Mathematics, Physics, Astronomy and Statistics

Degrees and Areas of Concentration

The Department of Mathematics, Physics, Astronomy and Statistics offers superb course work leading to the following degrees:

- B.A. in Mathematics
- B.S. in Mathematics with emphasis areas of
  - Data Science
  - Fiscal Mathematics
- B.A. in Physics
- B.S. in Physics with emphasis areas of
  - Astrophysics
  - Engineering Physics
  - General Physics
  - Biophysics
- B.A. or B.S. in Physics or Mathematics with Master's Level Coursework for Secondary Teacher Certification
- B.S. in Secondary Education with emphasis areas of
  - Mathematics
  - Science-Physics
- M.A. in Mathematics

Fellowships and Scholarships

The Department Mathematics, Physics, Astronomy and Statistics offers a number of scholarships and awards.

Mathematics Majors

- The Alumni Scholarship is awarded to outstanding undergraduate students and is open to all junior and senior mathematics majors.
- The Edward Z. Andalafte Memorial Scholarship is awarded to outstanding undergraduate mathematics majors at the sophomore level or higher.
- The Raymond and Thelma Balbes Scholarship in Mathematics is awarded to students at the sophomore level or higher who are pursuing a degree in mathematics, have an overall GPA of at least 3.0 and a GPA of at least 3.2 in mathematics and who have completed three semesters of calculus.
- The Joseph M. and Mary A. Vogl Scholarship in Mathematics is a need based monetary award for undergraduate mathematics majors.

Physics Majors

- Physics & Astronomy Alumni Scholarship is available to new physics majors with outstanding ACT or SAT scores or continuing physics majors with outstanding academic records.
- The Richard D. Schwartz Scholarship is available to full-time junior/senior physics majors in good academic standing with financial need.
- The Don C. and Susan P. Winter Endowed Scholarship in Physics & Astronomy is available to physics majors with a minimum ACT score of 24 or who have a minimum GPA of 3.0.
- The Feldman-Cheng Endowed Scholarship is available to physics majors in good academic standing.
- The Pierre Laclede/Physics & Astronomy Alumni Scholarship for undergraduate physics majors is available to physics majors who are also accepted into the Pierre Laclede Honors College.
- The Junior Alumni Award is awarded to physics majors who attain a 3.5 average or better in Physics 2111 and 2112. The award is given to the student in the semester they enroll in Physics 3200. Transfer students must take Physics 2112 on this campus to be eligible for this scholarship.
- The Senior Alumni Award is given to the outstanding physics major at the senior level with the highest GPA among the senior class.
- The Jeffrey Earl Award is given to an outstanding graduating senior every May.
- Undergraduate Research Awards are available for undergraduate physics majors who conduct a research project with a faculty mentor. Students receiving this award are required to enroll for at least one credit hour of Physics 3390 and present their research results at the campus Undergraduate Research Symposium in April.
- Teaching Assistantships with stipends may also be available to qualifying students to prepare them for the independent effort required in industry or graduate school.
- NASA Research Internships for the summer and academic year are available for students interested in astrophysics through the NASA/Missouri Space Grant Consortium.

Departmental Honors

The Department of Mathematics, Physics, Astronomy and Statistics will award departmental honors to those B.A. and B.S. degree candidates in Physics with an overall grade point average of 3.2 or better. They must also successfully complete at least 3 credits of PHYS 3390 (Research).

Career Outlook

For Mathematics Majors

A degree in mathematics prepares well-motivated students for interesting careers. Our graduates find positions in industry, government, and education. The demand for individuals well trained in statistics, data science, and mathematics is greater than the available supply. In addition, a number of graduates in mathematics have elected careers in business, law and other related fields where they find logical and analytical skills valuable.

Graduates in mathematics from UMSL are located throughout the country, and they also have a strong local presence. They have careers in banking, health care, engineering and manufacturing, law, finance, public service, management, and actuarial management. Many are working in areas such as systems management, information systems and data management, scientific computing, cryptography, and scientific positions in the armed services. Others have careers in education, especially at secondary and higher levels.

For Physics Majors

Many of our students have been successful in subsequent graduate studies in astrophysics and meteorology, as well as physics. Our alumni have pursued graduate studies and earned doctorate degrees at institutions such as Cornell University, MIT, University of Wisconsin, University of Chicago and Washington University. Students who have elected for careers in industry are now working in a variety of settings for such firms as Emerson Electric, Hewlett Packard, IBM, Boeing, MEMC Electronic Materials (now SunEdison), the National Geospatial-Intelligence

Agency, and Google. Several former students are currently teaching physics in high schools around the St. Louis area.

Undergraduate Degrees

Mathematics BA

Mathematics BS

Emphasis Areas:

- Data Science
- Fiscal Mathematics

Mathematics BA or BS/MA Dual Degree Program

Physics BA

Physics BS

Emphasis Areas:

- Astrophysics
- Biophysics
- Engineering Physics
- General Physics

Graduate Degrees

Mathematics MA

Emphasis Area:

- Data Science

Physics MS

Mathematical and Computational Science PhD

Emphasis Areas:

- Mathematics
- Statistics

Physics PhD

Minors

Mathematics Minor

Physics Minor

Statistics Minor

Affiliated Interdisciplinary Programs

Actuarial Science BS

Actuarial Science Undergraduate Certificate

Data Science Undergraduate Certificate

Secondary Education BSEd, Mathematics Emphasis

Secondary Education BSEd, Physics Emphasis

Astronomy Courses

ASTRON 1001 Cosmic Evolution Introductory Astronomy (MOTR ASTR 100): 3 semester hours
This course presents an overview of astronomy from the planets to the Big Bang. Topics include the celestial motions, planets and the formation of the solar system, stars and stellar evolution, galaxies, and cosmology. Students will be introduced to the latest discoveries and how they affect our understanding of the universe.

ASTRON 1001A Cosmic Evolution/Introduction Astronomy (MOTR ASTR 100): 3 semester hours
Overview of astronomy, from the planets to the Big Bang. Topics include the celestial motions, planets and the formation of the solar system, stars and stellar evolution, galaxies, and cosmology. Students will be introduced to the latest discoveries and how they affect our understanding of the universe. Three classroom hours per week. Same as ASTRON 1001 without the laboratory.

ASTRON 1001L Introductory Astronomy Laboratory: 1 semester hour
Prerequisite: ASTRON 1001 (may be taken concurrently). An introductory Astronomy laboratory to accompany ASTRON 1001. The format is a 2-hour laboratory session per week to enhance lecture material.

ASTRON 1011 Planets and Life in the Universe: 3 semester hours
Man's concept of the solar system from Stonehenge to Einstein; geology and meteorology of the planets of our solar system, with particular attention to results from the space program; exobiology--study of the possibilities of life on other worlds and the best method of communicating with it. Three lecture hours per week.

ASTRON 1012 The Violent Universe and the New Astronomy: 3 semester hours
A nontechnical course focusing on recent results which larger telescopes and the space program have made available. Pulsars, x-ray stars, and black holes; radio astronomy, our galaxy, and interstellar molecules; exploding galaxies and quasars; origin of the expanding universe. Three lecture hours and one observing session per week.

