Elective Courses for Odd (First and Third) Semesters

MAT 01E: Mathematical Statistics

Unit 1. Descriptive Statistics: Measures of central tendency, dispersion skewness and kurtosis Elements of probability: Sample space, discrete probability, independent events, Baye's theorem, random variables and distribution functions (univariate, bivariate, and genereralization to multivariate).

Unit 2. Mathematical expectation and moments: Moment generating function, Characteristic function and cumulants. Probabilistic inequalities (Tchebychev, Markov and Jensen). Modes of convergence: weak and strong laws of large numbers. Central limit theorem (i.i.d. case). Markov chains with finite and countable state space, Poisson and birth- and- death processes.

Unit 3. Some standard discrete and continuous univariate distributions (Binomial, Poisson, Normal, Gamma and Beta), Distribution of order statistics and range.

Unit 4. Correlation, Rank correlation. Regression lines. Multiple and partial correlation of three variables only. Data reduction techniques: Principle component analysis, discriminant analysis, cluster analysis, canonical correlation.

Unit 5. Concept of sampling and statistics: simple random sampling, Stratified sampling and systematic sampling, Probability proportional to size sampling, Ratio and regression methods.

Books Recommended:

1. M.G.Kendall: Advanced theory of statistics Vol. I &II, Charle's Griffiin & Co.

2. R. Hogg and A Craig: Introduction to Mathematical Statistics, Mac Millan & Co.

3. W.C. Cochran: Sampling techniques, Wiley Eastern, Reprint.

4. C.E. Weatherbun: A first course in Mathematical Statistics, The English Language Book Society And Cambridge University Press, 1961.

5. John A. Rice: Mathematical Statistics and Data Analysis, (3^{rd} Edition), Durbury, 2013.

6. C.R. Rao: Advanced statistical methods in Biometrical Research, John Wiley.

7. S.C. Gupta & V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand & Co.

MAT 03E: Theory of Numbers

Unit 1. Prime Numbers, Unique Factorization theorem, Farey series, Irrational numbers, Congruences, Residues, Quadratic reciprocity law, Primitive roots.

Unit 2. Fermet's theorem, Wilson's theorem, Continued fractions, Approximation of irrationals by rationals, Hurwitz theorem.

Unit 3. The fundamental theorem of arithmetic in K(1), K(i), K(ρ), Diophantine equation $X^2+Y^2 = Z^2$, $X^4+Y^4 = Z^4$, $ax^2+by^2+cz^2 = 0$, Quadratic fields.

Unit 4. The arithmetic function: d(n), σ(n), μ(n) and $\varphi(n)$ including elementary results on their order and average order.

Unit 5. Representation of numbers by two or four squares- Waring's problem, Elementary results on g(k) and G(k), The prime numbers theorem.

Books Recommended:

1. Hardy and Wright: Introduction to the theory of numbers.

2. D. M. Burton: Elementary Number Theory, 6^{th} Edition, Tata McgGraw Hill.

3. S. B. Malik: Basic Number theory, 2^{nd} edition, paper back, 1998.

4. Neal Koblitz: A Course in Number theory and cryptography: a Graduate Text, Springer (second Ed).

MAT 05E: Fluid Dynamics

Unit 1. Lagrangian and Eulerian methods, Equation of continuity, Boundary surface, Stream lines, Velocity potential, Euler's equation of motions, Bernoulli's theorem, Helmholtz equations, Cauchy's integral, Equation of motion under impulsive forces, Principal of energy.

Unit 2. Motion in two dimensions, Velocity potential and current functions, Sources and sinks, Doublet and images, Circle theorem, Motion of circular and elliptic cylinder in two dimensions, Blasius theorem, Joukowski transformation, Motion in three dimensions, Three dimensional sources, Sinks and doublets, Image of source in front of sphere, Motion of spheres, Stroke's stream function.

