

# MATHEMATICS AND STATISTICS

www.csupomona.edu/~math

Michael Green, Chair

Charles Amelin	Ioana Mihaila
Carla Gerberry	Jungwon Chris Mun
Dhanwant Singh Gill	Martin Nakashima
Berit Givens	Claudia Pinter-Lucke
Patricia Hale	Kamta Rai
Hoon Kim	Laurie Riggs
Mitsuo Kobayashi	Amber Rosin
Alan Krinik	Randall Swift
Christine Latulippe	Jennifer Switkes
Joe Latulippe	Hubertus F. von Bremen
Emille Lawrence	Robin Wilson
Karen Linton	Greisy Winicki-Landman
Lilian Metlitzky	Weiqing Xie

The Department of Mathematics and Statistics offers a flexible major program which may be adapted to serve a variety of needs and interests. Students may develop elective patterns which will prepare them for entry into employment in industry and government.

Each student is urged to develop an elective pattern which will also be preparatory for graduate study either in mathematics or in some quantitative discipline in the sciences, engineering, economics or business. Courses at the 500-level are available as part of a master's degree graduate program.

The Department of Mathematics and Statistics recommends that each student use several free electives to develop depth in some discipline other than mathematics.

Transfer students should complete as much of the calculus sequence as possible before entering Cal Poly Pomona. Physics courses to be transferred should be those which require calculus concurrently or as a prerequisite.

A high school student planning a major in mathematics should complete one year of physics, one year of chemistry and four years of mathematics to include thorough preparation in trigonometry and advanced algebra.

Students majoring in mathematics who have at least a 3.0 GPA may join the honorary society, Kappa Mu Epsilon. Additional information can be obtained from the Department of Mathematics and Statistics.

## REQUIRED CORE COURSES

Required of all students. A 2.0 cumulative GPA is required in core courses, including subplan courses, in order to receive a degree in the major.

Introduction to C++ . . . . .	CS	128	(4)
or FORTRAN . . . . .	CS	125	
Analytic Geometry and Calculus III . . . . .	MAT	116	(4)
Introduction to Numerical Methods . . . . .	MAT	201	(4)
Introduction to Linear Algebra . . . . .	MAT	208	(4)
Calculus of Several Variables I . . . . .	MAT	214	(3)
Calculus of Several Variables II . . . . .	MAT	215	(3)
Differential Equations . . . . .	MAT	216	(4)
Basic Set Theory and Logic . . . . .	MAT	310	(4)
Intermediate Analysis I . . . . .	MAT	314	(4)
Intermediate Analysis II . . . . .	MAT	315	(4)

Modern Algebra . . . . .	MAT	417	(4)
Modern Algebra . . . . .	MAT	418	(4)
Complex Variables . . . . .	MAT	428	(4)
Applied Probability Theory . . . . .	STA	241	(4)
Applied Statistics . . . . .	STA	341	(4)

## SUBPLAN/OPTION CORE COURSES

Required for specific subplan

### Secondary Teacher Preparation/Pure Math Subplan/Option Core Courses

Choose six courses from the following list. No more than two courses may be selected from MAT 330, MAT 415, MAT 416. The courses marked with “#” are suggested for those students who are preparing for a secondary teaching credential (see Subject Matter Preparation - Program for Prospective Teachers in Mathematics). The courses marked with a “+” are suggested for those students preparing to go on to graduate studies.

History of Mathematics # . . . . .	MAT	306	(4)
Topology + . . . . .	MAT	321	(4)
Introduction to Number Theory #, + . . . . .	MAT	325	(4)
Modern Euclidean Geometry # . . . . .	MAT	330	(4)
Graph Theory # . . . . .	MAT	370	(4)
Advanced Calculus + . . . . .	MAT	413	(4)
Foundations of Geometry # . . . . .	MAT	415	(4)
Projective Geometry # . . . . .	MAT	416	(4)
Abstract Linear Algebra + . . . . .	MAT	419	(4)
Differential Geometry # . . . . .	MAT	420	(4)
Functions of a Complex Variable + . . . . .	MAT	429	(4)
Combinatorics . . . . .	MAT	470	(4)
Foundations of Mathematics + . . . . .	MAT	450	(4)
Topics in Contemporary Secondary School Math III# . . . . .	MAT	497/497A	(3/1)

### Applied Mathematics Subplan/Option Core Courses

The student must complete two two-quarter sequences from the list below:

Mathematics of Operations Research . . . . .	MAT	380	(4)
Mathematics of Operations Research . . . . .	MAT	381	(4)
Numerical Analysis I . . . . .	MAT	401	(4)
Numerical Analysis II . . . . .	MAT	402	(4)
Differential Equations I . . . . .	MAT	431	(4)
Differential Equations II . . . . .	MAT	432	(4)
Mathematical Modeling and Simulation . . . . .	MAT	485	(4)
Mathematical Modeling and Simulation . . . . .	MAT	486	(4)

The student must complete two additional courses from the list above or the list below:

Graph Theory . . . . .	MAT	370	(4)
Combinatorics . . . . .	MAT	470	(4)
Mathematical Programming . . . . .	MAT	480	(4)