ASTRON 1050 Introduction to Astronomy I (MOTR ASTR 100): 3 semester hours
Prerequisites: MATH 1030 and MATH 1035. A survey of the history of astronomy from the ancient times to present. Theories for the formation and evolution of the solar system and the general features of the solar system and planetary motions are discussed. The physical concept of gravity is presented. The detailed properties of the planets, comets, and asteroids are reviewed, concentrating on recent results from space missions.

ASTRON 1051 Introduction to Astronomy II: 3 semester hours
Prerequisites: MATH 1030 and MATH 1035. A survey of astronomy beyond the solar system. Topics include stars and stellar evolution, neutron stars, and black holes. The physical concept of light and the design of telescopes is discussed in detail. The structure of the Milky Way Galaxy and the large scale structure of the universe are explored. Dark matter, quasars, and active galactic nuclei are discussed in the context of theories for the formation and evolution of the universe. Course does not need to be taken in sequence with ASTRON 1050.

ASTRON 4301 Astrophysics: 3 semester hours
Prerequisite: PHYSICS 3231 or consent of instructor. A moderately technical introduction to astrophysics. Topics will include: physics of stellar interiors and atmospheres; interpretation of stellar spectra; stellar evolution; radio astronomy; and cosmology.

ASTRON 4322 Observational Astronomy: 4 semester hours
Prerequisite: ASTRON 1050, ASTRON 1051 and PHYSICS 3231. Tools of the astronomer: telescopes, spectroscopy, photoelectric photometry. Students will work on a number of projects which will enable them to develop expertise in obtaining, reducing, and analyzing astronomical observations. Student night observing will be an important part of the course. This course is primarily for persons who are astronomy or physics majors or who have some equivalent background.

ASTRON 5322 Intermediate Observational Astronomy: 4 semester hours
Prerequisites: ASTRON 1050, ASTRON 1051, and PHYSICS 3231; or graduate standing. This course covers the tools of the astronomer: telescopes, spectroscopy, photoelectric photometry. Students will work on a number of intermediate projects, which will enable them to develop expertise in obtaining, reducing, and analyzing astronomical observations. Student night observing will be an important part of this course. This course is primarily for astronomy or physics majors. Students may not receive credit for both ASTRON 4322 and ASTRON 5322.

Atmospheric Science Courses

ATM SCI 1001 Elementary Meteorology: 3 semester hours
Prerequisites: MATH 1020 or equivalent. This course covers atmospheric phenomena, weather, and climate. Topics include temperature, pressure, and moisture distributions in the atmosphere and dynamical effects such as radiation, stability, storms, and general circulation.

ATM SCI 1001L Elementary Meteorology Laboratory: 1 semester hour
Prerequisite: Must be concurrently enrolled in ATM SCI 1001. An introductory meteorology laboratory to accompany ATM SCI 1001. The lab exercises consist of current weather studies to enhance the material in ATM SCI 1001.

ATM SCI 1002 Earth Climate Studies: 3 semester hours
Prerequisite: MATH 1020 or equivalent. This course covers the physical foundations of the Earth's climate system, scientific evidence for climate change and its causes, and the effects of climate change on the ecosystem of the Earth. This course satisfies the information literacy general education requirement.

Geology Courses

GEOL 1001 General Geology: 3 semester hours
This course looks at earth materials and processes, including geological aspects of the resource/energy problem.

GEOL 1001L General Geology Lab: 1 semester hour
This geology laboratory involves identification of common rocks and minerals.

GEOL 1002 Historical Geology: 3 semester hours
This course is a study of changes in geography, climate, and life through geological time. This study includes the origin of the continents, ocean basins, and mountains in the light of continental drift.

GEOL 1002L Historical Geology Lab: 1 semester hour
Prerequisites: GEOL 1002 (may be taken concurrently). This course is a Geology laboratory, which primarily involves the description and identification of fossils.

GEOL 1053 Oceanography (MOTR PHYS 110): 3 semester hours
The atmospheric and ocean circulations; the chemistry and geology of the deep sea; and their effects on the distribution of marine organisms.

Mathematics Courses

MATH 0005 Intermediate Algebra: 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. Preparatory material for college level mathematics courses. Covers systems of linear equations and inequalities, polynomials, rational expressions, exponents, quadratic equations, graphing linear and quadratic functions. This course carries no credit towards any baccalaureate degree.

MATH 1020 Contemporary Mathematics (MOTR MATH 120): 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course presents methods of problem solving, centering on problems and questions which arise naturally in everyday life. Topics may include aspects of algebra, the mathematics of finance, probability and statistics, exponential growth, and other topics chosen from traditional and contemporary mathematics which do not employ the calculus. It is designed for students who do not plan to take calculus and may not be used as a prerequisite for other mathematics courses. Credit will not be granted for MATH 1020 if credit has been granted for MATH 1310, MATH 1800, MATH 1100, MATH 1102, or MATH 1105. Concurrent enrollment in MATH 1020 and any of these courses is not permitted. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1021 Choice and Chance: 3 semester hours
Same as PHIL 1021. Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course provides an introduction to inductive logic and the theory of probability in an organized and systematic way, so as to give students tools for more effective decision-making. We will introduce the probability calculus, basic concepts of utility theory, decision theory and different approaches to understanding probability. This course is designed to be accessible to students of all levels. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1025 Geometry in the Real World: 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course presents topics in geometry designed to enrich the student's understanding of mathematics. Geometry as it applies to the physical world and such fields as art, music, nature, motion, architecture and city planning will be examined. This course is designed to be accessible to students of all levels. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1026 The Music of Math: 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course presents topics in mathematics as they relate to music. Fundamental concepts of music such as intervals, scales, chords, tuning will be explored by developing an understanding of their mathematical underpinnings. An ability to read music in treble and bass clef is strongly recommended. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1030 College Algebra (MOTR MATH 130): 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course, or approval of the department. This is a foundational course in math. Topics may include factoring, complex numbers, rational exponents, simplifying rational functions, functions and their graphs, transformations, inverse functions, solving linear and nonlinear equations and inequalities, polynomial functions, inverse functions, logarithms, exponentials, solutions to systems of linear and nonlinear equations, systems of inequalities, matrices, and rates of change. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1035 Trigonometry: 2 semester hours
Prerequisite: MATH 1030 or MATH 1040, or concurrent registration in either of these two courses, or a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. A study of the trigonometric and inverse trigonometric functions with emphasis on trigonometric identities and equations.

MATH 1045 PreCalculus (MOTR MATH 150): 5 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course is intended for students planning to take MATH 1800. It covers a range of topics including polynomials, logarithms, and complex numbers; functions and their graphs; systems of equations and inequalities; trigonometry; and more. fulfills the University's general education mathematics proficiency requirement. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1100 Basic Calculus: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course introduces plane analytic geometry and basic differential and integral calculus with applications to various areas. No credit for Mathematics majors. Credit not granted for both MATH 1800 and MATH 1100.

