INSTITUTE OF MATHEMATICS AND APPLICATIONS

COURSES OF STUDY

M.A./M.Sc. IN COMPUTATIONAL FINANCE

(w.e.f. 2019-20)

UTKAL UNIVERSITY

BHUBANESWAR-751004

M.A/M. Sc. IN COMPUTATIONAL FINANCE

REGULATIONS:

1. A candidate seeking admission to this programme should have passed Bachelor's degree with Mathematics/Statistics as a subject.

2. The duration of the programme is two years consisting of four semesters. Ordinarily the odd semester examinations shall be held in December and the even semester examinations shall be held in the month of April.

3. The programme shall have course credit system with internal valuation.

4. A student who has been admitted into this programme can register in a semester examination if he/she has obtained 75% (subject to a condonation of 15% in case of ailment) of attendance in the theory and a practical class of that semester and pays the required fees of the University.

5. Each semester examination shall consist of two parts: mid semester tests and end semester examination having weightage of 30% and 70% respectively for each course.

6. In order to pass a course a candidate has to secure at least 5 or above grade points in 10 points scale.

7. For passing a semester examination a candidate must pass in each course of that semester.

8. If a candidate passes all the semester examinations he/she shall be declared to have passed the M.A/M.Sc. in Computational Finance.

    i. In first class if he /she secures a total grade points average 6.5 or above.

    ii. In second class if he/she secures 5 or more but less that 6.5 of grade point average.

    Total grade point average ≡ sum of credit times grade point obtained divided by sum of credit. ($\Sigma\, c_i s_i \,/\, \Sigma\, c_i$) where c_i = course credit, s_i = grade point obtained.

9. If a candidate fails in any course (or courses) in any semester examination he /she has to appear the end semester examination for that course (or courses) only whenever the said semester examination is held. Passing the said semester examination is governed by regulation 7 and 8 above.

10. If a candidate in the 4^{th} semester examination fails to submit the Project Report/ Dissertation by the date fixed for the submission of Project Report/ Dissertation or if his/her Project Report or Dissertation is not found suitable by the examiners then

he/she shall be allowed to submit the Project Report/ Dissertation after three months of that year and he/she will be admitted into a special 4th semester examination of that year. If a candidate completes all requirements except two courses, he may be allowed to appear for a special examination within three months after the 4th semester examination.

11. A candidate who has passed a semester examination and wants to improve the results may appear only once for a maximum of three courses of that semester examination within a period of one year of passing the said semester examination. The higher of the grade points secured shall be taken into consideration for determining the result.

12. The candidate has to pass all the semester examinations within four academic years from the date of admission failing which his admission to the course will be cancelled.

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Throughout Credit 4-0-4 shall mean a four credit theory paper in which class room instruction of 4 hours per week shall be imparted. Similarly Credit 3-2-4 shall be a 4 credit course comprising of a theory component for 70 marks having 3 hours of class room instruction per week and a lab component for 30 marks with 2 hours of lab work per week.

SEMESTER-I

Paper Code	Course Title	Category	Marks	Credits
MCF 101	Computational Linear Algebra	Core	100	3-2-4
MCF 102	Theory of Probability	Core	100	4-0-4
MCF 103	Statistical Methods and Algorithm with Lab	Core	100	3-2-4
MCF 104	Micro Economic Theory	Core	100	4-0-4
MCF 105	Corporate Finance	Core	100	4-0-4
MCF 106	Programming (Python for financial modelling)	Core	100	4-0-4

SEMESTER-II

Paper Code	Course Title	Category	Marks	Credits
MCF 201	Accounting for Decision Making	Core	100	4-0-4
MCF 202	Data Analytics with Lab	Core	100	3-2-4
MCF 203	Financial Derivative	Core	100	4-0-4
MCF 204	Numerical Analysis with lab	Core	100	3-2-4
MCF 205	Numerical Optimization with lab	Core	100	3-2-4
MCF 206	Portfolio Theory & Investment Analysis	Core	100	4-0-4

SEMESTER-III

Paper Code	Course Title	Category	Marks	Credits
MCF 301	Stochastic Modelling and Stochastic calculus	Core	100	4-0-4
MCF 302	Fixed Income Security Analysis	Core	100	4-0-4
MCF 303	Financial Risk Management and measurement	Core	100	4-0-4
MCF 304	Machine Learning-I with lab	Core	100	3-2-4
MCF 305	Principles of Financial Engineering	Core	100	4-0-4
MCF 306	Computational Modelling of Financial Derivative with Lab	Core	100	3-2-4

SEMESTER-IV

Paper Code	Course Title	Category	Marks	Credits
MCF 401	Stochastic Process in Finance	Core	100	4-0-4
MCF 402	Monte Carlo Methods in Finance	Core	100	3-2-4
MCF 403	To be chosen from a group of elective papers A	Elective	100	4-0-4
MCF 404	To be chosen from a group of elective papers B	Elective	100	4-0-4
MDC 405	Dissertation with Viva-voce	Core	200	8-0-8

Elective Papers Group-A

A1. Actuarial Science.
A2. Quantitative Risk Management.
A3. Time Series Analysis and Forecasting.
A4. Credit Derivative Pricing Models.
A5. Dynamic Asset Management.

Elective Papers Group-B

B1. Soft Computing Methods in Finance.
B2. Object Oriented Software Engineering.
B3. Parallel Computing.
B4. Big Data Analytics.

DETAILED SYLLABUS

Semester–I

MCF 101: (Computational Linear Algebra) **Credit 3-2-4**

Unit-I:
Matrix Multiplication: Basic algorithm and notations, Structure and efficiency, Block matrices and algorithms, Fast matrix - vector products, Vectorization and locality, Parallel matrix multiplication.

Unit-II:
Matrix Analysis: Basic ideas from linear algebra, Vector norms, Matrix norms, The singular value decomposition, Subspace metrics, The sensitivity of square systems, Finite precision matrix computation. General Linear Systems: Triangular systems, The LU factorization, Round off error in Gaussian elimination, Pivoting, Improving and Estimating Accuracy, Parallel LU.

