Applied Mathematics & Statistics

Program Description

The Applied Mathematics and Statistics Department (AMS) offers an undergraduate degree in which students are exposed to a breadth of coursework in computational mathematics, applied mathematics, and statistics. In the senior year, students may choose an area of emphasis in either Computational and Applied Mathematics (CAM) or Statistics (STAT). Both options emphasize technical competence, problem-solving, teamwork, projects, relation to other disciplines, verbal, written, and graphical skills.

In a broad sense, these programs stress the development of practical applications and techniques to enhance the overall attractiveness of applied mathematics and statistics majors to a wide range of employers in industry and government. More specifically, AMS utilizes a modeling "field session" to introduce concepts and techniques in mathematical modeling and the senior capstone experiences in Computational and Applied Mathematics and Statistics to engage high-level undergraduate students in problems of practical applicability for potential employers. These courses are designed to simulate an industrial job or research environment. The close collaboration with potential employers and professors improves communication between our students and the private sector, and sponsors from other disciplines on campus.

Applied Mathematics and Statistics majors are encouraged to use free elective courses to gain knowledge in another discipline and incorporate either an Area of Special Interest (ASI) or a minor. This adds to the flexibility of the program and qualifies students for a wide variety of careers.

In addition to offering undergraduate and graduate degree programs, the Department provides the teaching skills and technical expertise to develop capabilities in computational mathematics, applied mathematics, and statistics for all Colorado School of Mines (CSM) students.

Program Educational Objectives

(Bachelor of Science in Applied Mathematics and Statistics)

In addition to contributing toward achieving the educational objectives described in the Mines Graduate Profile and the Accreditation Board for Engineering and Technology's (ABET) accreditation criteria, the Applied Mathematics and Statistics Program at Mines has established the following program educational objectives:

Students will demonstrate technical expertise within mathematics and statistics by:

- Designing and implementing solutions to practical problems in science and engineering; and,
- Using appropriate technology as a tool to solve problems in mathematics.

Students will demonstrate a breadth and depth of knowledge within mathematics by:

- Extending course material to solve original problems,
- Applying knowledge of mathematics to the solution of problems,
- Identifying, formulating and solving mathematics problems, and
- Analyzing and interpreting statistical data.

Students will demonstrate an understanding and appreciation for the relationship of mathematics to other fields by:

- Applying mathematics and statistics to solve problems in other fields,
- Working in cooperative multidisciplinary teams, and
- Choosing appropriate technology to solve problems in other disciplines.

Students will demonstrate an ability to communicate mathematics effectively by:

- Giving oral presentations,
- Completing written explanations,
- Interacting effectively in cooperative teams, and
- Understanding and interpreting written material in mathematics.

Curriculum

The calculus sequence emphasizes mathematics applied to problems students are likely to see in other fields. This supports the curricula in other programs where mathematics is important, and assists students who are under prepared in mathematics. Priorities in the mathematics curriculum include: applied problems in the mathematics courses and ready utilization of mathematics in the science and engineering courses.

This emphasis on the utilization of mathematics continues through the upper-division courses. Another aspect of the curriculum is the use of a spiraling mode of learning in which concepts are revisited to deepen the students' understanding.

The applications, teamwork, assessment and communications emphasis directly address ABET criteria and the Mines graduate profile. The curriculum offers the following two areas of emphases:

Degree Requirements (Applied Mathematics and Statistics)

Computational and Applied Mathematics (CAM) EMPHASIS

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, CBEN 110, CHGN 122, or CHGN 125	3.0		3.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
HASS100	NATURE AND HUMAN VALUES	4.0		4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0
Spring		**lec**	**lab**	**sem.hrs**
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
EDNS151	DESIGN I			3.0

MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
PHGN100	PHYSICS I - MECHANICS	3.0	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CSCI261	PROGRAMMING CONCEPTS	3.0		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Spring		**lec**	**lab**	**sem.hrs**
HASS200	GLOBAL STUDIES	3.0		3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3.0
MATH332	LINEAR ALGEBRA or 342	3.0		3.0
CSCIxxx	COMPUTER ELECTIVE[1]	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		**lec**	**lab**	**sem.hrs**
MATH300	FOUNDATIONS OF ADVANCED MATHEMATICS	3.0		3.0
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0		3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL ELECTIVE	3.0		3.0
MATH310	INTRODUCTION TO MATHEMATICAL MODELING			3.0
MATH	MATHEMATICS-CAM ELECTIVE[2]	3.0		3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
MATH301	INTRODUCTION TO ANALYSIS	3.0		3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0		3.0
MATH	MATHEMATICS-CAM ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL ELECTIVE	3.0		3.0
MATH431	MATHEMATICAL BIOLOGY			3.0
				15.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0		3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				18.0

Spring		**lec**	**lab**	**sem.hrs**
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	4.0		4.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				16.0

Total Semester Hrs: 128.5

[1] May be satisfied by CSCI262 or any other approved computationally intensive course.