MATH 1102 Finite Mathematics: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course introduces logic and set theory, partitions and counting problems, elementary probability theory, stochastic processes, Markov chains, vectors and matrices, linear programming, and game theory.

MATH 1105 Basic Probability and Statistics: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course or consent of the department. This course is an introduction to probability and statistics. Topics may include probability, descriptive statistics, discrete and continuous random variables and their distribution functions, sampling and sampling distributions, confidence intervals, and one-variable hypothesis testing. Credit will not be granted for more than one of MATH 1310, MATH 1320, and MATH 1105.

MATH 1150 Structure of Mathematical Systems I: 3 semester hours
Prerequisites: 45 hours of college credit and a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course OR successful completion of MATH 1030 no more than 2 years prior to enrollment in this course. This course examines topics including problem solving, patterns, sets, numeration systems, whole numbers and operations, positive rational numbers and operations, and an introduction to variables and equations, with an emphasis placed on using multiple techniques for each of the aforementioned topics.

MATH 1320 Introduction to Probability and Statistics: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or consent of the department. The course will cover basic concepts and methods in probability and statistics. Topics include descriptive statistics, probabilities of events, random variables and their distributions, sampling distributions, estimation of population parameters, confidence intervals and hypothesis testing for population means and population proportions, chi-square tests. A student may not receive credit for more than one of MATH 1310, MATH 1320 and MATH 1105.

MATH 1800 Analytic Geometry and Calculus I: 5 semester hours
Prerequisites: MATH 1030 and MATH 1035, or MATH 1040 and MATH 1035, or MATH 1045, or a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course, or approval of the department. This course provides an introduction to differential and integral calculus. Topics include limits, derivatives, related rates, Newton's method, the Mean-Value Theorem, Max-Min problems, the integral, the Fundamental Theorem of Integral Calculus, areas, volumes, and average values.

MATH 1900 Analytic Geometry and Calculus II: 5 semester hours
Prerequisite: MATH 1800. This course covers analytical geometry and additional aspects of calculus. Topics may include inverse functions, integration techniques, further applications of integration, parametric and polar equations, and infinite series, including Taylor series of functions.

MATH 2000 Analytic Geometry and Calculus III: 5 semester hours
Prerequisite: MATH 1900. Topics include vectors, cylindrical and spherical coordinates, vector-valued functions, arc length and curvature, functions of several variables, partial and directional derivatives, gradients, extrema, Lagrange multipliers, multiple integrals, change of variables, surface area, vector fields, Stokes' Theorem.

MATH 2010 Introduction to Inquiry Approaches to STEM Education (STEP I): 1 semester hour
Same as CHEM 2010, PHYSICS 2010, BIOL 2010, and SEC ED 2010. Prerequisites: Concurrent enrollment BIOL 1821, BIOL 1831, CHEM 1111, CHEM 1121, PHYSICS 2111, PHYSICS 2112, MATH 1800, or MATH 1900 or have a declared STEM major. Students who want to explore teaching careers become familiar with lesson plan development by writing, teaching and observing lessons in a local school class. Students build and practice inquiry-based lesson design skills and become familiar with and practice classroom management in the school setting. As a result of the STEP I experiences students should be able to decide whether to continue to explore teaching as a career and ultimately finishing the remainder of the WE TEACH MO curriculum leading to teacher certification. The classroom observations and teaching represent a major field component and requires at least one two hour block of free time during the school day once a week.

MATH 2011 Designing Inquiry-Based STEM Experiences (STEP II): 1 semester hour
Same as CHEM 2011, PHYSICS 2011, BIOL 2011, and SEC ED 2011. Prerequisites: BIOL 2010, CHEM 2010, PHYSICS 2010, MATH 2010, or SEC ED 2010. Students explore teaching careers, become familiar with STEM school setting through observing and discussing the school environment and by developing and teaching inquiry-based lessons.

MATH 2020 Introduction to Differential Equations: 3 semester hours
Prerequisite: MATH 2000. Topics will be chosen from: linear differential equations, equations with constant coefficients, laplace transforms, power series solutions, systems of ordinary differential equations.

MATH 2300 Introduction to Discrete Structures: 3 semester hours
Prerequisites: MATH 1100 or MATH 1800, and CMP SCI 1250. This course treats fundamental mathematical concepts in discrete structures useful for computer science. Topics include logic, sets, equivalence relations and partitions, functions, elementary number theory, cardinality, basic combinatorial methods, trees and graphs.

MATH 2450 Elementary Linear Algebra: 3 semester hours
Prerequisite: MATH 1100 or MATH 1900. An introduction to linear algebra. Topics will include complex numbers, geometric vectors in two and three dimensions and their linear transformations, the algebra of matrices, determinants, solutions of systems of equations, eigenvalues and eingenvectors.

MATH 2510 Structure of Mathematical Systems II: 3 semester hours
Prerequisites: MATH 1150. Topics include an introduction to probability, statistics, and displays of data; a study of elementary geometry, including points, lines, planes, angles, properties of triangles, properties of quadrilaterals, other 2- and 3-dimensional shapes; similarity; measurement and conversions; Pythagorean Theorem; perimeter; area; surface area, and volume. This course does not apply towards the elective requirements for any of the majors, minors or related areas in mathematics and statistics.

MATH 3000 Discrete Structures: 3 semester hours
Prerequisites: MATH 1800 or MATH 1100, and CMP SCI 1250 or equivalent. This course introduces fundamental concepts and important data structures in Discrete Mathematics and serves as an important foundation for subsequent courses in Computer Science. It provides a formal system on which mathematical reasoning is based, and various problem-solving strategies with emphasis on the algorithmic approach (both iterative and recursive). Topics include logic, sets, functions and relations; methods of proof, including mathematical induction; elements of number theory; order of growth and basic analysis of algorithms efficiency; recurrence relations; basic counting methods; graphs and trees. This course does not apply towards the elective requirements for any of the majors, minors or related areas in mathematics and statistics.

MATH 3250 Foundations of Mathematics: 3 semester hours
Prerequisites: MATH 1900 and CMP SCI 1250. The course will focus on developing an understanding of proofs and rigorous mathematical reasoning. Topics will include logic, sets, relations, functions, number theory, and counting methods.

MATH 3320 Applied Statistics: 3 semester hours
Prerequisites: MATH 1320. The course will cover topics including multiple regression, analysis of variance, generalized linear models, and applications of these methods. Using R for statistical analysis will be part of the course.

MATH 3520 Structure of Mathematical Systems III: 3 semester hours
Prerequisites: MATH 2510. Topics from MATH 1150 and MATH 2510 are continued. Other topics include integers and the real number system, relations and functions, coordinate system and linear equations, congruence, geometric constructions, geometric proofs, isometries, tessellations, and trigonometry. This course does not apply towards the elective requirements for any of the majors, minors or related areas in mathematics and statistics.

