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Center for Mathematics and Computer Science Education

The Center for Mathematics and Computer Science Education is a unit within the Department of Mathematics and Computer Science. The general purpose of the Center is to provide a permanent organization and campus facility, with its own coordinating committee and approved governing documents, that serves as a research and resource center in mathematics education and computer science education. Specific activities of the Center include: providing demonstration classrooms; stimulating research; coordinating activities involving local schools and industries; and initiating activities such as institutes, projects, conferences, and special lectures.

Computing Facilities

A wide variety of computing resources is available to students, including personal computers, minicomputers, mainframes, and supercomputers. The Department operates a Unix network of Sun workstations and two Sequent multiprocessor computers. In addition, there are laboratories containing more than 50 personal computers, networked via Ethernet and connected to the departmental switch from which they can access the departmental Unix network and other computers on campus and elsewhere.

The entire campus is networked via both Ethernet and 9600 baud serial lines. Several centrally managed microcomputer laboratories are located strategically around campus, the newest of which houses Sun and Silicon Graphics workstations, PCs, and Apple Macintoshes. An IBM 3090 running MVS and VM/CMS serves administration and faculty. Access is provided from all locations on campus to CSUNET, a T1 network connecting resources at all 20 CSU campuses. Via this network, access is provided to supercomputers, including those at the San Diego Supercomputer Center.

With these computer systems, students can become familiar with diverse operating systems and database management systems as well as gain expertise in high level languages such as Pascal, C, C++, LISP, FORTRAN, Modula-2, Ada, Prolog, LOGO and several assembly languages.

Restriction on Enrollment for Credit

Enrollment for credit in Math 8, 10, 12, 70, 71, 101, 106, 107A, and 107B will not be allowed for students who have received credit in Math 20, 21, 29, 30, 31, 32, unless the particular course in question must be taken in order to fulfill major, minor, or credential requirements.

Disqualification from the Major

The Mathematics and Computer Science Department has adopted the disqualification-from-the-major policy. All majors in the Department who are below a 2.0 grade point average for all units in the major at SJSU and have achieved less than a 2.0 grade point average in the major in two successive semesters will be disqualified from the Department. Students disqualified under this policy will be notified by the Director of Admissions and Records that the major will be changed to Undeclared unless another major for which they are qualified is selected.

Calculus Placement Examination

All students who wish to enroll in Math 30 who have not passed a course in college equivalent to Math 29, and all students who wish to enroll in Math 20 who have not passed a course in college equivalent to Math 8, are REQUIRED to take a Calculus Placement Examination. This examination covers material included in high school algebra, trigonometry, and analytic geometry.

All students who wish to enroll in Math 71 who have not passed a course in college equivalent to Math 7 are REQUIRED to take a Calculus Placement Examination. This examination covers material included in high school algebra.

Minimum Grade Requirement

A grade of C- or better is required for courses being used to meet any requirement in any minor or major offered by the Department of Mathematics and Computer Science, including support courses.

B.A.– Mathematics

The B.A. Degree in Mathematics is recommended for students who plan to become teachers or plan further study in mathematics. The program is sufficiently flexible so that applied mathematics can be emphasized in preparation for industrial work. A degree in mathematics is also excellent preparation for graduate work in numerous other disciplines.

Semester Units

General Education 42
Of the 51 units required by the University, 9 **may** be satisfied by completion of specified major and supporting courses. Consult major advisor for details.

American Institutions ..... (6)
Of the 6 units required by the University, all **may** be satisfied within General Education requirements as specified in the *Schedule of Classes.*

Physical Education 2

Support for the Major 6-8
One year of calculus-based physics. (With prior approval, 6 units of upper division mathematics-related courses from other departments may be substituted. However, the student must then complete the regular General Education Science program.)

Requirements in the Major 46-51

Lower Division 16-21
Math 30 (or 20), 31 (or 21), 32, 42 and CS 43 or 45 or 46A or 49.

Upper Division Core 15
Math 129A, 112A or 113 or 115 or 138, 128A, 131A, 128B or 129B or 131B or 175.

Additional Upper Division Requirements 15
Three courses chosen from Math 104, 108, 112A, 112B, 113,115, 126, 128B, 129B, 131B, 133A, 133B, 138, 142, 143C or 143M, 161 or 164, 162 or 163, 171, 175, 177, 178, 179, appropriate 196's and 203's 9
Two upper division mathematics or computer science courses, excluding Math 101, 106, 107A, 107B 6

Electives 21-28

Total Units Required for Degree 124

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B.A.– Mathematics

Concentration in Statistics

The Concentration in Statistics provides not only the basis for an entry level position in government or industry, but also a fine preparation for the student interested in advanced study in statistics, probability, or many other fields.

Semester Units

General Education 42
Of the 51 units required by the University, 9 **may** be satisfied by completion of specified major and supporting courses. Consult major advisor for details.

American Institutions ..... (6)
Of the 6 units required by the University, all **may** be satisfied within General Education requirements as specified in the *Schedule of Classes.*

Physical Education 2

Support for the Major 6-8
One year of calculus-based physics. (With prior approval 6 units of upper division mathematics-related courses from other departments may be substituted. However, the student must then complete the regular General Education Science program.)

Requirements for the Major 40-44

Lower Division 13-17
Math 30 (or 20), 31 (or 21), 32, 42. (CS 43 or 45 or 46A or 49 strongly recommended.)

Upper Division 27
Math 129A, 131A or 112B, 142 (9); Math 113 or 115 or CS 116A (3); Math 161, 162, 163, 164 (12); Upper division elective from Mathematics and Computer Science Department not to include Math 101, 106, 107A, or 107B (3).

