Computational Science, Engineering, and Mathematics (CSE)

CSE 370 Individual Reading and Research 3 Hours
Supervised study or research in a selected area of computational science, engineering, and mathematics by individual arrangement with a supervising instructor.

CSE 380 Tools and Techniques of Computational Science 3 Hours
Advanced introduction to the practical use of high performance computing hardware and software engineering principles for scientific technical computing. Topics include computer architectures, operating systems, programming languages, data structures, interoperability, and software development, management, and performance.

CSE 382G Computer Graphics 3 Hours
Advanced material in computer graphics, including in-depth treatments of techniques for realistic image synthesis, advanced geometric modeling methods, animation and dynamic simulation, scientific visualization, and high-performance graphics architectures.

CSE 382M Foundational Techniques of Machine Learning and Data Sciences 3 Hours
Introduction to computational and mathematical tools of data science. Cover statistical estimation and optimization algorithms, neural networks, geometry of high dimensional spaces, randomized methods, sparse approximation, and dimension reduction techniques.

CSE 383C Numerical Analysis: Linear Algebra 3 Hours
Survey of numerical methods in linear algebra: floating-point computation, solution of linear equations, least squares problems, algebraic eigenvalue problems.

CSE 383D Numerical Analysis: Interpolation, Approximation, Quadrature, and Differential Equations 3 Hours
Survey of numerical methods for interpolation, functional approximation, integration, and solution of differential equations.

CSE 383K Numerical Analysis: Algebra and Approximation 3 Hours
Advanced introduction to scientific computing, theory and application of numerical linear algebra, solution of nonlinear equations, and numerical approximation of functions.

CSE 383L Numerical Analysis: Differential Equations 3 Hours
Advanced introduction to the theory and practice of commonly used numerical algorithms for the solution of ordinary differential equations, and elliptic, parabolic, and hyperbolic partial differential equations.

CSE 384K Theory of Probability 3 Hours

CSE 384L Theory of Probability 3 Hours
Continuation of Computational Science, Engineering, and Mathematics 384K and Mathematics 385C.

CSE 384R Mathematical Statistics I 3 Hours
The general theory of mathematical statistics. Includes distributions of functions of random variables, properties of a random sample, principles of data reduction, an overview of hierarchical models, decision theory, Bayesian statistics, and theoretical results relevant to point estimation, interval estimation, and hypothesis testing.

CSE 384S Mathematical Statistics II 3 Hours
Continuation of Computational Science, Engineering, and Mathematics 384R and Mathematics 384C.

CSE 384T Regression Analysis 3 Hours
Simple and multiple linear regression, inference in regression, prediction of new observations, diagnosis and remedial measures, transformations, and model building. Emphasis on both understanding the theory and applying theory to analyze data.

CSE 384U Design and Analysis of Experiments 3 Hours
Design and analysis of experiments, including one-way and two-way layouts; components of variance; factorial experiments; balanced incomplete block designs; crossed and nested classifications; fixed, random, and mixed models; and split plot designs.

CSE 385M Methods of Mathematical Physics I 3 Hours
Theory of analytic functions; linear algebra and vector spaces; orthogonal functions; ordinary differential equations; partial differential equations; Green's functions; complex variables.

CSE 385N Methods of Mathematical Physics II 3 Hours
Continuation of Computational Science, Engineering, and Mathematics 385M and Physics 381M. Topology, functional analysis, approximation methods, group theory, differential manifolds.

CSE 385R Real Analysis 3 Hours
Measure and integration over abstract spaces; Lebesgue's theory of integration and differentiation on the real line.

CSE 385S Complex Analysis 3 Hours
Introduction to complex analysis.

CSE 386C Methods of Applied Mathematics 3 Hours
Topics include basic normed linear space theory; fixed-point theorems and applications to differential and integral equations; Hilbert spaces and the spectral theorem; applications to Sturm-Liouville problems; approximation and computational methods such as the Galerkin, Rayleigh-Ritz, and Newton procedures.

CSE 386D Methods of Applied Mathematics 3 Hours
Topics include distributions, fundamental solutions of partial differential equations, the Schwartz space and tempered distributions, Fourier transform, Plancherel theorem, Green's functions, Sobolev spaces, weak solutions, differential calculus in normed spaces, implicit function theorems, applications to nonlinear equations, smooth variational problems, applications to classical mechanics, constrained variational problems.

