Grade Code	Points
AS*	10 (Outstanding)
AA	10 (Excellent)
AB	9
BB	8
BC	7

***AS grade was introduced from the academic year 2015-2016 onwards (in my 7th semester).**

Note that the above grade codes list is not complete. Please refer Transcript for complete list.

STATISTICS

MA225, PROBABILITY THEORY AND RANDOM PROCESSES, Prof. Debanjan Mitra, AB, IIT Guwahati

Texts:

1. J. Medhi, Stochastic Processes, 3rd Ed., New Age International, 2009.
2. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.

Axiomatic construction of the theory of probability, independence, conditional probability, and basic formulae, random variables, probability distributions, functions of random variables; Standard univariate discrete and continuous distributions and their properties, mathematical expectations, moments, moment generating function, characteristic functions; Random vectors, multivariate distributions, marginal and conditional distributions, conditional expectations; Modes of convergence of sequences of random variables, laws of large numbers, central limit theorems.
Definition and classification of random processes, discrete-time Markov chains, Poisson process, continuous-time Markov chains, renewal and semi-Markov processes, stationary processes, Gaussian process, Brownian motion, filtrations and martingales, stopping times and optimal stopping.

MA226, MONTE CARLO SIMULATION, Prof. Arabin Kumar Dey, AA, IIT Guwahati

Text:

1. Handouts given by Professor.

Principles of Monte Carlo, generation of random numbers from a uniform distribution: linear congruential generators and its variations, inverse transform and acceptance-rejection methods of transformation of uniform deviates, simulation of univariate and multivariate normally distributed random variables: Box-Muller and Marsaglia methods, variance reduction techniques, generation of Brownian sample paths, quasi-Monte Carlo: Low discrepancy sequences.

MA471, STATISTICAL ANALYSIS OF FINANCIAL DATA, Prof. Arabin Kumar Dey, AS, IIT Guwahati

Texts:

1. D. Ruppert, Statistics and Finance: An Introduction, Springer India, 2009

Introduction to statistical packages (R / S-Plus / MATLAB / SAS) and data analysis - financial data, exploratory data analysis tools, kernel density estimation; Basic estimation and testing; Random number generator and Monte Carlo samples; Financial time series analysis - AR, MA, ARMA. ARIMA, ARCH and GARCH models, identification, inference, forecasting, stochastic volatility time series models for term structure of interest rates; Linear regression -least squares estimation, inference, model checking; Multivariate data analysis - multivariate normal and inference, Copulae and random simulation, examples of copulae family, fitting Copulas, Monte Carlo simulation with Copulas, dimension reduction techniques, principal component analysis; Risk management - riskmetrics, quantiles, Q-Q plots, quantile estimation with Cornish-Fisher expansion, VaR, expected short fall, time-to-default modeling, extreme value theory (generalized extreme value (GEV), generalized Pareto distribution (GPD); Block Maxima, and Hill methods).

MA691, STATISTICAL SIMULATION AND DATA ANALYSIS, Prof. Arabin Kumar Dey, AA, IIT Guwahati
Texts:
1. D. Kundu, Statistical Computing :existing methods and recent development, Alpha Science International, 2004.
2. Kevin R Murphy, Machine Learning - A Probabilistic Perspective, The MIT Press.
3. B.P. Robert and G. Casella, Monte Carlo Statistical Methods, Springer, 2004.
4. R. C. Mitsno, Genetic Algorithm and Engineering Optimization, Wiley Series in EDA, 2000.

Introduction to probability distributions. Basics of estimation and testing of hypothesis (frequentist approach, bayesian approach). Different censoring schemes: Type-I , Type-II, hybrid, progressive. Different models and EM algorithm: mixture model; bivariate distributions; cure rate model; competing risk model. Generating random sample: discrete and continuous multivariate distributions (multinomial, multivariate normal, multivariate exponential); acceptance rejection principle; monte carlo markov chain (metropolis hastings algorithm, gibbs sampler, slice sampling, Hamiltonian); Convergence of MCMC : Harris irreducibility, recurrence, minorization, limit theory for harris recurrent markov chains. Resampling techniques: jackknife; bootstrap. Hidden Markov Model (forward-backward algorithm, viterbi algorithm, baum-welch algorithm). Kalman Filter. Artificial Neural Network: framework, topology (feed forward neural network, recurrent neural network), training of ANN (supervised, unsupervised, reinforced learning) , robustness. Restricted Boltzmann Machines. Deep Belief Net. Genetic Algorithm: single objective GA, multi-objective NSGA.