Electives 28-34

Total Units Required for Degree 124

B.S.– Applied and Computational Mathematics

This degree is recommended for students who want a solid foundation in classical Applied Mathematics as well as the more recent field of Computational Mathematics. (Computational Mathematics involves the study of computer solutions to mathematics problems in the sciences and engineering.) This program prepares a student for direct employment to assist a group of scientists with numerical solution of their problems; also, it is a good background for graduate study in Applied Mathematics, Numerical Analysis, or Operations Research.

Semester Units

General Education 39
Of the 51 units required by the University, 12 **may** be satisfied by completion of specified major and supporting courses. Consult major advisor for details.

American Institutions ..... (6)
Of the 6 units required by the University, all **may** be satisfied within General Education requirements as specified in the *Schedule of Classes.*

Physical Education 2

Support for the Major 17
Phys 61, 62 8
Upper Division Physics 6
(With permission of advisor, Phys 63 (4) and 3 units of upper division physics [except 107, 166] may be substituted; or 6 upper division units in a single science such as chemistry or engineering.)

Engl 100W (Technical) 3

Requirements for the Major 60-64

Lower Division 24-28
Math 30 (or 20), 31 (or 21), 32, 42; CS 43, 46A, 46B.

Upper Division 27
Math 112A, 129A, 133A, 133B, 138, 143C, 143M or 129B, 162 or 163, CS 140.

Upper Division Electives 9
Chosen from the following (with advisor's approval, other courses may be substituted): Math 112B, 113, 126, 127, 128A, 128B, 129B, 131A, 131B, 142, 143M, 161, 162, 163, 164, 175, 177, 178, 179, 203; CS 116A, 116B, 146A, 147, 149, 155, appropriate 196's and 203's.

Electives 6-10

Total Units Required for Degree 128

B.S.– Computer Science

This degree provides a solid background for employment in the computing field. Graduates will be prepared for entry-level professional positions such as programmer, system analyst, or software engineer in government, business, and industry. This program also prepares students for graduate study in computer science and such related fields as management science and operations research.

This program in computer science is accredited by the Computer Science Accreditation Commission (CSAC) of the Computing Sciences Accreditation Board (CSAB), a specialized accrediting body recognized by the Commission on Recognition of Postsecondary Accreditation (CORPA) and the U.S. Department of Education.

Semester Units

General Education 36
Of the 51 units required by the University, 15 **may** be satisfied by completion of specified major and supporting courses. Consult major advisor for details.

American Institutions ..... (6)
Of the 6 units required by the University, all **may** be satisfied within General Education requirements as specified in the *Schedule of Classes.*

Physical Education 2

Support for the Major *36-40
Math 30 (or 20), 31 (or 21), 32, 42, 129A, 161 or 164 (19-23); Phys 61, 62 (8); one science course applicable to science major (3); Engl 100W (Technical) (3); Phil 110 (3).

Requirements for the Major *50

Lower Division 8
CS 46A, 46B.

Upper Division 24
CS 140, 142, 145A, 146A, 147, 149, 152, 154.

Elective computer science courses 18
At least two courses from two of the tracks below 12
Graphics: CS 116A, 116B.
Artificial Intelligence: CS 145B, 156; Math 171.
Computation Theory: CS 155; Math 171, 179.
Scientific Computing: Math/CS 143C, 143M; Math 177.
Software Engineering: CS 146B, 151, 159.
Distributed Computing: CS 157, 158, 159.
Programming Languages: CS 145B, 151, 153.
Two courses from CS 116A, 116B; Math/CS 143C, 143M; CS 145B, 146B, 151, 153, 155, 156, 157, 158, 159; Math 171, 177, 178, 179; appropriate 196's, 203's 6

Electives 0-4

Total Units Required for Degree 128

**The total of these two items must include at least 45 units of upper division Math and CS coursework.*

uirements for Admission to ndidacy for the M.S.– Computer cience

To be admitted to candidacy for the M.S. degree, a student must meet the all-University requirements as stated in The Academic Requirements Section of this Catalog and must satisfy the following requirements:

1. The student must have completed at least 12 units of course work that will count towards the M.S. degree with a grade point average of at least 3.0. At most, 12 units of course work taken before achieving Classified status can count toward the degree.
2. The student, with the help of an advisor, must prepare an approved program form which lists his/her proposed course work. The program is then submitted to the Mathematics and Computer Science Department Committee for approval.
3. The student must apply for admission to candidacy for the Master of Science degree. At this time, the approved program is forwarded to the Graduate Studies Office. Approval of the program by the Graduate School makes it official. Any changes at a later date must be obtained by petition.

Completing Requirements for the M.S.– Computer Science

Plan A (with Thesis)

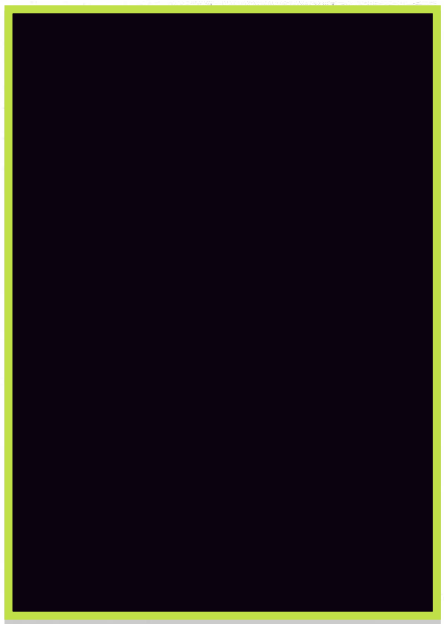
	Semester Units
Core Courses CS 247, 252, 254 and 255.	12
Option Courses Two courses from CS 216, 243, 249, 253, 256, 257, 258, Math 271A, 271B, 279, and appropriate CS 286, 290 and 296.	6
CS 299, Thesis After being admitted to candidacy, the student must obtain a thesis director who then becomes his/her advisor. A committee of three professors selected by the thesis director with the approval of the Department Chairperson must approve the thesis topic before work begins. Registration in CS 299 should be for the semester in which the candidate expects to complete the thesis. Upon completion of the thesis, the candidate must pass a comprehensive oral examination in the area of his/her thesis conducted by the thesis committee.	3
Electives These units may include a maximum of 3 units of CS 180 and/or CS 298. They can be upper division or graduate courses from the Department of Mathematics and Computer Science. In either case the student must obtain approval from his/her advisor prior to enrolling in the course. In no instance can more than 6 units be outside the Department of Mathematics and Computer Science.	9
Total Number of Units Required	30

Plan B (with Writing Project or Comprehensive Exam)

Plan B differs from Plan A only in the following respect. CS 299, Thesis, is replaced by CS 298, Special Study, in which the student will prepare a paper.

