Forest Kobayashi

Full List of All Math-Related Coursework — *Last updated January 6th, 2020*

Notes

- Formatted as follows: grade earned ($\star$ means "expected Spring 2020", IP indicates "in progress," † means "audited"); course code, title, term, and instructor; a list of topics covered; and the textbook (if applicable).
- HMC does not include core math classes (30, 35, 40, 45, 60, 65) in calculating major GPA. Note, Discrete Math (55) is non-core and thus *is* included.
- Finally, at HMC, students' first semesters are graded on a High Pass (HP), Pass (P), Fail (F) system. For me, this was Fall 2016.
- All courses listed were taken at the Claremont Colleges (mostly Harvey Mudd)

Analysis, DEs, and Calculus

A **Math 181**, *Dynamical Systems*, Spring 2020, Jon Jacobsen.
Existence and uniqueness theorems for systems of differential equations, dependence on data, linear systems, fundamental matrices, asymptotic behavior of solutions, stability theory, and other selected topics, as time permits.
Textbook: TBD

A **Math 137**, *Real Analysis I*, Fall 2019, Asuman Aksoy.
Abstract Measures, Lebesgue measure, and Lebesgue-Stieltjes measures on R; Lebesgue integral and limit theorems; product measures and the Fubini theorem; additional topics.
Textbook: Stein & Shakarchi's *Real Analysis: Measure Theory, Integration, and Hilbert Spaces*

A **Math 180**, *Introduction to Partial Differential Equations*, Fall 2019, Andrew Bernoff.
Partial Differential Equations (PDEs) including the heat equation, wave equation, and Laplace's equation; existence and uniqueness of solutions to PDEs via the maximum principle and energy methods; method of characteristics; Fourier series; Fourier transforms and Green's functions; Separation of variables; Sturm-Liouville theory and orthogonal expansions; Bessel functions.
Textbook: None

A **Math 132**, *Mathematical Analysis II*, Fall 2018, Francis Su.
Riemann-Stieltjes integration, function spaces, Banach fixed point theorem & Picard iteration, equicontinuity, inverse and implicit function theorems, differential forms, introduction to Lebesgue integration and measure theory.
Textbook: Baby Rudin, chapters 6, 7, 9, and 10

A **Math 131**, *Principles of Real Analysis I*, Fall 2017, Erica Flapan.
Lecture notes on Professor Flapan's Pomona faculty website (`http://pages.pomona.edu/~elf04747/Math%20131/131Lectures%20copy.pdf`). Metric spaces, basic topology, sequences, completeness, compactness, connectedness, Bolzano-Weirstrass, Heine-Borel, continuity, function spaces, uniform continuity & uniform convergence, Banach fixed point theorem.
Textbook: Rosenlicht (used sparingly)

A **Math 80**, *Intermediate Differential Equations*, Spring 2018, Nick Pippenger.
Existence and uniqueness, solutions in series, asymptotic methods, perturbation theory, numerical methods, stability and chaos.
Textbook: None

A **Math 60**, *Multivariable Calculus*, Fall 2017, Mario Micheli.
Linear approximations, the gradient, directional derivatives and the Jacobian; optimization and the second derivative test; higher-order derivatives and Taylor approximations; line integrals; vector fields, curl, and divergence; Green's theorem, divergence theorem and Stokes' theorem, outline of proof and applications.
Textbook: None

A **Math 45**, *Introduction to Differential Equations*, Spring 2017, Kenji Kozai.
Modeling physical systems, first-order ordinary differential equations, existence, uniqueness, and long-term behavior of solutions; bifurcations; approximate solutions; second-order ordinary differential equations and their properties, applications; first-order systems of ordinary differential equations.
Textbook: None

HP **Math 30B**, *Calculus*, Fall 2016, Michael Orrison.
Proof-based calculus class. Induction, series & convergence tests, continuity, limits, partial derivatives, double and triple integrals.
Textbook: Spivak, chapters 2, 5-7, 9-11, 13, 18-20, 22-23

Topology

A-/A **Math 197**, *Senior Thesis in Mathematics*, Fall 2019, Spring 2020, Supervised by Francis Su.
Topic: Wild Knots
Textbook: None

A **Math 196**, *Independent Study in Homology Theory*, Spring 2019, Supervised by Francis Su.
Partial notes can be found at https://bedmathandbeyond.xyz/files/homology-notes.pdf. Simplicial $\mathbb{Z}/2\mathbb{Z}$ homology, simplicial $\mathbb{Z}$ homology, Brouwer fixed-point theorem, Lefschetz fixed-point theorem, Mayer-Vietoris theorem, relative homology, basic homological algebra (exactness, the five lemma, the snake lemma, long exact sequence of a pair)
Textbook: Francis Su, *Topology Through Inquiry*

