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EDUCATION HISTORY - GRADUATE

- **CME444 - Computational Consulting** - Professor Margot Gerritsen
  Computational consulting to the Stanford research community by graduate students. Weekly briefings with faculty adviser and associated faculty to discuss ongoing consultancy projects and evaluate solutions.

- **ME333 - Mechanics** - Professor Adrian Lew
  Formulation of governing equations from a Lagrangian perspective. Examples with systems of particles and linear elastic solids. Waves in discrete and continuous media. Linear elasticity formulation in the static and dynamic cases, and elementary measures of stress and strain. Tensor and variational calculus.

- **CME356 - Engineering Functional Analysis and Finite Elements** - Professor Adrian Lew
  Concepts in functional analysis to understand models and methods used in simulation and design. Topology, measure, and integration theory to introduce Sobolev spaces. Convergence analysis of finite elements for the generalized Poisson problem. Extensions to convection-diffusion-reaction equations and elasticity. Upwinding. Mixed methods and LBB conditions. Analysis of nonlinear and evolution problems.

- **Math215A - Complex Analysis** - Professor Yanir Rubinstein
  Analytic functions, complex integration, Cauchy's theorem, residue theorem, argument principle, conformal mappings, Riemann mapping theorem, Picard's theorem, elliptic functions, analytic continuation and Riemann surfaces.

- **EE364A - Convex Optimization I** - Professor Stephen Boyd
  Stephen Boyd and Lieven Vandenberghe, *Convex Optimization*
  Convex sets, functions, and optimization problems; convex analysis and theory of convex programming: optimality conditions, duality theory, theorems of alternative, and applications. Least-squares, linear and quadratic programs, semidefinite programming, and geometric programming. Algorithms for smooth and equality constrained problems; interior-point methods for inequality constrained problems. Applications to signal processing, communications, control, analog and digital circuit design, computational geometry, statistics, machine learning, and mechanical engineering.

- **ME408 - Spectral Methods in Computational Physics** - Professor Parviz Moin
  Data analysis, spectra and correlations, sampling theorem, nonperiodic data, and windowing; spectral methods for numerical solution of ordinary and partial differential equations; accuracy and computational cost; FFT, Galerkin, collocation, and Tau methods; spectral and pseudospectral methods based on Fourier series and eigenfunctions of singular Sturm-Liouville problems; Chebyshev, Legendre, and Laguerre representations; convergence of eigenfunction expansions; discontinuities and Gibbs phenomenon; aliasing errors and control; efficient implementation of spectral methods; spectral methods for complicated domains; time differencing and numerical stability.

- **CME330 - Applied Mathematics in the Chemical and Biological Sciences** - Professor Eric Shaqfeh
  Mathematical solution methods via applied problems: chemical reaction sequences, mass and heat transfer in chemical reactors, quantum mechanics, fluid mechanics of reacting systems, and

chromatography. Generalized vector space theory, linear operator theory with eigenvalue methods, phase plane methods, perturbation theory (regular and singular), solution of parabolic and elliptic partial differential equations, and transform methods (Laplace and Fourier).

- **AA210A - Fundamentals of Compressible Flow** - Professor Brian Cantwell
  Development of the three-dimensional, non-steady, field equations for describing the motion of a viscous, compressible fluid; differential and integral forms; constitutive equations for a compressible fluid; the entropy equation; compressible boundary layers; shock waves; channel flow with heat addition and friction; flow in nozzles and inlets; oblique shock waves; Prandtl-Meyer expansion; the shock tube; small disturbance theory; acoustics in one-dimension; steady flow in two-dimensions; potential flow; linearized potential flow; lift and drag of thin airfoils.

- **MATH221 - Mathematical Methods of Imaging** - Professor George Papanicolaou
  Array imaging using Kirchhoff migration and beamforming and resolution theory for broad and narrow band array imaging in homogeneous media. Topics in high-frequency, variable background imaging with velocity estimation, interferometric imaging methods, the role of noise and inhomogeneities, and variational problems that arise in optimizing the performance of imaging algorithms and the deblurring of images.

- **CME342 - Parallel Methods in Numerical Analysis** - Professors Massimiliano Fatica and Patrick Legresley
  Maximum parallelism in numerical algorithms, especially matrix problems and partial differential equations and the subsequent mapping onto the computer. Implementation on parallel computers in MPI, OpenMP, and CUDA. Topics include parallel architecture, programming models, matrix computations, FFT, fast multiple methods, domain decomposition, and graph partitioning.

- **CME325 - Numerical Approximations of PDEs in Theory and Practice** - Professor Gunilla Kreiss
  Finite volume and finite difference methods for initial boundary value problems in multiple space dimensions. Emphasis is on formulation of boundary conditions for the continuous and the discrete problems. Analysis of numerical methods with respect to stability, accuracy, and error behavior. Techniques of treating non-rectangular domains, and effects of non-regular grids.