### Statistics Subplan/Option Core Courses

Choose 16 units from the following:

Sampling Theory and Applications . . . . .	STA	310	(4)
Nonparametric Statistics . . . . .	STA	420	(4)
Applied Survival Analysis . . . . .	STA	425	(4)
Applied Regression . . . . .	STA	432	(4)
Introduction to Random Processes . . . . .	STA	430	(4)

ANOVA and Design of Experiments	STA	435	(4)
Mathematical Statistics I	STA	440	(4)
Mathematical Statistics II	STA	441	(4)
Special Topics	STA	499	(1-4)
Computer Simulation	CS	390	(4)
Choose additional 8 units in consultation with your advisor			(8)

**REQUIRED SUPPORT COURSES**

The following major support courses should be used to satisfy the indicated GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 180 units.

Analytic Geometry and Calculus I (B4)	MAT	114	(4)
Freshman Composition (A2)	ENG	104	(4)
General Physics (B1)	PHY	131	(3)
General Physics Laboratory (B3)	PHY	131L	(1)
Analytic Geometry and Calculus II (B4)	MAT	115	(4)
General Physics	PHY	132	(3)
General Physics	PHY	133	(3)
General Physics Laboratory	PHY	132L	(1)
General Physics Laboratory	PHY	133L	(1)

**UNRESTRICTED ELECTIVES**

Select a sufficient number of courses so that the total from "Required Support", "GE", and "Unrestricted Electives" is at least 98 units.

Unrestricted Electives..... (6-18)

**GENERAL EDUCATION COURSES**

Students should consult the catalog website [www.csupomona.edu/~academic/catalog/](http://www.csupomona.edu/~academic/catalog/) for current information regarding this requirement. Courses must be selected from the list of approved courses under General Education Requirements, Areas A through E.

**Area A (12 units)**

1. Oral Communication
2. Written Communication
3. Critical Thinking

**Area B (16 units)**

1. Physical Science
2. Biological Science
3. Laboratory Activity
4. Mathematics/Quantitative Reasoning
5. Science and Technology Synthesis

**Area C (16 units)**

1. Visual and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

**Area D (20 units)**

1. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic, and Gender Studies
4. Social Science Synthesis

**Area E (4 units)**

Lifelong Understanding and Self-development

**SUBJECT MATTER PREPARATION – Program for Prospective Teachers in Mathematics**

The Department of Mathematics and Statistics offers a program in mathematics approved by the Commission on Teacher Credentialing.

Those individuals who wish to become mathematics teachers in California public schools must complete the comprehensive list of courses that follows. The core courses in the mathematics major together with appropriate selected courses in the pure subplan will satisfy most of the courses on the list. The rest of the required courses can be chosen to satisfy the free elective requirements for the degree.

Analytic Geometry and Calculus I	MAT	114	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)
Introduction to Linear Algebra	MAT	208	(4)
Calculus of Several Variables I	MAT	214	(3)
Calculus of Several Variables II	MAT	215	(3)
History of Math	MAT	306	(4)
Introduction to Logic and Set Theory	MAT	310	(4)
Intermediate Analysis I	MAT	314	(4)
Introduction to Number Theory	MAT	325	(4)
Modern Euclidean Geometry	MAT	330	(4)
Foundations of Geometry	MAT	415	(4)
or Projective Geometry	MAT	416	
Modern Algebra I	MAT	417	(4)
Modern Algebra II	MAT	418	(4)
Topics in Contemporary			
Secondary School Mathematics I	MAT	495/495A	(4)
Topics in Contemporary			
Secondary School Mathematics II	MAT	496/496A	(4)
Topics in Contemporary			
Secondary School Mathematics III	MAT	497/497A	(4)
Applied Probability Theory	STA	241	(4)
Applied Statistics	STA	341	(4)
Introduction to C++	CS	128	(4)

Select one course from the following: ..... (4)

MAT 201, 370, 380, 480, 485, CS 390, CHE 415, OM 419, STA 432, STA 435

**MINOR IN MATHEMATICS**

Analytic Geometry and Calculus I	MAT	114	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)
Calculus of Several Variables I	MAT	214	(3)
Calculus of Several Variables II	MAT	215	(3)
Differential Equations	MAT	216	(4)
or Elementary Linear Algebra and Differential			
Equations	MAT	224	(4)
Introduction to Linear Algebra	MAT	208	(4)

In addition to the above courses, choose any four upper division courses (except MAT 394, 395, 400, 461, 462, 463, 491, 492, 493, 494, 495, 496, 497, STA 309, 315). No more than two upper division STA courses can be counted towards the Mathematics Minor (see Statistics Minor). No more than one of MAT 317 or MAT 318 can be counted towards the mathematics minor.

Minimum number of units required: ..... (41)

It is recommended that the student confer with a minor advisor in the selection of courses. Since a maximum of flexibility is afforded, the student is cautioned to pay very careful attention to the prerequisites for the courses selected.