A **Math 199**, *Independent Study in Basic Category Theory & Topology*, Fall 2018, Supervised by Sam Nelson.
Partial notes can be found at https://bedmathandbeyond.xyz/files/category-notes.pdf. Basic category theory: natural transformations, functors, monics & epis, hom-sets, duality, contravariance, comma categories, and universals; basic topology: topological spaces, continuity, induced & quotient topologies, product spaces, compactness, Hausdorffness & separation axioms, connectedness & path connectedness, homotopy of maps, fundamental group.
Textbook: MacLane's *Categories for the Working Mathematician*, chapters 1 and 2; Kosniowski's *A First Course in Algebraic Topology*, chapters 1-15

Abstract & Linear Algebra

A **Math 174**, *Representation Theory*, Spring 2019, Dagan Karp.
Group rings, characters, orthogonality relations, induced representations, applications of representation theory, and other select topics from module theory.
Textbook: Bruce Sagan's *The Symmetric Group: Representations, Combinatorial Algorithms, and Symmetric Functions*

A **Math 173**, *Advanced Linear Algebra*, Fall 2018, Weiqing Gu.
Zorn's lemma, Hilbert spaces, SVD & PCA, Schur's theorem, spectral theory of self-adjoing mappings and definiteness, covariance & quadratic forms, normed linear spaces, Banach spaces, matrix calculus, Hahn-Banach theorem, Perron-Frobenius theorem, Johnson-Lindenstrauss lemma & matrix sketching methods, concentration inequalities, convex optimization & lagrange duality
Textbook: Peter Lax's *Linear Algebra and Its Applications* and Steven Roman's *Advanced Linear Algebra* were both used, but somewhat infrequently.

A- **Math 171**, *Abstract Algebra I: Groups & Rings*, Spring 2018, Shahriar Shahriari.
Basic group theory: group actions, Burnside's lemma, cosets & Lagrange's theorem, the class equations, Sylow theorems, Hasse diagrams & lattice of subgroups, normal subgroups and the conjugation action, homomorphism theorems; basic ring theory: characteristic, ideals, field of fractions, local rings, factorization, irreducibles, $\mathrm{ED} \Rightarrow \mathrm{PID} \Rightarrow \mathrm{UFD}$, Noetherian rings, polynomial rings
Textbook: Shahriar Shahriari, *Algebra in Action*, chapters 1-12, 15-19

B **Math 70**, *Intermediate Linear Algebra*, Spring 2018, Michael Orrison.
Vector spaces, linear transformations, eigenvalues, eigenvectors, inner-product spaces, spectral theorems, Jordan canonical Form, singular value decomposition, and others as time permits.
Textbook: Axler, *Linear Algebra Done Right*, chapters 3, 6-8.

C **Math 65**, *Differential Equations / Linear Algebra II*, Fall 2017, Tori Noquez.
General vector spaces and linear transformations; change of basis and similarity. Applications to linear systems of ordinary differential equations, matrix exponential; nonlinear systems of differential equations; equilibrium points and their stability.
Textbook: None

A **Math 40**, *Introduction to Linear Algebra*, Spring 2017, Susan Martonosi.
Theory and applications of linearity, including vectors, matrices, systems of linear equations, dot and cross products, determinants, linear transformations in Euclidean space, linear independence, bases, eigenvalues, eigenvectors, and diagonalization.
Textbook: David Poole, *Linear Algebra: A Modern Introduction*

Discrete Math & Probability

A **Math 157**, *Intermediate Probability*, Spring 2019, Arthur Benjamin.
Continuous random variables, distribution functions, joint density functions, marginal and conditional distributions, functions of random variables, conditional expectation, covariance and correlation, moment generating functions, law of large numbers, Chebyshev' theorem and central-limit theorem.
Textbook: Carlton & Devore, *Probability with Applications in Engineering, Science, and Technology*

A **Math 55**, *Discrete Mathematics*, Spring 2017, Andrew Bernoff & Nick Pippenger.
Basic combinatorics, number theory, and graph theory.
Textbook: Scheinerman, *Mathematics: A Discrete Introduction*

P **Math 35**, *Probability and Statistics*, Fall 2016, Talithia Williams.
Sample spaces, events, axioms for probabilities; conditional probabilities and Bayes' theorem; random variables and their distributions, discrete and continuous; expected values, means and variances; covariance and correlation; law of large numbers and central limit theorem; point and interval estimation; hypothesis testing; simple linear regression; applications to analyzing real data sets.
Textbook: None

Special Topics & Misc.