Unit 3. General theory of irrotational motion, Permanence of irrotational motion circulation, Stroke's theorem, Kelvin's circulation theorem, Green's theorem, Kelvin's minimum energy theorem, Conformal Representation, Kutta and Joukowski transformation, Theorems of Schwartz and Christoffel.
Unit 4. Vortex motion: Rectilinear vortices, Rectilinear vortex with a circular section, An infinite row of parallel rectilinear vortices, Karman stream, Use of conformal transformation, Vortex pairs.
Unit 5. Stationary waves, Long waves, Energy surface waves, Deep-water waves, Progressive waves reduced to steady motion. Waves at the common surfaces of two liquids , Group velocity. General theory of stress strain, Navier-Stroke's equations.

Books Recommended:
1. A. S. Ramsey: A Treatise on Hydrodynamics.
2. W. H.Besant and A. S. Ramsey: A Treatise on Hydrodynamics, CBS Publisher and Distributiors, Delhi, 1988.
3. F. Chorlton: A Text Book of Fluid Dynamics, CBC, 1985.

Unit 2. Boolean algebra, Boolean functions, Boolean expressions, Applications to switching circuits.
Unit 3. Elements of graph theory: Basic terminology, Paths and circuits, Eulerian and Hamiltonian graphs, Planar graphs, Directed graphs.
Unit 4. Trees: Rooted trees, path lengths, spanning trees, minimum spanning trees.
Unit 5. Permutations and Combinations, the rules of sums and products, Properties of binary relations, Equivalence relations and partitions, Functions and Pigeonhole principle, Principle of inclusion and exclusion.

Books Recommended:
1. C. L. Liu: Elements of discrete mathematics, Tata McGraw Hill Education, 2008.
2. Ram Babu: Disrete Mathematics, Pearson Edition India, 2011.
3. Lipschutz: Disrete Mathematics, Tata McGraw Hill, 2011.

MAT 09E: Computer Programming and Mathematical Computation

Unit 1. Introduction to Programming in C: Introduction to Algorithms & Flowcharts Variables, constant, Keywords, signed and unsigned modifiers.
Unit 2. Expression and operators: Arithmetic, logical and relational operators, bitwise operators, incremental operators, assignment operators. Functioning of these operators.
Control flow: If-else, switch, while, do-white, for loops, continue, break statements, Nesting of control statements and loops.
Unit 3. Working with functions: Variable and functions, Argument passing to functions, type of functions, storage classes, scope rule, C preprocessor and standard libraries.
Unit 4. Pointers, arrays and File handling: Pointers, addresses, arrays, multidimensional arrays, String, Input/ Output, Standard input and output, basic file handling.
Unit 5. User Defined Datatypes : Structure, Union, enumeration.
Practical assignments: Based on topics included in the paper.

Books recommended:
1. Ritchier & Kernighan: The C programming language, Prentice Hall of India.
2. V. Rajaraman: Computer Programming in 'C', Prentice Hall of India.
3. E. Balaguruswami: Programming in ANSI 'C', Tata McGraw Hill.

MAT 11E: Special Functions
Unit 1. Preliminaries, Gamma function and related functions, Gauss multiplication theorem, the hypergeometric differential equation, Gauss hypergeometric function. **Unit2.** Integral representation of hypergeometric function, Evaluation of hypergeometric function, the confluent hypergeometric differential equation, Confluent hypergeometric function.
Unit 3. Bessel's equation, solution of Bessel's equation, Bessel's functions $J_n(x)$, Recurrence Formulae, Equations reducible to Bessel's equation, orthogonality of Bessel's Functions, A generating function for $J_n(x)$, Basic properties.

Unit 4. Legendre's equation, Legendre's polynomial $P_n(x)$, Legendre's function of the second kind $Q_n(x)$, General solution of Legendre's equation, Rodrigue's formula, Legendre polynomials, A generating function of Legendre's polynomial , Orthogonality of Legendre polynomials, Recurrence formulae for $P_n(x)$.
Unit 5. Hermite's equation and its solution, hermite polynomial of order n, Generating function, Orthogonal property, Recurrence relations.

