary functions, elementary linear programming, the derivative, and the integral. Credit for this course is not given if a student has credit for MATH 051 or AP Calculus credit. Prerequisites: One of the following: (1) MATH 005 or MATH 041 with a grade of C- or higher (2) Math Placement (3) Exemption from Math Placement. (GE3B, GEQR, MATH)

**MATH 051. Calculus I. 4 Units.**

Students study differential calculus of algebraic and elementary transcendental functions, anti-derivatives, introductory definite integrals, and the Fundamental Theorem of Calculus. Applications include the first and second derivative tests and optimization. Credit is not given for this course if a student has AP Calculus I credit. Prerequisites: MATH 007 or MATH 041 with a "C-" or better, a score of 3 on either AP Calculus AB or BC exam, or an appropriate score on the placement test for calculus. (GE3B, GEQR, MATH)

**MATH 053. Calculus II. 4 Units.**

This course covers techniques and applications of integration, sequences and series, convergence of series, and Taylor Polynomials. Credit is not given for this course if a student has AP Calculus II credit. Prerequisites: MATH 051 with a "C-" or better, AP Calculus AB credit, or an appropriate score on the calculus placement test. (GE3B, GEQR, MATH)

**MATH 055. Calculus III. 4 Units.**

This course introduces multivariable calculus. Topics covered include vector geometry of the plane and Euclidean 3-space; differential calculus of real-valued functions of several variables, as well as partial derivatives, gradient, max-min theory, quadratic surfaces, and multiple integrals. Prerequisite: MATH 053 with a "C-" or better or AP Math BC credit.

**MATH 057. Applied Differential Equations I: ODEs. 4 Units.**

Students study ordinary differential equations, first-order equations, separable and linear equations. Also covered are direction fields, second order linear equations with constant coefficients, method of undetermined coefficients, laplace transforms, and unit impulse response and convolutions. Homogeneous systems of first order linear equations and matrix algebra determinants, eigenvalues, eigenvectors are also studied. Existence and uniqueness theorems are discussed and calculators or computers are used to display solutions and applications. Prerequisites: MATH 055 with a "C-" or better, or MATH 053 and MATH 075, both with a "C-" or better, or permission of instructor.

**MATH 064. Ancient Arithmetic. 4 Units.**

This course traces mathematical and historical developments throughout the ancient world, ending with the Scientific Revolution. Students will gain mathematical knowledge through the analysis of historical problems and solution methods, while contextualizing these endeavors into a larger historical context. Students will read mathematical primary sources, and will learn to think about the development of mathematical primary sources, and will learn to think about the development of mathematics as an intellectual pursuit over time. This course is cross-listed with HIST 066. Prerequisite: Fundamental Skills.

**MATH 072. Operations Research Models. 4 Units.**

Operations Research (OR) is concerned with scientific design and operation of systems which involve the allocation of scarce resources. This course surveys some of the quantitative techniques used in OR. Linear Programs are solved using graphical techniques and the simplex algorithm. Among the other models studied is the transportation, assignment, matching, and knapsack problems. Prerequisite: MATH 033 or MATH 045 or MATH 051 with a "C-" or better or the appropriate score on the calculus placement test.

**MATH 074. Discrete and Combinatorial Mathematics. 4 Units.**

The fundamental principles of discrete and combinatorial mathematics are covered. Topics include the fundamental principles of counting, the Binomial Theorem, generating functions, recurrence relations and introductory graph theory, that includes trees and connectivity. Prerequisite: MATH 033 or MATH 045 or MATH 051 with a "C-" or better, or an appropriate score on the calculus placement test.

**MATH 075. Introduction to Linear Algebra. 4 Units.**

Linear algebra is the generalized study of solutions to systems of linear equations. The study of such systems dates back over 2000 years and now is foundational in the design of computational algorithms for many modern applications. This course will serve as an introduction to basic computational tools in linear algebra including the algebra and geometry of vectors, solutions to systems of linear equations, matrix algebra, linear transformations, determinants, eigenvalue-eigenvector problems, and orthogonal bases. Prerequisite: MATH 051 with a "C-" or better.