The procedure and requirements for this paper will be the same as for the thesis except that the paper will not be bound or filed with the Graduate Office. A copy must be filed with the Department. The comprehensive oral examination is required upon completion of the paper.

Instead of a writing project, a student can take CS 203 or CS 240 and pass a comprehensive exam. The comprehensive exam is given each semester. Each student planning to take the exam is required to register for one unit of CS 298 during the first week of the semester in which he/she plans to take the exam.



Courses

Mathematics

Non-Baccalaureate

Math 3A. Intensive Learning Mathematics I
Integers, linear equations and inequalities, polynomials, factoring, rational expressions.
Prerequisites: ELM test required for placement; freshman status.
No credit for graduation.
CR/NC grading.
3 units

Math 3B. Intensive Learning Mathematics II
Linear equations and inequalities in two variables, systems of linear equations, quadratic equations, irrational numbers, simple geometric concepts.
Prerequisites: ELM test required for placement; CR grade in Math 3A; freshman status.
No credit for graduation.
CR/NC grading.
3 units

Math 5. Elementary Algebra
Sets, numbers, and relations; equations in one and two variables; systems of linear equations; polynomials, factors, and rational expressions; quadratic functions and simple geometric concepts.
Prerequisites: ELM test required for placement.
No credit for graduation.
CR/NC grading
4 units

Math 7. Intermediate Algebra
Systems of equations, determinants, quadratic relations, complex numbers, exponents and logarithms, polynomial functions.
Prerequisite: CR grade in Math 5 or appropriate ELM score.
No credit for graduation.
CR/NC grading.
4 units

Lower Division

Math 8. College Algebra and Trigonometry
Polynomial, rational, exponential, logarithmic, circular, and trigonometric functions; multiple angle formulas and other trigonometric identities; complex numbers and systems of equations.
Prerequisites: Credit in Math 7; satisfaction of ELM requirement.
3 units

Math 10. Mathematics for General Education
Topics from: methods of proof, problem solving, probability, statistics, applications to scheduling and apportionment, population studies, consumer math, theory of games, polyhedra, networks, graph theory, linear programming.
Prerequisites: Credit in Math 7; satisfaction of ELM requirement.
3 units

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Math 12. Number Systems
The structure of the real number system, numeration systems, elementary number theory, statistics, and problem solving techniques needed for elementary mathematical applications.

Prerequisites: Two years of high school algebra or Math 7; one year of high school geometry; satisfaction of ELM requirement.

3 units

Math 20. Analytic Geometry and Calculus I
The content of Math 30 together with the first half of Math 29. Topics include coordinate systems, the line, conic sections, limits, differentiation, integration, and applications.

Prerequisites: Math 8 with a grade of C- or better, or satisfactory score on Calculus Placement Exam (see Calculus Placement Exam information); satisfaction of ELM requirement.

5 units

Math 21. Analytic Geometry and Calculus II
The content of Math 31 together with the second half of Math 29.

Prerequisite: Math 20 or 30 with a grade of C- or better, or instructor consent.

5 units

Math 29. Analytic Geometry
Coordinate systems, the straight line and conic sections, higher plane curves, parametric equations, vector algebra, solid analytic geometry.

Prerequisites: Math 8 or equivalent with a grade of C- or better; satisfaction of ELM requirement.

4 units

Math 30. Calculus I
Introduction to calculus. Includes limits, continuity, differentiation, integration, and applications.

Prerequisites: Math 29 with a grade of C- or better or satisfactory score on the Calculus Placement Exam (see Calculus Placement Exam information); satisfaction of ELM requirement.

3 units

Math 31. Calculus II
Differentiation and integration of transcendental functions. Applications of the derivative and integral.

Prerequisite: Math 20 or 30 with a grade of C- or better, or instructor consent.

3 units

Math 32. Calculus III
Partial derivatives, multiple integrals, infinite series, and vector calculus.

Prerequisite: Math 31 or 21 with a grade of C- or better, or instructor consent.

4 units

Math 42. Discrete Mathematics
Sets, logic, methods of proof including mathematical induction, functions, relations, elementary combinatorics, probability, graphs, trees, Boolean algebras.

Prerequisite: Math 20 or 30 with a grade of C- or better, or instructor consent.

3 units

Math 43. FORTRAN Programming
See CS 43.

3 units

Math 45. Introduction to Programming in Logo
See CS 45.

3 units

Math 70. Finite Mathematics
Systems of linear equations and inequalities, matrices, set theory, and probability theory, applications to business and to social sciences.

Prerequisites: Credit in Math 7; satisfaction of ELM requirement.

3 units

Math 71. Calculus for Business and Aviation
Functions and graphs, limits, continuity, differentiation, integration, partial differentiation. Emphasis on business and economics applications.

Prerequisites: College credit in intermediate algebra or passing score on Math 71 Placement Test (see Calculus Placement Exam information); satisfaction of ELM requirement.

3 units

Upper Division

Math 101. Problem Solving for Teachers
Problem solving involving elementary number theory, algebra, geometry, logic, measurement, probability, and statistics. Selected problems explored and extended across content strands. Various instructional methods and assessment alternatives modeled. Designed specifically for teachers of mathematics, grades K-8.

