

Descriptive List of Upper Division and Graduate Coursework in Mathematics, Statistics and Computer Science

James Bailie

Mathematics:

1. MATH3320 Advanced Analysis 2: Lebesgue Integration and Hilbert Spaces

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructor: Professor Bryan Wang
- Grade: High Distinction, 94%
- Texts used: *Real Analysis* by Royden and Fitzpatrick, *Real Analysis* by Stein and Shakarchi.
- Subject matter covered: Lebesgue outer measure, measurable sets and integration, Lebesgue integral and basic properties, convergence theorems, connection with Riemann integration, Fubini's theorem, approximation theorems for measurable sets, Lusin's theorem, Egorov's theorem, L_p spaces, general measure theory, Radon-Nikodym theorem, Cauchy Schwartz inequality and polarization, nearest point, orthogonal complements, linear operators, Riesz duality, adjoint operator, basic properties of unitary, self adjoint and normal operators, review and discussion of these operators in the complex and real setting, applications to L_2 spaces and integral operators, projection operators, orthonormal sets, Bessel's inequality, Fourier expansion, Parseval's equality, applications to Fourier series.

2. MATH3325 Advanced Functional Analysis, Spectral Theory and Applications

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructor: Professor Scott Morrison
- Grade: High Distinction, 98%
- Texts used: *Functional Analysis* by Rudin
- Subject matter covered: functional calculus, Hilbert spaces, compact operators on Hilbert spaces, the spectral theorem for compact operators, Fourier transform, Schwartz functions, bounded linear transformation theorem, Parseval's formula, the central limit theorem, the Laplacian, Dirichlet problem, abstract measure theory, exterior measures, premeasures, abstract integration theory, Egorov's theorem, Fatou's lemma, Fubini's theorem, pushforwards, Lebesgue-Stieltjes integral, complete normed function spaces, Hölder's inequality.

3. MATH4204 Algebraic Topology Honours

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructor: Dr Vigleik Angeltveit
- Grade: High Distinction, 87%
- Texts used: *Algebraic Topology* by Hatcher
- Subject matter covered: homotopy type, cell complexes, the fundamental group, Van Kampen's theorem, covering spaces, projective spaces, simplicial and singular homology, degree, Mayer-Vietoris sequences, cohomology, the universal coefficient theorem, the cup product, a Künneth formula, Poincaré duality.

4. MATH4349 Special Topics in Mathematics: Category Theory

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructor: Professor Scott Morrison
- Grade: High Distinction, 97%
- Texts used: *Basic Category Theory* by Leinster; *Tensor Categories* by Etingof, Gelaki, Nikshych and Ostrik; *Category Theory in Context* by Riehl; *Categories for the Working Mathematician* by Mac Lane.
- Subject matter covered: categories, functors, natural transformations, universal properties, adjunctions, representables, the Yoneda lemma and embedding, limits, colimits, idempotent completion, monoidal categories, representations, tensor categories, string diagrams, abelian categories, braided monoidal categories, Temperley-Lieb.

5. MATH4349 Special Topics in Mathematics: Vector Bundles and K-Theory

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructor: Dr Vigleik Angeltveit
- Grade: High Distinction, 87%
- Texts used: *Vector Bundles and K-Theory* by Hatcher
- Subject matter covered: vector bundles, sections, inner products, tensor products, fibre bundles, pullbacks, clutching functions, the universal bundle, Grassmannians, the functor $K(X)$, the fundamental product theorem, Bott periodicity, Stiefel-Whitney and Chern classes, the J-homomorphism, Thom spaces, the Chern character.

6. MATH6216 Advanced Topics in Algebra

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructor: Dr James Borger
- Grade: High Distinction, 91%
- Texts used: Unpublished notes
- Subject matter covered: algebraic geometry, affine schemes, category theory, R-algebras, representable functors, universal objects, radical ideals, Zariski topology, varieties and closed subvarieties, subschemes, intersection and unions of subschemes, irreducibility, subfunctors, projective spaces.