MATH 4005 Exploratory Data Analysis with R: 3 semester hours
Prerequisites: (MATH 1100 or MATH 1800) and (ANTHRO 3220 /SOC 3220 or BIOL 4122 or CRIMIN 2220 or ECON 3100 or MATH 1320 or POL SCI 3000 or PSYCH 2201). This course covers data analysis methods with R. It introduces the basic goals and techniques of the data science process, methods of characterizing and visualizing data and building predictive and inferential models. R will be introduced at the beginning of the class and then used throughout the rest of the class.

MATH 4010 Financial Mathematics I: 3 semester hours
Prerequisites: MATH 1900 or MATH 1100, and MATH 1320 or SCMA 3300 (or equivalents). This course introduces the theory of interest, annuities (certain), annuities with differing pay periods, amortization schedules, and sinking funds.

MATH 4020 Financial Mathematics II: 3 semester hours
Prerequisite: MATH 4010. This course introduces the premium-discount formula for bonds, bond amortization, term structure of interest rates, and pricing theory for options.

MATH 4030 Applied Mathematics I: 3 semester hours
Prerequisite: MATH 2020 and MATH 2450. Topics chosen from Fourier series, special functions, partial differential equations, and boundary value problems.

MATH 4070 Introduction to Nonlinear Optimization: 3 semester hours
Prerequisites: MATH 1320, MATH 2000, MATH 2450 and (MATH 3000 or MATH 3250). This course will introduce the theory, methods, and applications of nonlinear optimization. It will cover convex functions, convex analysis, linear and quadratic programs, semidefinite programming and other optimization problems. Topics may include duality theory, algorithms of descent method, Newton's method and interior-point methods, and applications to signal processing, statistics and other fields will be covered. Credit cannot be earned for both MATH 4070 and MATH 5070.

MATH 4080 Introduction to Scientific Computation: 3 semester hours
Prerequisites: MATH 2000 and MATH 2450. This course will introduce fundamental algorithms in numerical linear algebra, matrix factorizations including SVD and QR, direct and iterative methods for solving linear systems, least squares problems and eigenvalue problems. Other topics covered will be chosen from numerical integration and differentiation, iterative methods for ODEs and PDEs, Discrete Fourier transform and FFT, spline smoothing and kernel smoothing. Credit cannot be earned for both MATH 4080 and MATH 5080.

MATH 4090 Introduction to High-dimensional Data Analysis: 3 semester hours
Prerequisites: MATH 1320, MATH 2000 and MATH 2450. This course introduces several advanced classical and modern techniques for modeling and analysis of high-dimensional datasets with low-dimensional structures. The topics covered in this course include principal component analysis, factor analysis, clustering-based methods, and sparse and low-rank recovery theory and algorithms. Credit cannot be earned for both MATH 4090 and MATH 5090.

MATH 4100 Real Analysis I: 3 semester hours
Prerequisites: MATH 3250, or CMP SCI 3130, or consent of instructor. This course provides an introduction to real analysis in one variable. Topics include the real number system, limits, continuity, differentiability, and sequences and series of functions.

MATH 4160 Complex Analysis I: 3 semester hours
Prerequisites: MATH 2000 or consent of the instructor. This course introduces complex numbers and their geometrical representation, point sets, analytic functions of a complex variable, complex integration, Taylor and Laurent series, residue theorem, and conformal mapping.

MATH 4200 Mathematical Statistics I: 3 semester hours
Prerequisites: MATH 1320 and MATH 2000. Introduction to the theory of probability and statistics using concepts and methods of calculus.

MATH 4210 Mathematical Statistics II: 3 semester hours
Prerequisites: MATH 4200. Continuation of MATH 4200. Sampling distributions, estimation theory, properties of estimators, hypothesis testing, NeymanPearson Theorem, likelihood ratio tests, introduction of analysis of variance and linear models. Basics of some nonparametric procedures.

MATH 4225 Introduction to Statistical Computing: 3 semester hours
Prerequisites: MATH 1320, MATH 2000 and MATH 2450. This course will introduce fundamental algorithms in Monte Carlo methods: random variable generation, Monte Carlo integration, Monte Carlo optimization, Markov chain Monte Carlo, Metropolis-Hastings algorithm, Gibbs sampler, Langevin algorithms and Hamilton Monte Carlo, perfect, iterated and sequential importance sampling. Other topics covered may include particle systems, hidden Markov models, parallel and cloud computing. Credit cannot be earned for both MATH 4225 and MATH 5225.

MATH 4250 Introduction to Statistical Methods in Learning and Modeling: 3 semester hours
Prerequisites: MATH 1320, MATH 2000 and MATH 2450. This course will introduce basic statistical principles and methods for modeling, inference, prediction and classification. The topics will be chosen from linear regression, basis expansion methods, kernel smoothing methods, model regularization, model selection and assessment, and other nonparametric methods. Credit cannot be earned for both MATH 4250 and MATH 5250.

MATH 4260 Introduction to Stochastic Processes: 3 semester hours
Prerequisites: MATH 4200. Basic theory and applications of stochastic processes. Markov chains, recurrent and transient states, stationary distributions, ergodic theorem, renewal processes, discrete martigales and stationary processes.

MATH 4350 Theory of Numbers: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3000 or MATH 3250; or consent of instructor. This course examines the properties of integers, multiplicative functions, congruences, primitive roots, and quadratic residues.

MATH 4390 Topics in Probability and Statistics: 3 semester hours
Prerequisites: Consent of instructor. A seminar on special topics in probability and statistics to be determined by the interests of the instructor. May be repeated for credit provided different topics are studied.

MATH 4400 Introduction to Abstract Algebra I: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course introduces groups, rings, and fields, with an emphasis on groups and rings.

MATH 4450 Linear Algebra: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course focuses on topics selected from vector spaces, bases, linear transformations, matrices, canonical forms, eigenvalues, hermitian and unitary matrices, inner product spaces, and quadratic forms.

MATH 4460 Introduction to Coding Theory: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3000 or MATH 3250. This course is an introductory course in coding theory. Topics may include linear codes, generator and parity check matrices, dual codes, weight and distance, encoding and decoding, and the Sphere Packing Bound; various examples of codes like the Hamming codes, Golay codes, binary Reed-Muller codes, and the hexacode; Shannon's theorem for the binary symmetric channel, upper and lower bounds on the size of linear and nonlinear codes; constructions and properties of finite fields, basic theory of cyclic codes; concepts of idempotent generator, generator polynomial, zeros of a code, and defining sets, special families of BCH and Reed-Solomon cyclic codes as well as generalized Reed-Solomon codes. Credit cannot be granted for both MATH 4460 and MATH 5460.

MATH 4500 Special Readings: 1-10 semester hours
Prerequisites: 6 credit hours at the Math 4000 level and consent of the instructor. Advanced topics in Mathematics. May be repeated for credit if the topic differs.

MATH 4550 Combinatorics: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3000 or MATH 3250; or consent of instructor. This course introduces advanced counting methods including the use of generating functions for the solution of recurrences and difference equations. Additional topics may include: graphs and trees, combinatorial designs, combinatorial games, error-correcting codes, and finite-state machines.

