MIT

Mathematics — Combinatorics

Textbook: Stanley’s Hyperplane Arrangements.

A 18.217, Combinatorial Theory, Fall 2018, Alex Postnikov.
Graduate combinatorics class on cluster algebras. Keywords: totally positive matrices, Laurent phenomenon, frieze patterns, triangulations of polygons, Ptolemy’s relation, associahedra, mutations, quivers, Somos sequences, octahedron recurrence, double Bruhat cells, Grassmannian, positroids, plabic graphs.
Textbook: None.

A+ 18.218, Topics in Combinatorics, Spring 2017, Alex Postnikov.
Textbook: None.

Seminar in theoretical computer science, with emphasis on approximation algorithms. Spectral graph theory, error correcting codes, derandomization, expanders, communication complexity. Constraint satisfaction problems and treewidth. LP and SDP relaxation and approximation. Rounding hierarchies, Hardness of approximation.
Textbook: None.

A- 18.5997, Graph Theory and Additive Combinatorics, Fall 2017, Yufei Zhao.
Extremal graph theory, Szemerédi’s regularity lemma and applications, pseudorandom graphs, graph limits, Roth’s theorem and Szemerédi’s theorem on arithmetic progressions, Gowers uniformity norms, and the Green-Tao theorem.
Textbook: None.

Mathematics — Analysis and Geometry

A+ 18.099, Discrete Analysis Seminar, Spring 2016, Peter Csikvári.
Seminar in additive combinatorics, with emphasis on Fourier analysis on Szemerédi’s theorem. Follows Terence Tao’s textbook.
Textbook: Tao/Vu, chapters 4, 10, 11.

Half the subject devoted to the theory of the Lebesgue integral with applications to probability, and half to Fourier series and Fourier integrals.
Textbook: Stein and Shakarchi.
*Textbook*: None.

A topics course on random domino/lozenge tilings. Dimer model, Kestelyn theory, Burgers equation, etc.
*Textbook*: None.

Starts with curves in the plane, and proceeds to higher dimensional submanifolds. Computations in coordinate charts: first and second fundamental form, Christoffel symbols. Discusses the distinction between extrinsic and intrinsic aspects, in particular Gauss’ theorema egregium. The Gauss-Bonnet theorem. Geodesics. Examples such as hyperbolic space.
*Textbook*: Do Carmo, *Geometry of Curves and Surfaces*.

Mathematics — Algebra and Number Theory

Introduction to the language of schemes and properties of morphisms. Sheaves, construction of schemes and morphisms between them, affine and projective schemes, dimension, smoothness.
*Textbook*: Vakil, chapters 1-12.

The next many chapters of Vakil. More on schemes. Quasicoherent/coherent/invertible sheaves and sheaf cohomology. Applications to curves.

*Textbook*: *An Introduction to Lie Groups and Algebra* by Kirillov, and *Linear Algebra* by Springer.

P 18.785, *Number Theory I*, Fall 2017, Andrew Sutherland.
Dedekind domains, decomposition of prime ideals, local fields, ramification, the discriminant and different, ideal class groups, and Dirichlet’s unit theorem. Zeta functions and $L$-functions, the prime number theorem, primes in arithmetic progressions, the analytic class number formula, and the Chebotarev density theorem. A little local and global class field theory.
*Textbook*: None.

Introduction to classical modular forms and their $L$-functions. I only completed about half this class, but officially passed anyways.
*Textbook*: *Modular Forms* by Miyake.

Other Mathematics

Graduate course on quantum computation. Qubits, entanglement, physics of information processing, quantum circuits, Shor’s algorithm, etc.
*Textbook*: None.

Introduction to electromagnetism which is slightly more advanced mathematically.
*Textbook*: Purcell.
Standard course on game theory. Utility functions, Nash equilibriums, partial information games, subgame-perfect equilibriums, sequential equilibrium, etc.
*Textbook*: None.

A more rigorous game theory class following 14.12. Iterated dominance, perfect Bayesian equilibrium, and sequential/perfect/proper equilibria. Cooperative games, matching allocation problems, auction and mechanism design, bargaining.
*Textbook*: None.