MATHEMATICS:

MA101, MATHEMATICS I, Prof. K.V. Krishna & Prof. Vinay Wagh, AA, IIT Guwahati
Texts:
1. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edn.,Brooks/Cole, 2005.
2. G. B. Thomas, Jr. and R. L. Finney, Calculus and Analytic Geometry, 9th Edn., Pearson Education India, 1996.

Systems of linear equations and their solutions; vector space Rn and its subspaces; spanning set and linear independence; matrices, inverse and determinant; range space and rank, null space and nullity, eigenvalues and eigenvectors; diagonalization of matrices; similarity; inner product, Gram-Schmidt process; vector spaces (over the field of real and complex numbers), linear transformations.
Convergence of sequences and series of real numbers; continuity of functions; differentiability, Rolle's theorem, mean value theorem, Taylor's theorem; power series; Riemann integration, fundamental theorem of calculus, improper integrals; application to length, area, volume and surface area of revolution.

MA102, MATHEMATICS II, Prof. Rafikul Alam & Prof. Anupam Saikia, AB, IIT Guwahati
Texts:
1. G. B. Thomas, Jr. and R. L. Finney, Calculus and Analytic Geometry, 9th Edn., Pearson Education India, 1996.
2. S. L. Ross, Differential Equations, 3rd Edn., Wiley India, 1984.

Vector functions of one variable - continuity and differentiability; functions of several variables - continuity, partial derivatives, directional derivatives, gradient, differentiability, chain rule; tangent planes and normals, maxima and minima, Lagrange multiplier method; repeated and multiple integrals with applications to volume, surface area,

moments of inertia, change of variables; vector fields, line and surface integrals; Green's, Gauss' and Stokes' theorems and their applications.
First order differential equations - exact differential equations, integrating factors, Bernoulli equations, existence and uniqueness theorem, applications; higher-order linear differential equations - solutions of homogeneous and nonhomogeneous equations, method of variation of parameters, operator method; series solutions of linear differential equations, Legendre equation and Legendre polynomials, Bessel equation and Bessel functions of first and second kinds; systems of first-order equations, phase plane, critical points, stability.

MA201, MATHEMATICS III, Prof. P.A.S. Sree Krishna & Prof. Siddhartha P. Chakrabarty, AA, IIT Guwahati
Texts:
1. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
2. I. N. Sneddon, Elements of Partial Differential Equations, McGraw Hill, 1957.

Complex numbers and elementary properties. Complex functions - limits, continuity and differentiation. Cauchy-Riemann equations. Analytic and harmonic functions. Elementary functions. Anti-derivatives and path (contour) integrals. Cauchy-Goursat Theorem. Cauchy's integral formula, Morera's Theorem. Liouville's Theorem, Fundamental Theorem of Algebra and Maximum Modulus Principle. Taylor series. Power series. Singularities and Laurent series. Cauchy's Residue Theorem and applications. Mobius transformations.
First order partial differential equations; solutions of linear and nonlinear first order PDEs; classification of second-order PDEs; method of characteristics; boundary and initial value problems (Dirichlet and Neumann type) involving wave equation, heat conduction equation, Laplace's equations and solutions by method of separation of variables (Cartesian coordinates); initial boundary value problems in non-rectangular coordinates.
Laplace and inverse Laplace transforms; properties, convolutions; solution of ODE and PDE by Laplace transform; Fourier series, Fourier integrals; Fourier transforms, sine and cosine transforms; solution of PDE by Fourier transform.

MA222, MODERN ALGEBRA, Prof. Vinay Wagh, AB, IIT Guwahati
Texts:
1. J. A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa, 1998.

Formal properties of integers, equivalence relations, congruences, rings, homomorphisms, ideals, integral domains, fields; Groups, homomorphisms, subgroups, cosets, Lagrange's theorem , normal subgroups, quotient groups, permutation groups; Groups actions, orbits,stabilizers, Cayley's theorem, conjugacy, class equation, Sylow's theorems and applications; Principal ideal domains, Euclidean domains, unique factorization domains, polynomial rings; Characteristic of a field, field extensions, algebraic extensions, separable extensions, finite fields, algebraically closed field, algebraic closure of a field.

MA224, REAL ANALYSIS, Prof. Rajesh Srivastava, BB, IIT Guwahati
Texts:
1. N. L. Carothers, Real Analysis, Cambridge University Press, 2000.