Mathematics-CAM elective list. CAM students must choose at least 2 electives from this list. [2]

MATH440	PARALLEL SCIENTIFIC COMPUTING	3.0
MATH454	COMPLEX ANALYSIS	3.0
MATH457	INTEGRAL EQUATIONS	3.0
MATH458	ABSTRACT ALGEBRA	3.0
MATH459	ASYMPTOTICS	3.0
MATH472	MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE	3.0
MATH500	LINEAR VECTOR SPACES	3.0
MATH501	APPLIED ANALYSIS	3.0
MATH514	APPLIED MATHEMATICS I	3.0
MATH515	APPLIED MATHEMATICS II	3.0
MATH550	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH551	COMPUTATIONAL LINEAR ALGEBRA	3.0
MATH	Department approval required for courses not on this list.	

Mathematics-STAT Elective List. CAM students may choose up to 4 electives from this list to satisfy CAM/STAT Elective requirements. [2]

MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
MATH432	SPATIAL STATISTICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH437	MULTIVARIATE ANALYSIS	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH439	SURVIVAL ANALYSIS	3.0
MATH482	STATISTICS PRACTICUM (CAPSTONE)	4.0
MATH530	INTRODUCTION TO STATISTICAL METHODS	3.0
MATH531	THEORY OF LINEAR MODELS	3.0
MATH534	MATHEMATICAL STATISTICS I	3.0
MATH535	MATHEMATICAL STATISTICS II	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
CSCI406	ALGORITHMS	3.0
MATH	Department approval required for courses not on this list.	

Statistics (STATS) EMPHASIS

Freshman

Fall		lec	lab	sem.hrs
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, CBEN 110, CHGN 122, or CHGN 125	3.0		3.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
HASS100	NATURE AND HUMAN VALUES	4.0		4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				16.0

Spring		lec	lab	sem.hrs
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
EDNS151	DESIGN I			3.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
PHGN100	PHYSICS I - MECHANICS	3.0	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Sophomore

Fall		lec	lab	sem.hrs
CSCI261	PROGRAMMING CONCEPTS	3.0		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.0

Spring		lec	lab	sem.hrs
CSCI262	DATA STRUCTURES	3.0		3.0
HASS200	GLOBAL STUDIES	3.0		3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3.0
MATH332	LINEAR ALGEBRA or 342	3.0		3.0
FREE	FREE ELECTIVE			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				15.5

Junior

Fall		lec	lab	sem.hrs
MATH300	FOUNDATIONS OF ADVANCED MATHEMATICS	3.0		3.0
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0		3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0		3.0
MATH	MATHEMATICS-STAT ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL ELECTIVE	3.0		3.0
MATH310	INTRODUCTION TO MATHEMATICAL MODELING			3.0
				18.0

Spring		lec	lab	sem.hrs
MATH301	INTRODUCTION TO ANALYSIS			3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0		3.0
MATH	MATHEMATICS-STAT ELECTIVE[2]	3.0		3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) MID-LEVEL ELECTIVE	3.0		3.0
				15.0

Senior

Fall		lec	lab	sem.hrs
CSCI403	DATA BASE MANAGEMENT			3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0		3.0
MATH	MATHEMATICS CAM/STAT ELECTIVE[2]	3.0		3.0
ELECTIVE	HUMANITIES & SOCIAL SCIENCE (H&SS) 400-LEVEL ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				18.0

Spring		lec	lab	sem.hrs
MATH437	MULTIVARIATE ANALYSIS			3.0

MATH482	STATISTICS PRACTICUM (CAPSTONE) (STAT Capstone)	4.0	4.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0	3.0
MATH	MATHEMATICS-CAM/STAT ELECTIVE[2]	3.0	3.0
FREE	FREE ELECTIVE	3.0	3.0
			16.0

Total Semester Hrs: 128.5

Mathematics-STAT Elective List. STAT students must choose at least 2 electives from this list. [2]

MATH432	SPATIAL STATISTICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH439	SURVIVAL ANALYSIS	3.0
MATH530	INTRODUCTION TO STATISTICAL METHODS	3.0
MATH531	THEORY OF LINEAR MODELS	3.0
MATH534	MATHEMATICAL STATISTICS I	3.0
MATH535	MATHEMATICAL STATISTICS II	3.0
MATH	Department approval required for courses not on this list.	