**MATH 081. Writing Math Problems. 1 Unit.**

This course is an introduction to LaTeX math typesetting software commonly used by mathematicians including document creation, special document classes, mathematics commands and terminology. Writing problems for contests in multiple content areas and proofreading math problems. Practicum aspect: students will provide the content and grading for Pacific's Avinash Raina High School Math Competition. Prerequisite may be taken concurrently: MATH 051. (Spring).

**MATH 093. Special Topics. 1-4 Units.****MATH 093E. Math Literacy for College. 3 Units.****MATH 093F. Special Topics. 4 Units.****MATH 095. Problem Solving Seminar. 1 Unit.**

The objective of this course is to learn mathematics through problem solving. Students in mathematics courses are often given the impression that to solve a problem, one must imitate the solution to a similar problem that has already been solved. This course will attempt to develop student creativity in solving problems by considering problems not commonly encountered in other mathematics courses. Students enrolled in this course are expected to participate in the William Lowell Putnam Mathematical Competition on the first Saturday in December. Students may take this course for credit at most four times. Prerequisite: MATH 053 with a "C-" or better.

**MATH 101. Introduction to Abstract Mathematics. 4 Units.**

An introduction to the spirit and rigor of mathematics is the focus of the course. The content may vary with instructor, but the objective is to develop the skills required to read and write mathematics and prove theorems. Concepts include elementary logic, sets and functions, cardinality, direct and indirect proofs, mathematical induction. Prerequisites: MATH 053 with a "C-" or better or permission of the instructor.

**MATH 110. Numerical Analysis. 4 Units.**

Numerical analysis deals with approximation of solutions to problems arising from the use of mathematics. The course begins with a necessary but brief discussion of floating point arithmetic, and then proceeds to discuss the computer solution of linear algebraic systems by elimination and iterative methods, the algebraic eigenvalue problem, interpolation, numeric integration, that includes a discussion of adaptive quadrature, the computation of roots of nonlinear equations and the numerical solution of initial value problems in ordinary differential equations. Prerequisite: MATH 055 with a "C-" or better.

**MATH 121. Financial Mathematics I. 3 Units.**

This course provides understanding of fundamental concepts in financial mathematics and how those concepts are applied in calculating present and accumulated values for various streams of cash flows as a basis for future use in reserving, valuation, pricing, asset/liability management, investment income, capital budgeting, and valuing contingent cash flows. Topics include interest rates, determinants of interest rates, and interest-related concepts, annuities involving both level and varying payments, and varying interest rates, projects appraisal evaluation, loans and loan payment methods, bonds and bond evaluations. This course, together with MATH 122, prepares students for the Society of Actuaries Financial Mathematics examination. Prerequisite: MATH 053 with a "C-" or better or permission of instructor.

**MATH 122. Financial Mathematics II. 3 Units.**

This course is the second semester of one-year financial mathematics. The course starts with reviewing bonds and bond evaluations. New topics include: discount model in common stock evaluation, analysis of term structure of interest rates, concepts of duration and convexity, and using and convexity to approximate bond price changes with respect to interest rate change, cash flow matching, immunization (including full immunization), Redington immunization, interest rate swaps. This course, together with MATH 121, prepares students for the Society of Actuaries Financial Mathematics examination. Prerequisite: MATH 121 with a "C-" or better or permission of instructor.

**MATH 122P. Problem Solving in Financial Mathematics. 1 Unit.**

This 1 unit course is designed to prepare students for actuarial professional Exam FM. The course will review basic concepts in theory of interest and interest rate swaps (material covered in both MATH 121 and MATH 122). The course is entirely problem driven. Prerequisite: MATH 122 with a "C-" or better.