Metrics and norms - metric spaces, normed vector spaces, convergence in metric spaces, completeness; Functions of several variables - differentiability, chain rule, Taylor's theorem, inverse function theorem, implicit function theorem; Lebesgue measure and integral - sigma-algebra of sets, measure space, Lebesgue measure, measurable functions, Lebesgue integral, dominated convergence theorem, monotone convergence theorem, L-p spaces.

MA322, SCIENTIFIC COMPUTING, Prof. Natesan Srinivasan, AA, IIT Guwahati
Texts:
1. D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd Ed., AMS, 2002.
2. G. D. Smith, Numerical Solutions of Partial Differential Equations, 3rd Ed., Calrendorn Press, 1985.

Errors; Iterative methods for nonlinear equations; Polynomial interpolation, spline interpolations; Numerical integration based on interpolation, quadrature methods, Gaussian quadrature; Initial value problems for ordinary differential equations - Euler method, Runge-Kutta methods, multi-step methods, predictor-corrector method, stability and convergence analysis; Finite difference schemes for partial differential equations - Explicit and implicit schemes; Consistency, stability and convergence; Stability analysis (matrix method and von Neumann method), Lax equivalence theorem; Finite difference schemes for initial and boundary value problems (FTCS, Backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff method, upwind scheme).

MA321, OPTIMIZATION, Prof. Sriparna Bandopadhyay, BC, IIT Guwahati[1]

Texts:

1. D. G. Luenberger and Y. Ye, Linear and Nonlinear Programming, 3rd Ed., Springer India, 2008.

Classification and general theory of optimization; Linear programming (LP): formulation and geometric ideas, simplex and revised simplex methods, duality and sensitivity, interior-point methods for LP problems, transportation, assignment, and integer programming problems; Nonlinear optimization, method of Lagrange multipliers, Karush-Kuhn-Tucker theory, numerical methods for nonlinear optimization, convex optimization, quadratic optimization; Dynamic programming; Optimization models and tools in finance.

MA423, MATRIX COMPUTATIONS, Prof. Rafikul Alam, BB, IIT Guwahati

Texts:

1. D. S. Watkins, Fundamentals of Matrix Computations, 2nd Ed., John Wiley, 2002.

Floating point computations, IEEE floating point arithmetic, analysis of roundoff errors; Sensitivity analysis and condition numbers; Linear systems, LU decompositions, Gaussian elimination with partial pivoting; Banded systems, positive definite systems, Cholesky decomposition - sensitivity analysis; Gram-Schmidt orthonormal process, Householder transformation, Givens rotations; QR factorization, stability of QR factorization. Solution of linear least squares problems, normal equations, singular value decomposition(SVD), polar decomposition, Moore-Penrose inverse; Rank deficient least-squares problems; Sensitivity analysis of least-squares problems; Review of canonical forms of matrices; Sensitivity of eigenvalues and eigenvectors. Reduction to Hessenberg and tridiagonal forms; Power, inverse power and Rayleigh quotient iterations; Explicit and implicit QR algorithms for symmetric and nonsymmetric matrices; Reduction to bidiagonal form; Golub- Kahan algorithm for computing SVD.

MA502, GRAPH THEORY, Prof. Bikash Bhattacharjya, AA, IIT Guwahati

Texts:

1. J. A. Bondy and U. S. R. Murty. Graph Theory with Applications.North-Holland, 1976.

Isomorphism, incidence and adjacency matrices, Sperner lemma, Trees,Cayley formula, connector problem, connectivity, constructing reliable communication network, Euler tours, Hamilton cycle, Chinese postman and traveling salesman problems, matchings and coverings, perfect matchings, edge colouring, Vizing Theorem, time table problem, Independent sets, Ramsey theorem, Turan theorem, Schur theorem, vertex colouring, Brook theorem, Hajos conjecture, chromatic polynomials, storage problem, planarity, dual graphs, Euler formula, Kuratowski theorem, five colour theorem, history of four colour theorem, nonhamiltonian planar graphs, planarity algorithm, directed graphs, job sequencing, one way road system, ranking participants in tournaments.

---

[1] I did not perform well in the course on optimization due to high workload from 8 other courses in the same semester. However, I did a self study of the course since I was aware of the importance and often use of its various concepts in Statistical Inference, Machine Learning and other fields.

Other Mathematical Courses:

MA271, Financial Engineering I, Prof. P.A.S. Sree Krishna, AB, IIT Guwahati

Texts:

1. M. Capinski and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2nd Ed., Springer, 2010.
2. J. C. Hull, Options, Futures and Other Derivatives, 8th Ed., Pearson India/Prentice Hall, 2011.