Mathematics-CAM Elective List. STAT students may choose up to 4 electives from this list to satisfy CAM/STAT Elective requirements. [2]

MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0
MATH431	MATHEMATICAL BIOLOGY	3.0
MATH440	PARALLEL SCIENTIFIC COMPUTING	3.0
MATH454	COMPLEX ANALYSIS	3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH457	INTEGRAL EQUATIONS	3.0
MATH458	ABSTRACT ALGEBRA	3.0
MATH459	ASYMPTOTICS	3.0
MATH472	MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE	3.0
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	4.0
MATH500	LINEAR VECTOR SPACES	3.0
MATH501	APPLIED ANALYSIS	3.0
MATH514	APPLIED MATHEMATICS I	3.0
MATH515	APPLIED MATHEMATICS II	3.0
MATH550	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH551	COMPUTATIONAL LINEAR ALGEBRA	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI406	ALGORITHMS	3.0
MATH	Department approval required for courses not on this list.	

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- CSCI100 through CSCI799 inclusive
- MACS100 through MACS799 inclusive (Previous subject code)
- MATH100 through MATH799 inclusive

Overview

The Mines guidelines for Minor/ASI can be found in the Undergraduate Information section of the Mines Catalog. The Department of Applied Mathematics and Statistics offers the following:

ASIs are available in:

Computational and Applied Mathematics (CAM)

Required Courses		
MATH225	DIFFERENTIAL EQUATIONS	3.0
or MATH235	DIFFERENTIAL EQUATIONS HONORS	
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0
MATH332	LINEAR ALGEBRA	3.0
or MATH342	HONORS LINEAR ALGEBRA	
Plus 3 hours of elective courses listed below.		

Statistics (STAT)

Required Courses		
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
Plus 3 hours of elective courses from the list below.		

Mathematical Sciences

Required Courses		
MATH225	DIFFERENTIAL EQUATIONS	3.0
Plus 9 hours of upper division or graduate level MATH courses. 3 of which must be at the 400-level.		

Minors are available in:

Computational and Applied Mathematics (CAM)

Required Courses		
MATH225	DIFFERENTIAL EQUATIONS	3.0
or MATH235	DIFFERENTIAL EQUATIONS HONORS	
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0
MATH332	LINEAR ALGEBRA	3.0
or MATH342	HONORS LINEAR ALGEBRA	
Plus 9 hours of electives from the list below.		

Statistics (STAT)

Required Courses		

MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
Plus 6 hours of electives from the list below		

Mathematical Sciences

Required Courses		
MATH225	DIFFERENTIAL EQUATIONS	3.0
Plus 15 hours of upper division or graduate level MATH courses. 3 of which must be at the 400-level.		

To complete a Minor/ASI in Computational and Applied Mathematics (CAM), students must choose 9 credits (Minor) or 3 credits (ASI) from the following elective list

MATH301	INTRODUCTION TO ANALYSIS	3.0
MATH310	INTRODUCTION TO MATHEMATICAL MODELING	3.0
MATH331	MATHEMATICAL BIOLOGY	3.0
MATH348	ADVANCED ENGINEERING MATHEMATICS	3.0
MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0
MATH437	MULTIVARIATE ANALYSIS	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH440	PARALLEL SCIENTIFIC COMPUTING	3.0
MATH454	COMPLEX ANALYSIS	3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH457	INTEGRAL EQUATIONS	3.0
MATH459	ASYMPTOTICS	3.0
MATH472	MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE	3.0
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	4.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI406	ALGORITHMS	3.0
CSCI441	COMPUTER GRAPHICS	3.0
CSCI444	ADVANCED COMPUTER GRAPHICS	3.0
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
CSCI474	INTRODUCTION TO CRYPTOGRAPHY	3.0
MATH3xx/4xx/5xx	Approved upper division or graduate course	