**MATH 124. Advanced Financial Mathematics. 4 Units.**

This course is designed to develop student's knowledge of the theoretical basis of certain actuarial models and the application of those models to insurance and other financial risks. The primary topics are: Option relations, binomial option pricing, Black-Scholes equation, market-making and delta hedging, exotic options, and Lognormal Distribution. Prerequisites: BUSI 123 and MATH 131 with a "C-" or better.

**MATH 125. Actuarial Models I. 3 Units.**

Actuaries put a price on risk, and this course considers constructing and analyzing actuarial loss models (risk theory, severity and ruin models). This is the first part of a two-course series that covers the theory and applications of actuarial modeling. Actuarial Models I covers topics in probability theory relevant to the construction of actuarial models. After a review of random variables and basic probability distributional properties, the course examines severity and frequency loss models. Aggregate loss models, risk measures and the impact of coverage modifications on both frequency and severity will also be discussed. Finally, we will explore various ways of simulating random variables. Prerequisite: MATH 132 with a "C-" or better or Permission of Instructor.

**MATH 126. Actuarial Models II. 3 Units.**

This course is the second part of a two-course series that covers the theory and applications of actuarial modeling. The course continues a study of the loss modeling processes introduced in Actuarial Models I. The primary topics the course cover are: (1) Estimation for complete data: empirical distributions for complete, individual data and grouped data. (2) Estimation for modified data: point estimation, Mean, variance, and interval estimation, kernel density models, approximations for large data sets. (3) Frequentist estimation: method of moments and percentile matching, maximum likelihood estimation, variance and interval estimation, Bayesian estimation, estimation for discrete distribution. (4) Frequentist estimation for discrete distribution. (5) Model selection: representations of the data and model, hypothesis tests, two types of selection criteria, extreme value models, copula models, models with covariates. (6) Simulation. Prerequisite: MATH 125 with a "C-" or better or Permission of Instructor.

**MATH 127. Models of Life Contingencies I. 4 Units.**

This course is an introduction to life contingencies as applied in actuarial practice. This course is the first semester of two-semester course sequence, and it is designed to develop knowledge of the theoretical basis of life-contingent actuarial models and the application of those models to insurance and other financial risks. It covers the mathematical and probabilistic topics that underlie life contingent financial instruments like life insurance, pensions and lifetime annuities. Topics include life tables, present value random variables for contingent annuities and insurance, their distributions and actuarial present values, equivalence principle, and other principles for determining premiums and reserves. Prerequisites: MATH 122; MATH 131 with a "C-" or better or Permission of Instructor.

**MATH 128. Models of Life Contingencies II. 4 Units.**

This course is a continuation of the study of life contingencies. It is designed to develop the student's knowledge of the theoretical basis of life-contingent actuarial models and the application of those models to insurance and other financial risks. Topics include insurance and annuity reserves, characterization of discrete and continuous multiple decrement models in insurance, employee benefits, benefit reserves, and multiple life models. Prerequisite: MATH 127 with a "C-" or better or Permission of Instructor.

**MATH 130. Topics in Applied Statistics. 3 Units.**

This course covers topics in applied statistics not normally covered in an introductory course. Students study multiple regression and correlation, analysis of variance of one- and two-way designs and other topics selected from non-parametric methods, time series analysis, discriminant analysis, factor analysis, that depend upon student interest. There is extensive use of packaged computer programs. Prerequisites: MATH 035 or MATH 037 with a "C-" or better.

**MATH 131. Probability and Mathematical Statistics I. 4 Units.**

This course covers counting techniques, discrete and continuous random variables, distribution functions, special probability densities such as binomial, hypergeometric, geometric, negative binomial, Poisson, Uniform, Gamma, Exponential, Weibull, and Normal. Students study joint distributions, marginal and conditional distributions, mathematical expectations, moment generating functions, functions of random variables, sampling distribution of the mean, and the Central Limit Theorem. Credit is not given for both MATH 039 and MATH 131. Prerequisite: MATH 053 with a "C-" or better.

