FUNDAMENTAL SKILLS

As part of Pacific’s 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.

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

1. Completion of Pacific’s highest level developmental skills course;
2. Completion of an appropriately articulated course at an accredited college or university;
3. Satisfactory performance on an approved, nationally administered examination; or
4. Satisfactory performance on Pacific’s placement examinations.

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.

University of the Pacific students are required to demonstrate fundamental competency in writing in order to graduate with a bachelor’s degree or a first professional degree. Their writing placement is based on their SAT Writing score, ACT English/Writing score, or an appropriately articulated college-level writing course. Students who place into ESL 015 must complete this course with a C- or higher in order to advance to take the sequence of fundamental writing skill level courses: WRIT 1, WRIT 2, and PACS 001P, which is taken concurrently with PACS 1.

The Developmental Writing Program consists of courses designed to develop the writing skills required for success as a college-level writer. To satisfy the University’s fundamental skills writing requirement, a student must

- Score 510 or higher on the SAT writing exam
- Score 22 or higher on the ACT English/Writing exam
- Complete PACS 001P with a C- or higher
- Completed a transferable course equivalent to a College Writing Course with a C or higher
- Achieve a high enough score Pacific’s Writing Diagnostic Exam (transfer students only)

Writing skills placement information is located at www.go.pacific.edu/writingsprograms.

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.

The Intensive English Program supports matriculated and non-matriculated students to improve their English language and cultural competencies. Matriculated students are required to demonstrate fundamental competency in writing in order to graduate with a bachelor’s or first professional degree. Their writing placement is based on their SAT Writing score, ACT English/Writing score, or an appropriately articulated college-level writing course. Students who place into ESL 015 must complete this course with a C- or higher in order to advance to take the sequence of fundamental writing skill level courses: WRIT 1, WRIT 2, and PACS 001P, which is taken concurrently with PACS 1.

Non-matriculated students are required to successfully complete coursework at the advanced level within two semesters of fulltime study in order to be considered for matriculation into an undergraduate or professional degree program. Completion requires (1) earning a B or higher as well as a combined midterm and final exam score of B- or higher in all requisite ESL courses, (2) producing writing samples sufficient to enter a fundamental writing skill level, (3) demonstrating verbal proficiency within an academic setting, and (4) obtaining a letter of support from the IEP Assistant Director recommending matriculation.

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

- score 540 or above on the mathematics level 1 SAT subject test
- score 520 or above on the mathematics level 2 SAT subject test
- pass Pacific’s Intermediate Algebra placement test (COMPASS or paper test)
- successfully complete MATH 5 (Intermediate College Algebra) or MATH 35 (Elementary Statistical Inference) with a grade of C- or higher
- complete an equivalent course to MATH 5 or MATH 35 from another college or university with a grade of C or better

Note: The mathematics section of the SAT test is NOT used for placement purposes. Students must submit the SAT mathematics subject level 1 or 2 test for placement purposes.

Math skills placement information is located at www.go.pacific.edu/mathskillsprogram (https://email.pacific.edu/owa/redir.aspx?URL=boMiTwLgV9f-n75XJlj-ekg_2OnErWhABXNOVY_0c4dq5Yz3eJrSCGgAdAB0AHAQ0gAvAC8AdwB3AhCAlgBnAG8ALgBwAGEAYw8pAGYAAQbJAC4AZQBkAHJALwBtAGEAdABoAHMAdw%3a%2f%2fwww.go.pacific.edu%2fmathskillsprogram).

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.
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 reading and writing and covers 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. 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. 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 001 with a "C-" or better to be eligible for advancement. Prerequisite: WRIT 001 with a "C-" or better.

WRIT 010. Accelerated Academic Writing. 2 Units.
This course is intended for students who need to fulfill the university’s fundamental skills requirement in writing, but are exempt from taking PACS 001 and PACS 002. This course will include approximately 5,000 words of edited composition. Students will develop advanced writing projects as they develop strong written and communication skills, critical thinking, and reading skills necessary for success in their majors and will engage in information literacy by locating, evaluating, and synthesizing source material from various disciplines. Students will also learn how to appropriately document papers, using APA, MLA, CMS and CSE citation styles as needed. Placement is determined by standardized or diagnostic test scores. Pass/No credit (P/NC) grading option is not allowed for this course. Prerequisite: A minimum of 28 college-level units.

WRIT 093I. Academic Writing Bridge. 1-4 Units.
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.