Prerequisites: Math 12 and 106 with a grade of C- or better in each, or instructor consent.

3 units

Math 104. History of Mathematics
Mathematical development from earliest times to the 20th Century.

Prerequisite: Upper division algebra or geometry course with a grade of C- or better, or instructor consent.

3 units

Math 106. Intuitive Geometry
Introductory geometry, measurement, constructions, congruence, coordinate geometry, computer literacy, introduction to probability, introduction to transformations.

Prerequisites: Math 12 with a grade of C- or better, and two years of high school algebra and one year of high school geometry, or instructor consent.

3 units

Math 107A. Explorations in Algebra
Comprehensive view of school algebra primarily for the mathematical preparation of teachers. The computer will be used to generate examples, investigate relationships, explore algorithms, and solve problems. Functions and relations used as a unifying theme throughout.

Prerequisites: Math 101 and CS/Math 45 or instructor consent.

3 units

Math 107B. Explorations in Geometry
Comprehensive view of elementary geometry primarily for the mathematical preparation of teachers. The computer will be used to investigate two- and three-dimensional patterns, measurement, and parallelism. Transformational approach to congruence and similarity. Nature of inductive reasoning and deductive proof.

Prerequisites: Math 101 and CS/Math 45 or instructor consent.

3 units

Math 108. Problem Solving in Mathematics
Introduction to general problem solving techniques: generalization, specialization, analogy, induction, recursion, and others. Application of these techniques in algebra, geometry, analysis, number theory, combinatorics.

Prerequisite: Math 32 with a grade of C- or better, or instructor consent.

3 units

Math 112A. Vector Calculus
Algebra and calculus of vectors, metric structure of Euclidean space, transformations, vector fields, integration, and applications, introduction to Cartesian tensors.

Prerequisite: Math 32 with a grade of C- or better, or instructor consent.

3 units

Math 112B. Advanced Calculus
Calculus of several variables; Frechet derivative, Jacobian, inverse and implicit function theorems, change of variables in integration and selected topics.

Prerequisite: Math 112A with a grade of C- or better, or instructor consent.

3 units

Math 113. Differential Geometry
Properties of curves and surfaces, Frenet-Serret formulas and the fundamental forms. Study of curves and surfaces in the small by means of differential calculus.

Prerequisite: Math 32 and 129A with a grade of C- or better in each, or instructor consent.

3 units

Math 115. Modern Geometry and Transformations
Synthetic and analytic theory of projective transformations, similarities, Euclidian motions, inversive geometry, and an introduction to non-Euclidean geometry.

Prerequisite: Math 31 (or 21) with a grade of C- or better, or instructor consent.

3 units

Math 126. Theory of Numbers
Divisibility, prime numbers, congruences of first and higher degrees, theorems of Fermat, Euler, and Wilson, quadratic residues.

Prerequisite: Math 31 (or 21), and Math 42 with a grade of C- or better in each, or instructor consent.

3 units

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Math 127. Applied Algebra

Group theory, group codes, Boolean algebras, finite state machines, finite fields, linear finite state machines.

Prerequisite: Math 42 and 129A with a grade of C- or better in each, or instructor consent.

3 units

Math 128A. Abstract Algebra I

Group theory: permutation groups, abelian groups, morphism theorems, finite groups. Introduction to rings and fields.

Prerequisite: Math 42 and 129A with a grade of C- or better in each, or instructor consent.

3 units

Math 128B. Abstract Algebra II

Emphasis on rings, integral domains, fields, field extensions, Galois theory.

Prerequisite: Math 128A with a grade of C- or better, or instructor consent.

3 units

Math 129A. Linear Algebra I

Matrices, systems of linear equations, vector spaces, vector geometry, linear transformations, inner product spaces, eigenvectors and eigenvalues.

Prerequisite: Math 31 (or 21) with a grade of C- or better in each, or instructor consent.

3 units

Math 129B. Linear Algebra II

Continuation of Math 129A. Linear transformations, dual spaces, diagonalization, Cayley-Hamilton theorem, minimal polynomials, Jordan Canonical form, rational canonical form, applications.

Prerequisite: Math 42 and 129A with a grade of C- or better in each, or instructor consent.

3 units

Math 131A. Introduction to Analysis

Properties of real numbers including completeness and compactness. Continuous functions, uniform continuity, the derivative.

Prerequisite: Math 32 and 42 with a grade of C- or better in each, or instructor consent.

3 units

Math 131B. Introduction to Real Variables

The theory of the Riemann integral, sequences and series of functions, spaces of functions.

Prerequisite: Math 131A with a grade of C- or better, or instructor consent.

3 units

Math 133A. Ordinary Differential Equations

First order equations, higher order linear equations, applications, Laplace transforms, series solutions. Additional topics.

Prerequisite: Math 32 with a grade of C- or better, or instructor consent.

3 units

Math 133B. Partial Differential Equations

Partial differential equations of physics and engineering, Fourier series, Legendre polynomials, Bessel functions, orthogonal functions, the Sturm-Liouville equation.

Prerequisite: Math 133A with a grade of C- or better, or instructor consent.

3 units

Math 138. Complex Variables

Analytic functions, complex integration, residues, and power series.

Prerequisite: Math 32 with a grade of C- or better, or instructor consent.

3 units

Math 142. Introduction to Combinatorics

Sets, permutations, combinations, probability, mathematical induction, counting techniques, generating functions, partitions, recurrence relations, inclusion-exclusion. Polya's theorem and applications to computer science, mathematics, engineering, and physical sciences.

Prerequisite: Math 32 and 42 with a grade of C- or better in each, or instructor consent.

