Mathematical Courses Taken

Theoretical Computer Science

A **Parameterized Algorithms (Graduate)**, *Spring 2020*.
FPT, kernelization, crown decomposition, bounded search trees, iterative compression, randomized methods, treewidth.

Cygan, et al.: *Parameterized Algorithms* (ch. 1-5, 7)

A **Computability and Complexity (Graduate)**, *Fall 2020*.
Turing machines, NP, uncomputability, oracle computation, space bounds, polynomial hierarchy, randomized complexity, circuit complexity, interactive proofs, PCP Theorem.

Arora and Barak: *Computational Complexity* (ch. 1-8, 11)

in progress **Communication Complexity (Graduate)**, *Winter 2021*.
Fooling sets, nondeterministic communication, discrepancy method, multiparty communication, Yao's principle, spectral methods, quantum communication, pattern matrix method.

Kushilevitz and Nisan: *Communication Complexity*
Later topics do not use a textbook.

in progress **Greatest Theory Hits of the 21st Century (Graduate)**, *Winter 2021*.
SL = L, QIP = PSPACE, two-source extractors, LP/SDP relaxations, homomorphic encryption, constructive Lovász local lemma, constructive discrepancy minimization.

No textbook.

planned **Current Topics in Computer Theory (Graduate)**, *Spring 2021*.
Topics not finalized.

Algebra

A/A **Linear Algebra**, *Fall 2019 and Winter 2020*.
Vector spaces, linear transformations, eigenvalues, inner product spaces, adjoint, unitary operators, dual spaces, quotient spaces, Caley-Hamilton theorem, Jordan canonical form.

Hoffman and Kunze: *Linear Algebra* (ch. 2-6, 8)
Freidberg, Insel, and Spence: *Linear Algebra* (ch. 5-7)

A/in progress **Abstract Algebra**, *Fall 2020 and Winter 2021*.
Integers, groups, Lagrange's theorem, isomorphism theorems, group actions, Sylow theorems, rings, UFDs, polynomials, finitely generated modules over a PID, matrix canonical forms.

Elman: *Lectures on Abstract Algebra* (ch. 1-4)

planned **Galois Theory**, *Spring 2021*.
Field extensions, algebraic closure, separability, squaring the circle and related problems, fundamental theorem of Galois theory, Hilbert's theorem 90, Abel–Ruffini theorem.

planned **Mathematical Crypotology**, *Spring 2021*.
Symmetric and public-key cryptosystems, one-way functions, signatures, key exchange, pseudoprimes, primality tests, quadratic reciprocity, rho method, RSA, discrete logs.

Analysis

B+/A **Multivariable Calculus and Analysis**, *Fall 2019 and Winter 2020*.
Euclidean topology, linear algebra, total derivative, inverse and implicit function theorems, integration, Fubini's theorem, differential forms, generalized Stokes' theorem.

Shurman: *Calculus and Analysis in Euclidean Space* (ch. 2-6, 9)

A/A **Real Analysis**, *Winter 2020 and Spring 2020*.
Construction of reals, sequences and series, metric topology, differentiation, integration, sequences of functions, special functions, Fourier series.

Rudin: *Principles of Mathematical Analysis* (ch. 1-8)

A- **Complex Analysis**, *Winter 2020*.
Goursat's theorem, Cauchy's integral theorem, Cauchy's integral formula, residue formula, argument principle, logarithm, Möbius transformations, Riemann mapping theorem.

Stein and Shakarchi: *Complex Analysis* (ch. 1-3, 8)

B- **Measure Theory and L^p Spaces (Graduate)**, *Fall 2020*.
Measures, measurable functions, Lebesgue integration, Fubini's theorem, absolute continuity, L^p spaces, convex functions, Banach spaces, Riesz representation theorem.

Evans and Gariepy: *Measure Theory and Fine Properties of Functions* (ch. 1)
Lieb and Loss: *Analysis* (ch. 2)

Geometry

in progress **Topology**, *Winter 2021*.
Topological spaces, continuity, compactness, connectedness, path-connectedness, separation axioms, product spaces, Tychonoff's theorem, homotopic paths, fundamental group.

Munkres: *Topology* (ch. 2-5, 9)

planned **Differential Geometry**, *Spring 2021*.
Curves and surfaces in 3-space, Frenet formulas, Gaussian curvature, congruence of curves and surfaces, intrinsic geometry of surfaces, isometries, geodesics, Gauss/Bonnet theorem.

Combinatorics

A **Graph Theory**, *Spring 2020*.
Graph score, Eulerian graphs, 2-connectivity, triangle-free graphs, trees, planar graphs, Euler's formula, 5 color theorem, matrix-tree theorem, Ramsey theory.

Matoušek and Nešetřil: An Invitation to Discrete Mathematics

planned **Enumerative Combinatorics**, *Spring 2021*.
Partitions, pentagonal number theorem, generating functions, derangements, Cayley's formula, Catalan numbers, chromatic polynomial, sequence unimodality and log-concavity.

Applied Math

A **Nonlinear Differential Equations**, *Winter 2020*.

1- and 2-dimensional differential equations, fixed points and stability, bifurcations, phase plane, existence and uniqueness theorems, conservative and reversible systems, limit cycles.

Strogatz: *Nonlinear Dynamics and Chaos* (ch. 1-7)

A **Optimization**, *Winter 2020*.

Newton's method, gradient methods and convergence, conjugate direction methods, linear programming, Simplex algorithm, duality, Lagrange condition, KKT condition.

Chong and Zak: *An Introduction to Optimization* (ch. 6-11, 15-17, 20-21)

Logic

A- **Mathematical Logic**, *Spring 2020*.

Propositional logic, first order logic, Tarski conditions, expressibility, soundness, completeness, compactness, Tarski's theorem, Gödel's first incompleteness theorem.

No textbook.

Other

P/P **Advanced Problem Solving**, *Fall 2019 and Fall 2020*.

Various problems from across undergraduate mathematics for Putnam preparation.

Andreescu and Gelca: *Putnam and Beyond* (ch. 2-6)