A **Math 198**, *Undergraduate Math Forum*, Spring 2019, Dagan Karp.
How to communicate math (written and spoken) to an audience (technical and general).
Textbook: None

A **Math 189R**, *Big Data Analytics*, Summer 2018, Weiqing Gu.
Linear regression, normal equations, covariance matrix, gradient descent, logistic regression, exponential family & generalized linear models, Poisson regression, softmax regression, marginalized Gaussian and the Schur complement, dimension reduction, SVD, PCA, generative learning algorithms, naive Bayes, regularization, lasso, SVMs, kernel methods, k-means, Jensen's inequality, EM algorithm, MAP estimation, learning theory, collaborative filtering, topic modelling & non-negative matrix factorization
Textbook: Kevin Murphy, *Machine Learning: a Probabilistic Perspective*

P **Math 189G**, *Mathematics of Voting*, Fall 2016, Michael Orrison.
Analysis of voting systems, Arrow's Theorem, computational simulation of elections

Textbook: Hodge and Klima, *The Mathematics of Voting and Elections.*

P **Math 21**, *Math of Games and Puzzles*, Fall 2016, Arthur Benjamin.
Analysis of casino games, Sudoku, and the Rubik's Cube. Other topics include Combinatorics, Probability, Dynamic Programming, Game Theory, and Group Theory.

Textbook: Mark Bollman, *Numbers Behind The Neon*

CS and Physics

⋆, † **Math 181W**, *Computability / Complexity / Games*, Spring 2020, Ran Libeskind-Hadas.
This course explores the fundamental limitations of computation and, for those problems that are "computable," explores the time and space required to solve them. For example, while we learn in CS 81 that the halting problem is uncomputable, there are much deeper results in computability theory that allow us to gain deeper insights into what makes a problem uncomputable. For those problems that we can solve, some are hard (e.g., NP-hard) and some are even harder (e.g., PSPACE-hard or harder). In fact, there are an infinite number of layers of increasingly harder problems and this course explores some of the most important and broadly applicable classes of hardness. We use a number of games and puzzles as motivating examples for the theoretical topics in this course.

Textbook: TBD

† **Math 168**, *Algorithms*, Fall 2019, Ran Libeskind-Hadas.
Algorithm design, computer implementation, and analysis of efficiency. Discrete structures, sorting and searching, time and space complexity, and topics selected from algorithms for arithmetic circuits, sorting networks, parallel algorithms, computational geometry, parsing, and pattern-matching.

Textbook: None

A **CS 81**, *Computability and Logic*, Fall 2018, Ran Libeskind-Hadas.
Logic: propositional logic, first-order predicate logic, natural deduction, PROLOG; computability: automata theory and the Chomsky hierarchy, closure properties of languages, Turing reductions, proof of Gödel's incompleteness theorem by Turing machines.

Textbook: None

A **Physics 52**, *Quantum Physics*, Spring 2018, Ann Esin & John Townsend.
Schrödinger equation, operators, eigenfunctions, superposition, commutators, uncertainty relations, and angular momentum. Applications, including atomic and molecular physics, solid state physics, nuclear physics, and particle physics.

Textbook: John Townsend, *Quantum Physics: a Fundamental Approach to Modern Physics*

A **Physics 111**, *Theoretical Mechanics*, Fall 2017, Brian Shuve.
Variational methods, the Euler-Lagrange equation, Lagrangian mechanics, Hamiltonian mechanics, conservation theorems, central-force motion, collisions, damped oscillators, rigid body dynamics, systems with constraints, orbital mechanics

Textbook: Taylor, *Classical Mechanics*

A **Physics 32**, *Gravitation*, Spring 2017, Liz Connolly.
Tidal forces, orbits and celestial mechanics, basic general relativity (equivalence principle, Schwarzschild metric, black holes and cosmology).

Textbook: None

HP **Physics 23**, *Special Relativity*, Fall 2016, Vatche Sahakian.
Inertial frames, einstein's postulates, time dilation, length contraction, relativity of simultaneity, paradoxes, Lorentz transformations, spacetime intervals, momentum, energy, applications to GPS, and gravitation.

Textbook: T. M. Helliwell, *Special Relativity*, chapters 1-14

HP **CS 5**, *Introduction to Computer Science*, Fall 2016, Zachary Dodds.
Basic programming in Python.

Textbook: None