3 units

Math 143C. Numerical Analysis and Scientific Computing

Development and comparison of important algorithms for scientific computing in terms of efficiency, accuracy, and reliability. Topics include nonlinear equations, interpolation, approximation theory, differentiation, integration, differential equations, numerical stability, and error analysis. Substantial assignments using contemporary software packages and professional subprogram libraries.

Prerequisite: Math 32 and one of CS 43, 46A, or 49 with a grade of C- or better in each, or instructor consent.

3 units

Math 143M. Numerical Analysis and Scientific Computing

Development and comparison of important algorithms for scientific computing in terms of efficiency, accuracy, and reliability. Topics include systems of linear equations–direct and iterative methods, least squares problems, eigenvalues and eigenvectors, numerical stability, and error analysis. Substantial assignments using contemporary software packages and professional subprogram libraries.

Prerequisite: Math 129A and one of CS 43, 46A, or 49 with a grade of C- or better in each, or instructor consent.

3 units

Math 161. Applied Statistics

Data classification, comparability and comparison, bases for analysis in one-way tables, standard comparisons and displays, analysis of n-way tables, transformations, linear and non-linear curve fitting, analysis of variance.

Prerequisite: Math 31 or 21 with a grade of C- or better, or instructor consent.

3 units

Math 162. Probability and Computation

Random sequences, simulations, relative frequencies and probability in the Bernoulli case, use of pseudo-random numbers, probabilistic solutions to computing problems, queueing theory.

Prerequisite: Math 31 or 21 with a grade of C- or better, or instructor consent.

3 units

Math 163. Probability Theory

Probability axioms; random variables; marginal and conditional density and distribution functions; binomial, geometric, Poisson, gamma, and normal probability laws; mathematical expectations, moment generating functions; and limit theorems.

Prerequisite: Math 32 and 42 with a grade of C- or better in each, or instructor consent.

3 units

Math 164. Mathematical Statistics

Sampling distributions, interval estimation, confidence intervals, order statistics, sufficient statistics, the Rao-Blackwell Theorem, completeness, uniqueness, point estimation, maximum likelihood, Bayes' methods, testing hypotheses.

Prerequisite: Math 163 with a grade of C- or better, or instructor consent.

3 units

Math 171. Foundations of Mathematics and Computer Science

Fundamental and unifying principles of logic and computation. Introduction to mathematical logic for the mathematician and computer scientist.

Prerequisite: Math 42 and upper division algebra with a grade of C- or better in each, or instructor consent.

3 units

Math 175. Introduction to Topology

Set theory, topological spaces and separation axioms, completeness, compactness, connectedness, functions and continuity, product spaces.

Prerequisite: Math 131A with a grade of C- or better, or instructor consent.

3 units

Math 177. Linear and Non-Linear Optimization

Linear inequalities, the simplex method and other algorithms, duality, integer optimization, convex optimization, quadratic optimization, game theory.

Prerequisite: Math 129A with a grade of C- or better, or instructor consent.

3 units

Math 178. Mathematical Modeling

Basic modeling techniques including graphing, proportion, curve fitting and interpolation, optimization, dimension analysis, probability and computer simulation, derivatives, and differences. Applications from business/economics, physical/life/social sciences.

Prerequisite: Math 129A or instructor consent.

3 units

Math 179. Introduction to Graph Theory

Hamiltonian and Eulerian properties, matching, trees, connectivity, coloring problems, and planarity. Emphasis on algorithms and applications, including optimal network flows.

Prerequisite: Math 42 and 129A with a grade of C- or better in each, or instructor consent.

3 units

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Math 180. Individual Studies
Individual study in a specific field.

Prerequisite: Department chair approval. CR/NC grading. Repeatable for credit.

1-4 units

Math 195. Honors Seminar
Senior project on advanced topics in mathematics as determined by the instructor and department honors committee. Written paper and oral presentation of the project required.

Prerequisite: At least junior standing as mathematics major, GPA of 3.5 or higher, and instructor consent.

3 units

Graduate

Math 201A. Mathematics for Secondary Teachers
Secondary school mathematics from an advanced viewpoint, plus topics from higher mathematics. Emphasizes inductive reasoning in problem solving. Applications useful to junior and senior high school teachers.

Prerequisite: Equivalent of Mathematics minor or Mathematics minor for K-8 Teachers or consent of instructor.

3 units

Math 201B. Mathematics for Secondary Teachers
Secondary school mathematics from an advanced viewpoint, plus topics from higher mathematics. Emphasizes deductive reasoning in problem solving. Applications useful to junior and senior high school teachers.

*Math 201A **not** a prerequisite.*

Prerequisite: Equivalent of Mathematics minor or Mathematics minor for K-8 Teachers or instructor consent.

3 units

Math 203. Applied Mathematics and Computer Science Projects
Supervised teamwork to solve a substantial problem in mathematics or computer science usually supplied by an outside agency such as a local company. The number of different projects offered and the topics will vary widely. A project usually continues for two consecutive semesters.

Prerequisite: Consent of instructor.

Repeatable for credit.

Credit/No Credit grading.

3 units

Math 211A. Geometry of Projective Spaces
Structure of projective planes; finite planes and combinatorics; automorphism groups; configuration theorems and coordinatizations; conics; introduction to projective n-space over a field; topological properties; subgeometries.

Prerequisite: Math 112A or Math 115, Math 129A recommended, or consent of instructor.

3 units; alternate years

Math 211B. Advanced Topics in Geometry
Projective n-space; linear geometry; crystallography; algebraic geometry; etc.

Prerequisite: Math 211A or consent of instructor.

3 units; alternate years.

Math 213. Advanced Differential Geometry
An intensive study of the intrinsic geometry of surfaces and of Riemannian geometry.

Prerequisite: Math 113 or consent of instructor.

3 units; alternate years.

Math 221A. Higher Algebra I
Topics from groups, rings, integral domains, modules, fields, vector spaces.

Prerequisites: Math 128B or consent of instructor.