Unit-III:
Special Linear Systems: Diagonal Dominance and symmetry, Positive definite systems, Banded systems, Symmetric indefinite systems, Block tridiagonal systems, Vandermonde systems, Classical methods for Toeplitz systems, Circulant and discreet Poisson systems.
Orthogonalization and Least Square: Householder and Givens transformations, The QR factorization, The full-rank least square problem, Other orthogonal factorizations, The rank deficient least square problem, Square and undetermined systems.

Unit-IV:
Modified Least Square problems and Methods: Weighting and regularization, constrained least squares, Total least squares, Subspace computations with SVD, Updating matrix factorizations.
Un-symmetric Eigen Value Problems: properties and Decompositions, Pertubation theory, Power iterations, The Hessen berg and real Schur Forms, The practical QR algorithm, Invariant subspace computations, The generalized eigen value problem, Hamiltonian and product eigen value problems, Pseudo spectra.

Unit-V:
Symmetric Eigen Value Problems: Properties and decompositions, Power iterations. The symmetric QR algorithm, More methods for tridiagonal problems, Jacobi methods, Computing the SVD, Generalized eigen value problem with symmetry.
Functions of Matrices: Eigen value methods, Approximation methods, The matrix exponential, The sign, Square root and Log of a matrix.

Books for reference:

1. *Gene. H. Golub, Charles F. Van Loan, Matrix Computations, Fourth Edition, The Johns Hopkins University Press, Baltimore 2013.*
2. *J. W. Demmel, Applied Numerical Linear Algebra, SIAM, !997.*

3. *P. G. Ciarlet, Introduction to numerical linear algebra and optimization*
4. *William Ford, Numerical linear algebra with applications, AP*
5. *Richard Bronson, G.B. Costa, Matrix Methods: Applied Linear Algebra, Third Edition, AP.*

Any other text recommended by the instructor.

MCF 102: (Theory of Probability) **Credit: 4-0-4**

Unit-I:

Preliminaries on Probability: Classical definition of Probability and its demerits. Kolmogorov's Axiomatic approach to define probability. Conditional Probability and Bayes Theorem, Definition of Random variables, distribution functions and density functions in continuous and discrete cases, Independence of events and independence of random variables, expectation, variance moment generating functions of random variables Tchebychev's inequality.

Unit-II:

Advance Probability: Joint and conditional distributions (continuous and discrete cases). Distribution of sums of independent and identically distributed Random variables, conditional Expectation Martingales, Elementary properties of Martingales, Central limit theorem for i.i.d. random variables with finite variance.

Unit-III:

Limit Laws: Elements of mode of convergence and their interrelationship (without proof of examples.) The weak Law of Large numbers. The strong law of large numbers for i.i.d. Random variables. Borel-Cantelli lemma, Three series Theorem, Kolmogorov's Zero-one-Law Doob's martingale convergence theorem. Iterated logarithms.

Unit-IV:

Integration in Probability measure space, Definition and properties, Monotone Convergence Theorem, Indefinite integrals, Uniform convergence of integrals Fubini's Theorem. Absolute continuity of measure, Randon-Nikodym Theorem and its applications, Halley Bray Theorem.

Recommended Texts:

1. *K. L. Chung, Elementary Probability Theory.*
2. *William Feller, Introduction to Probability and its Applications, Vol. I*
3. *Sheldon Ross, A first course in Probability, Pearson Lowpriced edition*
4. *Y. S. Chow and H. Tiecher, Probability Theory, Springer verlag.*
5. *P. Billingsley, Probability and Measures, Wiley inter Science.*

Any other text recommended by the Instructor.

MCF 103: (Statistical Methods with Lab) **Credit: 3-2-4**

Unit-I:

Distributions Derived from the Normal Distribution : Introduction, X^2, *t,* and *F* distribution, The sample Mean and the Sample Variance, Problems, **Survey Sampling**:

Introduction, Population parameters, Sample random Sampling - The Expectation and variance of the Sample Mean, Estimation of the Population Variance, The Normal Approximation to the Sampling Distribution of $\bar{X}$, Estimation of a Ratio.

Unit-II:

Estimation of Parameters and Fitting of Probability Distributions : Introduction, fitting the Poisson Distribution to Emissions of Alpha Particles, Parameter Estimation, The Method of Moments, The Method of Maximum Likelihood, Maximum Likelihood Estimates of Multinomial Cell Probabilities, Large sample theory for maximum likelihood estimates, Confidence intervals from Maximum likelihood estimates, The Bayesian Approach to Parameter Estimation – Further Remarks on priors, Large Sample Normal Approximation to the Posterior, computational Aspects, Efficiency and Sufficiency.

Unit-III:

Testing Hypotheses and Assessing goodness of Fit : Introduction, The Neyman-Person Paradigm- Specification of the Significance Level and the concept of a *p*-value, The Null Hypothesis, Uniformly Most Powerful Tests, The Duality of Confidence Intervals and Hypothesis Tests, Generalized Likelihood Ratio Test, Likelihood Ratio tests for the Multinomial Distribution, Probability Plots, Tests for Normality. **Summarizing Data**: Comparison of Location Estimates, Estimating Variability of Location Estimates by the Bootstrap, Measures of Dispersion, Boxplots, Exploring Relationship with Scatterplots.

Unit-IV:

Comparing Two Samples: Introduction, comparing Two Independent Sample – Methods Based on the Normal Distribution, Power, A Nonparametric Method-the Mann Whitney Test, Bayesian Approach, Comparing Paired Samples, Methods Based on the Normal Distribution, A Nonparametric Method-The Signed Rank Test, An Example-Measuring Mercury Levels in Fish.

Unit-V:

The Analysis of Variance: Introduction, The One-Way Layout- Normal Theory: the F Test, The Problem of Multiple Comparisons, A Nonparametric Method-The Kruskal Wallis Test.

LAB WORK:

Implementation of some of the techniques (selected by the instructor) using 'R'

Recommended Texts:

1. *Mathematical Statistics and Data Analytics - John A Rice, CENGAGE Learning , Third Edition.*

Reference Books:

1. *Robert I. Kabacoff, R in Action –Data analysis and graphics with R, Dreamtech press.*
2. *Wasserman, All of Statistics.*

Any other text recommended by the Instructor.

MCF 104: (Micro Economic Theory) Credit: 4-0-4

Unit-I:
Demand and supply, elasticity of demand and supply, market price determination, price control-taxes and subsidies –case of open economy.