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 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 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, MATH)

MATH 035. Elementary Statistical Inference. 4 Units.
Emphasis is on the applications and limitations of statistical methods of inference, especially in the social and behavioral sciences. Topics include: estimation and test of hypothesis concerning a signal group, One-way Analysis of Variance and analysis of categorical data. The use of statistical computer programs is addressed. Credit is not given for this course if a student has received credit for MATH 037 or has AP credit in Statistics. Prerequisite: MATH 003 or MATH 005 or MATH 041 with a “C-” or better, or an appropriate score on either the Elementary Algebra placement test, the Intermediate Algebra Placement test, or the Pre-calculus placement test or permission of instructor. (ENST, GE3B, MATH, PLAW)

MATH 037. Introduction to Statistics and Probability. 4 Units.
Students study elements of descriptive statistics: graphs, tables, measures of central tendency and dispersion. Probability models including binomial and normal are covered. The course introduces to estimation, hypothesis testing and analysis of variance in addition to linear and multiple regression and correlation. The use of statistical computer programs is addressed. The course is not recommended for first semester freshmen. Credit is not 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. (ENST, GE3B, 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, MATH)

MATH 045. Introduction to Finite Mathematics and Calculus. 4 Units.
This course introduces calculus, applications to problems in economics, management and other fields. Students study systems of equations, elements of matrix algebra, and elementary linear programming. Credit for this course is not given if a student has credit for MATH 051 or AP Calculus credit. Prerequisites: two years of high school Algebra and an appropriate score on either the Intermediate Algebra placement test, the Pre-calculus placement test, or the Calculus placement test; or MATH 005 or MATH 041 with a "C-" or better. (GE3B, MATH)

MATH 049. 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. Prerequisite: MATH 053 with a "C-" or better or permission of the instructor.

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. Students who earn AP Math AB credit do not receive credit for MATH 051. Prerequisites: MATH 007 or MATH 041 with a "C-" or better or four years of high school mathematics including Trigonometry and an appropriate score on the placement test for calculus. (GE3B, MATH)

MATH 052. A Calculus Companion. 1 Unit.
MATH 053. Calculus II. 4 Units.
This course covers techniques and applications of integration, sequences and series, convergence of series, and Taylor Polynomials. Students who earn AP Math BC credit do not receive credit for MATH 053. Prerequisite: MATH 051 with a "C-" or better or an appropriate score on the calculus placement test. (GE3B, 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. (GE3B)

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. Prerequisite: MATH 055 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. (GE3B)

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. (GE3B)

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 the appropriate score on the calculus placement test. (GE3B)

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 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 100. 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. 4 Units.
This course is designed to prepare students for Society of Actuaries Financial Mathematics examination and provides understanding of fundamental concepts of financial mathematics. Topics include interest rates, annuities, with level and varying payments, non-annual interest rates and annuities, projects appraisal and loans, term structure of interest rates, duration, convexity, and Immunization. This course covers about 60-65% of the topics on Exam FM. Prerequisite: MATH 053 or permission of instructor.

MATH 122. Financial Mathematics II. 4 Units.
The course is to provide an understanding of the fundamental concepts of 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. The students will also be given an introduction to financial instruments, including derivatives, and the concept of no-arbitrage as it relates to financial mathematics. This course consists of two parts. Part I covers the Financial Economics portion (about 40%) of the topics listed on Exam FM syllabus. Topics include the term structure of interest rates, cash flow matching, immunization (including full immunization), Redington immunization, general derivative markets, arbitrage-free model, options, forwards and future contracts, swaps, hedging and investment strategies. Part II serves as a preparation/review for the actuarial Exam FM. Prerequisite: MATH 121.
MATH 123. Models of Financial Economics I. 4 Units.
This course is the first semester of two-semester course sequence, and it 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 course is offered to cover the first half of the syllabus from Exam MFE Models for Financial Economics. The primary topics the course will cover are: Parity and Other Option Relationships, Binomial Option Pricing, The Black-Scholes Formula, Market Making and Delta-Hedging, and Exotic Options. A thorough knowledge of calculus, probability and interest theory is assumed. Knowledge of risk management at the level of Exam 1/P is also assumed. In addition, students are assumed to be familiar with the earlier chapters of the McDonald text, which are in the syllabus of Exam 2/FM. Prerequisites: MATH 122; MATH 131 with a "C-" or better or Permission of Instructor.

MATH 124. Models of Financial Economics II. 4 Units.
This course is the second semester of two-semester course sequence, and it 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 the course will cover are: Lognormal Distribution, Monte Carlo Valuation, Brownian Motion and Ito's Lemma, Black Scholes Equation, All-or-Nothing Options, Measurement of Volatility, Interest rate Models. Prerequisite: MATH 123 with a "C-" or better or Permission of Instructor.

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 123 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 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 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 cryptography 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. 4 Units.
Concepts of arithmetic and geometry underlying elementary school programs in mathematics are studied. Laboratory materials are used to reinforce understanding of concepts. Prerequisite: MATH 003 or higher with a "C-" or better, or appropriate score on the algebra placement test. Not open to freshmen this course does not count as an elective for a BS degree.

MATH 162. Elementary Concepts of Mathematics II. 4 Units.
Students study the development of arithmetic and geometric concepts within a classroom setting. The course includes related topics such as diagnostic/prescriptive techniques, the use of calculators and computers, approaches to K-8 math curriculum and current trends within mathematics education. The course includes field experiences, seminar discussions and laboratory workshops. Prerequisite: MATH 161 with a "C-" or better, or permission of the 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.