3 units each

Math 221B. Higher Algebra II
Continuation of Math 221A with additional advanced topics in algebra selected by instructor.

Prerequisites: Math 221A or instructor consent.

3 units

Math 226. Theory of Numbers
Residues of powers, quadratic residues, problems connected with quadratic forms, more difficult Diophantine equations, and additional topics varying with text and instructor.

Prerequisite: Math 126 or equivalent or consent of instructor.

3 units; alternate years.

Math 231A. Real Analysis I
Sigma algebras, construction of measures, differentiation, product measures, integration theory, the spaces L1 and C.

Prerequisite: Math 131B or consent of instructor.

3 units

Math 231B. Real Analysis II
Function spaces and their duals, operators on function spaces, applications to: analysis (classical and functional), and topics selected at the discretion of the instructor.

Prerequisite: Math 231A or consent of instructor.

3 units

Math 233A. Applied Mathematics I
Derivation of the partial differential equations of classical mathematical physics. Existence and uniqueness of solutions of first order ordinary and partial differential equations. The classical theory of initial and boundary value problems for hyperbolic, parabolic, and elliptic equations. Fourier series and transforms.

Prerequisite: Math 133B or consent of instructor.

3 units

Math 233B. Applied Mathematics II
Continuation of 233A. Selected topics such as Green's functions, eigenvalue problems, integral equations, or variational methods.

Prerequisites: Math 138 and 233A or consent of instructor.

3 units

Math 235A. Tensor Analysis and Riemannian Geometry I
Motivational ideas underlying tensor concepts; tensor algebra; transformation theory; Riemannian geometry; tensor calculus.

Prerequisites: Math 112A, and Math 129A or consent of instructor.

3 units

Math 235B. Tensor Analysis and Riemannian Geometry II
Applications of tensor algebra and analysis to relativity theories, cosmology, and classical dynamics.

Prerequisite: Math 235A or consent of instructor.

3 units; alternate years

Math 238. Advanced Complex Variables
A course specializing in one or more of the advanced branches of the theory of functions.

Prerequisite: Math138 or consent of instructor.

3 units; alternate years

Math 243. Advanced Numerical Analysis
Advanced topics in numerical methods.

Prerequisite: Math 143C or 143M or consent of instructor.

3 units

Math 271A. Mathematical Logic
Formal systems; introductory model theory (Godel's completeness theorem, compactness, Lowenhein-Skolem theorem, etc.); Godel's incompleteness theorems.

Prerequisites: Math 171 or consent of instructor.

3 units

Math 271B. Advanced Mathematical Logic
A course specializing in one or more of the advanced branches of mathematical logic such as set theory, recursion theory, proof theory, logic for computer science.

Prerequisite: Math 271A or consent of instructor.

3 units

Math 275. Topology
Separation convergence (nets and/or filters. Global and local compactness and connectedness. Compactification and completion. Function spaces. Other topics such as uniform spaces and topological groups, dimension, metrization.

Prerequisite: Math 175 or consent of instructor.

3 units; alternate years

Math 279. Graph Theory
Advanced course in graph theory covering graphs, digraphs, trees, networks, connectedness, eulerian circuits, hamiltonian cycles, graph embeddings, matchings, factorizations, graph colorings, and Ramsey theory.

Prerequisites: Math 179, or both Math 142 and an upper division algebra class, or instructor consent.

3 units

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Math 285. Advanced Topics in Mathematics
Selected topics in mathematics. Topics vary each semester.
Prerequisite: Suitable upper division background in mathematics set by instructor.
Repeatable for a maximum of 12 units.
3 units

Math 298. Special Study
Advanced individual research and projects.
Prerequisite: Approval of department chairperson.
Credit/No Credit grading.
1-4 units

Math 299. Master's Thesis
Prerequisite: Admission to candidacy for the M.A. or M.S. degree.
Credit/No Credit grading.
1-4 units

Mathematics Education

Upper Division

MtEd 166. Pre-Professional Experience
Participation in a tutoring program for lower division mathematics students or serving as teacher assistant. Instruction appropriate to tutoring.
CR/NC grading.
Repeatable for a maximum of 6 units.
1-3 units

MtEd 184Y. Student Teaching II–Classroom Teaching
Minimum 80-120 class periods of classroom teaching, laboratory or field teaching in appropriate single subjects, grades K-12, and related teaching activities and seminar.
Prerequisites: MtEd 394 and joint approval of major and education departments.
CR/NC grading.
4-6 units

MtEd 184Z. Student Teaching III–Classroom Teaching
Same as 184Y, but in a different subject or may be in a different school, and will be at a different grade level.
Prerequisite: MtEd 394. CR/NC grading.
4-6 units

MtEd 394. Secondary School Mathematics
The place and function of mathematics in secondary education, improvement and evaluation of instruction, and teaching the subject matter of secondary mathematics.
Prerequisites: MtEd 166 or instructor consent and either of the following: Minor in Math and passing score on NTE in Math, or within 9 units of completing the approved waiver program in mathematics.
3 units

Graduate

MtEd 242C. Educational Internship in Teaching
See EdTE 242C for course description.
Credit/No Credit grading.
4-6 units

MtEd 257. Supervised Student Teaching in the Community College
See EdTE 257 for course description.
Credit/No Credit grading.
4 units

Computer Science

Lower Division

CS 43. FORTRAN Programming
Introduction to scientific programming and technical details of FORTRAN. Numerous programming assignments.
Prerequisite: Math 21 or 31 with a grade of C- or better, or concurrent enrollment in Math 31 and Metr 60, or instructor consent.
3 units

CS 45. Introduction to Programming in Logo
Introduction to programming using Logo. Includes graphics, list processing, and numerical problem-solving. Recommended for learning how to program. Especially valuable for prospective elementary and secondary teachers.
Prerequisite: Credit in Math 7; satisfaction of ELM requirement, or instructor consent.
3 units

