PG DIPLOMA: Risk Management and Financial Engineering

School of Education Technology

Jadavpur University

Curriculum

Semester I

Theory	Subject	Contact Hours Per Week		Marks (Theory)	Marks (Sessional)	Credit (1cr = 16 to 20 hrs)
		T	S			
1.	Advanced Mathematics	3		100		3
2.	Statistics and Probability	3		100		3
3.	Principles of Risk Management	3		100		3
4.	Foundation of Finance	3		100		3
5.	Applied Numerical Methods	3		100		3
Sessional						
1.	Computational Methods Lab		4		100	3

Semester II

Theory	Subject	Contact hours Per Week		Marks (Theory)	Marks (Sessional)	Credit (1cr = 16 to 20 hrs)
		T	S			
1.	Advanced Mathematics for Finance	3		100		3
2.	Financial Optimization and Risk Decisions	3		100		3
3.	Corporate Governance, Regulations and Operational Risk	3		100		3
Sessional						
1.	Project : Thesis Viva Voce		20		 300 100	8

Mode of Dissemination

The course will be delivered initially 60% in face-to-face mode and 40% in Multimodal Digital Distance Education format. Gradually this proportion will be changed to face-to-face 20% and remaining 80% in Multimodal Digital Distance Education format.

Theory	Subject	Dissemination in Face to Face (60%)	Dissemination in MMDDE (40%)	Total
1.	Advanced Mathematics	36 hrs	24 hrs	60 hrs
2.	Statistics and Probability	36 hrs	24 hrs	60 hrs
3.	Principles of Risk Management	36 hrs	24 hrs	60 hrs
4.	Foundation of Finance	36 hrs	24 hrs	60 hrs
5.	Applied Numerical Methods	36 hrs	24 hrs	60 hrs
6.	Advanced Mathematics for Finance	36 hrs	24 hrs	60 hrs
7.	Financial Optimization and Risk Decisions	36 hrs	24 hrs	60 hrs
8.	Corporate Governance, Regulations and Operational Risk	36 hrs	24 hrs	60 hrs
Sessional				
1.	Computational Methods Lab	48 hrs		48 hrs
2.	Project	160 hrs		160 hrs
	Total	496 hrs	192 hrs	688 hrs

Syllabii

Advanced Mathematics

1. **Review of Prerequisites**
   a. **Set Theory (6 hrs)**
      - Sets, Subsets, Set Operations, Disjoint Sets, Products of Sets

   b. **Linear Algebra**
      - Vectors and vector spaces,
      - Matrices, Linear transforms,
      - Systems of linear Equations.
      - Eigen values and Eigen vectors.
      - Real Symmetric matrices,
      - Cholesky factorization.

   c. **Functions and Sequences**
      - Injections, Surjections, Bijections,
      - Sequences,
      - Countability,
      - functions on the Real Line
      - Limits and Convergence of Sequences,
        - Series-Ratio Test,
        - Root Test,
        - Power Series,
        - Absolute Convergence,

2. **Metric Spaces**
   - Euclidean Spaces,
   - Inner product and Norm,
   - Euclidean distance,
   - Usage of metric spaces,
   - Distance between points and sets,
   - Open and closed sets- interior,
   - Closure and boundary,
   - Open subsets of the real line.
   - Convergence and closed sets.
   - Cauchy sequence.
   - Completeness of metric spaces,
   - Compactness and compact subspaces.

3. **Functions on Metric Spaces**
   - Continuous Mappings,
   - Continuity and Open Sets,
   - Continuity and Convergence,
   - Real-Valued Functions.,
   - Rn-Valued Functions,
   - Compactness and Uniform Continuity,
   - Sequences of Functions,
   - Cauchy Criterion,
   - Continuity of Limit Functions ,
   - Lipschitz Continuous Functions,
   - Functionals.

4. **Convex Analysis**
   - Convex Sets and Convex Functions,
   - Projection,
   - Supporting Hyper-plane Theorem.

5. Elementary Measure Theory

- Algebras, Monotone Class Theorem,
- Measurable Spaces and Functions,
- Measurable Functions,
- Borel Functions,
- Compositions of Functions,
- Numerical Functions,
- Positive and Negative Parts of a Function,
- Indicators and Simple Functions,
- Approximations by Simple Functions,
- Limits of Sequences of Functions,
- Monotone Classes of Functions,
- Arithmetic of Measures,
- Finite, and sigma--finite,
- Specification of Measures,
- Image of Measure,
- Almost Everywhere.
- Integration: Definition of the Integral.,
- Integral over a Set ,
- Integrability,
- Elementary Properties.
- Monotone Convergence Theorem,
- Linearity of Integration.

Statistics and Probability

1. Introduction to Statistics

- Basic Concepts of Statistics
  - Definition, Classification, Characteristics of statistics
  - Population and sample
- Descriptive Statistics
  - Central tendency, Mean, Median, Mode
  - Measures of location, Quartiles, Percentiles, Deciles
  - Measures of variability or dispersion
    - Range , Special range, Quartile deviation
    - Mean deviation
    - Variance and standard deviation
    - Relative measures of dispersion
  - Shape characteristics of a distribution, Skewness, Kurtosis
  - Data Exploration with Graphical Means
    - Bar diagram, Pie chart, Histogram, Scatter diagram
    - Line diagram

2. Probability Concepts

- Random Phenomenon and Related Concepts
- Interpretations and Laws of Probability
  - Interpretations of probability
  - Laws of probability
- Probability Theorems
  - Total probability theorem
  - Bayes' theorem
- Probability Distribution Functions
  - Univariate and Bivariate distribution function
- Marginal, Conditional and Derived Distributions
  - Marginal distribution
  - Conditional distribution
  - Derived distribution