7. MATH4349 Special Topics in Mathematics: Representation Theory

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructors: Professor Scott Morrison and Dr Zsuzsanna Dancso
- Grade: High Distinction, 96%
- Texts used: *Introduction to Representation Theory* by Etingof et al.; *Representation Theory* by Fulton and Harris.
- Subject matter covered: algebras, representations, ideals, quotients, quivers, Lie algebras, tensor products, representations of $\mathfrak{sl}(2)$, semisimple categories, finite dimensional representations, extensions of representations, deformations.

8. MATH3343 Advanced Foundations of Mathematics

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructors: Dr Martin Ward
- Grade: High Distinction, 92%
- Texts used: Unpublished notes.
- Subject matter covered: deductive systems, formal languages, sentential logic, formal proofs, predicate logic, the deduction theorem, first order theories and systems, consistency and completeness, Morse-Kelley set theory, the axiom of choice, Zermelo-Fraenkel set theory, construction of the reals, transfinite arithmetic, computability, recursive functions, Gödel's theorem.

9. MATH3345 Advanced Algebra 2: Field Extensions and Galois Theory

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructors: Dr Bregje Pauwels, Dr Jesse Burke
- Grade: High Distinction, 94%

- Texts used: *Galois Theory* by Reid, *Abstract Algebra* by Dummit and Foote, *Algebra* by Artin.
- Subject matter covered: the symmetric function theorem, Lagrange's solution to the quartic, maximal and prime ideals, principal ideal domains, prime ideals in $k[x]$, algebraic and transcendental elements, Gauss' lemma, Eisenstein's criterion, homomorphisms of extensions, Tower law, intermediate field extensions, the field of constructible numbers, normal extensions, splitting fields, uniqueness of the splitting field.

10. **MATH3349 Special Topics in Mathematics: Kolmogorov Complexity**

- Department and school: Mathematical Sciences Institute, the Australian National University
- Instructors: Professor Stephen Roberts and Professor Marcus Hutter
- Grade: High Distinction, 90%
- Texts used: *An Introduction to Kolmogorov Complexity and Its Applications* by Li and Vitanyi; *Randomness and Complexity, from Leibniz to Chaitin* by Calude; *Lecture Notes on Descriptive Complexity and Randomness* by Gács.
- Subject matter covered: algorithmic information theory, Kolmogorov complexity, symmetric of information, prefix coding, recursion theory.

Statistics:

11. **STAT3013 Statistical Inference**

- Department and school: Research School of Finance, Actuarial Studies & Applied Statistics, the Australian National University
- Instructor: Dr Anton Westveld
- Grade: High Distinction, 92%
- Texts used: *Statistical Inference* by Casella and Berger
- Subject matter covered: properties of a random sample, principles of data reduction, point estimation, interval estimation, hypothesis testing, non-parametric statistics.

12. **STAT3004 Stochastic Modelling**

- Department and school: Research School of Finance, Actuarial Studies & Applied Statistics, the Australian National University
- Instructor: Dr Boris Buchmann
- Grade: High Distinction, 82%
- Texts used: *Introduction to Stochastic Modelling* by Karlin and Taylor; *Stochastic Processes and Models* by Stirzaker; *Introduction to Probability Models* by Ross.

- Subject matter covered: discrete- and continuous-time stochastic processes, Markov chains, Markov pure jump processes, Poisson processes, Brownian motion and other related Gaussian processes.

13. **STAT3015 Generalised Linear Modelling**

- Department and school: Research School of Finance, Actuarial Studies & Applied Statistics, the Australian National University
- Instructor: Ian McDermid
- Grade: High Distinction, 92%
- Texts used: Unpublished notes
- Subject matter covered: generalised linear modelling techniques in modern applied statistics, implementation in R, GLM model assumptions and model diagnostics, application to statistical analysis.

14. **STAT3008 Applied Statistics**

- Department and school: Research School of Finance, Actuarial Studies & Applied Statistics, the Australian National University
- Instructor: Dr Tao Zou
- Grade: High Distinction, 92%
- Texts used: *The Statistical Sleuth* by Ramsey and Schafer; *Practical Regression and Anova using R* by Faraway; *Extending the Linear Model with R* by Faraway.
- Subject matter covered: regression modelling with emphasis on model formulation, understanding the implication of model assumptions, diagnostic methods for model checking and interpretation, logistic regression for binary variables and binomial counts, log-linear regression for Poisson counts, exploratory tools for summarising multivariate responses, the bootstrap and jackknife.