MATH 4580 Mathematical Logic: 3 semester hours
Prerequisites: MATH 2450 and one of MATH 3250, CMP SCI 3130, or PHIL 4460; or consent of instructor. This course focuses on a study of the logic of mathematics by the axiomatic method, with a development of the propositional calculus and restricted predicate calculus emphasizing its application to the foundations of mathematics.

MATH 4660 Foundations of Geometry: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course focuses on a development of portions of Euclidean geometry from a selected set of axioms, including a discussion of consistency, independence, categoricity, and completeness of the axioms.

MATH 4670 Introduction to Non-Euclidean Geometry: 3 semester hours
Prerequisites: MATH 2000, MATH 2450, and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course focuses on a summary of the history of the non-Euclidean geometries and a study of hyperbolic plane geometry.

MATH 4890 Topics in Mathematics: 3 semester hours
Prerequisite: Consent of instructor.

MATH 4995 Internship in Actuarial Science: 1-3 semester hours
Same as ECON 4995. Prerequisites: Junior standing and consent of program director. Supervised off-campus training in a private or public sector position in which the student applies the knowledge and skills learned in their actuarial science coursework. The internship is monitored by a faculty member and the student must provide a written report at the end of the project. This course may be repeated for a maximum of 6 credit hours.

MATH 5070 Nonlinear Optimization: 3 semester hours
Prerequisites: Graduate standing. This course will introduce the theory, methods, and applications of nonlinear optimization. It will cover convex functions, convex analysis, linear and quadratic programs, semidefinite programming and other optimization problems. Topics chosen from duality theory, algorithms of descent method, Newton's method and interior-point methods, and applications to signal processing, statistics and other fields will be covered. Topics are identical to MATH 4070 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4070 and MATH 5070.

MATH 5080 Scientific Computation: 3 semester hours
Prerequisites: Graduate standing. This course will introduce fundamental algorithms in numerical linear algebra, matrix factorizations including SVD and QR, direct and iterative methods for solving linear systems, least squares problems and eigenvalue problems. Other topics covered will be chosen from numerical integration and differentiation, iterative methods for ODE's and PDE's, Discrete Fourier transform and FFT, spline smoothing and kernel smoothing. Topics are identical to MATH 4080 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4080 and MATH 5080.

MATH 5090 High-dimensional Data Analysis: 3 semester hours
Prerequisites: Graduate standing. This course introduces several advanced classical and modern techniques for modeling and analysis of high-dimensional datasets with low-dimensional structures. The methods covered in this course include principal component analysis, factor analysis, clustering-based methods, and sparse and low-rank recovery theory and algorithms. Topics are identical to MATH 4090 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4090 and MATH 5090.

MATH 5100 Real Analysis II: 3 semester hours
Prerequisites: MATH 4100. Introduction to measure and integration. Topics include the Riemann-Stieltjes integral, Lebesgue measure, measurable functions, the Lebesgue integral, Radon-Nikodym and Fubini theorems and the basics of Lp-spaces.

MATH 5140 Set Theory and Metric Spaces: 3 semester hours
Prerequisites: MATH 4100 or consent of instructor. Naive set theory, cardinal arithmetic, ordinal numbers, the axiom of choice and equivalents, metric spaces, convergence, continuity, compactness, contraction principals and applications. Construction of completions and examples like real numbers and p-adic numbers. Other topics could include the Stone-Weierstrass theorem and metrizability theorems.

MATH 5225 Statistical Computing: 3 semester hours
Prerequisites: Graduate standing. This course will introduce fundamental algorithms in Monte Carlo methods: random variable generation, Monte Carlo integration, Monte Carlo optimization, Markov chain Monte Carlo, Metropolis-Hastings algorithm, Gibbs sampler, Langevin algorithms and Hamilton Monte Carlo, perfect, iterated and sequential importance sampling. Other topics covered may include particle systems, hidden Markov models, parallel and cloud computing. Topics are identical to MATH 4085 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4225 and MATH 5225.

MATH 5250 Statistical Methods in Learning and Modeling: 3 semester hours
Prerequisites: Graduate standing. This course will introduce basic statistical principles and methods for modeling, inference, prediction and classification. The topics will be chosen from linear regression, basis expansion methods, kernel smoothing methods, model regularization, other nonparametric methods, and model selection and assessment. Topics are identical to MATH 4250 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4250 and MATH 5250.

MATH 5320 Topics in Statistics and its Applications: 3 semester hours
Prerequisites: MATH 4210 or consent of instructor. The course studies classical and recently developed statistical procedures selected from areas including multivariate analysis, linear and non-linear models, nonparametric methods, and statistical learning. Emphasis is on applications of the procedures.

MATH 5460 Coding Theory: 3 semester hours
Prerequisites: Graduate standing. This course is an introductory course in coding theory. Topics may include linear codes, generator and parity check matrices, dual codes, weight and distance, encoding and decoding, and the Sphere Packing Bound; various examples of codes like the Hamming codes, Golay codes, binary Reed-Muller codes, and the hexacode; Shannon's theorem for the binary symmetric channel, upper and lower bounds on the size of linear and nonlinear codes; constructions and properties of finite fields, basic theory of cyclic codes; concepts of idempotent generator, generator polynomial, zeros of a code, and defining sets, special families of BCH and Reed-Solomon cyclic codes as well as generalized Reed–Solomon codes. Topics are identical to MATH 4460 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be granted for both MATH 4460 and MATH 5460.

MATH 5500 Directed Readings: 1-6 semester hours
Prerequisite: Consent of instructor. Independent readings at an advanced level.

MATH 5550 Topics in Advanced Math for the Teacher: 3 semester hours
Prerequisite: Consent of instructor. This course will look at various topics in Algebra, Analysis, and Geometry that will deepen a teacher's understanding of the Mathematics of the precollegiate curriculum. It can be taken more than once for credit.

MATH 5600 Topics in Computation: 3 semester hours
Prerequisite: Consent of instructor. The course will cover various advanced topics in computation, and can be taken more than once for credit. Examples of such topics are: computer graphics, computer architecture, theories of language, analysis of operating systems, numerical geometry and computer aided design, etc.

MATH 5700 Topics in Applied Mathematics: 3 semester hours
Prerequisite: Consent of instructor. The course will cover various advanced topics on applied mathematics, and can be taken more than once for credit. Examples of such topics are: fast transforms, digital filters, etc.

MATH 5710 Topics in Analysis: 3 semester hours
Prerequisites: MATH 5100 or consent of instructor. Topics selected from the areas of Fourier analysis, harmonic analysis, functional analysis, special functions, generalized functions, and partial differential equations. May be taken more than once for credit with consent of department.

MATH 5770 Advanced Topics in Nonlinear Optimization: 3 semester hours
Prerequisites: MATH 4070 or MATH 5070; or consent of the instructor. Topics chosen from theory and algorithms of Lagrange multipliers, algorithms for solving variational inequalities, forward-backward splitting algorithms and proximal alternating minimization algorithm for non-convex optimization problems.