Unit-II:
Theory of consumer behaviour, consumer surplus, the theory of choice-utility theory under uncertainty (axioms of choice under uncertainty, developing utility functions, risk aversion), state preference theory (uncertainty and alternative future states, pure securities, No-arbitrage profit condition, economic determination of security prices)

Unit-III:
Theory of production (production function with one or two variable inputs, estimator of production function), cost theory (cost concepts, short and long run cost function), economic profits versus accounting profits, sunk costs, constrained output maximization and cost minimization, profit maximization.

Unit-IV:
Perfect competition, Derivation of short run and long run supply curves, monopoly, pricing strategies under monopoly, durable goods monopoly, Auctions, Revenue-maximizing monopolist. Theory of oligopoly-Kinked demand curve, Bertrand, cournot as stackelberg models, Nash equilibrium and subgame-perfect equilibrium. Budent differentiation.

Books Recommended:

1. *A. Sert- Microeconomics Theory and Applications, Oxford University Press*
2. *R. S. Pindyck and D. L. Rubinfeld, P. L. Meheta, Microeconomics, Pearson Education.*
3. *Micro economic Theory-A Mathematical Approach J. M. Herderson and R. E. Quardt, TMH*
4. *T. E. Copland, J. F. Weston, K. Sastri-Financial Theory and corporate policy-Pearson*.

Any other text recommended by the Instructor.

MCF-105: (Corporate Finance) Credit: 4-0-4

Unit-I:
Rational expectation and market efficiency, Basic valuation principles, valuation of debt and equity.

Unit-II:
Term structure, cost of capital, Mutual fund, portfolio evaluation.

Unit-III:
Equity research, capital structure, Dividend policy.

Unit-IV:
Cash flow analysis, capital budgeting under certainty, and capital budgeting under uncertainty.

Unit-V:
Balance of payments, Determination of Exchange rates, International capital budgeting and investments.

Books Recommended:

1. *Essentials of Investment, Zvi Bodie*
2. *Finance, Zvi Bodie and Robert C. Merton, Prentice Hall*
3. *Multinational Financial Management, Alan C. Shapiro, Wiley.*
4. *Corporate Finance, Ross Westerfield and Jaffe, Irwin / Mc GrawHill*

Any other text recommended by the Instructor.

MCF-106: (Python for Financial Modelling) Credit: 4-0-4

Unit-I:
Introduction to python, data types, variables, assignments, immutable variables, numerical types, arithmetic operators and expressions, comments in the program, understanding error messages, conditions, Boolean logic, logical operators, ranges, Control statements: if-else, loops (for, while).

Unit-II:
Lists, tuples, and dictionaries, basic list operators, replacing, inserting, removing an element, searching and sorting lists, dictionary literals, adding and removing keys, accessing and replacing values, traversing dictionaries. Design with functions, hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments, Program structure and design, Recursive functions.

Unit-III:
Strings and text files, manipulating files and directories, os and sys modules, text files, reading/writing text and numbers from/to a file, creating and reading a formatted file (csv or tab-separated), String manipulations, subscript operator, indexing, slicing a string, strings and number system, converting strings to numbers and vice versa, Numpy package, basic focus on array and matrices.

Unit-IV:
Object Oriented Programming, Classes and OOP, classes, objects, attributes and methods, defining classes, design with classes, data modeling, persistent storage of objects, Inheritance. Multi-threading, Synchronization and Multi-threading, Database

Connectivity, data visualization, feature importance and selection, dimensionality reduction, clustering, classification.

Unit-V:
Be familiar with the Jupyter Notebook environment for writing, testing, and debugging Python code, produce high quality 2D data visualizations using Matplotlib, Use Unix command line tools, understand basic shell command structure, and be familiar with Git and GitHub.

*Be familiar with principles and techniques for optimizing the performance of Python numeric applications. Understand parallel computing and how parallel applications can be written in Python. Experiment with developing GPU accelerated Python applications. Develop Python applications that utilize big data services such as Hadoop and Spark.

Books for Reference:

1. *Fundamentals of Python: First Programs Author: Kenneth Lambert Publisher: Course Technology, Cengage Learning, 2012 ISBN-13: 978-1-111-82270-5.*
2. *Think Python, Allen Downey, Green Tea Press.*
3. *Introduction to Parallel Computing, Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Pearson; 2 edition (January 26, 2003), ISBN 978-0201648652.*
4. *Big Data: Principles and best practices of scalable realtime data systems, 1st Edition, Nathan Marz, James Warren, ISBN 978-1617290343.*
5. *Data Science from Scratch: First Principles with Python, Joel Grus, O'Reilly Media (2015).*
6. *Learning Python, 5th Edition by Mark Lutz, O'Reilly Media, 2013. ISBN 978-1-4493-5573-9.*
7. *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython by Wes McKinny, O'Reilly Media, 2012. ISBN 978-1-4493-1979-3.*
8. *Clean Code: A Handbook of Agile Software Craftsmanship by Robert C. Martin, Prentice Hall, 2008. ISBN 000-0-1323-5088-2.*
9. *The Linux Command Line: A Complete Introduction by William E. Shotts, Jr., No Starch Press, 2012. ISBN 978-1-5932-7389-7.*
10. *Learning the Pandas Library: Python Tools for Data Mining, Analysis, and Visualization, Matt Harrison, Create Space Independent Publishing Platform (2016).*

Any other text recommended by the Instructor.

Semester–II

MCF-201: (Accounting for Decision Making) **Credit: 4-0-4**

Unit-I:
Conceptual Framework for Financial Accounting and Managerial Accounting, Asset Equity Relations - Accounting Records.

Unit-II:
Measurement of business income, Assets Accounting Depreciations, Sources of Funds.

Unit-III:
Financial Statements, Legal Framework of Company Accounts, Financial Statement Analysis.

Unit-IV:
Management Accounting, Cost Classification and Analysis, Statement of Cost, Job and Process Costing.

Unit-V:
Cost- Volume-Profit Analysis, Budgetary Control System Responsibility Accounting.