- **EE262 - Two-Dimensional Imaging** - Professor Howard Zebker
  Time and frequency representations, two-dimensional auto- and cross-correlation, Fourier spectra, diffraction and antennas, coordinate systems and the Hankel and Abel transforms, line integrals, impulses and sampling, restoration in the presence of noise, reconstruction and tomography, imaging radar. Tomographic reconstruction using projection-slice and layergram methods. Students create software to form images using these techniques with actual data. Final project consists of design and simulation of an advanced imaging system.

- **ME335A - Finite Element Analysis** - Professor Peter Pinsky
  Hughes, *Finite Element Method*
  Fundamental concepts and techniques of primal finite element methods. Method of weighted residuals, Galerkin's method, and variational equations. Linear elliptic boundary value problems in one, two, and three space dimensions; applications in structural, solid, and fluid mechanics and heat transfer. Properties of standard element families and numerically integrated elements. Implementation of the finite element method. Active column equation solver, assembly of equations, and element routines. The mathematical theory of finite elements.

- **ME335B - Finite Element Analysis** - Professor Peter Pinsky
  Hughes, *Finite Element Method*
  Finite element methods for linear dynamic analysis. Eigenvalue, parabolic, and hyperbolic problems. Mathematical properties of semi-discrete (t-continuous) Galerkin approximations. Modal decomposition and direct spectral truncation techniques. Stability, consistency, convergence, and

accuracy of ordinary differential equation solvers. Asymptotic stability, over-shoot, and conservation laws for discrete algorithms. Mass reduction. Applications in heat conduction, structural vibrations, and elastic wave propagation. Computer implementation of finite element methods in linear dynamics. Implicit, explicit, and implicit-explicit algorithms and code architectures.

- **ME335C - Boundary Element Analysis** - Professor Peter Pinsky
  The boundary integral equation and boundary element method with applications to potential theory and elastostatics. Green's function methods for transforming partial differential equations to integral equations with boundary conditions built in. Implementation of the method and treatments of weakly and strongly singular kernels. Coupling with finite element methods. Application to fracture mechanics, contact mechanics, and transient diffusion.

- **CS 249A - Object-Oriented Programming from a Modeling and Simulation Perspective** - Professor David Cheriton
  Large-scale software development approaches, encapsulation, use of inheritance and dynamic dispatch, design of interfaces and interface/implementation separation, exception handling, design patterns, minimalizing dependencies and value-oriented programming. The role of programming conventions/style/restrictions in surviving object-oriented programming for class libraries, frameworks, and programming-in-the-large; general techniques for object-oriented programming.

- **Phys330 - Quantum Field Theory** - Professor Renata Kallosh
  Peskin, Schroeder, *An Introduction to Quantum Field Theory*
  Quantization of scalar and Dirac fields. Introduction to supersymmetry. Feynman diagrams. Quantum electrodynamics. Elementary electrodynamic processes: Compton scattering; e+e- annihilation. Loop diagrams and electron (g-2).

- **CME306 - Numerical Solutions of PDEs** - Professor Ron Fedkiw
  Hyperbolic partial differential equations: stability, convergence and qualitative properties; nonlinear hyperbolic equations and systems; combined solution methods from elliptic, parabolic, and hyperbolic problems. Examples include: Burgers equation, Euler equations for compressible flow, Navier-Stokes equations for incompressible flow.

- **CME308 - Stochastic Methods in Engineering** - Professor Peter Glynn
  Monte Carlo simulation; state space models and time series; parameter estimation, prediction, and filtering; Markov chains and processes; stochastic control; and stochastic differential equations.

- **ME436 - Computational Molecular Modeling** - Professor Eric Darve
  Advanced methods for computer simulation of proteins. Long-range force calculation, particle mesh Ewald, fast multipole method, multigrid. Free energy methods, umbrella sampling, acceptance ratio, thermodynamic integration, non equilibrium methods, adaptive biasing force, parallel computing.

- **ME469A - Computational Fluid Dynamics** - Professor Gianluca Iaccarino
  Finite volume methods on stuctured and unstructured grids. Advanced methods for the solution of systems of equations. ADI schemes, preconditioned conjugate gradient and generalized minimum residual algorithms, multigrid methods, and deferred-correction approaches. Projection, fractional step, and artificial compressibility methods. Turbulent flows: direct numerical simulation, large eddy simulation, and Reynolds-averaged Navier-Stokes methods.

