Algebra

Number Theory

Dates: Jan–May, 2017 Course Number: MATH 367 School: University of San Francisco
Undergraduate Credit: 3 Instructor: Dr. Paul Zeitz

Textbooks: James E. Pommershem, Tim K. Marks, and Erica L. Flapan, *Number Theory,* 2010 Wiley.

Topics: Numbers, rational and irrational, mathematical induction, divisibility and primes, the Euclidean algorithm, linear Diophantine equations, the fundamental theorem of arithmetic, modular arithmetic, modular number systems, exponents modulo n, primitive roots, quadratic residues, primality testing, and Guassian integers.

Elliptic Function and Elliptic Curves (MASS Algebra)

Dates: Aug–Dec, 2017 Course Number: MATH 497.001 School: Pennsylvania State University
Undergraduate Credit: 4 Instructor: Dr. Yuriy Zarkhin

Textbooks: Boris M. Bekker and Yuri G. Zarhin, *The divisibility by 2 of rational points on elliptic curves,* 2017. https://arxiv.org/abs/1702.02255.

Topics: Subgroups and quotients of abelian groups. Cosets, Lagrange's theorem. Discrete subgroups of $\mathbb{C}$. Complex tori/elliptic curves, joints of order 2/half-periods, fundamental parallelograms. Elliptic functions, their zeros and poles. Weierstrass $\mathcal{P}$-function and its derivative, the differential equation for $\mathcal{P}$. Divisors on elliptic curves and divisors of elliptic functions. Elliptic functions as rational functions in $\mathcal{P}(z)$ and $\mathcal{P}'(z)$. Endomorphism rings and homomorphisms of elliptic curves. Projective planes and projective algebraic curves. Nonsingular points, tangent lines. Parameterization of conics/circles by rational functions. The upper half-plane and modular group. Fundamental domain. Modular and automorphic forms, their zeros and poles, j-invariant. Smooth plane projective cubics/elliptic curves, group law. Point of order 2. Division by 2 on elliptic curves. Points of order 3 on elliptic curves. Points of order 4 on elliptic curves.

Modern Algebra I

Dates: Jan–May, 2019 Course Number: MATH 335 School: San Francisco State University
Undergraduate Credit: 3 Instructor: Dr. Joseph Gubeladze

Textbooks: C. C. Pinter, *A Book of Abstract Algebra, Second Edition,* 1990 McGraw-Hill.

Topics: 1. Groups: Definition and basic properties of groups. Special emphasis on symmetric groups to emphasize the non-abelian structure. Subgroups. Cyclic groups. Homomorphisms, isomorphisms, and normal subgroups. Left and right cosets, Lagrange's theorem, factor/quotient groups, isomorphism theorems. The statement of the Fundamental Theorem of Finitely Generated Abelian Groups and applications. 2. Rings: Definition of rings, unit, zero-divisor, division ring, integral domain, field; basic properties. Ring homomorphisms and isomorphisms, subrings, images and kernels, definition of ideals and quotient rings, one- and two-sided ideals, isomorphism theorems, properties of ideals. PIDs, greatest common divisor. UFDs, division algorithm, irreducibility of polynomials.

Modern Algebra II

Dates: Sept–Dec, 2019 Course Number: MATH 735 School: San Francisco State University
Graduate Credit: 3 Instructor: Dr. Joseph Gubeladze

Textbooks: John Stillwell, *Elements of Algebra,* 2000 Springer.

Topics: 1. Groups: Quick review of fundamentals of group theory emphasizing quotient groups. Definition of group actions and examples, orbits, conjugation action, conjugacy class, conjugacy classes in the symmetric group. The statement of Sylow's Theorem and its simple applications. 2. Modules and Vector Spaces: Definition of modules, abelian groups as Z-modules, vector spaces as F-modules, vector spaces with linear transformations as F[x]-modules, submodules module homomorphisms, quotient modules, isomorphism theorems, direct sums, free modules. The statement of the main theorem of finitely generated modules over PIDs. 3. Fields and Field Extensions: Maximal and prime ideals. Characteristics of a field, field extension, degree of an extension, computing in a finite extension, algebraic extension, minimal polynomial, roots of unity. Splitting fields. Finite fields. 4. Miscellaneous topics: Galois theory.

Independent Study

Dates: Sept–Dec, 2019 Course Number: MATH 899 School: San Francisco State University
Graduate Credit: 3 Instructor: Dr. Joseph Gubeladze

Textbooks: Joseph Gubeladze, *Polytopes, Rings, and K-theory,* 2000 Springer.

Topics: Polyhedra and their faces, finite generation of cones, finite generation of polyhedra, polyhedral complexes, subdivisions and triangulations, regular subdivisions, rationality and integrality.