Books Recommended:

1. *Financial Accounting –A Managerial Prospective-R. Narayanaswamy, P.H.I.*
2. *Accounting Text and Cases –R. N. Anthomy, D.F. Hawkins, K. A. Merchant, Tata Mcgraw hill.*

Any other text recommended by the Instructor.

MCF-202: (Data Analytics with Lab.) **Credit: 3-2-4**

Unit-I:
Linear Methods for Regression and Classification: Overview of supervised learning, Linear regression models and least squares, Multiple regression, Subset selection, Ridge regression, least angle regression and Lasso, Linear Discriminant Analysis, Logistic regression.

Unit-II:
Model Assessment and Selection : Bias, Variance, and model complexity, Bias-variance trade off, Optimism of the training error rate, Estimate of In-sample prediction error, Effective number of parameters, Bayesian approach and BIC, Cross-validation, Boot strap methods, conditional or expected test error.

Unit-III:
Additive Models, Trees, and Boosting: Generalized additive models**,** Regression and classification trees, Boosting methods-exponential loss and Ada Boost, Numerical Optimization via gradient boosting, Examples (Spam data, California housing, Newzealand fish, Demographic data).

Unit-IV:
Support Vector Machines(SVM),and K-nearest Neighbor: Basis expansion and regularization, Kernel smoothing methods, SVM for classification, Reproducing Kernels, SVM for regression, K-nearest –Neighbour classifiers(Image Scene Classification)

Unit-V:
Unsupervised Learning and Random forests: Cluster analysis, Principal Components, Gaussian mixtures and selection. Random forests and analysis.

Lab work

Implementation of following methods using "R"

Simple and multiple linear regression, Logistic regression, Linear discriminant analysis, Ridge regression, Cross-validation and boot strap, Fitting classification and regression trees, K-nearest neighbours, Principal component analysis, K-means clustering.

Recommended Texts:

1. *Trevor Hastie, Robert Tibshirani, Jerome Friedman , The Elements of Statistical Learning-Data Mining, Inference, and Prediction, Second Edition, Springer Verlag, 2009.*
2. ***(For Lab Only)** -G. James, D. Witten, T. Hastie, R. Tibshirani - An introduction to statistical learning with applications in R, Springer, 2013.*

References:

1. *C. M. Bishop –Pattern Recognition and Machine Learning, Springer, 2006*
2. *L. Wasserman-All of statistics.*

Texts 1 and 2 and reference 2 are available online.

Any other text recommended by the Instructor.

MCF-203: (Financial Derivatives)	**Credit: 4-0-4**

Unit-I:
Introduction, Mechanics of futures markets, Hedging strategies using futures.

Unit-II:
Determination of forward and futures prices, Interest rate futures, swaps.

Unit-III:
Mechanics of options markets, Properties of stock options, Trading Strategies involving options.

Unit-IV:
Binomial model for pricing options, Hedging strategies using Greeks, Derivative markets in developing countries.

Unit-V:
Options on stock indices, currencies and futures, volatility smiles.

Recommended Text Books:

1. *Options, Futures and other Derivatives: - J. C. Hull, Prentice Hall of India, 7th Edition, [Chapter 1 through 18 excluding 4, 12, 13].*

References:

1. *An Introduction to Derivatives and Risk Management, D. M. Chance, Thomson - SPD-2004.*
2. *Derivatives - valuation and risk management, D. A. Dubofsky, T. W. Miller Oxford Univ. Press -2003.*
3. *Mathematics for Finance an introduction to Financial Engineering, M. Capinski, T. Zastanniak, Springer Verlog – 2003.*

Any other text recommended by the instructor.

MCF-204: (Numerical Analysis with Lab) Credit: 3-2-4

Unit-I:
Solution of Equations in One and Two Variables: Fixed point iteration method, Acceleration of convergence, Zeros of polynomials and Muller's method, fixed points for functions of several variables, Newton's method.

Unit-II:
Interpolation: Hermite interpolation, Cubic spline interpolation, parametric curves, Hermite, Bazier and B spline curves.

Unit-III:
Least Square Approximation: Discrete least square approximation, orthogonal polynomials, The Chebyshev polynomials and economization, rational approximation.

Unit-IV:
Numerical Integration: Elements, Composite integration, Romberg integration, The Gauss quadrature. APPROXIMATION of Multiple Integrals: Product rules, Rules exact for monomials, The Radon formula for integration of integrals in two dimensions.

Unit-V:
Numerical solutions of ordinary differential Equations: Picard's method of successive approximation, Euler's method, Modified Euler's method, The Taylor series method, Runge-Kutta methods, Multistep methods, Milne's method, Adam-Moulton method, Convergence criteria, Predictor-Corrector methods, Stability of numerical methods for solving IVP.

Implementation of Methods Using **C/ Matlab.**

Books for reference:

1. *R. L. Burden and J. D. Faires, Numerical Analysis, Books/ Cole, Thomson Learning, Seventh Edition.*
2. *P. J. Davis and Rabinowiwitz, Methods of Numerical Integration, A. P., Fourth Edition.*
3. *Curtis F. Gerald, Patrick O. Wheatley, Applied Numerical analysis, Sixth Edition, Pearson Education, Indian Reprint.*

Any other text recommended by the instructor.

MCF-205: (Numerical Optimization with Lab) **Credit: 3-2-4**

Unit-I:
One Dimensional Optimization: Function comparison methods, Polynomial interpolation, Iterative methods.

Unit-II:
Gradient Based Optimization Methods (I): Calculus on R^n , Method of steepest descend, Conjugate gradient method, The generalized reduced gradient method, Gradient projection method.

Unit-III:
Gradient Based Optimization Methods (II): Newton type methods (Newton's method, Marquardt's method), The Quasi-Newton method.

Unit-IV:
Linear Programming: Convex analysis, Simplex method, Two phase simplex method, Duality theory, Dual simplex method.

Unit-V:
Constrained Optimization Methods: Lagrange's multiplier, The Kuhn-Tucker conditions, Convex optimization, Penalty function techniques, The Method of multiplier, Linearly constrained problems-Cutting plane method. Primal dual method.

