# Evan Chen

*Transcript of Mathematics Coursework* *Last updated May 24, 2018.*

*Lecture notes for many of the math classes can be found at:*
*http://www.mit.edu/~evanchen/coursework.html.*

## MIT

### Mathematics — Combinatorics

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.

A- **18.217**, *Combinatorial Theory*, Fall 2015, Richard Stanley.
Graduate combinatorics class on hyperplane arrangements and their characteristic polynomials. Partially ordered sets, Möbius function, Möbius inversion, Möbius algebra. Intersection matroids and graphical arrangements. Matroid theory and geometric lattices. Lattice theory (modular elements, supersolvability). Finite field method. Random walks on arrangements, algebras on left-regular bands.
*Textbook*: Stanley's *Hyperplane Arrangements*.

A+ **18.218**, *Topics in Combinatorics*, Spring 2017, Alex Postnikov.
Graduate combinatorics class on algebraic combinatorics. Chip-firing and Cartan firing. Weyl groups, Coxeter groups, Dynkin diagrams, root systems. Weyl's characters and dimension formulas. Coxeter-Catalan combinatorics. Schubert, Kostant, and Grothendiek polynomials.
*Textbook*: None.

A+ **18.434**, *Seminar in Theoretical Computer Science*, Spring 2016, Yuan Zhou.
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.S997**, *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 — Algebra and Geometry

A **18.757**, *Representations of Lie Algebras*, Spring 2016, Laura Rider.
Representations of Lie groups/algebras, Peter-Weyl theorem, universal enveloping algebra, PBW theorem, Tannakian reconstruction. Jordan decompositions and toral subalgebras. Linear algebraic groups: Borel's fixed point theorem, Borel subgroups, parabolic subgroups, maximal tori. Diagonalizable groups, tori, characters. Weyl group and systems of positive roots, Borel–Weil theorem.
*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.

P **18.786**, *Number Theory II*, Spring 2018, Andrew Sutherland.
Introduction to classical modular forms and their $L$-functions. I actually only completed about half this class, but officially passed anyways.
*Textbook*: *Modular Forms* by Miyake..

A **18.950**, *Differential Geometry*, Fall 2015, Xin Zhou.
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*.

### Other Mathematics

B+ **2.111/8.370/18.435J**, *Quantum Computation*, Fall 2015, Seth Lloyd.
Graduate course on quantum computation. Qubits, entanglement, physics of information processing, quantum circuits, Shor's algorithm, etc.
*Textbook*: None.

A+ **8.022**, *Physics II*, Spring 2018, Nuh Gedik.
Introduction to electromagnetism which is slightly more advanced mathematically.
*Textbook*: Purcell.

A+ **14.12**, *Economics Applications of Game Theory*, Fall 2015, Glenn Ellison.
Standard course on game theory. Utility functions, Nash equilibriums, partial information games, subgame-perfect equilibriums, sequential equilibrium, etc.
*Textbook*: None.

A **14.16**, *Strategy and Information*, Spring 2016, Mihai Manea.
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.

A+ **18.821**, *Project Lab in Mathematics*, Spring 2016, David Vogan.
How to write a paper and give a presentation (i.e. oral and written communication).
*Textbook*: None.

B **24.244**, *Modal Logic*, Fall 2016, Stephen Yablo.
Propositional modal logic, Kripke frames, completeness, strict implication, modal predicate logic and its completeness, expanding domains, contingent identity, intensional objects.
*Textbook*: Hughes and Cresswell.

## 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.

A **Math 55b**, *Honors Real and Complex Analysis*, Spring 2015, Dennis Gaitsgory.
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.
*Textbook*: Karen Smith's *Invitation to Algebraic Geometry* (2004), chapters 1-6 and 8..

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.

A **Math 145b**, *Set Theory II*, Spring 2015, Peter Koellner.
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.

## 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).

## 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.
The real number system. Sequences, limits, and continuous functions in $\mathbb{R}$. Metric spaces. Uniform convergence, interchange of limit operations. Infinite series. Mean value theorem and applications. The Riemann integral.
*Textbook*: Pugh's *Real Mathematical Analysis*.

A+ **Math H113**, *Honors Intro to Abstract Algebra*, Spring 2012, Kelli Talaska.
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).