**STATISTICS MINOR**

Required Courses

Analytic Geometry and Calculus I	MAT	114	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)
Introduction to Linear Algebra	MAT	208	(4)
Calculus of Several Variables I	MAT	214	(3)
Calculus of Several Variables II	MAT	215	(3)
Applied Probability Theory	STA	241	(4)
and Applied Statistics	STA	341	(4)
or Statistical Methods for Computer Scientists	STA	326	(4)
Applied Regression Analysis	STA	432	(4)
or ANOVA and Design of Experiments	STA	435	(4)
Choose 8 units from the following:			
Sampling Theory and Applications	STA	310	(4)
Nonparametric Statistics	STA	420	(4)
Applied Survival Analysis	STA	425	(4)
Introduction to Random Processes	STA	430	(4)
Applied Regression Analysis	STA	432	(4)
ANOVA and Design of Experiments	STA	435	(4)
Mathematical Statistics I	STA	440	(4)
Mathematical Statistics II	STA	441	(4)
Special Topics	STA	499	(1-4)

Minimum number of units required (42)

**ELM REQUIREMENT**

All students must take the Entry-Level Math Test or satisfy exemptions prior to enrollment or a hold will be placed on all course registration. Students will not be allowed to enroll in any Mathematics coursework unless they have satisfied the ELM requirement. If the student's ELM score is below the minimum required for General Education level Mathematics coursework, the student must enroll in the appropriate preparatory courses the first quarter of their enrollment.

**PREPARATORY MATHEMATICS PROGRAM**

A three-quarter sequence of courses is provided for students needing intensive mathematics review in order to enroll in General Education mathematics or statistics courses. Courses receive unit load credit but not baccalaureate credit. Students must have achieved prerequisite scores on the ELM or the MDPT in order to enroll in MAT 10, MAT 11, or MAT 12.

**MATHEMATICS DIAGNOSTIC PLACEMENT TEST (MDPT)**

All pre-baccalaureate and many 100 level mathematics/statistics courses have prerequisites that may be satisfied by the CSU/UC Mathematics Diagnostic Placement Test (MDPT). The MDPT has two levels: Mathematical Analysis, and Precalculus. The Math Analysis Test places students into MAT 10, MAT 11, MAT 12, MAT 105, MAT106, MAT 125, MAT 137, MAT 191, and STA 120. The Precalculus Test places students into MAT 12, MAT 105, MAT 106, MAT 112, MAT 114, MAT 120 and MAT 130. MDPT scores are valid for placement for three quarters (including summer).

The Department of Mathematics and Statistics administers the MDPT each quarter. To take the test, students must sign up in advance with the Department, Room 8-113, or online at the Department of Mathematics and Statistics home page.

**INFORMATION ABOUT PREREQUISITES**

The prerequisites for MAT 10, MAT 11, MAT 12, MAT 105, MAT 106, MAT 112, MAT 114, MAT 120, MAT 125, MAT 130, MAT 191 and STA 120 are time-sensitive. The calculation of elapsed time may include quarters in which the student is not enrolled at Cal Poly Pomona (including summer quarter). Please refer to the schedule of classes for

current deadlines for specific courses.

Grades below C in a course may be used to extend the time in which a student is eligible to enroll in that course. A grade of D-, D, D+, or C- will extend the eligibility to enroll in the course for two quarters. A grade of F or WU will extend the eligibility for one quarter.

**COURSE DESCRIPTIONS**

F, W, Sp, and Su notations indicate the quarter(s) each course is normally offered. Unless otherwise specified, the course is offered this year during the indicated quarter(s).

**MAT 10 Prealgebra (4) FWSpSu**

Geometry, measurement geometry, introduction to algebra including variable expressions, linear equations, polynomials, techniques of factoring, integer exponents. 4 lecture/problem-solving. Letter grade only. Course does not earn Baccalaureate credit.

**MAT 11 Basic Algebra (4) FWSpSu**

Applications of linear equations, techniques of factoring, rational expressions, linear inequalities, graphs of linear functions, systems of linear equations, rational exponents and radicals, quadratic equations. 4 lecture/problem-solving. Letter grade only. Prerequisite: within the last three quarters, must have earned either a minimum placement score on the ELM or the appropriate MDPT, or C or better in MAT 10. Course does not earn Baccalaureate credit.

**MAT 12 Intermediate Algebra (4) FWSpSu**

Complex numbers, advanced quadratic equations with applications, quadratic and rational inequalities, functions, conic sections, logarithms, non-linear systems of equations, sequences and series, binomial expansions. 4 lecture/problem-solving. Letter grade only. Prerequisite: within the last three quarters, must have achieved either a minimum placement score on the ELM or the appropriate MDPT, or C or better in MAT 11. Course does not earn Baccalaureate credit.