Books for reference:

1. *M. C. Joshi, K. M. Moudgalya, Optimization: Theory and Practice, Narosa Publishing House, 2004.*
2. *J. A. Snyman, Practical Mathematical Optimization, Springer Sciences, 2005.*
3. *Nocedal J, Wright S. J., Numerical Optimization, Springer.*
4. *Stephen Boyd, Lieven Vandenberghe, Convex Optimization, Cambridge University Press.*

Any other text recommended by the instructor.

MCF-206: (Portfolio Theory and Investment Analysis) **Credit: 4-0-4**

Unit-I:
Risk and risk aversion, Measuring risk and return of a single asset and portfolio. Mean-Variance Portfolio Theory: Diversification, Forming Portfolios with on assets, efficient frontier. The Markowitz model, the two-fund theorem, Inclusion of a risk free asset, the one-fund theorem.

Unit-II:
The capital Asset Pricing Model: Market equilibrium, Capital Market line, Pricing Model, Security Market Line, Investment implications use of CAPM for performance evaluation, CAPM as a Pricing formula.

Unit-III:
Single and Multifactor models, CAPM as a factor model, Arbitrage pricing theory (APT), APT and CAPM, Estimation of Parameters of mean-variance portfolio theory, CAPM and APT. Tilting away from equilibrium.

Unit-IV:
Market Efficiency and behavioral Finance, Empirical Evidence on Security returns, Evaluation of Portfolio Performance, Equity evaluation models, International diversification. The process of portfolio management, the theory of active portfolio management.

Recommended Text Books:

1. *D. G. Luenberger- Investment Science, Oxford University Press.*
2. *Z. Bodie- A Kare, A. J. Marcus, P. Mohanty-Investments, 6th Edition, TMH.*
3. *E. J. Elton. M. J Gruber-Modern Portfolio Theory and Investment Analysis- John Wiley, Student Edition.*
4. *T. E. Copeland, J. Fred Weston, K. Shastri, Financial Theory and Corporate Policy-Addison Wesley.*

Any other text recommended by the Instructor.

Semester–III

MCF-301: (Stochastic Modelling & Stochastic Calculus) **Credit: 4-0-4**

Unit-I:
Random Walk and Ruin Problems: General Orientation, The classical ruin problem, Expected duration of a game connection with diffusion process.

Unit-II:
Markov chain: Definition, Transition probability matrices of a Markov chain, some Markov Chain Models classification of states and basic limit Theorems of Markov Chain.

Unit-III:
Poisson Process: The Poisson distribution and Poisson Process. The law of rare events, Distributions associated with Poisson Process.

Unit-IV:
Continuous Time Markov Chain: Birth Process, Death Process, Birth and Death process. The limit behavior of Birth and Death process. Birth and Death processes with absorbing states. Finite state continuous time Markov chain, Kolmogorov's Forward and Backward Equations.

Unit-V:
Queuing system: Queuing process, Poisson arrivals exponential service times, General Service time distribution variations and extensions. **Renewal phenomena:** Definition of Renewal process and related concepts some examples of Renewal process, Poisson process viewed as a Renewal process. The asymptotic behavior of Renewal process.

Books for Reference:

1. *Introduction to Stochastic Modeling H. M. Taylor and S. Karlin Academic Press.*
2. *A first course on Stochastic Process Sheldon Ross, Low Priced Edition.*
3. *Introduction to Probability and its Applications, W. Feller, Vol I, Wielley.*

Any other text recommended by the Instructor.

MCF-302: (Fixed Income Security Analysis) Credit: 4-0-4

Unit-I:
Bond characteristics, Bond Pricing, Bond yields, Bond prices over time.

Unit-II:
Term structure of interest rates under certainty, interest rate uncertainty and forward rate, forward rate agreements, theories term structure, measures the term structure.

Unit-III:
Interest rate sensitivity, duration, conversity, passive and active bond management.

Unit-IV:
Interest rate derivatives (Bond options, interest rate caps and floors, hedging interest, rate derivatives, convexity, timing, and quanto adjustments).
Interest rate derivative models-Modes of short rate, HJM and LMM.

Unit-V:
Mortgage- Backed securities, and their analysis.

Books Recommended:

1. *Z. Bodie, A. Kane, A. J. Marchs, P. Mohanty-Investments, 6th Editions, TMH, 2006.*
2. *J. C. Hull- Options, Futures, and other derivatives- 7th Edition- Peason Edition-2009.*
3. *Y.D. Lyuu- financial Engineering and Computation. Cambridge University Press -2002.*

Any other text recommended by the Instructor.

MCF-303: (Financial Risk Management and Measurement) Credit: 4-0-4

Unit-I:
Regulation of financial Institutions, Need of regulation, credit risk and the Basle accord, regulatory frame work in India, UK & US.

Unit-II:
Market Risk: key issues, Value at Risk (VaR), Risk grades, capital adequacy and market risk, yield validity and return validity, VaR for exchange rate risk.

Unit-III:
VaR: Mapping cash Flows-VaR for equity portfolio, coupon paying bonds, FAR, FRN and Suraps, FX forwards and options, VaR and the single index model. Statistical issues of VaR – parameter estimation, nonparametric measures of portfolio val, validation of forecasts, Monte Carlo simulation, VaR and stress testing.

Unit-IV:
Credit Risk: Credit metrics approach, measuring joint credit migration, types of exposure, incentives and RAROC, Hedging and credit derivatives, regulation, credit rating changes, credit risk of a swap, credit risk models (structural approach, reduced from approach and empirical approach.

Unit-V:
Firm value and share price-based models pricing equations, solution to pricing equations, Practiacal implementation, Unobservable firms values and credit grades, advantage and disadvantages.

Books Recommended:

1. *P. J. Schonbucher - Credit derivatives pricing Models-models, pricing and Implementation - John Wiley 2003.*
2. *Paul Wilmott an Quantitative finance, P. Wilmott, John Wiley 2006.*
3. *Cutliberatson and Nitzsoche- Financial Engineering, Derivatives and Risk Management, John Wiley.*
4. *J. C. Hull: Option, Future and other derivatives, Pearson Education.*
5. *G. Chako, A. Sjoman, H. Motolashi, V. Dessaiv- Credit Derivatives and primer on credit risk, modeling and instruments-Wtarton school publication.*

Any other text recommended by the Instructor.