To complete a Minor/ASI in Statistics (STAT), students must choose 6 credits (Minor) or 3 credits (ASI) from the following elective list

MATH432	SPATIAL STATISTICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH437	MULTIVARIATE ANALYSIS	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH439	SURVIVAL ANALYSIS	3.0
MATH498	SPECIAL TOPICS	1-6
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
CSCI403	DATA BASE MANAGEMENT	3.0
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
MATH3xx/4xx/5xx	Approved upper division or graduate course	

Courses

MATH100. INTRODUCTORY TOPICS FOR CALCULUS. 3.0 Semester Hrs.
(S) An introduction and/or review of topics which are essential to the background of an undergraduate student at CSM. This course serves as a preparatory course for the Calculus curriculum and includes material from Algebra, Trigonometry, Mathematical Analysis, and Calculus. Topics include basic algebra and equation solving, solutions of inequalities, trigonometric functions and identities, functions of a single variable, continuity, and limits of functions. Does not apply toward undergraduate degree or GPA. 3 hours lecture; 3 semester hours.

MATH111. CALCULUS FOR SCIENTISTS AND ENGINEERS I. 4.0 Semester Hrs.
(I, II, S) First course in the calculus sequence, including elements of plane geometry. Functions, limits, continuity, derivatives and their application. Definite and indefinite integrals; Prerequisite: precalculus. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH112. CALCULUS FOR SCIENTISTS AND ENGINEERS II. 4.0 Semester Hrs.
Equivalent with MATH122,
(I, II, S) Vectors, applications and techniques of integration, infinite series, and an introduction to multivariate functions and surfaces. Prerequisite: Grade of C- or better in MATH111. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH113. CALCULUS FOR SCIENTISTS AND ENGINEERS II - SHORT FORM. 1.0 Semester Hr.
(I, II) This is a bridge course for entering freshmen and new transfer students to CSM who have either a score of 5 on the BC AP Calculus exam or who have taken an appropriate Calculus II course at another institution (determined by a departmental review of course materials). Two, three and n-dimensional space, vectors, curves and surfaces in 3-dimensional space, polar, cylindrical and spherical coordinates, and applications of these topics. Prerequisite: Placement by Mines Transfer Specialist or AMS Department recommendation. 1 hour lecture; 1 semester hour.

MATH122. CALCULUS FOR SCIENTISTS AND ENGINEERS II HONORS. 4.0 Semester Hrs.
Equivalent with MATH112,
(I, II) Same topics as those covered in MATH112 but with additional material and problems. Prerequisites: Grade of C- or better in MATH111. 4 hours lecture; 4 semester hours.

MATH198. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MATH199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MATH201. PROBABILITY AND STATISTICS FOR ENGINEERS. 3.0 Semester Hrs.
Equivalent with MATH323,
(I,II,S) This course is an introduction to Probability and Statistics, including fundamentals of experimental design and data collection, the summary and display of data, elementary probability, propagation of error, discrete and continuous probability models, interval estimation, hypothesis testing, and linear regression with emphasis on applications to science and engineering. Prerequisites: MATH112, MATH122 or concurrent enrollment in MATH113. 3 hours lecture; 3 semester hours.

MATH213. CALCULUS FOR SCIENTISTS AND ENGINEERS III. 4.0 Semester Hrs.
(I, II, S) Multivariable calculus, including partial derivatives, multiple integrals, and vector calculus. Prerequisites: Grade of C- or better in MATH112 or MATH122 or Concurrent Enrollment in MATH113. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH214. CALCULUS FOR SCIENTIST AND ENGINEERS III - SHORT FORM. 1.0 Semester Hr.
(I, II) This is a bridge course for entering freshmen and new transfer students to CSM who have taken an appropriate Calculus III course at another institution (determined by a departmental review of course materials). Vector Calculus including line and surface integrals with applications to work and flux, Green's Theorem, Stokes' Theorem and the Divergence Theorem. 1 hour lecture; 1 semester hour.

MATH223. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS. 4.0 Semester Hrs.
(II) Same topics as those covered in MATH213 but with additional material and problems. Prerequisite: (Grade of B- or better in MATH112 or MATH113 or MATH122) OR (concurrent enrollment in MATH113 for new students with pending AP or transfer credit for Calculus II). 4 hours lecture; 4 semester hours.

