Technical Coursework

Physics

A+ **8.06,** *Quantum Physics III*, Spring 2023, Prof. Max Metlitski

Part of standard quantum physics sequence.

A+ **8.08,** *Statistical Physics II*, IAP 2024, Prof. Julien Tailleur

Modern non-equilibrium statistical mechanics, focusing on stochastic dynamics (in or out of equilibrium) applied to single or many-body systems. Langevin and Fokker-Planck equations, master equations, ratchet currents, stochastic thermodynamics, emergent behaviors. Systems studied range from soft-matter physics to biophysics including colloid dynamics, bacterial motion, as well as active-matter systems. Simulation methods to study non-equilibrium dynamics.

P **8.223** *Classical Mechanics II*, IAP 2023, Prof. Mike Williams

Generalized coordinates, Lagrangian and Hamiltonian formulations, canonical transformations, and Poisson brackets. Applications to continuous media. The relativistic Lagrangian and Maxwell's equations.

A+ **8.323** *Quantum Field Theory I*, Spring 2023, Prof. Hong Liu

A one-term self-contained subject in quantum field theory. Concepts and basic techniques are developed through applications in elementary particle physics, and condensed matter physics. Topics: classical field theory, symmetries, and Noether's theorem. Quantization of scalar fields, spin fields, and Gauge bosons. Feynman graphs, analytic properties of amplitudes and unitarity of the S-matrix. Calculations in quantum electrodynamics (QED). Introduction to renormalization.

A **8.324** *Quantum Field Theory II*, Fall 2024, Prof. Washington Taylor

The second term of the quantum field theory sequence. Develops in depth some of the topics discussed in 8.323 and introduces some advanced material. Topics: perturbation theory and Feynman diagrams, scattering theory, Quantum Electrodynamics, one loop renormalization, quantization of non-abelian gauge theories, the Standard Model of particle physics, other topics.

A **8.325** *Relativistic Quantum Field Theory III*, Spring 2024, Prof. Washington Taylor

The third and last term of the quantum field theory sequence. Its aim is the proper theoretical discussion of the physics of the standard model. Topics: quantum chromodynamics; Higgs phenomenon and a description of the standard model; deep-inelastic scattering and structure functions; basics of lattice gauge theory; operator products and effective theories; detailed structure of the standard model; spontaneously broken gauge theory and its quantization; instantons and theta-vacua; topological defects; introduction to supersymmetry.

A **8.334** *Statistical Mechanics II*, Spring 2024, Prof. Mehran Kardar

Explores topics from modern statistical mechanics: the hydrodynamic limit and classical field theories. Phase transitions and broken symmetries: universality, correlation functions, and scaling theory. The renormalization approach to collective phenomena. Dynamic critical behavior. Random systems.

A+ **8.370** *Quantum Computation*, Fall 2023, Prof. Aram Harrow

Provides an introduction to the theory and practice of quantum computation. Topics covered: physics of information processing; quantum algorithms including the factoring algorithm and Grover's search algorithm; quantum error correction; quantum communication and cryptography.

A **8.962** *General Relativity*, Spring 2024, Prof. Netta Engelhardt

The basic principles of Einstein's general theory of relativity, differential geometry, experimental tests of general relativity, black holes, and cosmology.

Mathematics

A **18.212** *Algebraic Combinatorics*, Spring 2024, Prof. Alexander Postnikov

Applications of algebra to combinatorics. Topics include walks in graphs, the Radon transform, groups acting on posets, Young tableaux, electrical networks.

P **18.701** *Algebra I*, Fall 2022, Prof. Henry Cohn

Introduction to algebra, focusing on group theory, geometry, and linear algebra.

A **18.702** *Algebra II*, Spring 2023, Prof. Andrei Negut

Continuation of 18.701. Focuses on group representations, rings, ideals, fields, polynomial rings, modules, factorization, integers in quadratic number fields, field extensions, and Galois theory.

A **18.721** *Introduction to Algebraic Geometry*, Spring 2024, Prof. David Yang

Presents basic examples of complex algebraic varieties, affine and projective algebraic geometry, sheaves, cohomology.

A **18.745** *Lie Groups and Lie Algebras I*, Fall 2023, Prof. Ju-Lee Kim

Covers fundamentals of the theory of Lie algebras and related groups. Topics may include theorems of Engel and Lie; enveloping algebra, Poincare-Birkhoff-Witt theorem; classification and construction of semisimple Lie algebras; the center of their enveloping algebras; elements of representation theory; compact Lie groups and/or finite Chevalley groups.

A **18.755** *Lie Groups and Lie Algebras II*, Spring 2024, Prof. Pavel Etingof

A more in-depth treatment of Lie groups and Lie algebras. Topics may include homogeneous spaces and groups of automorphisms; representations of compact groups and their geometric realizations, Peter-Weyl theorem; invariant differential forms and cohomology of Lie groups and homogeneous spaces; complex reductive Lie groups, classification of real reductive groups.

A+ **18.905** *Algebraic Topology I*, Fall 2023, Prof. Paul Seidel

Singular homology, CW complexes, universal coefficient and Künneth theorems, cohomology, cup products, Poincaré duality.

Computer Science

P **6.1010** *Fundamentals of Programming*, Fall 2022, Prof. Adam Hartz

Designed to develop skills in applying basic methods from programming languages to abstract problems. Topics include programming and Python basics, computational concepts, software engineering, algorithmic techniques, data types, and recursion. Lab component consists of software design, construction, and implementation of design.

P **6.1220** *Design and Analysis of Algorithms*, Fall 2022, Prof. Piotr Indyk

Sorting, search trees, heaps, and hashing. Divide-and-conquer, dynamic programming, and greedy algorithms. Amortized analysis. Graph algorithms and shortest paths. Network flow, computational geometry, number-theoretic algorithms, polynomial and matrix calculations, caching, and parallel computing.

A+ **6.7900** *Machine Learning*, Fall 2023, Prof. Pulkit Agrawal

Principles, techniques, and algorithms in machine learning from the point of view of statistical inference; representation, generalization, and model selection; and methods such as linear/additive models, active learning, boosting, support vector machines, non-parametric Bayesian methods, hidden Markov models, Bayesian networks, and convolutional and recurrent neural networks.