CSE 386L Mathematical Methods in Science and Engineering 3 Hours
Explore mathematical frameworks for understanding and solving practical problems. Examine basic concepts in multidimensional real analysis, ordinary differential equations and dynamical systems, elementary calculus of variations, Hilbert space theory and duality, Sturm-Liouville theory, Lax-Milgram and Babuska-Necas Theorems, and applications to partial differential equations.

CSE 386M Functional Analysis in Theoretical Mechanics 3 Hours
An introduction to modern concepts in functional analysis and linear operator theory, with emphasis on their application to problems in theoretical mechanics; topological and metric spaces, norm linear spaces, theory of linear operators on Hilbert spaces, applications to boundary value problems in elasticity and dynamical systems.

CSE 389C Introduction to Mathematical Modeling in Science and Engineering I 3 Hours
First part of a two-part introduction to the elements of classical mechanics, physics, chemistry, and biology needed to begin work in computational engineering and sciences. Develops from first principles the classical mathematical theories underlying many of the models of physical phenomena important in modern applications.

CSE 389D Introduction to Mathematical Modeling in Science and Engineering II 3 Hours
Second part of a two-part introduction to elements of classical mechanics, physics, chemistry, and biology needed to work in computational engineering and sciences. Develops from first principles the classical mathematical theories underlying many of the models of physical phenomena important in modern applications.

CSE 190, 390 Individual Research 1,3 Hours
Individual study or research in computational science, engineering, and mathematics arranged by mutual agreement between student and supervising faculty member.

CSE 390T Training in the Teaching of Computational Science, Engineering, and Mathematics 3 Hours

CSE 392 Topics in Computer Science 3 Hours
Advanced topics in the theory and application of computer science. Recent topics include geometric modeling and visualization, and high-performance and parallel computing.

CSE 392.1 Parallel Algorithms in Scientific Computing 3 Hours
Explore the application of parallel algorithms in machine learning, graph analytics, and modeling and simulation. Examine high-performance computing, parallel non-numerical and numerical algorithms for shared and distributed memory architectures. Discuss examples including sorting, merging, searching, linear algebra, graph algorithms, KD-trees, and fast transforms. Explore theory, programming, and performance optimization and analysis.

CSE 393 Topics in Numerical Analysis 3 Hours
Advanced topics in the theory and application of numerical analysis. Recent topics include numerical methods for partial differential equations, computational problems in linear algebra, iterative methods and fast algorithms, numerical methods in functional approximation, and computational and variational methods for inverse problems.

CSE 393.1 The Finite Element Method 3 Hours
Examine introductory concepts such as weighted residual methods; strong and weak forms; boundary conditions; global v. local basis functions; error estimates; smooth and nonsmooth problems; one-dimensional second- and fourth-order problems; two-dimensional potential and plate problems; two-dimensional and three-dimensional elasticity; dynamic and eigenvalue problems; numerical, computational, and meshing issues; applications using commercial software.

CSE 393F Finite Element Methods 3 Hours
Derivation and implementation of the finite element method; basic coding techniques; application to problems of stress and diffusion.

CSE 393H Advanced Theory of Finite Element Methods 3 Hours
Contemporary topics in the theory and application of finite element methods.

CSE 393N Numerical Methods for Flow and Transport Problems 3 Hours
Approximate solution methods for flow and transport problems in engineering and applied science. Finite element, finite difference, and residual methods for linear and nonlinear problems.

CSE 393P Computational and Variational Methods for Inverse Problems 3 Hours
Examine computational and variational methods for inverse problems governed by partial differential equations, including variational formulations, ill-posedness, regularization, adjoint methods for sensitivity analysis, variational discretization, and efficient large-scale optimization algorithms. Explore a brief introduction to the Bayesian formulation and relationship to the deterministic setting. Discuss examples drawn from different areas of science and engineering, including continuum fluid and solid mechanics, geophysics, and image processing.

CSE 394 Topics in Probability and Statistics 3 Hours
Advanced topics in the theory and application of probability and statistics. Recent topics include nonparametric statistics and advanced probability.