**MAT 105 College Algebra (4) FWSpSu**

Real numbers, inequalities, absolute value, coordinate systems, functions, progressions, linear and quadratic systems, polynomials, rationals, exponentials, and logs, and mathematical induction. 4 lecture/problem-solving. Prerequisites: Within the last three quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 106, or MAT 125, or MAT 191, or STA 120; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

**MAT 106 Trigonometry (4) FWSpSu**

The circular functions, general reduction formulas, inverse functions, graphs, Law of Sines, Law of Cosines, identities and complex numbers. Course fulfills GE Sub-area B4. 4 lecture/problem-solving. Prerequisites: Within the last three quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12. or MAT 105, or MAT 125, or MAT 191, or STA 120; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

**MAT 112 Preparation for Calculus (4) FWSpSu**

Function, theory, techniques for graphing functions (polynomials, rational functions, trigonometry functions, exponential functions, log functions, and compositions of these such as trig polynomials), solutions of systems of linear and non-linear equations, inequalities, introduction to limits. 4 lecture/problem-solving. Prerequisites: within the last three

quarters, must have achieved either a minimum placement score on the appropriate MDPT, or C or better in both MAT 105 and MAT 106.

#### **MAT 114 Analytic Geometry and Calculus I (4) FWSpSu**

Functions, limits, continuity, derivatives of all functions including trig, exponential, log, inverse trig and implicit functions. Applications of derivatives including max/min problems. Course fulfills GE Sub-area B4. 4 lecture/problem-solving. Prerequisite: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT or B or better in both MAT 105 and MAT 106 or C or better in MAT 112.

#### **MAT 115 Analytic Geometry and Calculus II (4) FWSpSu**

Definite and indefinite integrals. The Fundamental Theorem of Calculus. Applications of the definite integral. Integration techniques including integration by parts, integrals of trig products, partial fractions, substitution, trig substitution. Hyperbolic functions. Course fulfills GE Sub-area B4. 4 lecture/problem-solving. Prerequisite: C or better in MAT 114 or consent of the instructor.

#### **MAT 116 Analytic Geometry and Calculus III (4) FWSpSu**

Sequences and series, L'Hospital's rule, improper integrals, polar coordinates, parametric equations and conic sections. Course fulfills GE Sub-area B4. 4 lecture/problem-solving. Prerequisites: C or better in MAT 115 or consent of the instructor.

#### **MAT 120 Calculus for the Life Sciences (4) FWSp**

Study of the calculus of algebraic, exponential and logarithmic functions. Graphing, limits, derivatives, differentials and integrals of single variable functions listed above. Brief introduction to partial derivatives and double integrals of multivariable functions. Special emphasis is given to applications in life sciences. Course fulfills GE Sub-area B4. 4 lecture/problem-solving. Prerequisites: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT, or C or better in MAT 105.

#### **MAT 125 Introductory Calculus for Business (4) FWSpSu**

Graphing, differentiation, integration of rational and exponential functions, with special emphasis on applications to business. Not open to any student whose major requires the MAT 114 sequence. Course fulfills GE Sub-area B4. 4 lecture/problem-solving. Prerequisite: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT, or C or better in MAT 12, or MAT 105, or MAT 106, or MAT 191, or STA 120.

#### **MAT 130 Technical Calculus I (4) FWSpSu**

Differential calculus of rational functions and applications of the derivative. Integral calculus and applications of the integral. Course fulfills GE Sub-area B4. 4 lecture/problem-solving. Prerequisite: within the last three quarters, must have achieved either a minimum placement score on the appropriate MDPT, or B or better in both MAT 105 and MAT 106 or C or better in MAT 112.

#### **MAT 131 Technical Calculus II (4) FWSpSu**

Analytic geometry. Derivatives and integrals of trigonometric, logarithmic, and exponential functions and applications. Infinite Series. 4 lecture/problem-solving. Prerequisite: C or better in MAT 130 or consent of instructor.

#### **MAT 132 Technical Calculus III (4) FWSp**

Techniques of multidimensional calculus, introduction to ordinary differential equations and Laplace transforms. 4 lecture/problem-

solving. Prerequisite: C or better in MAT 131 or consent of instructor.

#### **MAT 191 Survey of Mathematics (4) FWSpSu**

Emphasis on modern applications of selected topics from sets, logic, probability, statistics and mathematical modeling. Course fulfills GE Sub-area B4. 4 lecture/problem-solving. Prerequisites: Within the last 3 quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 105, or MAT 106, or MAT 125, or STA 120; or, within last year must have earned 50 or better on the ELM; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

#### **MAT 194 Mathematical Concepts for Elementary School Teachers: Number Systems (4)**

Development of the real number system including sets, operations and properties; topics in number theory. Development of problem solving strategies, introduction to proof and inductive and deductive reasoning. Application of technology to these topics. 4 lecture/problems. Students must complete MAT 194, MAT 394, MAT 395, and MAT 494 to meet the GE Area B4 requirement. Prerequisites: Within the last 3 quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 105, or MAT 106, or MAT 125, or STA 120; or, within last year must have earned 50 or better on the ELM; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

#### **MAT 200 Special Study for Lower Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

#### **MAT 201 Introduction to Numerical Methods (4) FSp**

Numerical methods of topics from algebra and calculus. Topics will include function evaluation and graphing, limits, summation, solving nonlinear equations, numerical integration and differentiation and an introduction to numerical error. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 and CS 128 or consent of instructor.