Calculus I

Dates: Sept–Dec 2007 Course Number: AM–1050AC School: National Dong Hwa University
Undergraduate Credit: 3 Instructor: Dr. Tzer-Jen Wei
Textbooks: James Stewart, *Calculus,* 5th ed, 2002 Brooks Cole.
Topics: Principles of Problem Solving. 2. Limits. The Tangent and Velocity Problems. The Limit of a Function. Calculating Limits Using the Limit Laws. The Precise Definition of a Limit. Continuity. 3. Derivatives. Derivatives and Rates of Change. The Derivative as a Function. Differentiation Formulas. Derivatives of Trigonometric Functions. The Chain Rule. Implicit Differentiation. Rates of Change in the Natural and Social Sciences. Related Rates. Linear Approximations and Differentials. 4. Applications of Differentiation. Maximum and Minimum Values. The Mean Value Theorem. How Derivatives Affect the Shape of a Graph. Limits at Infinity; Horizontal Asymptotes. Summary of Curve Sketching. Graphing With Calculus and Calculators. Optimization Problems. Newton's Method. Antiderivatives. 5. Integrals. Areas and Distances. The Definite Integral. The Fundamental Theorem of Calculus. Indefinite Integrals and the Net Change Theorem. The Substitution Rule. 6. Applications of Integration. Areas Between Curves. Volume. Volumes by Cylindrical Shells. Work. Average Value of a Function. 7. Inverse Functions: Exponential, Logarithmic, and Inverse Trigonometric Functions. Inverse Functions. Exponential Functions and Their Derivatives. Logarithmic Functions. Derivatives of Logarithmic Functions. Exponential Growth and Decay. Inverse Trigonometric Functions. Hyperbolic Functions. Indeterminate Forms and L'hospital's Rule. 8. Techniques of Integration. Integration by Parts. Trigonometric Integrals. Trigonometric Substitution. Integration of Rational Functions by Partial Fractions. Strategy for Integration. Integration Using Tables and Computer Algebra Systems. Approximate Integration. Improper Integrals. 9. Further Applications of Integration. Arc Length.

Calculus II

Dates: Jan–May 2008 Course Number: AM–1080AC School: National Dong Hwa University
Undergraduate Credit: 3 Instructor: Dr. Tzer-Jen Wei

Textbooks: James Stewart, *Calculus,* 5th ed, 2002 Brooks Cole.

Topics: 11. Parametric Equations and Polar Coordinates. Curves Defined by Parametric Equations. Calculus With Parametric Curves. Polar Coordinates. Areas and Lengths in Polar Coordinates. Conic Sections. Conic Sections in Polar Coordinates. 12. Infinite Sequences and Series. Sequences. Series. The Integral Test and Estimates of Sums. The Comparison Tests. Alternating Series. Absolute Convergence and the Ratio and Root Tests. Strategy for Testing Series. Power Series. Representation of Functions as Power Series. Taylor and Maclaurin Series. Applications of Taylor Polynomials. 13. Vectors and the Geometry of Space. Three-dimensional Coordinate Systems. Vectors. The Dot Product. The Cross Product. Equations of Lines and Planes. Cylinders and Quadric Surfaces. 14. Vector Functions. Vector Functions and Space Curves. Derivatives and Integrals of Vector Functions. Arc Length and Curvature. Motion in Space: Velocity and Acceleration. 15. Partial Derivatives. Functions of Several Variables. Limits and Continuity. Partial Derivatives. Tangent Planes and Linear Approximations. The Chain Rule. Directional Derivatives and the Gradient Vector. Maximum and Minimum Values. Lagrange Multipliers. 16. Multiple Integrals. Double Integrals Over Rectangles. Iterated Integrals. Double Integrals Over General Regions. Double Integrals in Polar Coordinates. Applications of Double Integrals. Triple Integrals. Triple Integrals in Cylindrical. Triple Integrals in Spherical Coordinates. Change of Variables in Multiple Integrals. 17. Vector Calculus. Vector Fields. Line Integrals. The Fundamental Theorem for Line Integrals. Green's Theorem.

Matrices and Vector Analysis

Dates: Jan–May, 2008 Course Number: PHYS 10900 School: National Dong Hwa University
Undergraduate Credit: 3 Instructor: Dr. Yung-Kang Guo and Chi-Ning Chen

Textbooks: Peter V. O'Neil, *Advanced Engineering Mathematics,* 5th ed, 2002 Brooks/Cole.

Topics: vectors and vector spaces, matrices and systems of linear equations, determinants, eigenvalues and diagonalization, vector functions of one variable, vector field, gradient field, divergence and curl, line integrals and surface integrals, Green's theorem, divergence theorem of Gauss, and integral theorem of Stokes.

Real Analysis

Dates: Jan–May, 2017 Course Number: MATH 453 School: University of San Francisco
Undergraduate Credit: 3 Instructor: Dr. Stephen Devlin

Textbooks: Stephen Abbott, *Understanding Analysis,* 2015 Springer.

Topics: the axiom of completeness, sequences and series, topology of the real line, limits and continuity, the real number system, the derivative and Riemann integral.