15. **Survey Methods 1**

- Department and school: Methodology Division, the Australian Bureau of Statistics
- Instructor: Peter Radisch
- Grade: 90%
- Texts used: Unpublished notes
- Subject matter covered: linear unbiased estimator, the Horvitz-Thompson estimator, variance estimation, Taylor series approximations, sampling design, stratified sampling, probability proportional to size sampling, the post-stratified estimator, the ratio estimator, the generalised regression (calibration) estimator, multi-phase and -stage sampling.

16. Time Series Methods 1

- Department and school: Methodology Division, the Australian Bureau of Statistics
- Instructor: Brock Hermans
- Grade: 98%
- Texts used: Unpublished notes
- Subject matter covered: time series decomposition, SARIMA modelling, stationarity, model invertibility and causality, Fourier analysis, spectral density, periodograms, filter-based methods, the linear filter theorem, structural time series models, state space models, Kalman filters and smoothing.

Computer Science

17. COMP3620 Artificial Intelligence

- Department and school: Research School of Computer Science, the Australian National University
- Instructors: Professor Marcus Hutter, Professor Sylvie Thiebaux, Dr Miquel Ramirez
- Grade: High Distinction, 97%
- Texts used: *Artificial Intelligence* by Russell and Norvig; *Reinforcement Learning* by Sutton and Barto.
- Subject matter covered: search algorithms, knowledge representation and reasoning, constraint satisfaction problems, constraint propagation, planning problems, reinforcement learning.

18. COMP4620 Advanced Topics in Artificial Intelligence

- Department and school: Research School of Computer Science, the Australian National University
- Instructor: Professor Marcus Hutter
- Grade: High Distinction, 100%
- Texts used: *Universal Artificial Intelligence* by Hutter, *Machine Super Intelligence* by Legg.
- Subject matter covered: foundations of artificial intelligence, general AI, rational agents, reinforcement learning, decision theory, Solomonoff's universal induction, universal sequence prediction, Kolmogorov complexity, AIXI, Bayes mixture distributions.

19. COMP3600 Algorithms

- Department and school: Research School of Computer Science, the Australian National University
- Instructor: Associate Professor Weifa Liang

- Grade: High Distinction 92%
- Texts used: *Introduction to Algorithms* by Cormen, Leiserson, Rivest and Stein
- Subject matter covered: Algorithm analysis, lower bound and upper bound, recurrences, divide-and-conquer, dynamic programming, greedy algorithms, data structures, priority queues, binary search trees, red-black trees, hash tables, graph search techniques, Depth-First Search, Breadth-First Search, graph algorithms, minimum spanning trees, single source shortest path trees and all pairs of shortest paths.

20. **COMP3630 Theory Of Computation**

- Department and school: Research School of Computer Science, the Australian National University
- Instructors: Professor Marcus Hutter, Dr Charles Gretton, Dr Dirk Pattinson
- Grade: High Distinction, 98%
- Texts used: *Introduction to Automata Theory, Languages, and Computation* by Hopcroft, Motwani and Ullman
- Subject matter covered: formal programs and languages, finite automata, pushdown automata, context free grammars, Turing machines, undecidability, the halting problem, complexity, P vs NP, Kolmogorov complexity.

21. **COMP4630 Overview of Logic and Computation**

- Department and school: Research School of Computer Science, the Australian National University
- Instructors: Professor Rajeev Gore, Dr Michael Norrish, Dr Peter Baumgartner, Dr Jeremy Dawson
- Grade: High Distinction, 92%
- Texts used: Unpublished notes.
- Subject matter covered: foundations of mathematical logic, essentials of first order logic, completeness proofs, proof theory, model theory, modal and temporal logic, automated reasoning, untyped and typed lambda calculi, the Curry-Howard isomorphism, SAT problems.