MATH 5820 Topics in Algebra: 3 semester hours
Prerequisite: Consent of instructor. Topics selected from the theory of groups, rings, fields, algebras and other algebraic systems. May be taken more than once for credit with consent of department.

MATH 5890 Advanced Topics in Mathematics: 3 semester hours
Prerequisites: Consent of the instructor. The course will cover various advanced topics in mathematics, statistics, or data science. May be taken more than once if the topic differs.

MATH 6900 Masters Thesis: 1-6 semester hours
Prerequisite: Consent of instructor. Thesis work under the supervision of a faculty member. The course is designed for those students intending to present a thesis as part of their M.A. program. Students who do not write a thesis cannot apply MATH 6900 to a degree.

MATH 7990 Ph.D. Dissertation Research: 1-9 semester hours
Prerequisites: Completion of comprehensive examinations. May be taken for no more than nine hours.

Physics Courses

PHYSICS 1001 How Things Work (MOTR PHYS 100): 3 semester hours
Can baseball players hit home runs more easily when the weather is hot and humid? This course provides a practical introduction to understanding common life experiences by using physical intuition and basic ideas of physics. Powerful scientific principles are demonstrated through topics ranging from airplane wings to compact disk players, from lightning strikes to lasers.

PHYSICS 1011 Basic Physics I: 3 semester hours
Prerequisites: MATH 1030 and MATH 1035 required, MATH 1100 or MATH 1800 strongly recommended, concurrent enrollment in PHYSICS 1011L recommended. This course is specifically designed for students in health and life sciences covering the topics in classical mechanics such as kinematics, Newton's laws, energy, momentum and oscillations. This course will not fulfill the PHYSICS 2111 requirement for physics, chemistry, and engineering majors.

PHYSICS 1011L Basic Physics I Laboratory: 1 semester hour
Prerequisite: PHYSICS 1011 (may be taken concurrently). This laboratory course accompanies PHYSICS 1011, which is specifically designed for students in health and life sciences covering topics in classical mechanics such as kinematics, Newton's laws, energy, momentum and oscillations.

PHYSICS 1012 Basic Physics II: 3 semester hours
Prerequisites: PHYSICS 1011, concurrent enrollment in PHYSICS 1012L recommended. This continuation of PHYSICS 1011 is specifically designed for students in health and life sciences covering electricity, magnetism, light, optics and waves. This course will not fulfill the PHYSICS 2112 requirement for physics, chemistry, and engineering majors.

PHYSICS 1012L Basic Physics II Laboratory: 1 semester hour
Prerequisites: PHYSICS 1012 (may be taken concurrently). This laboratory course accompanies PHYSICS 1012, which is specifically designed for students in health and life sciences, covering electricity, magnetism, light, optics and waves.

PHYSICS 1099 Windows on Physics: 1 semester hour
A seminar designed to introduce physics majors to research areas in physics and physics-related fields in the Department of Physics and Astronomy. In addition to fundamental areas of physics, the areas of astrophysics, biophysics, materials science, and nanotechnology will be included. Career opportunities for students with physics degrees will be discussed and the physics curriculum will be reviewed. The course meets weekly and is required of all physics majors and minors who are transfer students.

PHYSICS 2010 Introduction to Inquiry Approaches to STEM Education (STEP I): 1 semester hour
Same as CHEM 2010, BIOL 2010, MATH 2010, and SEC ED 2010. Prerequisites: Concurrent enrollment BIOL 1821, BIOL 1831, CHEM 1111, CHEM 1121, PHYSICS 2111, PHYSICS 2112, MATH 1800, or MATH 1900 or have a declared STEM major. Students who want to explore teaching careers become familiar with lesson plan development by writing, teaching and observing lessons in a local school class. Students build and practice inquiry-based lesson design skills and become familiar with and practice classroom management in the school setting. As a result of the STEP I experiences students should be able to decide whether to continue to explore teaching as a career and ultimately finishing the remainder of the WE TEACH MO curriculum leading to teacher certification. The classroom observations and teaching represent a major field component and requires at least one two hour block of free time during the school day once a week.

PHYSICS 2011 Designing Inquiry-Based STEM Experiences (STEP II): 1 semester hour
Same as CHEM 2011, BIOL 2011, MATH 2011, and SEC ED 2011. Prerequisites: BIOL 2010, CHEM 2010, PHYSICS 2010, MATH 2010, or SEC ED 2010. Students explore teaching careers, become familiar with STEM school setting through observing and discussing the school environment and by developing and teaching inquiry-based lessons.

PHYSICS 2111 Physics: Mechanics and Heat: 4 semester hours
Prerequisites: MATH 1900 (may be taken concurrently). This course introduces students to the phenomena, concepts, and laws of mechanics and heat for physics majors and students in other departments. Three classroom hours and one hour discussion per week.

PHYSICS 2111L Mechanics and Heat Laboratory: 1 semester hour
Prerequisites: PHYSICS 2111 (may be taken concurrently). This laboratory course accompanies PHYSICS 2111, which covers the phenomena, concepts, and laws of mechanics and heat.

PHYSICS 2112 Physics: Electricity, Magnetism, and Optics: 4 semester hours
Prerequisites: PHYSICS 2111 and MATH 2000 (MATH 2000 may be taken concurrently). This course provides a phenomenological introduction to the concepts and laws of electricity and magnetism, electromagnetic waves, optics and electrical circuits for physics majors and students in other departments. Three hours of lecture and one hour of discussion per week.

PHYSICS 2112L Electricity, Magnetism, and Optics Laboratory: 1 semester hour
Prerequisites: PHYSICS 2112 (may be taken concurrently). This laboratory course accompanies PHYSICS 2112, which covers the phenomena, concepts and laws of electricity and magnetism, electromagnetic waves, optics and electrical circuits.

PHYSICS 3200 Mathematical Methods of Theoretical Physics: 3 semester hours
Prerequisites: PHYSICS 2112 and MATH 2000. Mathematical techniques specifically used in the study of mechanics, electricity, magnetism, and quantum physics are developed in the context of various physical problems. Course includes the topics of vector calculus, coordinate systems, the Laplace equation and its solutions, elementary Fourier analysis, & complex variables. Applications to electrostatics, mechanics, and fluid dynamics are emphasized. Three hours of lecture per week.

PHYSICS 3221 Mechanics: 3 semester hours
Prerequisites: PHYSICS 3200 and MATH 2020 (MATH 2020 may be taken concurrently). Advanced course covering single and many particle dynamics, rigid-body dynamics, and oscillations. Variational principles and Hamiltonian formulations of mechanics are covered. Three hours of lecture per week.

PHYSICS 3223 Electricity and Magnetism: 3 semester hours
Prerequisites: PHYSICS 3200 and MATH 2020 (MATH 2020 may be taken concurrently). Advanced course covering the rigorous development, from basic laws, of Maxwell's equations for electromagnetic fields along with applications of these equations. Topics covered are electrostatics and electrodynamics including currents, magnetic fields, motion of charged particles in fields and an introduction to electromagnetic waves. Three hours of lecture per week.