MATH224. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS. 4.0 Semester Hrs.
(I, II) Early introduction of vectors, linear algebra, multivariable calculus. Vector fields, line and surface integrals. Prerequisite: (Grade of B- or better in MATH112 or MATH113 or MATH122) OR (concurrent enrollment in MATH113 for new students with pending AP or transfer credit for Calculus II). 4 hours lecture; 4 semester hours.

MATH225. DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.
(I, II, S) Classical techniques for first and higher order equations and systems of equations. Laplace transforms. Phase-plane and stability analysis of non-linear equations and systems. Applications from physics, mechanics, electrical engineering, and environmental sciences. Prerequisites: Grade of C- or better in MATH112 or MATH122 or Concurrent Enrollment in MATH113. 3 hours lecture; 3 semester hours.

MATH235. DIFFERENTIAL EQUATIONS HONORS. 3.0 Semester Hrs.
(I, II) Same topics as those covered in MATH225 but with additional material and problems. 3 hours lecture; 3 semester hours. Prerequisite: Grade of B- or better in MATH112 or MATH 113 or MATH122, or concurrent enrollment in MATH113 for new students with pending AP or transfer credit for Calculus II.

MATH298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MATH299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MATH300. FOUNDATIONS OF ADVANCED MATHEMATICS. 3.0 Semester Hrs.
(I) (WI) This course is an introduction to communication in mathematics. This writing intensive course provides a transition from the Calculus sequence to theoretical mathematics curriculum in CSM. Topics include logic and recursion, techniques of mathematical proofs, reading and writing proofs. Prerequisites: MATH112 or MATH122. 3 hours lecture; 3 semester hours.

MATH301. INTRODUCTION TO ANALYSIS. 3.0 Semester Hrs.
Equivalent with MATH401,
(II) This course is a first course in real analysis that lays out the context and motivation of analysis in terms of the transition from power series to those less predictable series. The course is taught from a historical perspective. It covers an introduction to the real numbers, sequences and series and their convergence, real-valued functions and their continuity and differentiability, sequences of functions and their pointwise and uniform convergence, and Riemann-Stieltjes integration theory. Prerequisite: MATH300. 3 hours lecture; 3 semester hours.

MATH307. INTRODUCTION TO SCIENTIFIC COMPUTING. 3.0 Semester Hrs.
Equivalent with CSCI407,MATH407,
(I, II, S) This course is designed to introduce scientific computing to scientists and engineers. Students in this course will be taught various numerical methods and programming techniques to solve basic scientific problems. Emphasis will be made on implementation of various numerical and approximation methods to efficiently simulate several applied mathematical models. Prerequisites: MATH213 or MATH223 or MATH224. Co-requisites: MATH225 or MATH235. 3 hours lecture; 3 semester hours.

MATH310. INTRODUCTION TO MATHEMATICAL MODELING. 3.0 Semester Hrs.
An introduction to modeling and communication in mathematics. A writing intensive course providing a transition from the core math sequence to the upper division AMS curriculum. Topics include a variety of mathematical and statistical modeling techniques. Students will formulate and solve applied problems and will present results orally and in writing. In addition, students will be introduced to the mathematics software that will be used in upper division courses. Prerequisite: MATH201, MATH225.

MATH332. LINEAR ALGEBRA. 3.0 Semester Hrs.
(I, II) Systems of linear equations, matrices, determinants and eigenvalues. Linear operators. Abstract vector spaces. Applications selected from linear programming, physics, graph theory, and other fields. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH334. INTRODUCTION TO PROBABILITY. 3.0 Semester Hrs.
(I) An introduction to the theory of probability essential for problems in science and engineering. Topics include axioms of probability, combinatorics, conditional probability and independence, discrete and continuous probability density functions, expectation, jointly distributed random variables, Central Limit Theorem, laws of large numbers. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture, 3 semester hours.

MATH335. INTRODUCTION TO MATHEMATICAL STATISTICS. 3.0 Semester Hrs.
(II) An introduction to the theory of statistics essential for problems in science and engineering. Topics include sampling distributions, methods of point estimation, methods of interval estimation, significance testing for population means and variances and goodness of fit, linear regression, analysis of variance. Prerequisite: MATH334. 3 hours lecture, 3 semester hours.

MATH340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I, II, S) (WI) Supervised, full-time engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions. Repeatable.