Analytic Number Theory
Dates: Jan–May, 2018 Course Number: MATH 398 School: University of San Francisco
Undergraduate Credit: 3 Instructor: Dr. Paul Zeitz
Textbooks: G. J. O. Jameson, *The Prime Number Theorem,* 2003 Cambridge University Press, G. Tenenbaum and M. M. France *The Prime Numbers and their Distribution,* 2003 Cambridge University Press, and Lars V Ahlfors, *Complex Analysis,* 1979 McGraw-Hill.
Topics: Counting prime numbers, arithmetic functions, Abel summation, estimation of sums by integers, Euler's summation formula, the function $\mathrm{li}(x)$, Chebyshev's theta function, Dirichlet series and the zeta function, Euler product, Möbius function, the series for $\log \zeta(s)$ and $\zeta'(s)/\zeta(s)$, Chebyshev's psi function and powers of primes, estimates of some summation functions, extension of the definition of the zeta function, inversion of Dirichlet series, the integral version of the fundamental theorem, an alternative method; Newman's proof, the limit and series versions of the fundamental theorem, the prime number theorem, error estimates and the Riemann hypothesis.

Introduction to Complex Analysis
Dates: Jan–May, 2019 Course Number: MATH 380 School: San Francisco State University
Undergraduate Credit: 3 Instructor: Dr. Chun-Kit Lai
Textbooks: Brown and Churchill, *Complex Variable and Applications, 6th Edition,* 1995 McGraw-Hill.
Topics: The Field of Complex Numbers. Analytic Functions: properties of analytic functions, Cauchy-Riemann equations. Elementary Functions: algebraic, trigonometric and logarithmic functions. Contour Integrals of Complex Functions: Cauchy's Theorem, Cauchy's Integral Formula, Cauchy's Inequalities, Liouville's Theorem, Morera's Theorem, Maximum Modulus Theorem and elementary properties of harmonic functions. Complex Series: power series, Taylor's Theorem, Laurent's Theorem and Laurent series, residues. Conformal mapping with applications chosen from: Dirichlet and Neumann problems, heat conduction, fluid flow and electric potential.

Real Analysis I
Dates: Sept–Dec, 2019 Course Number: MATH 370 School: San Francisco State University
Undergraduate Credit: 3 Instructor: Dr. Chun-Kit Lai
Textbooks: William Wade, *An Introduction to Analysis, 3rd Edition,* 2003 Prentice Hall.
Topics: The Real Number System: ordered field axioms, the Well-Ordering Principle, the Completeness Axiom, countability. Sequences in : limit theorems, Bolzano-Weierstrass Theorem, Cauchy sequences. Continuity on : two and one-sided limits of functions, limits of functions at infinity, continuity, uniform continuity. Differentiability on : the derivative, differentiability theorems, the Mean Value Theorem, L'Hospital's Rule, monotone functions, the Inverse Function Theorem. The Riemann integral: Riemann sums, The Fundamental Theorem of Calculus.

Real Analysis II: Several Variables
Dates: Jan–May, 2020 Course Number: MATH 770 School: San Francisco State University
Graduate Credit: 3 Instructor: Dr. Alex Schuster
Textbooks: William Wade, *An Introduction to Analysis, 3rd Edition,* 2003 Prentice Hall.
Topics: Infinite sequences and series of functions, uniform convergence. Introduction to metric spaces, Heine-Borel Theorem. Differentiable maps between Euclidean spaces; Derivative matrix, Chain Rule, Mean-Value Theorem. Inverse Function Theorem.

Geometry of Infinite Dimensional Spaces (MASS Analysis)

Dates: Aug–Dec, 2017 Course Number: MATH 497.002 School: Pennsylvania State University
Undergraduate Credit: 4 Instructor: Dr. Moisey Guysinsky
Textbooks: Anatole Katok, *SPACES: FROM ANALYSIS TO GEOMETRY AND BACK,* 2011 MASS Program.
Topics: Metric, metric spaces, complete metric spaces. Contracting map theorem. Compact sets in complete metric spaces. Norms, equivalence of the norms in $\mathbb{R}^n$. Euclidean finite dimensional spaces, Cauchy-Schwarz inequality. Gram-Schmidt procedure. Banach spaces.Geometric description of a unit ball in a Banach spaces. Isomorphism of separable Hilbert spaces. Fourier Transform of the space $L^2(\mathbb{S}^1)$. Sobolev spaces $W^n(\mathbb{S}^1)$. Linear maps in normed spaces The definition of the operator norm of a linear map. Linear functionals. The definition of dual spaces and double dual spaces. Canonical isometric embedding from a vector space to its double dual. Proof that if H is a Hilbert space, then there is a canonical isometric isomorphism between H and H^*. The dual space to ℓ^1 and $\ell^p, 1 < p < \infty$. The space of functions of bounded variation. Riemann-Stieltjes integral. Proof that the $C[0,1]^*$ is isometricaly isomorphic to the space of functions of bounded variation such that $f(0) = 0$. Hanh-Banach theorem. Baire category theorem. Open map theorem. Closed graph theorem. Uniform boundedness theorem. Spectrum of a bounded linear operator. Closeness of the spectrum. Spectral radius. Compact linear operators. The description of the spectrum of a compact operators. The existence of an orthonormal basis consisting from the eigenvectors for a compact self-adjoint operator.