**MATH 131P. Problem Solving in Probability. 1 Unit.**

This course is designed to prepare students for actuarial professional Exam P. This course will review basic concepts in theory of probability. The primary focus is problem solving; applying fundamental probability tools in assessing risks. Prerequisite: MATH 131 or permission of instructor.

**MATH 132. Probability and Mathematical Statistics II. 4 Units.**

Sampling distributions such as Chi-square, t and F are studied as estimation methods such as methods of moments, maximum likelihood and least squares. The course covers properties of estimators such as unbiasedness, consistency, sufficiency, tests of hypothesis concerning means, difference between means, variances, proportions, one and two-way analysis of variance. Prerequisite: MATH 131 with a "C-" or better.

**MATH 133. Statistical Learning Methods. 4 Units.**

This course will describe, implement and compare statistical models for classification and regression problems including ordinary least squares regression, logistic regression, K-nearest neighbors, shrinkage methods, decision trees, random forests, clustering algorithms, principal component analysis, neural networks, random walks, and autoregressive models. Common methods for the selection and validation of models such as stepwise selection, cross-validation, training/testing sets and data visualization will also be discussed. The use of statistical software will be emphasized. An introductory background in programming is recommended. Prerequisites: MATH 037, DATA 051, or MATH 131 with a "C-" or better or permission of instructor.

**MATH 141. Linear Algebra. 4 Units.**

Fundamental linear algebra concepts from an abstract viewpoint, with the objective of learning the theory and writing proofs. Concepts include: vector spaces, bases, linear transformations, matrices, invertibility, eigenvalues, eigenvectors, invariant subspaces, inner product spaces, orthogonality, and the spectral theorem. Prerequisites: MATH 049, MATH 075 with a "C-" or better.

**MATH 143. Abstract Algebra I. 4 Units.**

This is an introductory course to groups, rings and fields, with an emphasis on number theory and group theory. Students study finite groups, permutation groups, cyclic groups, factor groups, homomorphisms, and the isomorphic theorem. The course concludes with an introduction to polynomial rings. Prerequisite: MATH 049 with a "C-" or better or permission instructor.

**MATH 144. Abstract Algebra II. 4 Units.**

This course is a continuation of MATH 143, and it emphasizes field theory and the application of groups to geometry and field extensions. Students study algebraic and separable field extensions, dimension, splitting fields, Galois theory, solvability by radicals, and geometric constructions. Prerequisite: MATH 143 with a "C-" or better or permission of instructor.

**MATH 145. Applied Linear Algebra. 4 Units.**

This is the second semester course in linear algebra with an emphasis on the theory and application of matrix decompositions. Topics include methods for solving systems of equations, QR factorization, the method of least squares, diagonalization of symmetric matrices, singular value decomposition, and applications. Prerequisites: MATH 053, MATH 075 with a "C-" or better.

**MATH 148. Cryptography. 3 Units.**

Cryptography and cryptanalysis from historical cryptosystems through the modern use of cryptology in computing are studied. Topics include public and symmetric key cryptosystems, digital signatures, modular arithmetic and other topics in number theory and algebra. Possible additional topics include error correcting codes, digital cash, and secret sharing techniques. Prerequisite: MATH 053 with a "C-" or better or permission of instructor.

**MATH 152. Vector Analysis. 4 Units.**

Vector analysis and topics for students of applied mathematics, physics and engineering are studied. Topics include vector fields, gradient, divergence and curl, parametric surfaces, line integrals, surface integrals, and integral theorems. Formulations of vector analysis in cylindrical and spherical coordinates are also included. Prerequisites: MATH 055 with a "C-" or better.

**MATH 154. Topology. 4 Units.**

This course introduces general topology and its relation to manifold theory. Topics include metric spaces, general spaces, continuous functions, homeomorphisms, the separation axioms, connectedness, compactness, and product spaces. Prerequisite: MATH 049 with a "C-" or better.