MATH342. HONORS LINEAR ALGEBRA. 3.0 Semester Hrs.
(II) Same topics as those covered in MATH332 but with additional material and problems as well as a more rigorous presentation. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH348. ADVANCED ENGINEERING MATHEMATICS. 3.0 Semester Hrs.
(I, II, S) Introduction to partial differential equations, with applications to physical phenomena. Fourier series. Linear algebra, with emphasis on sets of simultaneous equations. This course cannot be used as a MATH elective by MCS or AMS majors. Prerequisite: MATH225 or MATH235 and MATH213 or MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH398. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MATH399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MATH408. COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.
(I) This course is designed to introduce computational methods to scientists and engineers for developing differential equations based computer models. Students in this course will be taught various numerical methods and programming techniques to simulate systems of nonlinear ordinary differential equations. Emphasis will be on implementation of various numerical and approximation methods to efficiently simulate several systems of nonlinear differential equations. Prerequisite: MATH307. 3 hours lecture, 3 semester hours.

MATH424. INTRODUCTION TO APPLIED STATISTICS. 3.0 Semester Hrs.
(I) Linear regression, analysis of variance, and design of experiments, focusing on the construction of models and evaluation of their fit. Techniques covered will include stepwise and best subsets regression, variable transformations, and residual analysis. Emphasis will be placed on the analysis of data with statistical software. Prerequisites: MATH201 or MATH335 and MATH332 or MATH342. 3 hours lecture; 3 semester hours.

MATH431. MATHEMATICAL BIOLOGY. 3.0 Semester Hrs.
This course will discuss methods for building and solving both continuous and discrete mathematical models. These methods will be applied to population dynamics, epidemic spread, pharmacokinetics and modeling of physiologic systems. Modern Control Theory will be introduced and used to model living systems. Some concepts related to self-organizing systems will be introduced. Prerequisite: MATH307, MATH310, MATH332 or MATH342.

MATH432. SPATIAL STATISTICS. 3.0 Semester Hrs.
(I) Modeling and analysis of data observed in a 2- or 3-dimensional region. Random fields, variograms, covariances, stationarity, nonstationarity, kriging, simulation, Bayesian hierarchical models, spatial regression, SAR, CAR, QAR, and MA models, Geary/Moran indices, point processes, K-function, complete spatial randomness, homogeneous and inhomogeneous processes, marked point processes. Prerequisite: MATH335. Corequisite: MATH424. 3 hours lecture; 3 semester hours.

MATH436. ADVANCED STATISTICAL MODELING. 3.0 Semester Hrs.
(II) Modern methods for constructing and evaluating statistical models. Topics include generalized linear models, generalized additive models, hierarchical Bayes methods, and resampling methods. Time series models, including moving average, autoregressive, and ARIMA models, estimation and forecasting, confidence intervals. Prerequisites: MATH335 and MATH424. 3 hours lecture; 3 semester hours.

MATH437. MULTIVARIATE ANALYSIS. 3.0 Semester Hrs.
(II) Introduction to applied multivariate techniques for data analysis. Topics include principal components, cluster analysis, MANOVA and other methods based on the multivariate Gaussian distribution, discriminant analysis, classification with nearest neighbors. Prerequisites: MATH335 or MATH201 and MATH332 or MATH342. 3 hours lecture; 3 semester hours.

MATH438. STOCHASTIC MODELS. 3.0 Semester Hrs.
(II) An introduction to stochastic models applicable to problems in engineering, physical science, economics, and operations research. Markov chains in discrete and continuous time, Poisson processes, and topics in queuing, reliability, and renewal theory. Prerequisite: MATH334. 3 hours lecture, 3 semester hours.

MATH439. SURVIVAL ANALYSIS. 3.0 Semester Hrs.
(I) Basic theory and practice of survival analysis. Topics include survival and hazard functions, censoring and truncation, parametric and non-parametric inference, hypothesis testing, the proportional hazards model, model diagnostics. Prerequisite: MATH335. 3 hours lecture; 3 semester hours.

MATH440. PARALLEL SCIENTIFIC COMPUTING. 3.0 Semester Hrs.
Equivalent with CSCI440,
(I) This course is designed to facilitate students' learning of parallel programming techniques to efficiently simulate various complex processes modeled by mathematical equations using multiple and multi-core processors. Emphasis will be placed on implementation of various scientific computing algorithms in FORTRAN 90 and its variants using MPI and OpenMP. Prerequisites: MATH307 or CSCI407. 3 hours lecture; 3 semester hours.