Overview of financial engineering, financial markets and financial instruments; Interest rates, present and future values of cash flow streams; Riskfree assets - bonds and bonds pricing, yield, duration and convexity, term structure of interest rates, spot and forward rates; Risky assets - risk-reward analysis, mean variance portfolio optimization, Markowitz model and efficient frontier, CAPM and APT; Discrete time market models assumptions, portfolios and trading strategies, replicating portfolios, No-arbitrage principle; Derivative securities forward and futures contracts, hedging strategies using futures, pricing of forward and futures contracts, interest rate futures, swaps;General properties of options, trading strategies involving options; Binomial model, risk neutral probabilities, martingales, valuation of European contingent claims, Cox-Ross-Rubinstein (CRR) formula, American options in binomial model, Black-Scholes formula derived as a continuous-time limit; Options on stock indices, currencies and futures, overview of exotic options.

MA372, Stochastic Calculus for Finance, Prof. Sameer Kamal, BB, IIT Guwahati

Texts:

1. S. Shreve, Stochastic Calculus for Finance, Vol. 2, Springer India, 2004.
2. M. Baxter and A. Rennie, Financial Calculus, Cambridge University Press, 1996.
3. S. Shreve, Stochastic Calculus for Finance, Vol. 1, Springer India, 2004.

General probability spaces, filtrations, conditional expectations, martingales and stopping times, Markov processes; Brownian motion and its properties; Itôintegral and its extension t classes of integrands, isometry and martingale properties of Itôintegral, Itôocesses, Itôeblin formula; Derivation of the Black-Scholes-Merton differential equation, Black-Scholes-Merton formula, the Greeks, put-call parity, multi-variable stochastic calculus; Risk-neutral valuation risk-neutral measure, Girsanov's theorem for change of measure, martingale representation theorems, representation of Brownian martingales, the fundamental theorems of asset pricing; Stochastic differential equations, existence and uniqueness of solutions, Feynman-Kac formula and its applications.

MA373, Financial Engineering II, Prof. N. Selvaraju, AB, IIT Guwahati

Texts:

1. T. Bjork, Arbitrage Theory in Continuous Time, 3rd Ed., Oxford University Press, 2003.
2. J. C. Hull, Options, Futures and Other Derivatives, 8th Ed., Pearson India/Prentice Hall, 2011.

Continuous time financial market models, Black-Scholes-Merton model, Black-Scholes PDE and formulas, risk-neutral valuation, change of numeraire, pricing and hedging of contingent claims, Greeks, implied volatility, volatility smile; Options on futures, European, American and Exotic options; Incomplete markets, market models with stochastic volatility, pricing and hedging in incomplete markets; Bond markets, term-structures of interest rates, bond pricing; Short rate models, martingale models for short rate (Vasicek, Ho-Lee, Cox-Ingersoll-Ross and Hull-White models), multifactor models; Forward rate models, Heath-Jarrow-Morton framework, pricing and hedging under short rate and forward rate models, swaps and caps; LIBOR and swap market models, caps, swaps, swaptions, calibration and simulation.

MA473, Computational Finance, Prof. Natesan Srinivasan, AA, IIT Guwahati
Texts:

1. P.Glasserman, Monte Carlo Methods in Financial Engineering, Springer, 2004.
2. R. U. Seydel, Tools for Computational Finance, 4th Ed., Springer, 2009.

Review of financial models for option pricing and interest rate modeling, Black -Scholes PDE; Finite difference methods, Crank-Nicolson method, American option as free boundary problems, computation of American options, pricing of exotic options, upwind scheme and other methods, Lax-Wendroff method; Monte-Carlo simulation, generating sample paths, discretization of SDE, Monte-Carlo for option valuation and Greeks, Monte-Carlo for American and exotic options; Term-structure modeling, short rate models, bond prices, multifactor models; Forward rate models, implementation of Heath-Jarrow-Morton model; LIBOR market model, Volatility structure and Calibration.

Other Computing Courses:
MA Dept, **Data Structures and Algorithm**, Prof. Kalpesh Kapoor, AA
MA Dept, **Parallel Computing**, Prof. Kalpesh Kapoor, AA
MA Dept, **Formal Languages and Automata**, Prof. G.K. Das, AB
CSE Dept, **Artificial Intelligence**, Prof. Rashmi Dutta Baruah, Audited - Pass
CSE Dept, **Intelligent Systems and Interfaces**, Prof. Ashish Anand, Audited - Pass

Other courses:
HSS Dept, **Game Theory and Economics**, Prof. Debarshi Das, AB

Please check the following link for more details: http://www.iitg.ernet.in/maths/acads/btech_struct.php