**MATH 155. Real Analysis I. 4 Units.**

This course focuses on properties of real numbers, sequences and series of real numbers, limits, continuity and differentiability of real functions. Prerequisites: MATH 049 and MATH 055 with a "C-" or better.

**MATH 156. Real Analysis II. 4 Units.**

This course covers integration, series of real numbers, sequences and series of functions, and other topics in analysis. Prerequisite: MATH 155 with a "C-" or better.

**MATH 157. Applied Differential Equations II. 4 Units.**

This course covers partial differential equations, derivation and solutions of the Wave, Heat and Potential equations in two and three dimensions as well as Fourier series methods, Bessel functions and Legendre polynomials, and Orthogonal functions. Additional topics may include Fourier integral transform methods, the Fast Fourier Transform and Sturm-Liouville theory. Computer exercises that use MATLAB are included. Prerequisite: MATH 057 with a "C-" or better.

**MATH 161. Elementary Concepts of Mathematics I. 3 Units.**

Concepts and principles underlying elementary and middle school programs in mathematics. Laboratory materials will be used to reinforce understanding of concepts. Prerequisite: MATH 004, suitable score on placement test, or exemption from placement test. Not open to freshman. This course does not count as an elective for a B.S. degree.

**MATH 162. Elementary Concepts of Mathematics II. 3 Units.**

Continuation of MATH 161. Concepts and principles of elementary and middle school mathematics. Prerequisites: MATH 161 (concurrency allowed) or permission of instructor.

**MATH 164. Topics in History of Mathematics. 3 Units.**

Topics in mathematics are studied from a historical perspective. Topics are chosen from: numeration systems; mathematics of the ancient world, especially Greece; Chinese, Hindu and Arabic mathematics; the development of analytic geometry and calculus; and modern axiomatic mathematics. Students solve problems using historical and modern methods. Students read and report on the biography of a mathematician. Prerequisite: MATH 053 with a "C-" or better. Junior standing or permission of the instructor.

**MATH 166. Mathematical Concepts for Secondary Education. 3 Units.**

This course covers secondary school mathematics from an advanced viewpoint and pedagogical perspective. Content is aligned with the mathematics subject matter requirements from the California Commission on Teacher Credentialing. Prerequisite: MATH 053 with a "C-" or better.

**MATH 168. Modern Geometries. 4 Units.**

Selected topics in this course are from Euclidean, non-Euclidean and transformational geometry in addition to both analytic and synthetic methods. The history of the development of geometries and axiomatic systems is covered. The course uses laboratory materials and computer packages used to reinforce understanding of the concepts. The course is required for high school teacher candidates. Prerequisite: MATH 049 with a "C-" or better or permission of instructor.

**MATH 174. Graph Theory. 4 Units.**

This course is an in-depth consideration of discrete structures and their applications. Topics include connectivity, Eulerian and Hamiltonian paths, circuits, trees, Ramsey theory, digraphs and tournaments, planarity, graph coloring, and matching and covering problems. Applications of graph theory to fields such as computer science, engineering, mathematics, operations research, social sciences, and biology are considered. Prerequisites: MATH 051 or MATH 074 or COMP 047 with a "C-" or better or an appropriate score on the calculus placement test.

**MATH 189A. Statistical Consulting Practicum. 2 Units.**

While working under close faculty supervision, students gain valuable practical experience in applying statistical methods to problems presented by University researchers, business and industry. Students enrolled in MATH 189A ordinarily participate in more sophisticated projects and take a more responsible role than students in MATH 089A. Pass/No credit. Prerequisites: for MATH 089A, MATH 130 with a "C-" or better or permission of the instructor; for MATH 189A, 089A with a "C-" or better and permission of the instructor.

**MATH 191. Independent Study. 2-4 Units.**

Student-initiated projects cover topics not available in regularly scheduled courses. A written proposal that outlines the project and norms for evaluation must be approved by the department chairperson.