- **CME304 - Numerical Optimization** - Professor Walter Murray
  Unconstrained nonlinear problems, Linear equality constrained problems, Linear inequality constrained problems, Nonlinear equality constrained problems, Nonlinear inequality constrained

problems via Linesearch, Trust-region, Newton's method, Modified Newton's methods, Quasi-Newton methods, Linear and nonlinear conjugate gradient, Simplex method, Penalty function methods, Barrier function methods, Augmented Lagrangian methods, Sequential linearly constrained methods, and Sequential quadratic programming.

- **CME305 - Discrete Mathematics and Algorithms** - Professor Amin Saberi
  Enumeration (permutations, stirling numbers, Cayley's theorem), SDR, flows and cuts (deterministic and randomized algorithms), eigenvalues and expansion arguments, asymptotics (NP-hardness and approximation algorithms). Topics illustrated with EE, CS, and bioinformatics applications.

- **CME302 - Numerical Linear Algebra** - Professor Gene H. Golub
  Solution of systems of linear equations, covering the following topics: direct methods, error analysis, structured matrices, iterative methods, least squares, and parallel techniques.

- **MATH220A - Partial Differential Equations of Applied Mathematics** - Professor András Vasy
  Fully nonlinear PDEs via method of characteristics, conservation laws and weak solutions, wave equations in multiple dimensions, Fourier series solutions, method of reflection.

- **CS205 - Math Methods for Computer Vision, Robotics, and Graphics** - Professor Ron Fedkiw
  Accuracy and stability of numerical calculations, matrix factorizations and methods, SVD, steepest descent, conjugate gradient, constrained numerical optimization, interpolation and quadrature, Newmark methods and position/velocity grids, numerical methods of boundary value PDEs.

Education History - Undergraduate

Upper Level Mathematics:

- **Linear Algebra I & II**
- **Differential Equations I & II**
- **Multivariable Calculus I & II**
- **Probability and Statistics**

- **Discrete Mathematics ()** - Professor Micheal E. Orrison
  Scheinerman, E. *Mathematics: A Discrete Introduction, 2nd Edition.*
  Combinatorics, number theory, and graph theory, with an emphasis on creative problem solving and learning to read and write rigorous proofs.

- **Abstract Algebra ()** - Professor Micheal E. Orrison
  Dummit, D., and Foote, R. *Abstract Algebra.*
  Groups and isomorphism theorems. Rings and other structures.

- **Fourier Analysis and Boundary Value Problems ()** - Professor Darryl Yong
  Complex variables and residue calculus, Laplace transforms, Fourier transforms, Separation of variables, Fourier series, Sturm-Liouville eigenvalue problems, Bessel functions, orthogonal polynomials, the heat equation, wave equation, and Laplace's equation.

- **Mathematical Analysis ()** - Professor Lesley Ward
  Rudin, W. *Principles of Mathematical Analysis. Third Edition.*
  Countable sets, least upper bound, and metric space topology including compactness, completeness, connectivity, and uniform convergence.

Upper Level Computer Science:

- **Principles of Computer Science** () - Professor Bob Keller

  Information structures, functional programming, object-oriented programming, grammars, logic, logic programming, correctness, algorithms, complexity analysis, finite-state machines, basic processor architecture, and theoretical limitations.

- **Data Structures/Program Development** () - Professor Melissa O'Neill

  Abstract data types including priority queues, dynamic dictionaries, and disjoint sets. Efficient data structures for these data types, including heaps, self-balancing trees, and hash tables. Analysis of data structures including worst-case, average-case, and amortized analysis. Storage allocation and reclamation. Secondary storage considerations. Extensive practice in implementing these data structures for a variety of applications.

- **Computability and Logic** () - Professor Christopher Stone

  Martin, John. *Introduction to Languages and the Theory of Computation.*

  Logic, automata, and computability theory with emphasis in constructing and writing proofs.

- **Algorithms** () - Professor Belinda Thom

  T. Cormen, C. Leiserson, R. Rivest, and C. Stein. *Introduction to Algorithms, 2nd Edition*

  Algorithm design, analysis, and correctness. Divide-and-conquer and dynamic programming. Solutions to recurrence relations and amortization. Invariants and inductive proofs. Sorting and searching, graph theoretic problems such as shortest path and network flow, and topics selected from arithmetic circuits, parallel algorithms, computational geometry, and others. An introduction to computational complexity, NP-completeness, and approximation algorithms.

- **Scientific Computing** () - Professor LG DePillis

  D. Kahaner, C. Moler and S. Nash. *Numerical Methods and Software.*

  Introduction to mathematical modeling. Matlab, error analysis for differential equations, modeling with linear systems, analysis for solving linear systems and eigenvalue problems, modeling with ordinary differential equations, parallel computing with MPI, modeling with partial differential equations.