MCF-304: (Machine Learning with Lab-I) **Credit: 3-2-4**

Unit-I:
Introduction, generative models for discrete data (Bayesian concept learning, Naïve Bayes classifier), Gaussian discriminant analysis, Inference in jointly Gaussian distributions, Bayesian statistics, Bayesian linear and logistic regression.

Unit-II:
General linear models and exponential family, Mixture models and EM algorithm, Sparse linear models, Review of SVM, Multiclass SVM, kernels for building generative models, Multiple kernels, kernels for strings, trees, and graphs, Gaussian Processes.

Unit-III:
Graphical models- DIRECTED Graphical models (Bayesian networks), Markov and Hidden Markov Models, Markov Random fields, Conditional Random fields.

Unit-IV:
Neural Networks-Perceptron, MLP and back propagation , Methods of acceleration of convergence of BPA.

Unit-V:
Dimensionality reduction (Factor analysis, Kernel PCA, Independent Component analysis, ISOMAP, LLE), feature Selection, Spectral clustering.

Books for Reference:

1. *Kevin P. Murphy , Machine learning – a Probabilistic Perspective, MIT Press,2012.*
2. *Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.*
3. *Simon Haykin, Neural Network – a comprehensive foundation, Pearson Education-1994.*
4. *Tom Mitchel, Machine Learning – McGraw Hill Science, 1997.*

Any other text book recommended by the Instructor.

MCF-305: (Principle of Financial Engineering) **Credit: 4-0-4**

Unit-I:
Cast flow engineering and forwards contracts, engineering simple interest derivatives.

Unit-II:
Introduction to swap engineering, market strategy in financial engineering.

Unit-III:
Dynamic replication methods and synthetics, option engineering applications.

Unit-IV:
Tools for volatility engineering, volatility swaps and volatility trading, smile effects in engineering.

Unit-V:
Credit derivatives in financial engineering, engineering of equity instruments.

Books Recommended:

1. *Text: S. N. Neftci- Principles of financial engineering, Elsevier (2005).*

Any other text recommended by the Instructor.

MCF-306: (Computational Modelling of Financial Derivative and Lab.)	**Credit: 3-2-4**

Unit-I:
Construction of finite difference schemes for Laplace and heat equation. Solution of Tri diagonal system of linear equations, iterative methods (Jacobi Successive over relaxation) Introduction to stability and convergence of finite difference method, crank Nicholson and ADI methods.

Unit-II:
The Black Scholes (B.S.) Model: Derivation of B.S. equation using no arbitrage argument, options dividend paying equities, Derivation of B.S. formula for calls, Puts and simple digitals, obtaining formulae for Greeks and their numerical computation, Finite Difference method for solution of B.S. equation.

Unit-III:
Simple generalization of B. S. model (Dividend payments, time dependent parameters), Early exercise and American options (Perpetual American call and put, general payoff, local solutions), American option problem as free boundary problems, Finite difference method for American options, Monte-Carlo simulation.

Unit-IV:
Exotic and path dependent options: General introduction, Barrier options, Strongly path dependent options, Asian options, Look back options, Multi Asset options, Numerical implementation.

Unit-V:
Extensions of B-S. Model: Defects in B-S Models, Discrete hedging, Transaction costs, stochastic volatility. Jump diffusion, Crash modelling.

Books Recommended:

Text: Paul Wilmott: Paul Wilmott on quantitative finance John Wiley – 2006

Reference Books:

1. *Quantitative Methods in Derivative pricing - an introduction to computational Finance, D. A. Tavella , John Wiley – 2002.*
2. *The concepts and practice of mathematical finance, M. S. Joshi, Cambridge Univ. Press - 2003.*
3. *Derivative Securities and Difference Methods, Y. Zhu, X. Wu, F. Chern, Springer Verlag- 2004.*
4. *Numerical Solution of PDE, G.D. Smith, CUP.*

Any other text recommended by the Instructor.

Semester–IV

MCF-401: (Stochastic Processes in Finance) **Credit: 4-0-4**

Unit-I:
Brownian motion: Brownian Motion as the limit of scaled Random walk. Quadratic variation of Brownian Motion and it's Markov property. First passage time distribution and Reflection principle of Brownian Motion, Geometric Brownian Motion and it's Quadratic variation and it's importance in Financial modeling.

Unit-II:
Stochastic Calculus: Ito integral and its quadratic valuation, Ito formula, Black-Scholes, Metron Equation, Stochastic differential equation driven by Brownian Motion and it's solution (Proof not required), Samuelson Model. O.U. Process, Mean reverting process and square root process and their solution process.

Unit-III:
Introduction to Jump Processes: Compound Poisson Process, Jump process and their integrals. Stochastic Calculus for Jump Process and Quadratic Valuation.

Unit-IV:
Risk Neutral asset price modeling driven by Brownian Motion.

Unit-V:
Interest Models: CIR Model, HJM Model, Hull White Model and Vasicek Model, Solution Process of these models describes by S.D. Equations, Calculation of Expectation and Variance of the solution processes.

Books recommended

1. *Stochastic Calculus for Finance I and II by S. E. Shreve, Springer Verlag.*

2. *Stochastic Process by J. Medhi (Wiley Eastern).*
3. *A First Course on Stochastic Process by S. Karlin & J. Tayler (Academic Press).*

Any other text recommended by the Instructor.

MCF-402: (Monte Carlo Methods in Finance) **Credit: 3-2-4**

Unit-I:
Principles of Monte Carlo, Generating random numbers and random variables: Random number generation, general sampling methods, normal random variables.

Unit-II:
Generating Sample paths: Brownian and Geometric Brownian motions; Gaussian start rate methods; Square root diffusions; process with jumps; Forward rate models; simple rates and continuous rates.

Unit-III:
Variance Reduction Techniques.

Unit-IV:
Discretization methods.

Unit-V:
Pricing American Options.