CS 46A. Computer Science I
Basic skills and concepts of computer programming in a high-level language. Program control structures, functions and argument passing, iteration and recursion, arrays and records, problem solving by step-wise refinement, programming and documentation style.
Prerequisite: Math 20 or 30 with a grade of C- or better, or instructor consent.
Lecture 3 hours/lab 3 hours.
4 units

CS 46B. Computer Science II
Abstract date types, encapsulation and information hiding, modular programming and separate compilation, assertions and loop invariants, pointers and dynamic storage allocation, lists, stacks, queues, trees, graphs, searching and sorting algorithms.
Prerequisite: Math 42 and CS 46A with a grade of C- or better, or instructor consent.
Lecture 3 hours/lab 3 hours.
4 units

CS 49. Programming in C
Beginning course in the C language.
Prerequisite: Previous programming experience and completion of Math GE.
3 units

Upper Division

CS 110L. Advanced Computing Laboratory
Programming projects demonstrating data structures, modular design, input/output handling, debugging, testing, error trapping, documentation. Required for use of department labs.
Corequisite: Any Math or CS course and instructor consent.
Lab 3 hours.
1 unit

CS 116A. Introduction to Computer Graphics
Vector geometry, geometric transformations, and the graphics pipeline. Basic raster graphics algorithms for drawing discrete lines, clipping, visible surface determination and shading. Display of curves and surfaces. Graphics data structures.
Prerequisites: Math 32, 129A, and CS 146A with a grade of C- or better in each, or instructor consent.
3 units

CS 116B. Computer Graphics Algorithms
In-depth discussion of algorithms and techniques used in computer graphics and their implementation. Topics include: animation, fractals, anti-aliasing, fill algorithms, visible surface algorithms, color and shading, ray tracing, radiosity and texture maps. Substantial programming required.
Prerequisite: CS 116A with a grade of C- or better.
3 units

CS 140. Assembly Language and Computer Organization
Number bases, representation of instructions and data, data conversion, stacks and other elementary data structures, subroutines, recursion, coroutines, input/output handling, traps, macros. Considerable assembly language programming.
Prerequisite: CS 43 or 46A or 49 with a grade of C- or better, or instructor consent.
3 units

CS 142. Introduction to Combinatorics
See Math 142.
3 units

CS 143C. Numerical Analysis and Scientific Computing
See Math 143C.
3 units

CS 143M. Numerical Analysis and Scientific Computing
See Math 143M.

CS 145A. Declarative Programming
Introduction to concepts and techniques of declarative programming: function abstraction and application, polymorphic functions, higher-order functions, abstract data types, list and symbol processing, closures, tail recursion, eager vs. delayed evaluation, streams, environments, and environment models of evaluation.
Prerequisite: CS 46B with a grade of C- or better, or instructor consent.
3 units

CS 145B. Declarative Programming Topics
Possible topics include: the data drive paradigm, continuations, type inference, unification, resolution, combinators, lambda calculus, stores, and storage models of evaluation.
Prerequisite: CS 145A with a grade of C- or better, or instructor consent.
3 units

M

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CS 146A. Data Structures and Algorithms
Abstract data types, advanced tree structures, directed and undirected graphs, searching and sorting techniques, heaps, hashing, dictionaries, O-notation, introduction to design and analysis of algorithms, introduction to memory management.

Prerequisite: Math 31 (or 21) and Math 42 and CS 46B with a grade of C- or better in each, or instructor consent.

3 units

CS 146B. Software Engineering
Major topics in software engineering, including the software life cycle, prototyping, specification, design, implementation, testing, maintenance. Principles of data abstraction, information hiding, object-oriented design, modularity, good coding style examined in the context of a contemporary language.

Prerequisite: CS 146A with a grade of C- or better and Engl 100W (Technical); or instructor consent.

3 units

CS 147. Machine Structures
Abstract machines and realizations of abstract machines, architecture and organization of computers, primitive operations and man-machine interfaces. Extensive assembly language programming.

Prerequisite: CS 140 with a grade of C- or better, or instructor consent.

3 units

CS 149. Introduction to Operating Systems
Fundamentals: Contiguous and non-contiguous memory management; processor scheduling and interrupts; concurrent, mutually exclusive, synchronized, and deadlocked processes; files. Substantial programming project required.

Prerequisites: CS 146A and 147 with a grade of C- or better in each, or instructor consent.

3 units

CS 151. Object-Oriented Programming
Concepts and techniques of object-oriented programming. Objects, classes, methods, inheritance, polymorphism. Memory management of objects. Windowing systems. Comparison of object-oriented languages (C++, Smalltalk, CLOS).

Prerequisite: CS 146A with a grade of C- or better, or instructor consent.

3 units

CS 152. Programming Language Principles
Unifying concepts fundamental to the understanding of programming languages, including syntax specification, declarations, scope, environments, data types, evaluation strategies, and execution models. Modularization issues, including the specification and implementation of abstract data types. Programming projects in several different languages.

Prerequisites: CS 145A and 146A with a grade of C- or better in each, or instructor consent.

3 units

CS 153. Concepts of Compiler Design
Theoretical aspects of compiler design, including parsing context free languages, lexical analysis, translation specification, and machine-independent code generation. Programming projects to demonstrate design topics.

Prerequisites: CS 140 and 146A with a grade of C- or better in each, or instructor consent.

3 units

CS 154. Formal Languages and Computability
Finite automata, context-free languages, Turing machines, computability.

Prerequisite: CS 142 with a grade of C- or better, or instructor consent.

3 units

CS 155. Introduction to the Design and Analysis of Algorithms
Algorithm design, O-notation, recurrence relations, average case behavior, fast Fourier transform, NP-completeness. Analysis of searching, sorting, and graph algorithms.

Prerequisites: CS 142 and CS 146A with a grade of C- or better in each, or instructor consent.

