Qualifying exam syllabus

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Committee
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Major topic: Probability theory (Probability)

Preliminaries σ-algebras, Dynkin's π-λ theorem, Independence, Borel–Cantelli lemma, Kolmogorov's 0-1 law, Kolmogorov's maximal inequality, Strong and weak laws of large numbers

Central limit theorems Weak convergence, Uniform integrability, Characteristic functions, I.I.D. central limit theorem, Lindeberg–Feller CLT

Conditioning Conditional probability, Conditional expectation, Conditional independence, Regular conditional probabilities

Martinagles Stopping times, Upcrossing inequality, A.S. convergence, Doob's decomposition, Doob's inequality, L^p convergence, L^1 convergence, Reverse martingale convergence, Optional stopping theorem, Wald's identity

Markov chains Countable state space, Stationary measures, Convergence theorems, Recurrence and transience, Asymptotic behavior

References Durrett, Probability: Theory and Examples, Chapters 1–3, 5–6

Major topic: Theoretical statistics (Probability)

Exponential family Densities, Parameters, Moments, Cumulants, Generating functions

Estimators and statistics Risks, Estimators, Sufficient statistic, Complete statistic, Ancillary statistic, Factorization theorem, Minimal sufficient statistic, Basu's theorem, Rao–Blackwell theorem

Unbiased estimation UMVU estimators, Variance bounds, Fisher information, Cramér–Rao bound, Higher dimension variance bounds

Bayesian estimation Prior and posterior distribution, conjugate distribution

Large sample theory Convergence in probability, Convergence in distribution, Central limit theorem, Delta method, Asymptotic relative efficiency

Estimating equations Weak law for random functions, Kullback–Leibler divergence, Consistency of maximum likelihood estimator, limiting distribution for MLE, Confidence interval, asymptotic confidence interval

Empirical Bayes Empirical Bayes estimator, James–Stein estimator

Hypothesis testing Test function, Power, Significance, Neyman–Pearson lemma, Uniformly most powerful tests, Monotone likelihood ratio, Duality between testing and interval estimation, Generalized Neyman–Pearson lemma, Two-sided hypothesis, Unbiased test

References Keener, Theoretical Statistics, Chapters 2–4, 6–9, 11

Minor topic: Numerical linear algebra (Applied Mathematics)

Linear equation solving Gaussian elimination, Perturbation theory, Blocking algorithms, Special linear systems (real symmetric position definite matrices, symmetric indefinite matrices, general sparse matrices)

Linear least squares Normal equations, QR decomposition, Singular value decomposition, Householder transformations, Givens rotations, Rank-deficient least square problems, Perturbation theory

Nonsymmetric eigenproblem Power method, Inverse iteration, Orthogonal iteration, QR iteration, Tridiagonal and bidiagonal reduction, Perturbation theory

Symmetric eigenproblem Tridiagonal QR iteration, Rayleigh quotient iteration, Divide-and-conquer, Bisection and inverse iteration, Perturbation theory

References Demmel, Applied Linear Algebra, Chapters 2–5