MATH454. COMPLEX ANALYSIS. 3.0 Semester Hrs.
(II) The complex plane. Analytic functions, harmonic functions. Mapping by elementary functions. Complex integration, power series, calculus of residues. Conformal mapping. Prerequisite: MATH225 or MATH235 and MATH213 or MATH223 or MATH224. 3 hours lecture, 3 semester hours.

MATH455. PARTIAL DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.
(I, II) Linear partial differential equations, with emphasis on the classical second-order equations: wave equation, heat equation, Laplace's equation. Separation of variables, Fourier methods, Sturm-Liouville problems. Prerequisites: MATH225 or MATH235 and MATH213 or MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH457. INTEGRAL EQUATIONS. 3.0 Semester Hrs.
(I) This is an introductory course on the theory and applications of integral equations. Abel, Fredholm and Volterra equations. Fredholm theory: small kernels, separable kernels, iteration, connections with linear algebra and Sturm-Liouville problems. Applications to boundary-value problems for Laplace's equation and other partial differential equations. Prerequisites: MATH332 or MATH342, and MATH455. 3 hours lecture; 3 semester hours.

MATH458. ABSTRACT ALGEBRA. 3.0 Semester Hrs.
(I) This course is an introduction to the concepts of contemporary abstract algebra and applications of those concepts in areas such as physics and chemistry. Topics include groups, subgroups, isomorphisms and homomorphisms, rings, integral domains and fields. Prerequisites: MATH300. 3 hours lecture; 3 semester hours.

MATH459. ASYMPTOTICS. 3.0 Semester Hrs.
Equivalent with MATH559,
(I) Asymptotic methods are used to find approximate solutions to problems when exact solutions are unavailable or too complicated to be useful. A broad range of asymptotic methods is developed, covering algebraic problems, integrals and differential equations. Prerequisites: MATH213 and MATH225. 3 hours lecture; 3 semester hours.

MATH470. MATHEMATICAL MODELING OF SPATIAL PROCESSES IN BIOLOGY. 3.0 Semester Hrs.
This course is an introduction to mathematical modeling of spatial processes in biology. The emphasis is on partial differential equation models from a diverse set of biological topics such as cellular homeostasis, muscle dynamics, neural dynamics, calcium handling, epidemiology, and chemotaxis. We will survey a variety of models and analyze their results in the context of the biology. Mathematically, we will examine the diffusion equation, advection equation, and combinations of the two that include reactions. There will be a significant computational component to the course including bi-weekly computational labs; students will solve the model equations and perform computations using MATLAB. Prerequisite: MATH331, MATH455 or equivalent courses and familiarity with MATLAB.

MATH472. MATHEMATICAL AND COMPUTATIONAL NEUROSCIENCE. 3.0 Semester Hrs.
(II) This course will focus on mathematical and computational techniques applied to neuroscience. Topics will include nonlinear dynamics, hysteresis, the cable equation, and representative models such as Wilson-Cowan, Hodgkin-Huxley, and FitzHugh-Nagumo. Applications will be motivated by student interests. In addition to building basic skills in applied math, students will gain insight into how mathematical sciences can be used to model and solve problems in neuroscience; develop a variety of strategies (computational, theoretical, etc.) with which to approach novel mathematical situations; and hone skills for communicating mathematical ideas precisely and concisely in an interdisciplinary context. In addition, the strong computational component of this course will help students to develop computer programming skills and apply appropriate technological tools to solve mathematical problems. Prerequisite: MATH331. 3 hours lecture; 3 semester hours.

MATH482. STATISTICS PRACTICUM (CAPSTONE). 4.0 Semester Hrs.
This is the capstone course in the Statistics option. Students will apply statistical principles to data analysis through advanced work, leading to a written report and an oral presentation. Choice of project is arranged between the student and the individual faculty member who will serve as advisor. Prerequisite: MATH335, MATH424.

MATH484. MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE). 4.0 Semester Hrs.
This is the capstone course in the Computational and Applied Mathematics option. Students will apply computational and applied mathematics modeling techniques to solve complex problems in biological, engineering and physical systems. Mathematical methods and algorithms will be studied within both theoretical and computational contexts. The emphasis is on how to formulate, analyze and use nonlinear modeling to solve typical modern problems. Prerequisite: MATH331, MATH307, MATH455.

MATH491. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
(I) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

MATH492. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.
(II) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: none. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

MATH498. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MATH499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

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