Domenico Mergoni

Details of courses

As a Teaching Assistant (LSE)

Mathematics

2021/22   **MA210**, Discrete Mathematics

Counting: selections; inclusion-exclusion; generating functions; recurrence relations. Graph Theory: basic concepts; walks, paths, tours and cycles; trees and forests; colourings. Coding theory: basic concepts; linear codes.

2021   **ME306**, Real Analysis   *Summer School*

Basics: proof, logic, sets and functions. Real numbers and sequences. Functions, limits and continuity. Infinite series. Metric and normed spaces. Convergence, completeness and compactness. Continuity in metric spaces. The derivative. Convexity. Fixed point theorems

2020-22   **MA103**, Introduction to Abstract Mathematics

Logic, sets and functions, relations, real numbers, infimum and supremum, sequences, limits and continuity, integers, prime numbers, greatest common divisor and modular arithmetic, complex numbers, groups and vector spaces.

Statistics

2023   **ST455**, Reinforcement Learning

Markov decision process, Bellman optimality equation, Dynamic programing and Monte Carlo methods. Temporal difference learning, Sarsa, Q-learning and n-step temporal difference predictions, TD(lambda). On-policy prediction with approximation, gradient based methods, convergence guarantees with linear function approximator, and semi-gradient n-step Sarsa. Q-learning type algorithms with function approximation, fitted q-iteration, deep q-network, double deep q-learning, convergence analysis. Policy gradient methods, REINFORCE, actor-critic methods. Trust-region policy optimization. Batch off-policy evaluation, importance sampling-based method, doubly robust method, marginalized importance sampling, double reinforcement learning. Recent advances in offline reinforcement learning algorithms.

2022   **ST310**, Machine Learning

Core machine learning techniques in the context of high-dimensional or large datasets (i.e. big data). Nearest neighbours, linear regression, logistic regression, regularisation, cross-validation, and variable selection. Regression and classification trees, random forests, bagging, boosting, deep neural networks, k-means clustering and hierarchical clustering. Causal inference. Hands-on experience using R or Python (programming languages and software environments for data analysis, computing and visualisation).

Finance

2023 **FM250**, Finance   *Summer School*

Net Present Value technique. Introduction to portfolio theory. The Capital Asset Pricing Model (CAPM). Stock market efficiency. Forward and futures contracts, option pricing. Investment decisions and the significance of real options. Capital structure and dividend decisions. Capital restructuring: Initial Public Offering.

2023 **ME200**, Comp. Meth. in Financial Math.s   *Summer School*

Monte Carlo estimation. Variance reduction techniques. Binomial asset pricing model. No-arbitrage. Black-Scholes option pricing model. Monte Carlo methods to pricing financial derivatives. Option pricing with multiple periods.

Selected courses as student

Algebra

2017 **Algebra I**, Prof. G.Gaiffi, 6 ECTS.   *30/30 cum Laude*

Action of group. Sylow thms. Semidirect product. Automorphisms of $\mathcal{S}_n$. Thm of classification of finitely generated abelian groups. Free product. Galois extensions. Galois thms. Fundamental thm of Algebra. Cyclotomic polynomial. Construction of the fraction field.

2019 **Commutative Algebra**, Prof. P.Nelson, 10 ECTS.   *5.75/6*

Hilbert's basis thm. Hilbert's Nullstellensatz. Localization. Modules (in particular ideals). Tensor product, flatness. Associated primes. Primary decomposition. Cayley-Hamilton thm. Artin-Rees thm. Tor. Completions. Artin Rings. Krull's PIT. Valuation rings. Integral Domains.

Probability

2018 **Probability**, Prof. F.Flandoli, 6 ECTS.   *30/30*

Measures and integrability. Monotone class thm. Radon–Nikodym thm. Independence and Borel-Cantelli thm. Product of probability spaces and Fubini Tonelli. Characteristic functions. Convergence of random variables. Limit thms (CLT and LLN). Introduction to Stochastic Processes.

2019 **Applied Stoch. Processes**, Prof. V.Tassion, 8 ECTS.   *Attended*

Poisson process. Poisson point processes in general spaces. Renewal processes. Renewal processes with delay. Renewal equation. Markov chains. Markov properties. Recurrence and transience. Reversibility. Ergodic thm and convergence. Continuous time Markov chains.

Combinatorics

2019 **Random Comb. Structures**, Prof. V.Féray, 6 ECTS.   *6/6*

Combinatorial Classes. Probability generating function and analytic approach. Bivariate generating functions. Class operators. Labelled classes and exponential BGF. Moment methods. Azuma inequality.

2019 **Graph Theory**, Prof. B.Sudakov, 10 ECTS. *5.75/6*

Trees. Connectivity (Menger's thm). Eulerian graphs (Dirac's thm). Matchings. Planar graphs. Graph colourings (Brook's thm). Edge colouring (Vizing's thm). Matrix tree thm. Hamiltonicity. Ramsey theory. Turan's thm. Kuratowski thm.

2019 **Algebraic Methods in Comb.**, Prof. B.Sudakov, 6 ECTS.

Various examples of algebraic proofs in combinatorial problems (finite field Kakeya's problem, Set Systems with restricted intersections et al.). Spectral graph theory. Spectral inequalities. Sensitivity conjecture. Chevalley–Warning Theorem. Combinatorial Nullstellensatz. The cap-set problem.

2019 **Combinatorics of Words**, Prof. M.Bouvel, 3 ECTS.

Patterns and Periods. Equations on words. Infinite words (construction with morphisms and properties). Ultimate Periodicity. Thue-Morse word. Fibonacci word. Sturmian words. Chomsky hierarchy. Automata theory.

Individual Projects

2020 **MSc Thesis**. Supervisor: Prof. B. Sudakov *5.75/6*

Under the supervision of Dr. S. Glock, I analysed possible approaches to the Pentagon Conjecture. My analysis included the study of state of the art probabilistic bounds, and a possible approach via cavity method.

2019 **Reading Course**. Supervisor: Prof. V. Féray *5.75/6*

Integral reading of: "Algebraic Combinatorics" by R.P. Stanley. Particular focus on Ch. VIII "A Glimpse of Young Tableaux", on which I wrote a report and gave a presentation.

2019 **Semester Paper**. Supervisor: Prof. B. Sudakov *Passed*

With Dr. Istvan Tomon we are trying to find a separator thm for ordered graphs avoiding certain bipartite ordered matchings.

2019 **Autonomous study**. Advisor: Prof. V. Féray

Reading of articles suggested by Prof. V. Féray regarding Integrable Probability and the KPZ equation and universality class. In particular: partial (almost completed) reading of "Lectures on integrable probability" by A. Borodin and V. Gorin. Partial reading of "The Surprising Mathematics of Longest Increasing Subsequences" by D. Romik. Partial reading of "The KPZ equation and Universality class" by I. Corwin.

2018 **BSc Thesis**, 9 ECTS, Supervisor: Prof. F. Flandoli. *10/10*

"On the Hausdorff dimension of Brownian Motion".

Construction of the BM and Strong Markov Property. Hausdorff dimension and methods for the upper bound. Potential methods and Taylor thm. Frostman's Lemma and McKean's thm. Kaufman's doubling thm.