PHYSICS 3231 Introduction to Modern Physics I: 3 semester hours
Prerequisites: PHYSICS 2111, PHYSICS 2112, and MATH 2020 (MATH 2020 may be taken concurrently) and PHYSICS 3200 strongly recommended. Photons and the wave nature of particles, wave mechanics, Schroedinger equation, with applications to atomic physics; and radiation; the physics of solids; elementary particles; special relativity; health physics. Three hours of lecture per week.

PHYSICS 3281 Directed Readings in Physics: 1-5 semester hours
Prerequisite: Consent of instructor. An independent study of special topics in physics. A paper may be required on an approved topic. Topics must be substantially different. Hours arranged.

PHYSICS 3390 Research: 1-10 semester hours
Prerequisite: Consent of department. Independent physics research projects arranged between student and instructor. Hours arranged.

PHYSICS 4305 Bayesian Data Analysis for the Sciences: 3 semester hours
Prerequisites: Consent of instructor. This is a cross-disciplinary course in two parts. Part one covers Bayesian inference as applied to data analysis in general, with a special focus on the mathematics of model-selection in the physical and life sciences. Part two concentrates specifically on the Bayesian use of log-probability (i.e. information) measures to track order-disorder transitions in thermodynamics, and to track the evolution of sub-system correlations (via both digital and analog means) in a wide variety of complex systems. Expect weekly empirical observation exercises, and opportunities for asynchronous as well as synchronous collaboration.

PHYSICS 4306 Nanoscience Practicals: 1-3 semester hours
Studies of Nanoscience characterization, synthesis, modeling techniques designed for clients of these tools, as well as for technical users interested in a current overview. Course consists of a set of 1/3 semester modules. Check with the instructor on more specialized modules, (e.g, on materials microscopy), if interested. Each module will cover instrumentation, current applications, weaknesses, and will involve lab visits for hands-on experience, weekly web interaction and classroom hours.

PHYSICS 4310 Modern Electronics: 3 semester hours
Prerequisite: PHYSICS 2112. This course is an integrated recitation/laboratory study of modern analog and digital electronics with emphasis on integrated circuits, which consist of active and passive electrical circuit elements integrated on a single semiconductor substrate. This course includes the study of the properties of the various specialized electronic devices that are constructed with integrated circuits along with a study of the various circuit elements. This course has four contact hours of lecture/laboratory per week.

PHYSICS 4311 Advanced Physics Laboratory I: 3 semester hours
Prerequisite: Advanced standing with at least nine completed hours of Physics at or above the 3000 level. Physics majors are introduced to the experimental techniques used in research. A student will choose and do several special problems during the semester. Six hours laboratory per week.

PHYSICS 4323 Modern Optics: 3 semester hours
Prerequisite: PHYSICS 3223. A study of modern optics including diffraction theory, polarization, light propagation in solids, quantum optics, and coherence.

PHYSICS 4331 Intro to Quantum Mechanics: 3 semester hours
Prerequisites: PHYSICS 3200 and PHYSICS 3231. Photons and the wave nature of particles; wave mechanics, Schroedinger equation, operator and matrix formulations, and Dirac notation; applications to single particle systems, atomic physics, and spectroscopy.

PHYSICS 4341 Thermal and Statistical Physics: 3 semester hours
Prerequisites: MATH 2000 and PHYSICS 3231. Introduction to statistical mechanics, classical thermodynamics, and kinetic theory.

PHYSICS 4343 Selected Topics in Physics I: 3 semester hours
Prerequisites: PHYSICS 3221, PHYSICS 3223, PHYSICS 3231, PHYSICS 4341. Topics include special phenomena for research areas such as physics of waves, biophysics, nonlinear physics, geophysical fluid dynamics and the atmospheric sciences treated by methods of advanced mechanics, electromagnetism, statistical mechanics, thermodynamics and quantum mechanics. Three hours of lecture per week.

PHYSICS 4345 Introduction to Nonlinear Dynamics and Stochastic Processes: 3 semester hours
Prerequisites: PHYSICS 3221 and PHYSICS 4341 and consent of instructor. This course is an introduction to dynamical systems and stochastic processes and their applications within various fields. Topics may include: theory of oscillations; bifurcation theory and chaos in dissipative systems, dynamics of nonlinear systems perturbed by noise; noise-induced phase transitions; and linear and nonlinear time series analysis. Students may not receive credit for both PHYSICS 4345 and PHYSICS 5345.

PHYSICS 4347 Introduction to Biophysics: 3 semester hours
Prerequisites: PHYSICS 3231, BIOL 1821, and BIOL 1831; or permission of instructor. This course is an introduction to the application of physical principles to problems in biology. The course may cover topics such as molecular biophysics (e.g., ion transport, protein folding, molecular motors), collective dynamics and self-assembly of biological systems, nonlinear dynamics and electrophysiology in the heart and brain, and physics-based approaches to modeling gene networks and evolutionary dynamics. Students will complete a final project investigating a particular area of biophysics. Students may not receive credit for both PHYSICS 4347 and PHYSICS 5347.

PHYSICS 4350 Computational Physics: 3 semester hours
Prerequisites: PHYSICS 3221, PHYSICS 3223, PHYSICS 4331 and MATH 2450. This course explains how to solve physics-based problems using computational techniques. Mechanics, electrodynamics, and quantum physics problems are solved by (1) numerically solving ordinary and partial differential equations, (2) using Fourier analysis, and (3) solving eigenvalue problems.

PHYSICS 4353 Physics of Fluids: 3 semester hours
Prerequisites: PHYSICS 3221, PHYSICS 3223, and PHYSICS 4341, or consent of instructor. Dynamical theory of gases and liquids. Course covers the mathematical development of physical fluid dynamics with contemporary applications.

PHYSICS 4354 Atmospheric Physics: 3 semester hours
Prerequisites: PHYSICS 4341 and PHYSICS 3221. The mathematical application of physical laws to atmospheric dynamics and physical meteorology. Application of mechanics, thermodynamics, optics, and radiation to atmospheric phenomena including the ionosphere.

PHYSICS 4358 Introduction to Global Geodynamics: 3 semester hours
Prerequisites: PHYSICS 3221 and PHYSICS 3223. This advanced course covers the development, from basic laws, of equations describing the many geodynamic processes underpinning geological modeling and geological data. Topics covered are paleomagnetism, plate tectonics, viscoelastic media, heat transfer, gravity, fluid mechanics, rheology, faulting, and geochronology.

PHYSICS 4370 Relativity and Cosmology: 3 semester hours
Prerequisites: PHYSICS 3221, PHYSICS 3223 and PHYSICS 3231. An introduction to Einstein's general theory of relativity. Topics will include special relativity in the formalism of Minkowski's four dimensional space-time, Principle of Equivalence, metric description of curved space, geodesic equation, Einstein Field Equation, black holes, and cosmology.