**MATH 197. Undergraduate Research. 2-4 Units.**

## Writing Courses

**WRIT 001. Academic Writing I. 2 Units.**

This course includes approximately 4,000 words of edited composition. During the semester, students will accrue points on essays, assignments, classwork and research projects. Students will engage in higher-level writing and will cover the essay writing process, note taking, outlining, summarizing, and editing. It also focuses on development of vocabulary, comprehension, concentration, memory and fluency skills. Critical thinking, analysis and evaluation are emphasized as students engage with themed materials. Students will develop research skills in the use of outside reference materials including locating and evaluating sources and properly documenting source information. Students are expected to progress in a variety of academic writing forms including, but not limited to, reports, short term papers, essays and journal writing, incorporating increasingly complex rhetoric. This course is part of a sequence designed for those students who need to meet the university fundamental skills requirement. Pre-requisites for placement are determined by qualifying standardized or diagnostic test scores. Pass/No credit (P/NC) grading option is not allowed for this course. Students taking this course are required to take WRIT 002 the following semester and must earn a "C-" or better to be eligible for advancement.

**WRIT 002. Academic Writing II. 2 Units.**

This course will include approximately 4,000 words of edited composition. Students will develop advanced writing projects as they locate, evaluate, and synthesize source material from various disciplines and compose research papers using APA, MLA, CMS and CSE documentation as needed. Special emphasis is placed on the skills related to vocabulary development, critical thinking and interpretation of scholarly material for the purpose of in-class discussions, expository writing assignments and literary analysis. This course is part of a sequence designed for those students who need to meet the university fundamental skills requirement. Pass/No credit (P/NC) grading option is not allowed for this course. Students taking this course are required to take PACS Plus in the upcoming fall semester and must earn a "C-" or better to be eligible for advancement. Prerequisite: WRIT 001 with a "C-" or better.

**WRIT 010. Academic Writing. 2 Units.**

This course is intended for students who need to fulfill the university's fundamental skills requirement in writing. This course will include approximately 5,000 words of edited composition. Students will work on various writing projects as they develop strong written and oral communication skills, critical thinking, and reading skills necessary for success in their majors and will gain information literacy by locating, evaluating, and synthesizing source material from various disciplines. Students will also learn how to appropriately document papers, using APA and MLA citation styles as needed. Pass/No credit (P/NC) grading option is not allowed for this course. A grade of C- or better is required to satisfy the university's fundamental skills requirement in writing. WRIT 010 cannot be repeated if a grade of C- or better is earned. Students who repeat the course must choose a new topic for their research paper.

**WRIT 093I. Academic Writing Bridge. 1-4 Units.****WRIT 093L. Reading & Writing Lab. 1 Unit.****WRIT 093W. Academic Writing Intensive. 4 Units.**

This course is designed as a transition into college-level writing and will include approximately 5,000 words of edited composition. During the session, students will accrue points on essays, assignments, classwork and research projects. Students will engage in the higher-level reading and writing skills necessary for university work. The course primarily focuses on academic expository writing and covers the essay writing process, note taking, outlining, summarizing, and editing. Critical thinking, analysis and evaluation is emphasized as students engage with themed materials. Students will also begin to develop research skills in the use of outside reference materials including locating and evaluating sources and properly documenting source information. Students will be exposed to a variety of academic writing forms including but not limited to reports, short term papers, essays and journal writing. This course is part of a sequence designed for those students who need to meet the university fundamental skills requirement. Pass/No credit (P/NC) grading option is not allowed for this course. Students taking this course are required to take PACS 1 Plus in the upcoming fall semester and must earn a C- or better to be eligible for advancement.

**WRIT 093X. Academic Reading and Writing I. 1-4 Units.****WRIT 093Y. Academic Reading and Writing II. 1-4 Units.****WRIT 093Z. Accelerated Academic Reading and Writing. 1-4 Units.****WRIT 191. Independent Study. 1-4 Units.**