Theory of Functions of a Complex Variable

Dates: Jan–May, 2020 Course Number: MATH 730 School: San Francisco State University
Graduate Credit: 3 Instructor: Dr. Chun-Kit Lai
Textbooks: E. M. Stein and R. Shakarchi, *Princeton Lectures in Analysis: Complex Analysis,* 2003 Princeton University Press.
Topics: holomorphic functions, Schwarz reflection principle, complex integration, Cauchy's theorem and its consequences, harmonic functions, sequences and series of analytic functions, isolated singularities, open mapping theorem, conformal mapping, the Dirichlet problem in a strip, Schwarz lemma, automorphisms of the disc and upper half-plane, Riemann mapping theorem, and Montel's theorem.

Measure & Integration

Dates: Jan–May, 2020 Course Number: MATH 710 School: San Francisco State University
Graduate Credit: 3 Instructor: Dr. Sheldon Axler
Textbooks: Sheldon Axler, *Measure, Integration & Real Analysis,* 2020 Springer.
Topics: Infinite sequences and series of functions, uniform convergence. Introduction to metric spaces, Heine-Borel Theorem. Differentiable maps between Euclidean spaces; Derivative matrix, Chain Rule, Mean-Value Theorem. Inverse Function Theorem.

Advanced Linear Algebra
Dates: Sept–Dec, 2020 Course Number: MATH 725 School: San Francisco State University
Graduate Credit: 3 Instructor: Dr. Henry Boateng
Textbooks: Sheldon Axler, *Linear Algebra Done Right,* 2015 Springer.
Topics: Vector spaces, linear independence, bases, dimension. Linear maps, null space, range, matrix representations, invertibility. Invariant subspaces, upper triangular matrix representations, eigenvectors and eigenvalues. Inner products, norms, orthonormal bases, Gram Schmidt process, orthogonal projection and best approximation, linear functionals and adjoints, Riesz representation. Self-adjoint and normal operators, the Spectral Theorem, positive operators, isometries, polar and singular-value decompositions. Generalized eigenvalues, characteristic and minimal polynomials, nilpotent operators, Jordan canonical form.

Functional Analysis
Dates: Jan–May, 2021 Course Number: MATH 711 School: San Francisco State University
Graduate Credit: 3 Instructor: Dr. Sheldon Axler
Textbooks: Sheldon Axler, *Measure, Integration & Real Analysis,* 2021 Springer.
Topics: Metric spaces, Baire Category Theorem. Banach and Hilbert spaces, classical examples. Bounded operators and dual spaces. Hahn-Banach, closed graph, and open mapping theorems.

Topology and Geometry

Differential Geometry
Dates: Jan–May, 2017 Course Number: MATH 482 School: University of San Francisco
Undergraduate Credit: 4 Instructor: Dr. Tristan Needham
Textbooks: Barrett O'Neill, *Elementary Differential Geometry, 2nd Edition,* 2006 Academic Press.
Topics: Calculus on Euclidean space, frame fields, Euclidean geometry, calculus on a surface, shape operators, geometry of surfaces in $\mathbb{R}^3$, Riemannian geometry, global structure of surfaces.

MASS Geometry: Knot Theory
Dates: Aug–Dec, 2017 Course Number: MATH 497.002 School: Pennsylvania State University
Undergraduate Credit: 3 Instructor: Dr. Sergei Tabachnikov
Textbooks: C. C. Adams, *The Knot Book,* 2004 American Mathematical Society.
Topics: Knots and links, isotopies, wild and tame knots, polygonal knots, knot diagrams, Reidmeister moves, simple knot invariants, linking number, three-coloring, connected sum of knots, classical knot invariants, unknotting number, crossing number, torus knots, surfaces, projective plane, Klein bottle, classification of closed oriented surfaces, Seifert surfaces, genus of a knot, braid group, closure of a braid, Alexander's and Markov's theorems, Cauchy-Crofton formula, total curvature of closed curves, Fenchel and Fáry-Milnor theorems, Fundamental group, Van Kampen theorem, Wirtinger presentation, bracket polynomial, Jones polynomial, proof of Tait's conjecture, Skein relations, Alexander-Conway polynomial, tensor product of vector spaces, quantum knot invariants, Yang-Baxter equation, singular knots, Vassiliev knot invariants, chord diagrams, weight systems, Lie algebras, weight systems from Lie algebras with an invariant scalar product, and Kontsevich integral.

Topology
Dates: Sep–Dec, 2020 Course Number: MATH 450 School: San Francisco State University
Undergraduate Credit: 3 Instructor: Dr. Emily Clader
Textbooks: James Munkres, *Topology, 2nd Edition,* 2000 Pearson College Div, and Michael Starbird and Francis Su, *Topology Through Inquiry* 2019 American Mathematical Society.
Topics: Metric Spaces: open and closed sets, interior, closure, boundary of sets, connected sets, compact sets, and continuous functions. Topological Spaces: the same concepts as above, this time in the context of general topological spaces. Special Topics: knot theory, fundamental groups, Zarski topology.

Differential Equations

Applied Mathematics I
Dates: Jan–May 2009 Course Number: PHYS 20800 School: National Dong Hwa University
Undergraduate Credit: 3 Instructor: Dr. Lin Chi Yong
Textbooks: G. B. Arfken and H. J. Weber, *Mathematical Methods for Physicists, 6th Edition,* 2005 Academic Press, P. V. O'Neil Advanced Engineering Mathematics, *Mathematical Methods for Physicists, 7th Edition,* 2011 Cengage India, D. J. Griffiths, *Introduction to Electrodynamics, 3rd Edition,* 1988 Prentice Hall, and S. T. Thornton and J. B. Marion, *Classical Dynamics of Particles and Systems, 5th edition,* 2003 Cengage Learning.
Topics: Elementary calculus in polar, spherical and cylindrical coordinates with applications in electrostatics. Curvilinear coordinates, vector analysis, differential operators in curvilinear coordinates, first-order differential equations (separable equations, exact differential equations, linear differential equations), second-order differential equations (the constant coefficient homogeneous and inhomogeneous linear equations) with applications to classical mechanics and electric circuits, power series solutions, Legendre equation, Legendre polynomials (its definition and properties), Power series solutions around singular points (Frobenius method).

Applied Mathematics II
Dates: Jan–May 2009 Course Number: PHYS 20900 School: National Dong Hwa University
Undergraduate Credit: 3 Instructor: Dr. Lin Chi Yong
Textbooks: G. B. Arfken and H. J. Weber, *Mathematical Methods for Physicists, 6th Edition,* 2005 Academic Press.
Topics: Finite-dimensional linear spaces, important concepts of a normed vector space, infinite-dimensional vector space (space of functions), orthogonal functions, basis and expansions, Fourier series of a function, convergence of Fourier series, Fourier cosine series and Fourier sine series of a function, integration and differentiation of Fourier series, complex Fourier series, Sturm-Liouville theory, eigenfunction expansion, Legendre polynomials, Associated Legendre functions and spherical harmonics, Bessel equation, Gamma and Beta functions, Bessel functions, special functions related to Bessel functions, integral transform, Fourier transform, Fourier integrals, convolution and applications, and Laplace transform.

Statistics

Statistics with Applications

Dates: Jan–May, 2018	Course Number: MATH 371	School: University of San Francisco
Undergraduate	Credit: 4	Instructor: Dr. Xuemei Chen

Textbooks: L. J. Bain and M. Engelhardt, *Introduction to Probability and Mathematical Statistics, 2nd Edition,* 1992 Brooks/Cole.

Topics: Review of probability (conditional probability, discrete random variables, continuous random variables, moment generating functions, special discrete and continuous distributions, joint discrete and continuous distributions, conditional distributions, conditional expectation, joint moment generating functions, transformation variables, limiting distributions, central limit theorem), and mathematical statistics, including t, F, and beta sampling distributions, point estimation, interval estimation (confidence intervals, pivotal quantity method), tests of hypotheses, final project: Fisher exact test.

Combinatorics

Combinatorics

Dates: Sept–Dec, 2016	Course Number: MATH 422	School: University of San Francisco
Undergraduate	Credit: 4	Instructor: Dr. Paul Zeitz

Textbooks: R.B.J.T. Allenby and A. Slomson, *How to Count: An Introduction to Combinatorics, 2nd Edition,* 2010 Chapman and Hall.

Topics: classic combinatorics problems, permutations, combinations, applications to probability problems, multinomial theorem, counting the solutions of equations, Stirling numbers, the inclusion-exclusion principle, Catalan numbers, partitions and dot diagrams, generating functions and recurrence relations, the Hardy-Ramanujan formula, permutations as groups, symmetry groups, orbits, stabilizers, axioms for group actions, Pólya's counting theorem, Dirichlet's pigeonhole principle, Ramsey theory.

Combinatorics

Dates: Jan–May, 2019	Course Number: MATH 720	School: San Francisco State University
Graduate	Credit: 3	Instructor: Dr. Joseph Gubeladze

Textbooks: Richard A. Brualdi, *Introductory Combinatorics, 5th Edition,* 2004 Prentice Hall.

Topics: The pigeonhole principle. Counting techniques. Fundamental combinatorial objects (sets, permutations, combinations, partitions). Generating functions. Eulerian graphs and Hamiltonian graphs. Partially ordered sets. The probabilistic method.

Non-mathematics courses that have substantial mathematical components.

Physics.

Mathematical Physics I
Dates: Sept–Dec 2009 Course Number: PHYS 30000 School: National Dong Hwa University
Undergraduate Credit: 3 Instructor: Dr. Hsin-Chang Chi
Textbooks: G. B. Arfken and H. J. Weber, *Mathematical Methods for Physicists, 6th Edition,* 2005 Academic Press, M. L. Boas, *Mathematical Methods in the Physical Sciences, 3rd Edition,* 2005 Wiley, and Brown and Churchill, *Complex Variable and Applications, 6th Edition,* 1995 McGraw-Hill.
Topics: Elementary linear algebra, partial differentiations and total differentials, complex functions, Laplace and Fourier transformations, conformal mapping, and Green's function.

Quantum Field Theory II
Dates: Sept–Dec, 2011 Course Number: PHYS 8018 School: National Taiwan University
Graduate Credit: 3 Instructor: Dr. Jiunn-Wei Chen
Textbooks: M. E. Peskin and D. V. Schroeder, *An Introduction to Quantum Field Theory,* 1995 CRC Press, M. Srednicki, *Quantum Field Theory,* 2007 Cambridge University, and A. Zee, *Quantum Field Theory in a Nutshell,* 2010 Princeton University Press.
Topics: Loop corrections in Yukawa theory, beta functions in Yukawa theory, functional determinants, electrodynamics in Coulomb gauge, LSZ reduction for photons, path integral pair production, Klein-Gordon field, the Dirac field, spinor electrodynamics, scattering in spinor electrodynamics, spinor helicity for spinor electrodynamics, scalar electrodynamics, loop correction in spinor electrodynamics, the vertex function in spinor electrodynamics, the magnetic moment of the electron, loop corrections in scalar electrodynamics, beta functions in quantum electrodynamics, Ward identities in quantum electrodynamics, non-abelian gauge theory, the path integral for non-abelian gauge theory, Feynman rules for non-abelian gauge theory, interacting fields and Feynman diagrams, elementary processes of quantum electrodynamics, radiative corrections, functional methods, systematics of renormalization, BRST symmetry, renormalization and symmetry, the renormalization group, symmetry and symmetry breaking, minimal supersymmetric standard model, quantum Hall fluids, sigma model as effective field theories, fractional statistics, anomalies and the path integral for fermions, Chern-Simons term, topological field theory, and Chern-Simons theory.

Introduction to Particle Physics
Dates: Sept–Dec, 2011 Course Number: PHYS 5013 School: National Taiwan University
Undergraduate Credit: 3 Instructor: Dr. Yee Bob Hsiung
Textbooks: B. R. Martin and G. Shaw, *Particle Physics,* 2008 John Wiley & Sons, and D. Griffiths, *Introduction to Elementary Particles,* 2008 Wiley-VCH.
Topics: quarks and leptons, interactions and fields, symmetry and conservation laws, quarks in hadrons, lepton and quark scattering, QCD, weak interactions, electroweak and standard model, neutrino oscillations and physics beyond standard model, experimental methods.

Introduction to Differential Geometry for Physicists
Dates: Sept–Dec, 2011 Course Number: PHYS 5013 School: National Taiwan University
Undergraduate Credit: 3 Instructor: Dr. Wu-Pei Su
Textbooks: C. Nash and S. Sen, *Topology and Geometry for Physicists,* 1983 Academic Press, M. Nakahara, *Geometry, Topology and Physics,* 1990 CRC Press, S. S. Chern, *Studies in Global Geometry and Analysis,* 1967 The Mathematical Association of America, k. Ueno, K. Shiga, and S. Morita, *A Mathematical Gift I,* 2003 American Mathematical Society, H. Flanders, *Differential forms with applications to the physical sciences* 1989 Dover Publications.
Topics: Euler characteristic, curvature of surface, Gauss-Bonnet and Poincaré-Hopf theorem, Berry phase, Berry's curvature-analysis and topology, classical tensor analysis, connection, and curvature, differential forms, homology and cohomology groups, spin Hamiltonians and fiber bundles, differential geometry of surface, global geometry of surface, geometry of fiber bundles, characteristic classes, harmonic forms, and index theorem.

Special Topics in Field Theory
Dates: Jan–May 2012 Course Number: PHYS 8027 School: National Taiwan University
Graduate Credit: 4 Instructor: Dr. Pei-Min Ho
Reading twelve papers in field theory, including Faddeev–Jackiw (Hamiltonian formulation), Feynman (path integral formulation), Paul Dirac (Dirac's method and Dirac's equation), Weinberg, Jackiw–Rebbi, Fujikawa, Wess–Zumino, Fulling, Hawking (QFT in curved spacetime and Hawking radiation), Delamotte, Polchinski (scale and conformal invariance in QFT), and Gomis–Weinberg.
Topics: This course starts with a brief intro of quantum field theory, then focuses on historical development of quantum field theory, including the original ideas of vacuum periodicity in a Yang-Mills quantum theory, path integral formalism, renormalization group, scale and conformal invariance, and quantum chromodynamics.

Computations.

Intro to Computer Science I
Dates: Jan–May 2015 Course Number: CS 110 School: University of San Francisco
Undergraduate Credit: 4 Instructor: Dr. Cindy Thompson
Textbooks: A. B. Downey, J. Elkner, and C. Meyers, *How to Think Like a Computer Scientist: Learning with Python,* 2002 Green Tea Press.
Topics: Variables, expressions, and statements, Functions, Data types, Numpy, File I/O, Modules, Recursion, Object Oriented Programming, Exceptions, Fitting and Scientific Data Handling, and Plotting with matplotlib.

Automata Theory
Dates: Sept–Dec 2015 Course Number: CS 411 School: University of San Francisco
Undergraduate Credit: 4 Instructor: Dr. David Galles
Textbooks: Harry Lewis, Christos Papadimitriou, *Elements of the Theory of Computation,* 1997 Prentice-Hall.
Topics: Sets, relations, and languages, finite automata, context-free languages, Turing machines, Undecidability, Computational Complexity, NP-complete.

Data Structures & Algorithms
Dates: Jan–May 2016 Course Number: CS 245 School: University of San Francisco
Undergraduate Credit: 4 Instructor: Dr. David Galles
Textbooks: Thomas Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein, Christos Papadimitriou, *Introduction to Algorithms,* 2009 MIT Press.
Topics: Analysis of Algorithms, Rate of growth: $O(n)$, $o(n)$, $\Omega(n)$, $\omega(n)$, $\theta(n)$, Time vs. Space, Stacks & Queues, Arrays vs. Linked Lists, Binary Trees, Binary Tree Manipulation, Ordered Binary Trees / Binary Search Trees, Heaps, Priority Queues, Sorting, Insertion Sort / Selection Sort, Merge Sort / Quicksort, Heapsort, Bucket Sort, Radix Sort, Hash Tables, Hash Functions, Open Hashing, Closed Hashing, B Trees, Graph Algorithms, Dijkstra's Algorithm, Prim's Algorithm, Kruskal's Algorithm, Depth First Search, Connected Components, Maximum Flow, Dynamic Programming, AVL Trees, NP-Completeness, and Binomial Heaps.

Game Engineering
Dates: Jan–May 2016 Course Number: CS 420 School: University of San Francisco
Undergraduate Credit: 4 Instructor: Dr. David Galles
Textbooks: Fletcher Dunn, and Ian Parberry, *3D Math Primer for Graphics and Game Development,* 2011 A K Peters/CRC Press.
Topics: C++ Programming, Using Modern Graphics Engines, OGRE, Object-oriented Graphics Rendering Engine, Content Creation, Using Blender: Basics, Creating 3D Models (Blender), Creating Textures and UV mapping (Blender), Rigging and Animating (Blender), Content Pipeline (Blender and OGRE), 3D Math, Introduction and Transformation Between Spaces, Linear Transformations and Homogeneous Matrices, Orientation and Quaternions, Computational Geometry and Intersection of 3D objects, Physics Engines, Scripting Languages, Writing lua programs/scripts, Integrating lua and C/C++.

Algorithms
Dates: Jan–May 2016 Course Number: CS 673 School: University of San Francisco
Graduate Credit: 4 Instructor: Dr. David Galles
Textbooks: Thomas Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein, Christos Papadimitriou, *Introduction to Algorithms,* 2009 MIT Press.
Topics: Mathematical Foundations (Recurrence Relations, Proof Techniques Used in Theoretical Computer Science), Randomized Algorithms, Sorting & Selection (Heapsort, Quicksort, Randomized Quicksort, Mergesort, Selection Problem, $O(n \ln(n))$ Quicksort (worst case), sub-$O(n \ln(n))$ sorting, counting sorts, radix sort, bucket sort), Modifying Data Structures (Red/Black Trees & Interval Trees, Leftest Heaps, Fibonacci Heaps), Dynamic Programming (Relation to Divide and Conquer, Fibonacci Numbers, Matrix Chain Multiplication, Longest Common Subsequence, Polygon Triangulation), Greedy Algorithms (Scheduling, Huffman Codes, Proving Correctness, Matroids), Amortized Analysis (Basic Concepts, Aggregate method, Accounting method, Potential Method), Graph Algorithms (Graph representations, BFS / DFS, Spanning Trees, Shortest Path, Maximum Flow), String Matching, RSA & Encryption, Computational Geometry, Approximation Algorithms).

Math Colloquium

Dates: Aug–Dec, 2016 Course Number: MATH 350 School: University of San Francisco
Undergraduate Credit: 4 Instructor: Dr. Paul Zeitz

Topics: Gt Seminar: Howard Masur (U. Chicago). The Mathematics of Doodling (Ravi Vakil, Stanford). Adding Realism When Choosing and Constructing Optimal Designs (Christine Anderson-cook, Los Alamos National Laboratory). Gaussian Svm: What It Is and How to Tune Its Parameters (Guangliang Chen, San Jose State University). Connecting Art and Mathematics (Carlo H. Sequin, U.c. Berkeley). Quantum Algorithms (Prof. Jennifer Chubb, University of San Francisco). The Monitoring and Improvement of Surgical Outcome Quality (Dr. William H. Woodall, Virginia Tech). Integer-valued Time Series: Superposition Methods (James Livsey, U.s. Census Bureau).