How to write a paper and give a presentation (i.e. oral and written communication).
*Textbook*: None.

Propositional modal logic, Kripke frames, completeness, strict implication, modal predicate logic and its completeness, expanding domains, contingent identity, intensional objects.
*Textbook*: Hughes and Cresswell.

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**Harvard College**

A **Math 55a**, *Honors Abstract and Linear Algebra*, Fall 2014, Dennis Gaitsgory.
Groups, rings/ideals, modules, spectral theory (eigenvalues), classification of finite abelian groups, group actions, Sylow’s Theorem, inner forms, tensor products, wedge products, representation theory (Maschke, Schur, characters, and classification of irreducible representations of $S_n$).
*Textbook*: None.

Metric and topological spaces, normed vector spaces, derivatives and integrals in $\mathbb{R}^n$, inverse and implicit function theorem, ODE’s, Stoke’s theorem, holomorphic functions, Cauchy formula, Taylor expansions.
*Textbook*: None used officially, but loosely follows Rudin.

A **Math 129**, *Number Fields*, Spring 2015, Mark Kisin.
Algebraic number theory: number fields, factorization of ideals, class group, unit group, Frobenius elements, local fields, ramification, weak approximation, adeles, and ideles.
*Textbook*: Samuel’s *Theory of Numbers*, (2-6).

A **Math 137**, *Introduction to Algebraic Geometry*, Spring 2015, Yaim Cooper.
Classical algebraic geometry. Affine spaces, projective and quasiprojective varieties, smoothness, birational geometry, line bundles and divisors.

A **Math 145a**, *Set Theory I*, Fall 2014, Peter Koellner.
ZFC (ordinal and cardinal arithmetic, combinatorics, descriptive set theory), model theory (reflection, Skolem hulls, the constructible universe, forcing), and independence of Continuum Hypothesis.
*Textbook*: None.

Large cardinals and their inner models: Covers Woodin’s recent advances toward finding an ultimate version of Gödel’s $L$. Ultrafilters, extenders, (iterated) ultrapowers. Cardinals beyond Choice (Reinhardt, super-Reinhardt, and Berkeley). Measurable, (super)strong, and (super)compact cardinals. Weak extender models, the HOD Dichotomy Theorem, and the HOD Conjecture.
*Textbook*: None.
A  **CS 125, Algorithms and Complexity**, Fall 2014, Michael Mitzenmacher and Salil Vadhan.

A new course combining Harvard’s CS 121 and CS 124. Algorithms (sorting, greedy, dynamic programming, shortest path, linear programming, network flows), models of computation (Word RAMs, Turing machines, finite automata), randomized and nondeterministic algorithms, NP-completeness, undecidability and Gödel incompleteness, approximation algorithms.

*Textbook*: none.

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**San Jose State University**

A+  **Math 275, Topology**, Fall 2012, Richard Kulbelka.

Graduate course in algebraic topology. Homotopy, fundamental group, covering projections and universal covers, retractions, Borsuk-Ulam, van Kampen, groups of covering transformations, fiber bundles.

*Textbook*: Munkres’ *Topology* (9-11, 13).

A+  **Math 179, Intro to Graph Theory**, Spring 2013, Wasin So.

Hamiltonian and Eulerian properties, matching, trees, connectivity, coloring problems and planarity.

*Textbook*: Chartrand and Zhang, *A First Course in Graph Theory* (1-10).

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**University of California Berkeley**

A+  **Math 249, Algebraic Combinatorics**, Fall 2014, Lauren Williams.

Simplicial complexes (shellability, CW complexes), matroids (GGMS theorem, positroids, MacPhersonian, flag matroids), polytopes (H-vectors, g-theorem), posets (EL-shellability).

*Textbook*: None.

A+  **Math 104, Intro to Real Analysis**, Fall 2014, Charles Pugh.


*Textbook*: Pugh’s *Real Mathematical Analysis*.


Groups (quotient groups, Sylow’s Theorem. Finitely generated abelian groups, semidirect products), rings and ideals (Euclidean domains, PID’s, UFD’s), fields and field extensions.

*Textbook*: Dummit and Foote (1-5, 7-9, 13).