#### **MAT 208 Introduction to Linear Algebra (4) FWSpSu**

Introduction to linear transformations of the plane, vector space of n-tuples, matrix algebra, determinants, systems of linear equations. 4 lecture/problem-solving. Prerequisite: C or better in MAT 214 or consent of instructor.

#### **MAT 214 Calculus of Several Variables I (3) FWSpSu**

Introduction to vectors, dot products, cross products, equations of lines and planes. Calculus of Vector Valued Functions including unit tangents, unit normals and curvature. Introduction to multivariable functions, the Differential Calculus of Multivariable Functions, the chain rule, applications including extreme problems and Lagrange multipliers. 3 lecture/problem-solving. Prerequisite: C or better in MAT 116 or consent of instructor.

#### **MAT 215 Calculus of Several Variables II (3) FWSpSu**

Integral Calculus of Multivariable functions, double and triple Integrals, applications of double and triple integrals, line and surface integrals, Green's Theorem, Divergence Theorem, Stokes Theorem. 3 lecture/problem-solving. Prerequisite: C or better in MAT 214 or consent of instructor.

#### **MAT 216 Differential Equations (4) FWSpSu**

The theory of ordinary differential equations with emphasis on the linear



case. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 or consent of instructor.

#### **MAT 224 Elementary Linear Algebra and Differential Equations (4)**

Separable and linear ordinary differential equations; numerical and analytical solutions. Linear algebra: vectors in  $n$ -space, matrices, linear transformations, eigenvalues, eigenvectors, diagonalization; applications to the study of systems of linear differential equations. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 or consent of instructor.

#### **MAT 299/299A/299L Special Topics for Lower Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Lecture/Activity/Laboratory or a combination. Prerequisite: Consent of instructor.

#### **MAT 306 History of Mathematics (4) FSp**

Development of mathematics over four millennia. Recommended for students preparing to teach mathematics. 4 lecture. Prerequisite: C or better in MAT 215 or consent of instructor.

#### **MAT 310 Basic Set Theory and Logic (4) FWSp**

Basic set theory and logic, relations, functions, mathematical induction, countable and uncountable sets. Emphasis on how to present and understand mathematical proof. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 or consent of instructor.

#### **MAT 314, 315 Intermediate Analysis (4) (4) FW/WSp**

Metric spaces and continuity. Analysis of functions of a single variable. Sequences, limits, continuity, differentiation, integration, introduction to function spaces. 4 lecture/problem-solving. Prerequisite for MAT 314: C or better in MAT 215 and MAT 310 or consent of instructor. Prerequisite for MAT 315: C or better in MAT 314 or consent of instructor.

#### **MAT 317 Laplace Transforms and Fourier Series (3) FWSpSu**

Introduction to Fourier Series and Integrals with applications. Elementary theory of Laplace transformation with applications including the solution of differential equations. 3 lecture/problem-solving. Prerequisite: C or better in MAT 216 or consent of instructor.

#### **MAT 318 Mathematical Analysis of Engineering Problems (3) FSpSu**

Introduction to the algebra and calculus of vectors including the divergence and Stokes' theorem. Introduction to analytic functions of a complex variable. Not open to mathematics majors for math elective credit. 3 lecture/problem-solving. Prerequisite: C or better in MAT 215 or consent of instructor.

#### **MAT 321 Introduction to Topology (4) F**

Topology of the line and plane, topological spaces, continuity and topological equivalence and topics selected from the following: bases and sub-bases, metric and normed spaces, countability axioms, separation axioms, compactness, connectedness, product spaces, completeness and function spaces. 4 lecture/problem-solving. Prerequisite: C or better in MAT 310 or consent of instructor.

#### **MAT 325 Introduction to the Theory of Numbers (4) FW**

Fundamentals of the system of integers, divisibility, congruences, theorems of Fermat and Wilson, power residues and indices, quadratic reciprocity, factorization techniques, diophantine equations, theorems of Euler, Gauss and Lagrange. Elementary results concerning the

distribution of primes. 4 lecture/problem-solving. Prerequisite: junior standing or consent of instructor.

#### **MAT 330 Modern Euclidean Geometry (4) FW**

Euclidean geometry using modern techniques of transformations, inversions. Extension of elementary geometry to elegant results on triangles, circles, polygons, famous theorems of geometry, unsolved problems. Introduction to deductive reasoning and techniques of proof. 4 lecture/problem-solving. Prerequisite: consent of instructor.

#### **MAT 370 Graph Theory (4) FSp**

The study of graphs, trees, Eulerian, Hamiltonian, planar graphs, connectivity, coloring, independence and covering numbers, directed graphs, theorems of Menger, Ramsey with applications. 4 lecture/problem-solving. Prerequisite: consent of instructor.

#### **MAT 380 Mathematics of Operations Research (4) F (even years)**

Introduction to mathematics of linear programming (LP): algebra and geometry of simplex method, solution of LP problems by Gauss-Jordan elimination method. Duality theory and sensitivity analysis. Development of revised and dual simplex algorithms. Introduction to parametric and separable convex programming. Applications of LP: computational considerations, case studies. 4 lecture/problem-solving. Prerequisites: C or better in MAT 208 and 215 or consent of instructor.