Books Recommended:
1. E.D.Rainville: Special functions.
2. Nirvikar Saran: Special Functions.
3. W.W. Bell: Special Function for Scientists and Engineers, Dever publications, 2002,
4. U.P. Singh: Special Function & Their application , WISDOM PRESS, 2012.

MAT 13E: Fourier Analysis
Unit 1. Genesis and Basic Properties of Fourier Series: Derivation and Solutions of wave and heat equations, Definition of Fourier series and Examples, Uniqueness, convolution, Cesaro means and summation, Fejers theorem, Abel mean and summation, Poisonkernel and Dirichlet's problem in the unit Disc.

Unit 2. Convergence and some applications of Fourier Series: Mean square convergence of Fourier series, pointwise convergence, Isoperimetric inequality, Weyle's equidistribution theorem, continuous but nowhere differentiable function, Heat equation on the circle.

Unit 3. Fourier Transforms: Elementary theory and definition of Fourier transforms, Schwartz space, Fourier transform on S, The Fourier inversion, Plancherel formula, Weierstrass approximation theorem, Application of Fourier transform to some partial differential equations.
Unit 4. Poison summation formula, Theta and Zeta functions, Heat and Poisson Kernels, Heisenberg uncertainty principle.

Unit 5. Finite Fourier analysis : The group *Z(N),* Fourier inversion theorem and Plancherel identity on Z(N), The Fast Fourier Transforms, Fourier analysis on finite abelian groups, introduction to wavelets.

Books Recommended:
1. Elias M. Stein & Rami Shakarchi: Fourier Analysis, An Introduction: Levant Books, Kolkata
2. Rajendra Bhatia: Fourier Analysis.
3. E. C.Titchmarsh: A Theory of Functions, Oxford University, Press, 1939.
4. A. Zygmund: Trigonometric series Vol. I, The University Press, Cambridge, 1959.

MAT 15E: Financial Mathematics
Unit 1. An introduction to Discrete Probability,Probability spaces,Independence,Binomial probabilities,Random variables,Conditional probabilities,Expectation,Conditional expectation,Variance,standard deviation,Covariance and correlation,Best linear predictor,Stochastic processes,Normal,Lognormal and Cauchy variates,Filtrations and Martingales.The Central limit theorem.

Unit 2. Arbitrage, Return and Interest, The time value of money, Bonds, Shares and Indices, Models and Assumptions. **Deterministic Cash Flow:** Net Present Value, Internal Rate of Return, A Comparison of IRR and NPV, Bonds: Price and Yield, Clean and dirty price, Price –Yield Curves, Duration Term Structure of Interest Rates, Immunization, Convexity, Callable Bonds. **Random Cash Flow:** Random Returns, Portfolio Diagrams and Efficiency, Feasible Set, Markowitz Model, Capital Asset Pricing Model, Diversification, CAPAM as a Pricing Formula, Numerical Techniques

Unit 3. Forwards and Futures: Forwards and Futures, Forwards and Futures Price , Value of a futures Contract, Method of Replicating Portfolios, Hedging With Futures, Currency Futures, Stock index futures
Unit 4. Stock Price Model: Lognormal Model, Geometric Brownian Motion, Suitability of GBM for Stock Prices, Binomial tree Model**. Options:** Call Options, Put Options, Put- call Parity, Binomial Options Pricing Model, Pricing American Option, Factors Influencing Option Premiums, Options on Assets with Dividends, Dynamic Hedging, Risk- Neutral Valuation

Unit 5. The Black- Scholes Model: Risk- Neutral Valuation, The Black Scholes Formula, options on Futures, Options on Assets with Dividends, black- Scholes and BOPM, Implied Volatility, Dynamic Hedging, The Greeks, The Black Scholes PDE, Speculating With Options**.Value at Risk:** Definition of VaR, Linear Model, Quadratic Model, Monte Carlo Simulation, The Martingale.

Books Recommended:

1. Amber Habib: The Calculus of Finance, Universities Press, Hyderabad.

2. Steven Roman: Introduction to the Mathematics of Finance (Chapters 1-9), Springer International Edition.