PHYSICS 4381 Directed Readings in Physics: 1-10 semester hours
Prerequisite: Consent of instructor. An independent study of special topics in physics for senior undergraduates or graduate students.

PHYSICS 5306 Advanced Nanoscience Practicals: 1-3 semester hours
Prerequisites: Graduate standing in physics or consent of instructor. Advanced studies of Nanoscience characterization, synthesis, and modeling techniques designed for clients of these tools, as well as for technical users interested in a current overview. The course consists of a set of 1/3 semester modules. Check with the instructor on more specialized modules, (e.g, on materials microscopy), if interested. Each module will cover instrumentation, current applications, and weaknesses and will involve lab visits for hands-on experience, weekly web interaction and classroom hours.

PHYSICS 5345 Nonlinear Dynamics and Stochastic Processes: 3 semester hours
Prerequisites: PHYSICS 3221 and PHYSICS 4341 and consent of instructor. Dynamical systems; theory of oscillations; introduction to bifurcation theory and chaos in dissipative systems with applications in physics and biology; introduction to stochastic processes with applications in physics, chemistry and biology; dynamics of nonlinear systems perturbed by noise; noise-induced phase transitions; linear and nonlinear time series analysis. Three classroom hours per week.

PHYSICS 5347 Intermediate Biophysics: 3 semester hours
Prerequisites: Graduate standing, PHYSICS 3231, BIOL 1821 and BIOL 1831 or permission of instructor. This course is applies physical principles to problems in biology. Topics may include molecular biophysics (e.g., ion transport, protein folding, molecular motors), collective dynamics and self-assembly of biological systems, nonlinear dynamics and electrophysiology in the heart and brain, and physics-based approaches to modeling gene networks and evolutionary dynamics. Students will complete a final project investigating a particular area of biophysics. Students will be expected to design projects containing a significant component of original research. Students may not receive credit for both PHYSICS 4347 and PHYSICS 5347.

PHYSICS 5350 Intermediate Computational Physics: 3 semester hours
Prerequisites: PHYSICS 3221, PHYSICS 3223, PHYSICS 4331 and MATH 2450; or graduate standing. This course explains how to solve physics-based, intermediate-level problems using computational techniques. Mechanics, electrodynamics, and quantum physics problems are solved by (1) numerically solving ordinary and partial differential equations, (2) using Fourier analysis, and (3) solving eigenvalue problems. Students may not receive credit for both PHYSICS 4350 and PHYSICS 5350.

PHYSICS 5353 Intermediate Physics of Fluids: 3 semester hours
Prerequisites: PHYSICS 3221, PHYSICS 3223, and PHYSICS 4341; or graduate standing. This course covers intermediate level dynamical theory of gases and liquids. This course examines mathematical fluid dynamics along with some contemporary applications. Students may not receive credit for both PHYSICS 4353 and PHYSICS 5353.

PHYSICS 5358 Intermediate Global Geodynamics: 3 semester hours
Prerequisites: Graduate standing, PHYSICS 3221 and PHYSICS 3223 or permission of the Instructor. This course intermediate course covers the development of equations describing the many geodynamic processes underpinning geological modeling and geological data. Topics covered may include paleomagnetism, plate tectonics, viscoelastic media, heat transfer, gravity, fluid mechanics, rheology, faulting, and geochronology. Students will complete a final project investigating a particular area of geodynamics. Students will be expected to develop a more advanced project. Students may not receive credit for both PHYSICS 4358 and PHYSICS 5358.

PHYSICS 5370 Intermediate Relativity and Cosmology: 3 semester hours
Prerequisites: PHYSICS 3221, PHYSICS 3223, and PHYSICS 3231; or graduate standing. Topics will include special relativity in the formalism of Minkowski's four dimensional space-time, Principle of Equivalence, geodesic equation, Einstein Field Equation, black holes, and cosmology. Differential geometry from metric description to Riemann curvature tensor will be studied.

PHYSICS 5402 Introduction to Mathematical Physics: 3 semester hours
Prerequisites: Graduate standing in physics or consent of instructor. A course covering mathematical techniques as applied in advanced theoretical physics including generalized vector spaces and their dual spaces, linear operators and functionals, generalized functions, spectral decomposition of operators, tensor analysis, and complex variables. Three hours of lecture per week.

PHYSICS 6300 Master's Thesis: 3 semester hours
Prerequisite: Consent of instructor. Thesis work under the supervision of a faculty member. The course is designed for those students intending to present a thesis as part of their M.S. program. Students who do not write a thesis cannot apply PHYSICS 6300 to a degree. This course transfers to the Cooperative Ph.D. program as three research credits.

PHYSICS 6400 Special Problems: 1-5 semester hours
Must have faculty mentor and approval of Department Chairperson. A study of special topics in physics for graduate students.

PHYSICS 6401 Special Topics: 1-4 semester hours
Prerequisite: Consent of instructor. This course is designed to give the department an opportunity to test a new course.

PHYSICS 6409 Theoretical Mechanics I: 3 semester hours
Prerequisite: PHYSICS 3221. Classical mechanics, methods of Newton, Lagrange, and Hamilton applied to motion of particles and rigid bodies, elasticity, hydrodynamics.

PHYSICS 6410 Seminar: 1-3 semester hours
Prerequisite: Approval of Department Chair. Discussion of current topics.

PHYSICS 6411 Electrodynamics I: 3 semester hours
Prerequisite: PHYSICS 3223. A rigorous development of the fundamentals of electromagnetic fields and waves. Electrostatics, magnetostatics, Maxwell's equations, Green's functions, boundary value problems, multipoles, conservation laws.

PHYSICS 6413 Statistical Mechanics: 3 semester hours
Prerequisite: PHYSICS 4331, PHYSICS 4341. A study of statistical ensembles; Maxwell-Boltzmann, Fermi-Dirac and Einstein-Bose distribution laws, application to some physical systems.

PHYSICS 6423 Electrodynamics II: 3 semester hours
Prerequisite: PHYSICS 6411. A continuation of PHYSICS 6411. Applications of time-dependent Maxwell's equations to such topics as plasmas, wave guides, cavities, radiation: fields of simple systems and multiples. Relativity: covariant formulation of Maxwell's equations and conservation laws, fields of uniformly moving and accelerated charges.

PHYSICS 6461 Quantum Mechanics I: 3 semester hours
Prerequisite: PHYSICS 4331. A study of the Schroedinger wave equation, operators and matrices, perturbation theory, collision and scattering problems.

PHYSICS 6463 Quantum Mechanics II: 3 semester hours
Prerequisite: PHYSICS 6461. Continuation of PHYSICS 6461. To include such topics as Pauli Spin-Operator Theory, classification of atomic states, introduction to field quantization, and Dirac Electron Theory.

PHYSICS 6490 Research: 1-10 semester hours
Prerequisite: Must have a faculty mentor and approval of the department chair. Investigations of an advanced nature leading to the preparation of a thesis or dissertation.

PHYSICS 6495 Continuous Registration: 1-6 semester hours
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy.