Matthew Kowalski • Fall 2021 • Mathematics PhD Applicant

Denotes Graduate Courses	Denotes Honors Courses

Mathematics Courses

Semester	Course Title	Course Number	Grade	Professor (Dr.)	Textbook	Chapters	Catalog Description	Description
Senior								
Spring 2021	Real Analysis II (Grad)	MTH928	n/a	I. Kachkovskiy	n/a	n/a	Continuation of MTH 828. Topics include Borel measures on locally compact spaces, complex measures, differentiable transformations and changes of variables in Rn.	Upcoming
	Quantum Information (Independent Study)	n/a	n/a	J. Schenker	*The Theory of Quantum Information* by Watrous	n/a	n/a	Upcoming
Fall 2020	Real Analysis I (Grad)	MTH828	(currently) 4.0	J. Schenker	*An Introduction to Measure Theory* by Terence Tao	Chapter 1	Lebesgue measure on real line, general measure theory. Convergence theorems, Lusin's theorem, Egorov's theorem, Lp-spaces, Fubini's theorem. Functions of bounded variation, absolutely continuous functions, Lebesgue differentiation theorem.	Qualifying real analysis course. Covered the majority of Terence Tao's Introduction to Measure Theory. Began the course with a construction of the Lebesgue measure and integral. Moved forwards to abstract measure thoery. Finished Terence Tao's book with pre-measures and product measures. Currently going past Tao's book with a discussion of signed and complex measures.
Junior								
Summer 2020	Machine Learning	MTH890	4.0	D. Liu	*Machine Learning: A Probabilistic Perspective* by Murphy	1-15,17,19,23-25	Reading course. Focused on machine learning.	Graduate level machine learning course. Covered the statistics and mathematics that support modern machine learning methods. Taught basic machine learning models, such as regression, and concluded with a discussion of clustering methods and Markov chain Monte Carlo methods.
Spring 2020	Honors Algebra 2	MTH419H	4.0	R. Kulkarni	*Algebra* by Artin	11-16	Algebraic field extensions, Galois theory. Classification of finite fields. Fundamental Theorem of Algebra.	Concluded Artin's Algebra textbook. Began with definition of rings and fields. Discussed factoring and quadratic number fields. Concluded the course with discussion of Galois theory.
	Complex Analysis 1 (Grad)	MTH829	4.0	I. Kachkovskiy	*Complex Analysis* by Lang	1-11, 15, 16	Cauchy theorem, identity principle, Liouville's theorem, maximum modulus theorem. Cauchy formula, residue theorem, Rouche's theorem. Casorati-Weierstrass theorem, Arzela-Ascoli theorem. Conformal mapping, Schwarz lemma, Riemann mapping theorem.	Qualifying complex analysis course. Began the course with a discussion of complex differentiability and contour intergration. Concluded the course with geometric functioin theory, such as analytic continuation, and with some special topics like the prime number theorem.
Fall 2019	Honors Algebra 1	MTH418H	4.0	L. Shen	*Algebra* by Artin	2,7,8,9,10	Theory of groups, Sylow theory, the structure of finite Abelian groups, ring theory, ideals, homomorphisms, and polynomial rings.	First abstract algebra course. Course began with a discussion of group theory, continued through to the sylow theorems and group classification, and concluded with group representations.
	Numerical Analysis 1	MTH451	4.0	M. Miklavcic	*Numerical Methods and Computing* by Cheney and Kincaid	1-9	Numerical solution of linear and nonlinear algebraic equations and eigenvalue problems. Curve fitting. Interpolation theory. Numerical integration, differentiation, and solution of differential equations. Algorithms implementation with a programming language like Fortran, C/C++ or MATLAB.	Numerical analysis course that focused on implementing numerical methods through programming. Began the course with simple numerical methods, interpolations, splines, etc, and concluded the course with a brief discussion of Monte Carlo methods and numerical partial differential equations.

	Machine Learning (Capstone)	MTH496	4.0	D. Nguyen	n/a	n/a	A capstone course integrating several areas of mathematics. Focused on machine learning methods.	Introductory machine learning course. Developed machine learning methods such as regression and k-nearest neighbors and concluded with clustering algorithms. Focused on programming side of machine learning rather than mathematical side.
Sophomore								
Spring 2019	Honors Real Analysis	MTH429H	4.0	J. Kitagawa	*Principles of Mathematical Analysis* by Walter Rudin; *Calculus on Manifolds* by Michael Spivak; *The Elements of Integration and Lebesgue Measure* by Bartle	9,10,11; 1,2,3; 1-7	Continuation of MTH 327H. Convergence of sequences and series of functions, differentiation and integration in higher dimensional settings. Inverse and implicit function theorems.	First half of the course was dedicated to completing standard real analysis curriculum with multivariable functions, integrals, and derivatives. Second half of course was dedicated to measure theory and the Lebesgue integral.
	Partial Differential Equations	MTH442	4.0	M. Miklavcic	*Applied Differential Equations with Fourier Series and Boundary Value Problems* by Richard Haberman	1-9	Classification of second order partial differential equations. Boundary and initial value problems for heat, Laplace, and wave equations in dimensions 1, 2 and 3. Variational methods and maximum principles. Separation of variables, Fourier series, Sturm-Liouville theory. Greens functions.	Partial differential equations course focused on fourier series and on the applications of partial differential equations. Began the course with a discussion of the heat equation and concluded with a brief discussion of Green's functions.
Fall 2018	Honors Introduction to Analysis	MTH327H	4.0	K. Hendricks	Principles of Mathematical Analysis by Walter Rudin	1-9	Emphasis on foundations and metric topology. Convergence of sequence and series, continuity of functions. Differentiation and integration in one dimension.	First analysis course. Began with the construction of the natural numbers through the Peano axioms and ended with Riemann integration and sequences of functions.
Freshman								
Spring 2018	Discrete Mathematics 1	MTH481	4.0	R. Davis	*Combinatorics and Graph Theory* by John M Harris, Jeffry L Hirst, Michael J Mossinghoff	1.1-1.6, 2.1-2.6	Binomial and multinomial theorems. Graphs and digraphs, graph coloring. Generating functions, asymptotic analysis, trees. Representing graphs in computers.	Split course between combinatorics and graph theory. Covered basic notions of combinatorics and introductory graph theory.
Fall 2018	Honors Linear Algebra	MTH317H	4.0	J. Wald	*Linear Algebra Done Wrong* by Sergei Treil	1-7	Systems of equations, matrix algebra, vector spaces, linear transformations, geometry of R^n, eigenvalues, eigenvectors, diagonalization, inner products. Emphasis on mathematical reasoning, proofs, and concepts.	Introductory proof-based and linear algebra course. Began with the basics of proofs and vector spaces. Ended with bilinear forms and a brief discussion of dual spaces. Unfortunately stopped just before any discussion of tensors.
Self-Study								
Summer 2020	Complex Analysis	n/a	n/a	n/a	*Visual Complex Analysis* by Needham	1-9	n/a	Sought out a more intuitive understanding of Complex Analysis after my conclusion of the graduate complex analysis course. Participated in a book club centered around Needham's Visual Complex Analysis. Book focused on an intuitive understanding of advanced complex analysis topics. Covered chapters 1-9, basics of complex numbers through contour integration.
	Topology	n/a	n/a	n/a	*Topology without Tears* by Morris	1-6	n/a	Sought out a book on the basics of topology because I didn't have the chance to take a course on it. Follows Topology without Tears due to its focus on intuitive methods and reasoning. Covered basics of topology through to continuous maps and compact spaces.

Relevant Physics Courses

Semester	Course Title	Course Number	Grade	Professor (Dr.)	Textbook	Chapters	Catalog Description	Description
Senior								
Spring 2021	Classical Electrodynamics I (Grad)	PHY841	n/a	A. Von Manteuffel	*Classical Electrodynamics* by Jackson	n/a	Electrostatics, magnetostatics, time-varying fields and Maxwell's equations. Gauge transformations. Poynting's theorem and conservation laws.	n/a
	Survey of Nuclear Physics (Grad)	PHY802	n/a	D. Lee	n/a	n/a	Survey of phenomena and conceptual foundations of nuclear physics.	n/a
Fall 2020	Quantum Mechanics I (Grad)	PHY851	4.0 (current)	S. Pratt	Professor's Lecture Notes Based on Dirac and Sakurai	n/a	Axioms of quantum and wave mechanics, applications to spherically symmetric potentials. Hydrogen atom, harmonic oscillator, matrix mechanics, angular momentum theory, rotations.	Qualifying quantum mechanics course. Began with the basics of Dirac's formulation of quantum mechanics and ended with quantum scattering and low energy scattering. Focused on physical intuition throughout the course.
	Introduction to Condensed Matter Physics	PHY491	4.0 (current)	C. Piermarocchi	n/a	n/a	Many-electron atoms. Molecules, crystal structure, lattice dynamics. Band models of metals and semiconductors, transport properties.	Standard condensed matter course. Began with quantum mechanical description off Hydrogen, built that outwards to many-particle models, studied lattices, and concluded with material properties
Junior								
Spring 2020	Survey of Elementary Particle Physics (Grad)	PHY803	4.0	R. Schwienhorst	*Introduction to Elementary Particles* by Griffiths	1-11	Overview of high-energy physics, including the standard model, quark composition of hadrons, collider physics and the role of elementary particle physics in cosmology.	Overview of modern particle physics. Started the course with a description of relativistic kinematics, the hydrogen atom, and Feynman calculus. Concluded the course with neutrino oscillations and a brief discussion of super symmetry.
Fall 2019	Classical Mechanics (Grad)	PHY820	4.0	H. Hergert	*Classical Mechanics* by Goldstein	1-10	Two-body central force problem, Hamilton's principle, Lagrangian and Hamiltonian equations of motion, variational methods, small oscillations, classical fields.	Qualifying classical mechanics course. Began the course with a refresher on Lagrangian mechanics with an emphasis on modern problems such as spinning tops. Concluded the course with Hamiltonian mechanics.
	Advanced Laboratory	PHY451	4.0	X. Ke	n/a	n/a	General research techniques, design of experiments, and the analysis of results based on some historical experiments in modern physics.	Final physics laboratory course. Focused on long-term projects (4 weeks on average) with an emphasis on proper research techniques and documentation. Concluded the course with a thorough research paper and presentation.
Sophomore								
Spring 2019	Thermal and Statistical Physics	PHY410	4.0	N. Birge	*Thermal Physics* by Kittel and Kroemer	1-10	Equilibrium statistical mechanics and thermodynamics, kinetic theory, phase transformations.	Thermal physics and Statistical Mechanics course, specifically at equilibrium. Course focused on derivation of thermal physics and statistical mechanics, with an emphasis on fundamental ideas.
Self-Study								
Summer 2020	Quantum Mechanics	n/a	n/a	n/a	*Principles of Quantum Mechanics* by Dirac	1-4	n/a	Sought a wider and more intuitive understanding of modern quantum mechanics through Dirac's textbook. Completed chapters 1 through 4, which covers the theory behind bra-ket based quantum mechanics through representations and unitary transformations. Acted as a prequel to PHY851.

Relevant Computer Science Courses

Semester	Course Title	Course Number	Grade	Professor (Dr.)	Textbook	Chapters	Catalog Description	Description
Senior								
Fall 2020	Computer Organization and Architecture	CSE320	4.0 (current)	M. McCullen	n/a	n/a	Boolean algebra and digital logic. Combinational and sequential circuits. Representations of data and instructions. Architecture and major components of computer systems. Assembly language programming and interfacing to high level languages. Assembler and linker processing.	Course outlining the most basic functions of computers. Began class with discussion of circuits and logic through circuit implementation. Continued concepts forward to binary coding, assembly, and low-level programming.
Sophomore								
Spring 2019	Algorithms and Data Structures	CSE331	4.0	S. Onsay	*n/a*	n/a	Linear data structures, trees, graphs and algorithms which operate on them. Fundamental algorithms for searching, sorting, string matching, graph problems. Design and analysis of algorithms.	Standard algorithms and data structures course. Course focused on runtime and space efficiency while constructing the fundamental data structures and algorithms.