#### **MAT 381 Mathematics of Operations Research (4) W (odd years)**

Solution of transportation, transshipment and assignment problems. Formulation and solution of network problems: maximal flow, minimal spanning tree, shortest route problems; PERT-CPM techniques. Introduction to dynamic and integer programming. Elements of game theory, solution of games by linear programming. Introduction to non-linear programming: Kuhn-Tucker conditions, quadratic and convex programming; SUMP solution procedure. 4 lecture/problem-solving. Prerequisite: C or better in MAT 380 or consent of instructor.

#### **MAT 394 Elementary Mathematics from an Advanced Viewpoint: Algebra (4) FWSpSu**

Analysis of patterns and functions; proportional reasoning as foundational to algebra; inductive and deductive reasoning; proofs. 4 lecture/problem-solving. Prerequisite: C or better in MAT 194 or equivalent. (See Mathematics department for details).

#### **MAT 395 Elementary Geometry from an Advanced Viewpoint: Geometry (4) FWSpSu**

Analysis of construction of geometric figures; estimation and measurement of perimeter, area and volumes of shapes; induction and deductive geometric proofs. 4 lecture/problem-solving. Prerequisites: C or better in MAT 394.

#### **MAT 400 Special Study for Upper Division Students (1-2)**

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

#### **MAT 401 Numerical Analysis (4) F (odd years)**

Theoretical error and machine error associated with algorithms. Solutions of non-linear equations, systems of linear equations and systems of non-linear equations. 4 lecture/problem-solving. Prerequisite: C or better in MAT 201, MAT 208, MAT 215 and CS 128 or consent of instructor.

**MAT 402 Numerical Methods in Differential Equations (4) W (even years)**

Polynomial interpolation, cubic splines, numerical differentiation and integration, numerical solutions of differential equations including Runge-Kutta methods and predictor-corrector methods for solving initial value problems and the shooting method for solving boundary value problems. 4 lecture/problem-solving. Prerequisites: C or better in MAT 216 and either MAT 401 or CS 301 or consent of instructor.

**MAT 413 Advanced Calculus (4) Sp (odd years)**

Differential and integral calculus of functions and transformations in several real variables. 4 lecture/problem-solving. Prerequisite: C or better in MAT 315 or consent of instructor.

**MAT 415 Foundations of Geometry (4) Sp (even years)**

Axiomatic development of selected topics from Euclidean and neutral geometries; introduction to non-Euclidean geometry with emphasis on the hyperbolic case. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 and 215 or consent of instructor.

**MAT 416 Projective Geometry (4) Sp (odd years)**

Synthetic and analytic treatment of selected topics from projective geometry; classical theorems, conics, polarities; quadratic and bilinear forms. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 and 215 or consent of instructor.

**MAT 417, 418 Modern Algebra (4) (4) FW/WSp**

Introduction to algebraic structures; groups, rings, integral domains, fields; mappings with emphasis on morphisms. 4 lecture/problem-solving. Prerequisite for MAT 417: C or better in MAT 310 or consent of instructor. Prerequisite for MAT 418: C or better in MAT 417 or consent of instructor.

**MAT 419 Abstract Linear Algebra (4) Sp (even years)**

Vector spaces and dimension, linear transformations, dual spaces, adjoints of transformations, multilinear forms, eigenvectors, the Cayley-Hamilton theorem, inner product spaces, orthogonality, similarity transformations, the spectral theorem, Jordan form. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 or consent of instructor.

**MAT 420 Differential Geometry (4) W (even years)**

The Frenet formulas, covariant derivatives, frame fields, the structure equations, differential forms on a surface, normal curvature, Gaussian curvatures; intrinsic geometry of surfaces in  $E^3$ , the Gauss and Bonnet theorem. 4 lecture/problem-solving. Prerequisite: C or better in MAT 314 and MAT 216 or consent of instructor.

**MAT 428 Functions of a Complex Variable I (4) F (odd years) W**

Algebra and geometry of complex numbers; analyticity, mappings of elementary functions; Cauchy integral formula, Taylor and Laurent series, the residue theorem; conformal mapping with applications. 4 lectures/problem-solving. Prerequisite: C or better in MAT 314 or consent of instructor.

**MAT 429 Functions of a Complex Variable II (4)**

Check with Department. Continuation of Topics in MAT 428. 4 lecture/problem-solving. Prerequisite: C or better in MAT 428 or consent of instructor.

**MAT 431, 432 Differential Equations (4) (4) W/Sp (odd years)**

Partial differential equations with applications to wave actions, heat

transfer and fluid flow. Ordinary differential equations; linear with variable coefficients, linear systems; stability and qualitative behavior of solutions. 4 lecture/problem-solving. Prerequisite: C or better in MAT 216 and 208 or consent of instructor.

**MAT 444 Vector and Tensor Analysis (4) W (odd years)**

An integrated course in the algebra and calculus of vectors and tensors; topics in differential geometry; applications to mechanics of deformable media, hydrodynamics, general relativity. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 and 216 or consent of instructor. PHY 321 is recommended.