- **Programming Languages** () - Professor Melissa O'Neill

  Scott, Michael L. *Programming Language Pragmatics.*

  Examination of issues and features in language design and implementation including language provided data structuring and data-typing, modularity, scoping, inheritance, and concurrency. Compilation and run-time issues. Formal semantics.

- **Computer Systems** () - Professor Mike Erlinger

  Bryant, Randal E. and O'Hallaron, David R. *Computer Systems: A Programmer's Perspective.*

  Data representations, machine level representations of programs, processor architecture, program optimizations, the memory hierarchy, linking, exceptional control flow (exceptions, interrupts, processes, and Unix signals), performance measurement, virtual memory, system-level I/O, and basic concurrent programming.

- **Advanced Topics in Algorithms** () - Professor Ran Libeskind-Hadas

  Rigorous treatment of complexity theory. The complexity classes P, NP, and the Cook-Levin Theorem. Approximability of NP-complete problems. The polynomial hierarchy, PSPACE completeness, L and NL-completeness, #P-completeness. IP and Zero-knowledge proofs. Randomized and parallel complexity classes. The speedup, hierarchy, and gap theorems.

Upper Level Physics:

- **Quantum Physics ()** - Professor John Townsend
  Eisberg & Resnick. *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles*
  Operators, eigenfunctions and eigenvalues, superposition, commutators, and uncertainty relations. After discussion of angular momentum and simple three-dimensional systems, applications of quantum mechanics to atomic and molecular physics, solid state physics, nuclear physics, particle physics, modern atom interferometry, and the Schrodinger equation.

- **Theoretical Mechanics ()** - Professor Vatche Sahakian
  Hand and Finch. *Analytical Mechanics*
  Calculus of variations and Noether's theorem. D'Alembert's Principle is then used to derive the Lagrange equations, and many applications are developed. Hamilton's equations are derived. Applications include central-force motion and orbital mechanics in central gravitational fields, normal mode oscillation, and rigid-body rotation. The course also shows that the Principle of Stationary Action follows from Feynman's sum over paths approach in quantum mechanics.

- **Electronics Lab ()** - Professor Chih-Yung Chen
  Construction and analysis of a variety of analog and digital circuits using resistors, capacitors, diodes, transformers, operational amplifiers, photodiodes, light-emitting diodes, digital logic gates, flip-flops, and clocks. Applications include rectifiers, amplifiers, differentiators and integrators, passive and active filters, oscillators, counting circuits, digital-to-analog and analog-to-digital conversion.

- **Quantum Mechanics ()** - Professor Peter Saeta
  John S. Townsend. *A Modern Approach to Quantum Mechanics*
  Dirac notation from a discussion of the Stern-Gerlach device and spin-1/2 particles. General formalism, one-dimensional and three-dimensional problems, angular momentum states, Bell's theorem and experiment, perturbation theory, and identical particles. Applications to atomic and nuclear systems.

- **Optics Lab ()** - Professor Chih-Yung Chen
  A laboratory-lecture course on classical and modern optics. Diffraction, interferometry, Fourier transform spectroscopy, grating spectroscopy, lasers, and coherence of waves. Developing skills in experimental design and execution with flexible, multi-part experiments. Experiments in Fraunhofer and Fresnel diffraction, scanning Fabry-Perot interferometry of a He-Ne laser including the Lamb dip and the Zeeman effect, Michelson interferometry and white light fringes, and an independent technical experiment investigating large reproducible errors in the Zeeman effect experiment.

- **Computational Methods in Physics ()** - Professor Peter Saeta
  Integration of functions and initial value problems, Fourier transform methods and applications, boundary value problems, and stochastic methods. High emphasis on clear technical writing and innovation.

- **Electromagnetic Fields ()** - Professor Tom Donnelly
  Griffiths, David J. *Introduction of Electrodynamics*
  Seminar course taught by enrolled students and directed by the professor. An emphasis on advanced analytical techniques. Electrostatics, solution of Laplace's and Poison's equations in various coordinate systems and boundaries, fields in matter, electrodynamics and radiation.

- **Statistical Mechanics ()** - Professor Ann Esin
  Kittel and Kroemer. *Thermal Physics.*

Quantum and classical statistical mechanics and thermodynamics of many particles: classical and quantum gases, isolated spins in a magnetic field, photons, and phonons. Development and application of thermodynamic laws to uniform phases, phase and chemical equilibria, heat engines, refrigerators, and other practical devices.

- **General Relativity and Cosmology ()** - Professor Vatche Sahakian
  Stephani, Hans. *Relativity.*
  The principle of equivalence, Riemannian geometry, Einstein's field equations, and the Schwarzschild and cosmological solutions are all developed, along with experimental and observational tests of the theory.