Books recommended:

1. *Monte Carlo Methods in Financial Engineering, By Paul Glasserman, Springer: Applications of Mathematics. 53, 2004.*
2. *Introduction to databases, including simple relational databases, data warehouses and introduction to online analytical data processing.*
3. *Association rules and prediction, data attributes, applications to electronic commerce.*

Books for reference:

1. *Berson, A. and Smith, S.J. (1997). Data Warehousing, Data Mining, and OLAP. (McGraw-Hill).*
2. *Breiman, L., Friedman, J.H., Olshen, R. A. and Stone, C. J. (1984). Classification and Regression Trees. (Wadsworth and Brooks/Cole).*
3. *Han,J. and Kamber, M. (2000). Data Mining; Concepts and Techniques. (Morgan Kaufmann).*
4. *Mitchell, T.M. (1997). Machine Learning. (McGraw-Hill).*
5. *Ripley, B.D. (1996). Pattern Recognition and Neural Networks. (Cambridge University Press).*
6. *S. Koutroumbas, K. Theodoridis, Pattern Recognition, 4th Edition, AP, 2009.*
7. *C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.*

8. *S. Haykin, Neural Networks- A Comprehensive Foundation, Pearso Education, 2001.*
9. *E. Alpaydin, Introduction to Machine Learning, MIT, 2004 (PHI-2006).*

Any other text recommended by the Instructor.

Elective Papers Group-A

A1.

MCF-403: (Actuarial Science) **Credit: 4-0-4**

Unit-I:
Principles of premium calculation: Properties of premium principles, Examples of premium principles.

Unit-II:
The collective risk model: Reinsurance, The effect of reinsurance, Recursive calculation of aggregate claims distributions, Extensions of the Panjer recursion formula, The application of recursion formulae, Approximate calculation of aggregate claims distributions.

Unit-III:
The individual risk model: De Pril's recursion formula, Kornya's method, Compound Poisson approximation, Numerical illustration.

Unit-IV:
Introduction to ruin theory: A discrete time risk model, The probability of ultimate ruin, The probability of ruin in finite time, Lundberg's inequality.

Unit-V:
Classical ruin theory: The classical risk process, Poisson and compound Poisson process, Definitions of ruin probability, The adjustment coefficient, Lundberg's inequality, Survival probability, Recursive calculation, Approximate calculation of ruin probabilities.

Books Recommended:

1. *Actuarial Models (The Mathematics of Insurance) by Vladimir I. Rotar, Chapman and Hall (CRC).*
2. *Fundamentals of Actuarial Mathematics by S. David Promislow , Wiley.*
3. *Risk Analysis in Finance and Insurance by Alexandar Melnikov, Chapman and Hall (CRC).*
4. *International Series on Actuarial Science (Insurance Risk and Ruin) by David C. M. Dickson, Cambridge.*

Any other text recommended by the Instructor.

A2.

MCF-403: (Quantitative Risk Management-II)	**Credit: 4-0-4**

Unit-I:
Basic concepts in risk management, Multivariate Models (Basic of multivariate modeling, Normal mixture distributions, and Dimension reduction techniques), volatility models and risk estimation, fundamentals of multivariable time series, multivariate GRACH Process.

Unit-II:
Copulas and dependence (Copulas, Dependence measures, Normal mixture copulas, flitting copulas to data), Aggregate risk (coherent measures of risk, bounds for aggregate risk capital allocation).

Unit-III:
Extreme value theory (Maxima, Tails of specific, Models, Point process models, Multivariate maxima), Operational risk and Insurance analysis (Operational risk in perspective, Elements of insurance analytics).

Unit-IV:
Credit risk management, (credit risk modeling threat hold, mixture Monte Carlo Models, Dynamic credit risk models (mathematical tools, financial and Actuarial pricing of credit risk, pricing with doubly stochastic default time, conditionally independent defaults).

Book Recommended:

A. J. Mc Neil, R. Frey, and P. Embrechts- Quantitative Risk Management –Concept, techniques, Tools. Princeton University Press, 2005.

Any other text recommended by the Instructor.

A3.

MCF-403: (Time Series Analysis and Forecasting)	**Credit: 4-0-4**

Unit-I:
Linear Time Series Analysis and its Applications: Stationary, Correlation and Autocorrelation Function. White Noise and Linear Time Series, Simple Autoregressive Models, Simple Autoregressive Models.

Unit-II:
Conditional Hoteroscedastic Models: Characteristic of Volatility, Structure of a Model, Model Building, The Arch MODEL, The GARCH Model, The Integrated GARCH Model, The GARCH-M Model, The Exponential GARCH Model, The threshold GARCH Model, The

CHARAM Model, Random Coefficient Autoregressive Models, The stochastic Volatility Model, Application.

Unit-III:
Nonlinear Models and Their Applications: Nonlinear Models, Nonlinearity Tests, Modelling, Forecasting, Applications.

Unit-IV:
High- Frequency Data Analysis and Market Microstructure: Nonsynchronous Trading, Bid-Ask Spread, Empirical Characteristics of Transactions Data, Models for price changes, Duration Models, Nonlinear Duration Models, Bivariate Models for Price Change and Duration.

Unit-V:
Principle Component Analysis and Factor Models: A Factor Model, Macro econometric Factor Models, Fundamental Factor Models, Principal Component Analysis, Statistical Factor Analysis, Asymptotic Principal Component Analysis.

Recommended Book:

Analysis of Financial Time Series, by Ruey S. Tsay, Wiley Series in Probability and Statistics.

A4.

MCF-403: (Credit Derivative Pricing Models)	**Credit: 3-2-4**

Unit-I:
Credit Derivatives - Overview, hedge based Pricing, exotic credit derivatives, Default correlation products and CDOs, credit linked notes.

Unit-II:
Credit spreads and implied default probabilities, Recovery modelling, Building blocks for credit derivatives pricing, pricing with the building blocks, constructing, and calibrating credit spread curves implementation issues.

Unit-III:
Advanced credit spread models - Poisson processes, Intromogeneous Poisson Processes, stochastic credit spread, Recovery Modelling.

Unit-IV:
Implementation of Intensity - based models - Tractable models of the spot intensity, computation of credit derivatives in the CIR model, Tree models, and Partial differential equation based implementation, Term and structure of credit spreads, Monte Carlo simulation.

Unit-V:
Firm value and share price - based models pricing equations, solution to pricing equations, Practical implementation, Unobservable firms values and credit grades, advantages and disadvantages.