**MAT 450 Foundations of Mathematics (4) Sp (odd years)**

Introduction to axiom systems including consistency, independence, satisfiability and completeness; transfinite arithmetic; the continuum hypothesis; well-ordering and its equivalents. 4 lecture/problem-solving. Prerequisite: C or better in MAT 310 or consent of the instructor.

**MAT 461, 462 Senior Project (2) (2)**

Selection and completion of a project under faculty supervision. Projects typical of problems which graduates must solve in their fields of employment. Project results are presented in a formal report. Minimum of 120 hours total time.

**MAT 463 Undergraduate Seminar (2)**

Discussions through seminar methods of new developments in the fields of student's particular interests. 2 lecture/discussion. Prerequisite: senior standing in mathematics.

**MAT 470 Combinatorics (4) FW**

Study of enumeration techniques, permutations, combinations, principle of inclusion and exclusion, finite fields, combinatorial designs, error-correcting codes. 4 lecture/problem-solving. Prerequisite: C or better in Mat 208 or consent of instructor.

**MAT 480 Mathematical Programming (4) Sp (odd years)**

Treatment of linear inequalities, duality, general algorithms, application of linear programming. Introduction to discrete and nonlinear programming. 4 lecture/problem-solving. Prerequisite: C or better in MAT 208 and either CS 125 or 128 or consent of instructor.

**MAT 485, 486 Mathematical Modeling and Simulation (4) (4) W/Sp (even years)**

Introduction to the general principles of modeling. Models will be selected from the areas such as physics, biology, political science, chemistry, engineering and business. Analytical, numerical and simulation methods will be used to solve the models. 4 lecture/problem-solving. Prerequisites: C or better in the following courses: CS 128 or CS 125, MAT 201, MAT 208, MAT 216 and STA 241 or consent of instructor.

**MAT 492 Technological Applications in Mathematics (4) WSu**

Use of computers, microcomputers, calculators and other technologies in doing mathematics. Evaluation and utilization of instructional software in mathematics; use of application software including databases and spreadsheets; social issues related to microcomputer use. This course is intended for future teachers at the middle and high school levels. 4 lecture/problem-solving.

**MAT 493 Algebraic Structures and Computing for Elementary and Middle School Teachers (4) FSp**

Development of algebraic structures from groups to fields. Study of

modular arithmetic, relationships and functions. Use of the computer, to investigate algebraic relationships and algorithms. 4 lecture/problem-solving.

**MAT 494 Elementary Mathematics from an Advanced Viewpoint: Probability, Statistics, and Data Analysis (4)**

Basic notions of chance and probability, inferences, predictions and arguments based on data collection, organization and representation. 4 lectures/problem-solving. Prerequisite: C or better in MAT 394.

**MAT 495/495A, MAT 496/496A, MAT 497/497A Topics in Contemporary Secondary School Mathematics I, II, III (3/1) (3/1) (3/1) F/W/Sp**

Examination of the high school mathematics curriculum from an advanced viewpoint. Analysis of current issues and trends in secondary school mathematics. Use of technology in learning mathematics. Assessment of students' competency in mathematics. Field experiences in educational and non-educational settings. MAT 495/495A and MAT 496/496A are mandatory credit/no credit grading basis. 3 hours lecture, 1 two-hour activity. Prerequisites: Completion of 28 units of 300 and 400-level mathematics courses, including MAT 417, 325, 306 and a course in Geometry selected from MAT 330, 415, or 416 or the equivalent of these three courses.

**MAT 499/499A/499L Special Topics for Upper Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units with a maximum of 4 units per quarter. Prerequisite: consent of instructor. Lecture/activity/laboratory or combination of these.









## STATISTICS

Hoon Kim, Coordinator

### STA 120 Statistics with Applications (4) FWSpSu

Collection and summarization of data; measures of central tendency and dispersion; probability; binomial and normal distributions, confidence intervals and hypothesis-testing. Not open to mathematics or engineering majors. 4 lecture/problem-solving. Prerequisites: Within the last THREE quarters, must have either achieved a minimum placement score on the appropriate MDPT or C or better in MAT 12, or MAT 105, or MAT 106, or MAT 125, or MAT 191; or, within the last year must have earned 50 or better on the ELM; or, within the last 18 months must have earned either 550 or better on the SAT or 23 or better on the ACT.

### STA 200 Special Study for Lower Division Students (1-2)

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

### STA 210 Statistical Computing (4) Sp

Use of computer packages, inferences about means of two populations, dependent and independent samples, small and large samples, inferences about proportions and variances, correlation and regression. 4 lecture/problem-solving. Prerequisite: C or better in STA 120 or consent of instructor.

### STA 220 Discrete Probability Models (4) W

Set-theoretic approach to probability in finite sample spaces. Conditional probability, independence, binomial, hypergeometric and related distributions. 4 lecture/problem-solving. Prerequisite: C or better in MAT 105 or consent of instructor.

### STA 241 Applied Probability Theory (4) FW

Rules of Probability, random variables, expected values of random variables, distribution of functions of a random variable. Discrete and continuous probability distributions with applications. Sampling methods. Descriptive statistics, central limit theorem and estimation. 4 lecture/problem-solving. Prerequisite: C or better in MAT 116 or MAT 131 or consent of instructor. Not open to students with credit in STA 315 or ECE 315.