CSE 394.1 Stochastic Processes I 3 Hours
Study Ito-diffusion processes, stochastic calculus, and stochastic integration. Explore stochastic differential equations and their connection to classical analysis. Discuss an introduction to optimal stochastic control of diffusion processes, the Hamilton-Jacobi-Bellman equation (classical and viscosity solutions), singular stochastic control, and linear filtering. Present applications, mainly from mathematical finance, inventory theory, decision analysis, and insurance. Examine brief overview of multi-scale problems in stochastic analysis.

CSE 396 Topics in Applied Mathematics 3 Hours
Advanced topics in the theory and application of applied mathematics. Recent topics have included partial differential equations, dynamical systems, kinetic theory, quantum mechanics, ergodic theory, statistical mechanics, Hamiltonian dynamics, nonlinear functional analysis, Euler and Navier-Stokes equations, microlocal calculus and spectral asymptotics, calculus of variations, and nonlinear partial differential equations.

CSE 396.1 Partial Differential Equations I 3 Hours
Analyze nonlinear partial differential equations, emphasizing elliptic and parabolic equations.

CSE 397 Topics in Computational Science and Engineering 3 Hours
Advanced topics in the theory and application of computational science and engineering.

CSE 397.1 Multiscale Methods in Computational Fluid Dynamics 3 Hours
Explore stabilized and variational multiscale methods in computational fluid dynamics with a focus on advective-diffusive equations, the Boltzmann equation, and the compressible and incompressible Navier-Stokes equations.

CSE 397.2 Nonlinear Static and Dynamic Finite Element Analysis 3 Hours
Explore code architecture and fundamental analytical technologies used in the nonlinear finite element and isogeometric analysis of solids and structures.

CSE 397.3 Validation and Uncertainty Quantification in Computational Models 3 Hours
Assess reliability of computational models of physical systems through validation and uncertainty quantification. Develop uncertainty analysis in terms of Bayesian probability and inference, and techniques for probabilistic model validation.

CSE 397.4 Computational Modeling of the Cardiovascular System 3 Hours
Explore mathematical models and simulation of the cardiovascular system, with an emphasis on the biomechanical function of the heart, heart valves, and the vasculature. Analyze mathematical models at the level of single cells, tissues, and whole organs. Discuss image-to-model software basics to allow creation of a model of choice from any available imaging data for a project of interest.

CSE 397.5 Biomechanics of Tissues, Scaffolds, and Cells 3 Hours
Discuss biosolid mechanics, covering the complex mechanical behaviors of living tissues and related biomaterials, with a focus on modeling how they respond under loading. Examine major application areas to provide context to the theory and applications. Explore necessary mathematical, mechanics, and biological fundamentals in the context of applications and problems in biomedical research and medical devices.

CSE 397.6 Introduction to Computational Oncology 3 Hours
Develop a familiarity with the common computational techniques used in modeling various aspects of cancer at multiple spatial and temporal scales. Investigate how computational modeling offers unique and complementary information to traditional methods of cancer research. Examine the integration of theory and experiment while identifying the current barriers preventing computational modeling from having a broader impact on both cancer biology and clinical oncology.

CSE 397.7 Introduction to Mathematical and Physical Biology 3 Hours
Discuss the common mathematical and physical techniques used in modeling various aspects of biology at multiple spatial and temporal scales. With emphasis placed on the integration of theory and experiment, identify the current barriers preventing computational modeling from having a broader impact in biology.

CSE 397.8 Biomedical Imaging: Signals and Systems 3 Hours
Explore the physical principles and signal processing techniques used in thermographic, ultrasonic, and radiographic imaging, including image reconstruction from projections such as CT scanning, MRI, and millimeter wave determination of temperature profiles.

CSE 397.9 Mathematical Physiology 3 Hours
Explore mathematical modeling in physiology, how physiological problems can be formulated and modeled, and how such models give rise to interesting and challenging functional features. Examine several exemplar physiological systems. Discuss the mathematical aspects of growth and remodeling in living systems, an area unique to living systems.

CSE 397H Graduate Research Internship 3 Hours
Practical work experience in a research/industrial setting. Internship to be arranged by student and approved by instructor.

CSE 698 Thesis 6 Hours

CSE 398R Master's Report 3 Hours
Preparation of a report to fulfill the requirement for the master's degree under the report option.

CSE 399W, 699W, 999W Dissertation 3,6,9 Hours