Books Recommended Texts:

1. *P. J. Schonbucher - Credit derivatives Pricing Models- models, Pricing and Implementation- John Wiley 2003.*
2. *G. Chacko, A. Sjoman, H. Motohasli, V. Dessain- Credit Derivatives-Wharton School Publishing, 2007.*

References:

1. *Paul Wilmott an Quantitative finance, P. Wilmott , John Wiley 2006.*
2. *Quantitative Risk Management - Concepts, Techniques, Tools, A. J. Meiveils R. Frey, P. Embrelts, Princton Univ. Press – 2005.*
3. *Credit Risk Pricing Models - Theory and Practice, B. Schmid - Springer 2004.*

Any other text recommended by the Instructor.

A5.

MCF-403: (Dynamic Asset Management)	**Credit: 4-0-4**

Unit-I:
Dynamic Asset Pricing – Multi-period mode, Dynamic Proffering approach, Infinite horizon, setting, state prices and martingale measures, portfolio and consumption choice equilibrium.

Unit-II:
Managing individual and institutional Investor portfolios, Capital Market expectations.

Unit-III:
Asset allocation, fixed income portfolio management, equity portfolio management, Alternative Investments portfolio management.

Unit-IV:
Execution of Portfolio Decisions, Monitoring and rebalancing, Evaluating Portfolio performance, Global Investment performance standards.

Books Recommended:

1. *Darrell Deffie-Dynamic Asset Pricing Theory-Princeton University Press, 2001.*
2. *J. L. Maginn, D.L. Tuttle, J.E. Pinto, D. W. Mcleavey- Managing Investment Portfolios-A Dynamic Process, CFA Institute, 2007.*

Any other text recommended by the Instructor.

Elective Papers Group-B

B1.

MCF-404: (Soft Computing Methods in Finance) **Credit: 4-0-4**

Unit-I:
Neural Network topologies, activation functions and learning methods, perception training algorithm, The multilayer perception (MLP), Back Propagation learning algorithm, financial applications.

Unit-II:
Self-organization maps, Support vector machine for classification and regression, application to finance.

Unit-III:
Genetic algorithm (GA), MLP-GA, SVM-GA hybrid methods and financial applications.

Unit-IV:
Elements of fuzzy set theory, Fuzzy logic and approximate reasoning, Neuro-fuzzy and Fuzzy –GA hybrid methods, Rough set theory financial applications.

Unit-V:
The particle swarm optimization algorithm, Discrete PSO, MLP-Swarm Hybrids, Ant colony optimization methods, financial applications.

Recommended Text Books:

1. *S. Haykin-Neural Networks: A Comprehensive Foundation, Pearson Education, 2001.*
2. *Brabazan, M.O' Neill-Biologically Inspired Algorithm for Financial Modelling-Springer-2006.*
3. *R. A. Aliev, B. Fazlollahi, R.R. Aliev-Soft Computing and its Applications in Bussines and Economic, Springer Verlag, 2004.*
4. *Relevant research papers an use of soft computing methods for financial problems.*

Any other text recommended by the Instructor.

B2.

MCF-404: (Object Oriented Software Engineering) **Credit: 4-0-4**

Unit-I:
Introduction, Software life cycle modules, Requirements Analysis and specification, software design, Function oriented software design.

Unit-II:
Coding and Testing, Software reliability and quality management, Computer Aided Software Engineering, Software maintenance.

Unit-III:
Introduction to object oriented Analysis and Design, Iterative Development and the unified process, case study-The next-Gen POS, Inception, Understanding Requirements, Use case Model, Identifying other requirements.

Unit-IV:
Elaboration, Use case Model, Drawing system sequence diagrams, Visualizing concepts, Adding Associations, adding attributes, adding details with operation contracts, interaction diagram notation.

Unit-V:
PATTERNS, GRASP, Creating design class diagrams, GOF Design pattern Planning and project queues comments on iterative development and the UP, Rational Unified Process.

Recommended Text Books:

1. *Crag Larman: Applying UML and Patterns-An introduction OOAP & D and the Unified process, Pearson Education Asia.*
2. *Rajib Mail: Fundamentals of Software Engineering, PHI.*

Any other text recommended by the Instructor.

B3.

MCF-404: (Parallel Computing)	**Credit: 4-0-4**

Unit-I:
Introduction to Parallel Computing –Motivation and Scope. Parallel computing platforms, physical organization of parallel computing platforms. Communication costs in parallel machines.

Unit-II:
Principles of Parallel Algorithm Design- Decomposing, Tasks and interactions, mapping techniques for load balancing, methods of containing interaction overheads, parallel algorithm model), Basic communication operations.

Unit-III:
Analytical modeling of parallel programs-(Sources of overhead, performance metrics, scalability, asymptotic analysis of parallel programs). Sorting on parallel computers (Sorting Networks, Quick sort).

Unit-IV:
Dense Matrix Algorithms- Matrix-Vector multiplication, Matrix-Matrix multiplication, solving system of linear equation-direct and interactive methods.

Recommended Text Book:

A. Grma, A. Gupta, G. Karypis, V. Kumar. Introduction to Parallel Computing, Pearson Education, Indian reprint, 2005.

Any other text recommended by the Instructor.

B4.

MCF-404: (Big Data Analytics With Lab.)	**Credit: 3-2-4**

Unit-I:
Evolution of data management , Introduction to Big data , Introduction to Databases, Relational Model, and SQL, Data exploration and reproducibility, Data quality.

Unit-II:
Introduction to map reduce , Map reduce algorithm patterns and relations, Parallel data bases vs Map Reduce, Storage solutions, Introductions to Spark , Hadoop, Hive, Pig-Latin.

Unit-III:

Big Data Algorithms/Mining techniques- 1 (Finding similar items and spark, exploring spatio-temporal data, mining association rules, EM algorithm for text processing).

Unit-IV:
Big Data Algorithms/Mining techniques-2(Page Rank and K-means in Pig and Spark, Efficient regularized SGD, Hash kernels for logistic regression, Matrix factorization, Matrix factorization with SGD, DGMs for naive Bayes, Fast sampling for LDA.

Unit-V:
Large scale graph processing –Pregel, Large-Scale visualisation.

Books for Reference:

Mining Massive Datasets, Anand Rajaraman, J. Leskovec and Jeff Ullman.
Data-Intensive Text Processing with MapReduce, J. Lin and C. Dyer.

Any other text recommended by the Instructor.

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