### STA 299/299A/299L Special Topics for Lower Division Students (1-4)

Group study of a selected topic; the title to be selected in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Lecture/activity/laboratory or a combination. Prerequisite: consent of instructor.

### STA 309 Statistical Methods in Engineering and the Physical Sciences (3) FWSp

The uses of statistics in testing, inspection and production, measures of central tendency and dispersion, probability, binomial and normal distributions, sampling theory, hypothesis-testing and estimation, comparison of two populations. Not open to students required to take STA 315 or ECE 315. 3 lecture/problem-solving. Prerequisite: C or better in MAT 116 or MAT 131 or consent of instructor.

### STA 310 Sampling Theory and Applications (4) Sp (odd years)

Random Sampling including stratified, cluster, systematic, multistage, multiphase, and probability sampling methods. Derivations of estimators, error bounds and sample sizes. 4 lecture/problem-solving.

Prerequisite: C or better in STA 120 or equivalent or consent of instructor

### STA 315 Probability and Statistics for Engineers (4)

Statistical and probabilistic concepts for the analysis of electrical and electronic systems associated with random phenomena. Application to communication, control, instrumentation and logic systems. 4 lecture/problem-solving. Prerequisite: C or better in MAT 215 or consent of instructor. Not open to students with credit in ECE 315, STA 309 or students required to take STA 241.

### STA 326 Statistical Methods for Computer Scientists (4) FWSpSu

Rules of Probability. Discrete and continuous distributions including the multinomial distribution. Sampling distributions. Point and interval estimation. Hypothesis-testing. Large and small sample inferences for means, proportions and variances. Introduction to queueing theory and regression. 4 lecture/problem-solving. Prerequisite: C or better in MAT 214 or consent of instructor. Not open to students required to take STA 241.

### STA 341 Applied Statistics (4) FWSp

Joint distributions, central limit theorem. Maximum likelihood estimation. Point and interval estimation, hypothesis-testing. Small and large sample inferences. Contingency table analysis and Chi-square tests. Linear regression and correlation. Use of computer package for applied problems. 4 lecture/problem-solving. Prerequisite: C or better in STA 241 and MAT 215 or consent of instructor.

### STA 400 Special Study for Upper Division Students (1-2)

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

### STA 420 Nonparametric Statistics (4) W (odd years)

Common nonparametric tests such as permutation tests, sign tests, Wilcoxon test, chi-square test and rank correlation tests. Null distributions and their approximations. 4 lecture/problem-solving. Prerequisite: C or better in STA 210 or STA 326 or STA 341 or consent of instructor.

### STA 425 Applied Survival Analysis (4) (even years)

Survival models. Types of censoring. Life-tables. Estimation of survival functions from complete and incomplete mortality data. Actuarial and maximum likelihood methods. Kaplan-Meier estimator, Mantel-Haenszel and Log-rank tests. Probit and Logit models. Use of computer package such as SAS or MINITAB or S-plus. 4 lecture/problem-solving. Prerequisite: C or better in STA 341 or STA 326 or consent of instructor.

### STA 430 Introduction to Random Processes (4) Sp (even years)

General types of stochastic processes. Random walks, Poisson processes, counting processes, Markov chains and topics from other areas, such as Markov jump processes, Birth-death processes, Gaussian processes. 4 lecture/problem-solving. Prerequisite: C or better in STA 326 or STA 241 or consent of instructor.

### STA 432 Applied Regression Analysis (4) F (odd years)

Matrix approach to regression models, least square estimation, correlation, multiple regression, transformation of variables, analysis of residuals, multicollinearity and auto-correlation. Use of computer packages for applied problems. 4 lecture/problem-solving. Prerequisites: C or better in STA 326 or STA 341 and MAT 208 or consent of instructor.

**STA 435 Analysis of Variance and Design of Experiments (4) F (even years)**

ANOVA techniques, computer solutions, randomized groups and blocks designs, interactions, analysis of covariance. Latin square, split-plot, simple and confounded factorial designs; treatment of missing data, incomplete block designs. 4 lecture/problem-solving. Prerequisite: C or better in STA 326 or STA 341 or consent of instructor.

**STA 440 Mathematical Statistics I (4) W (odd years)**

Discrete and continuous probability distributions; moments, moment generating functions, special distributions, distributions of functions of random variables. 4 lecture/problem-solving. Prerequisite: C or better in MAT 215 or consent of instructor.

**STA 441 Mathematical Statistics II (4) Sp (odd years)**

Asymptotic distributions; central limit theorem; point and interval estimation; completeness and sufficient statistics; Neyman-Pearson theory of testing hypotheses. 4 lecture/problem-solving. Prerequisite: C or better in STA 440 or consent of instructor.

**STA 499/499A/499L Special Topics for Upper Division Students (1-4)**

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units with a maximum of 4 units per quarter. Lecture/activity/laboratory or combination of these. Prerequisite: consent of instructor.

Graduate courses are listed in the "Graduate Studies" section of the catalog.