MASS Seminars

Dates: Aug–Dec, 2018 Course Number: MATH 497 School: Pennsylvania State University
Undergraduate Credit: 3 Instructor: Dr. Sergei Tabachnikov

Topics: Fundamental Theorem of Algebra: two topological proofs, complex analysis: Cauchy theorem and the residue formula, Euler-Maclaurin summation formula, Basel problem, Fewomials and Descartes rule, irrationality of Pi, introduction to fundamental group, basics of classical mechanics: Hamiltonian equations, Poisson bracket, Kepler's problem, introduction to mathematical billiards, Euler's theorem on rotations of space, special orthogonal group in dimension three as the real projective space, Finsler metrics and Hilbert's fourth problem, Borsuk-Ulam theorem, basics of Lie groups and Lie algebras, solving cubic equations, Abel-Ruffini theorem, Pick's formula, Farey sequences, and Frieze patterns and Conway-Coxeter theorem.

MASS Colloquium

Dates: Aug–Dec, 2018 Course Number: MATH 497 School: Pennsylvania State University
Undergraduate Credit: 3 Instructor: Dr. Sergei Tabachnikov

Topics: Fibonacci or not? New and old research on phyllotaxis (Christophe Golé). How to count spanning trees (Anton Petrunin). The man who knew infinity (George Andrews). Diving into the three-body problem (Richard Montgomery). Tricks and methods in search for integrable systems (Vladimir Matveev). How to pick a random matrix? (Igor Rivin) On the large-scale description of periodic structures, using only elementary topology and analysis (Dimitri Burago). Number theory, dynamical systems and Benford's law (Gil Bor). Cyclic competition, evolutionary games, and escaping extinction (Andrew Belmonte). On Monoids and McNuggets (Scott Chapman).

Independent Study

Dates: Jan–May, 2021	Course Number: MATH 899	School: San Francisco State University
Graduate	Credit: 3	Instructor: Dr. Chun-Kit Lai

Textbooks: L. R. Ford, *Automorphic Functions,* 1929 Chelsea Publishing Company, J. Lehner, *Discontinuous Groups,* 1964 American Mathematical Society, David Borthwick, *Spectral theory of infinite-area hyperbolic surfaces,* 2007 Springer, Alan Beardon, *The geometry of discrete groups,* 2012 Springer Science & Business Media, Svetlana Katok, *Fuchsian groups*, 1992 University of Chicago press, D. Mumford, C. Series, and D. Wright, *Indra's Pearls–The vision of Felix Klein* 2002 Cambridge, J. G. Ratcliffe, *Foundations of Hyperbolic Manifolds.* 1994 Springer New York, F. Dal'Bo, *Geodesic and Horocyclic Trajectories*, 2011 Springer-Verlag London, and Lars Ahlfors, *Möbius transformations in several dimensions*, 1981 Lecture Notes at University of Minnesota.
Topics: Euclidean geometry, spherical geometry, hyperbolic geometry, inversive geometry, isometries of hyperbolic space, geometry of discrete groups, classical discrete groups, geometric manifolds, geometric surfaces, limit sets of Fuchsian groups, and geometric orbitfolds.

Master Thesis

Dates: Sept–Dec, 2021	Course Number: MATH 898	School: San Francisco State University
Grade: In Progress	Credit: 3	Instructor: Dr. Chun-Kit Lai

Textbooks: L. R. Ford, *Automorphic Functions,* 1929 Chelsea Publishing Company, J. Lehner, *Discontinuous Groups,* 1964 American Mathematical Society, David Borthwick, *Spectral theory of infinite-area hyperbolic surfaces,* 2007 Springer, Alan Beardon, *The geometry of discrete groups,* 2012 Springer Science & Business Media, Svetlana Katok, *Fuchsian groups*, 1992 University of Chicago press, D. Mumford, C. Series, and D. Wright, *Indra's Pearls–The vision of Felix Klein* 2002 Cambridge, J. G. Ratcliffe, *Foundations of Hyperbolic Manifords.* 1994 Springer New York, F. Dal'Bo, *Geodesic and Horocyclic Trajectories*, 2011 Springer-Verlag London, and Lars Ahlfors, *Möbius transformations in several dimensions*, 1981 Lecture Notes at University of Minnesota.
Topics: Eulidean geometry, spherical geometry, hyperbolic geometry, inversive geometry, isometries of hyperbolic space, geometry of discrete groups, classical discrete groups, geometric manifolds, geometric surfaces, hyperbolic 3-manifolds, hyperbolic n-manifolds, geometrically finite n-manifolds, limit sets of Kleinian groups, and geometric orbitfolds.