3 units

CS 156. Introduction to Artificial Intelligence
Basic concepts and techniques of artificial intelligence: Problem solving, search strategies, game playing. Topics include natural languages, vision systems, and robotics.

Prerequisite: CS 145A with a grade of C- or better, or instructor consent.

3 units

CS 157. Introduction to Data Base Management Systems
Concepts and structures for implementation of data base management systems; file and data organization; descriptions, integrity, and reliability of data models; query languages; design strategies.

Prerequisite: CS 146A with a grade of C- or better, or instructor consent.

3 units

CS 158. Computer Networks
Introduction to computer networks, network layered architectures, performance and queuing characteristics of network models. Labwork using networks.

Prerequisites: CS 146A and 147 with grades of C- or better, or instructor consent.

3 units

CS 159. Introduction to Parallel Processing
Major parallel architectures: shared memory, distributed memory, SIMD, MIMD. Parallel algorithms: techniques for scientific applications, measures of performance. Parallel programming: principles and implementations in various languages. Assignments on available parallel and vector computers.

Prerequisites: CS 146A with a grade of C- or better, or instructor consent.

3 units

CS 180. Individual Studies
Individual study in a specific field.

Prerequisite: Department chair approval.
Repeatable for credit.
CR/NC grading.
1-3 units

CS 195. Honors Seminar
Senior project on advanced topics in computer science as determined by the instructor and departmental honors committee. Written paper and oral presentation of the project required.

Prerequisites: At least junior standing as computer science major, GPA in major of 3.5 or higher, and instructor consent.

3 units

Graduate

CS 216. Geometric Modeling
Representation of curves and surfaces, basic differential geometry, solid modeling fundamentals, implementation considerations.

Prerequisites: CS 116A or consent of instructor.

3 units

CS 240. Software Project
A semester-long software project. Students will be assigned a software project by the instructor. Issues pertaining to the project will be discussed in class, including software design methodologies, applicable algorithms and data structures, and system interfaces.

Prerequisite: Classified status in MSCS program

3 units

CS 243. Advanced Numerical Analysis
See Math 243.

3 units

CS 247. Advanced Computer Architecture
Advanced topics in vector architectures, including: pipelined architectures, dataflow computers, VLSI architectures, butterfly connections; bus and memory architectures; cache structures; hardware implementations of algorithms.

Prerequisite: Math 142, CS 147, and 149; or consent of instructor.

3 units

CS 249. Advanced Operating Systems
Current issues in operating systems, including multiprocessor systems and distributed computing, networks, security, and performance. Case studies of current operating systems.

Prerequisite: CS 149 and 247 or consent of instructor.

3 units

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252. Advanced Programming Language Principles

Language design and paradigms, including concepts underlying functional, logic, object-oriented, and parallel paradigms. Theoretical foundations, including lambda calculus, denotational and axiomatic semantics. Proofs of program correctness. Programming projects emphasizing different aspects of language design.

Prerequisites: CS 152 and 254; or consent of instructor.

3 units

CS 253. Advanced Compiler Design

Review of attribute analysis and static semantic evaluation. Runtime environments and code generation. Basic blocks and flow graphs. Register allocation and storage classes. Common subexpression elimination and constant propagation. Loop optimizations. Global data flow analysis. Completion of a code optimization project.

Prerequisite: CS 153 or instructor consent.

3 units

CS 254. Theory of Computation

Models of computation; decidability; complexity measures; hierarchies; P, NP, and other complexity classes; intractable problems.

Prerequisite: CS 154 or consent of instructor.

3 units

CS 255. Design and Analysis of Computer Algorithms

NP-completeness of particular problems. Approximation algorithms. Probabilistic algorithms. Parallel algorithms.

Prerequisite: CS 154 and 155 or consent of instructor.

3 units

CS 256. Topics in Artificial Intelligence

Introduction to tocs in Artificial Intelligence such as problem solving methods, game playing, understanding natural languages, pattern recognition, computer vision, and the general problem of representing knowledge. Students will be expected to use LISP.

Prerequisites: CS 255 and 156 or consent of instructor.

3 units

CS 257. Data Base Management Systems

A study of the organization, design, and development of computer data base systems. Topics covered are : basic objectives of data base organization, a review of existing and proposed data base management systems and their logical views of data, physical storage structuring techniques and related access methods and assessment of the impact of newer storage technologies of future data base system development.

Prerequisites: CS 157 and 255 or consent of instructor.

3 units

CS 258. Computer Communication Systems

Design and analysis of message-switched networks of terminals and computers. Topics include topological design, line capacity allocation, routing and flow control algorithms, transmission protocols and teleconferencing applications.

Prerequisite: CS 158 or consent of instructor.

3 units

CS 286. Advanced Topics in Computer Science

Selected topics in computer science. Topics vary each semester.

Prerequisite: Suitable upper division background in mathematics and computer science set by instructor.

Repeatable for a maximum of 12 units.

3 units

CS 290. Topics in Computer Science

Advanced topics in computer science:

Topics in Data Structures

Prerequisite: CS 255.

Topics in Computer Graphics.

Prerequisite: CS 116A and 255.

Topics in Computation Theory

Prerequisite: CS 254.

Topics in Algorithms

Prerequisite: CS 255.

Topics in Parallel Programming

Prerequisite: CS 255 or consent of instructor.

3 units each

CS 295. Graduate Seminar in Computer Science

Current topics from computer science research literature. Each student will read one or more papers and present the subject matter in an in-class oral presentation and complete a term paper on the same or similar subject.

Prerequisite: All core courses for the MSCS.

3 units

CS 298. Special Study

Advanced individual research and projects.

Prerequisite: Approval of Department chair.

Credit/No Credit grading.

1-3 units

CS 299. Master's Thesis

Prerequisite: Admission to candidacy for the M.S. degree.

Credit/No Credit grading.

1-3 units

M