3. Properties of Random Variables
- Introduction to Estimation Theory
- Properties of Parameter Estimator
- Methods of Parameter Estimation
    - Method of moments
    - Method of maximum likelihood

4. Probability Distributions and Their Application
- Discrete Distributions
    - Binomial, Poisson, Hypergeometric, Exponentiel, Gamma distribution
    - Multinomial distribution
- Continuous Distributions
    - Normal distribution
    - Uniform/Rectangular Exponentia, Erlangian, Weibull, Cauchy distribution
    - Beta distribution
    - Lognormal distribution
    - Pareto distribution
- Synthesized Distributions, Mixed Gaussian

5. Correlation and Regression
- Correlation and Partial Correlation
    - Correlation
    - Partial correlation
- Simple Linear Regression
    - Partitioning the sum of squares in simple regression
    - Coefficient of determination
    - Testing a hypothesis and making an inference concerning
    - Confidence interval for a mean value of Y given a value
    - Prediction interval for a new individual value given a value
- Multiple Linear Regression
- Regression Diagnostics
- Issues of Multicollinearity

6. Concepts of Stochastic Processes
- MARKOV Process
- Brownian Motion

7. Time Series Analysis
- Introduction to Time Series Modelling
- Steps in Time Series Modelling
- Autoregressive Processes and ARMA Model
    - Formulation, identification, estimation and diagnostic checking
    - Forecasting
    - Data generation
- GARCH Model
    - Introduction
    - ARCH(1) processes
    - The AR(1) / ARCH(1) Model
    - ARCH(q) Models
    - GARCH(p,q) Models
    - GARCH processes have heavy tails
    - Comparison of ARMA and GARCH processes

Principles of Risk Management

1. Risk and Its Classification
- The Nature and Perception of Risk
- Risk and Return
- Classification of Risk, Financial, Operational, Engineering
- Risk and Culture

2. Basic Concepts of Financial Risk
- Nature of Financial Risk
- Risk and Investment
- Risk, Probability and volatility

3. Quantification and measures of Financial Risk
- Measurement of Financial Risk
- Risk of loss, 'value at risk' (VaR) and expected shortfall
- Generalization Risk measures and Utility theory
- Diversification and utility – satisfaction thresholds
- Temporal aspects: draw down and cumulated loss

4. Investment Portfolio and Financial Risk
- Concept of Portfolio
- Elementary Portfolio Theory
    - Market Risk and Specific Risk
    - Risk and diversification
    - Strategies of Portfolio selection
    - The Risk-Return Frontier
- Selection with two risky securities. Case Study (Excel example: portfolio selection)
- Portfolio selection with a riskless security.
- Portfolio selection with multiple risky securities. Excel example: portfolio optimizer

5. Risk Management in Engineering Context
- Risk Identification Techniques
    - HAZOP
    - Management by Walking About
    - Brainstorming
- Risk Assessment Techniques
    - Qualitative Techniques
    - Quantitative Techniques
- Risk Management Strategies in Engineering Context
    - Physical Measures
    - Insurance

6. Risk Management in Corporations
- Statutory Requirement
- Risk Management Team
- Risk Monitoring Process

Foundation of Finance

(Objective of this course will be to introduce basic concepts of finance to students with no background of finance. The treatment will be largely qualitative. Mathematical aspects will be treated in companion courses on Mathematical Finance in the Second semester)

1. Introduction

- Finance and Society
- Evolution of Financial Theory
- Landmarks in Financial Theories

2. Corporate Finance

- Understanding Financial Statements and Cash Flows
- Evaluating a Firm's Financial Performance
- Capital-Budgeting Techniques and Practice
    - Cash Flows and Other Topics in Capital Budgeting
    - Cost of Capital
    - Determining the Financing Mix
- Dividend Policy and Internal Financing
- Short-term financial planning, Working-Capital management
- International Business Finance

3. Overview of Financial Markets and Products

- Financial instruments and why we need them.
- The Financial Markets and Interest Rates, Time value of money. FV, PV, annuities, perpetuities
- Simple Fixed income instrument= bond
- Financial markets. How securities are traded.
- Return measures
- Risk and expected return.
- Fixed income securities: Prices and yields. Yield curve and forward rates

4. Asset Pricing

- Bond Valuation
- Stock Valuation
- Equilibrium asset pricing and arbitrage
- Overview of Capital Asset Pricing Models

5. Options and Derivatives

- Call and Put options
- European and American Options
- No-arbitrage bounds on options and the put-call parity
- The Greeks
- Modern derivative Pricing Theory and Black Scholes.
- Binomial Option Pricing

Applied Numerical Methods

1. Scripting Languages for Numerical Modelling (Spreadsheet, Mat lab and Scilab)
2. Numerical Methods for solving systems of linear equations
3. Generation random Numbers
4. Solution Linear Programming Problem
5. Linear Regression and fitting of functions
6. Quadrature and Numerical Integration

7. Numerical Solution of Ordinary Differential Equations, R-K Method
8. Numerical Methods for PDEs; review and generalization of finite difference methods, explicit methods, Crank-Nicolson implicit method, Fourier stability methods, alternating directions implicit method, upwinding, higher level schemes, nonlinear equations, predictor corrector methods, financial engineering applications, computer problems.
9. Numerical Methods for Elliptic PDEs; analytical methods, Jacobi's method, Gauss-Seidel method, successive over-relaxation method.
10. Monte Carlo and Quasi Monte Carlo simulation

Computational Methods Lab

- Familiarisation with Spreadsheet, Mat lab and Scilab
- Writing Scripts and Functions for
    - Solving systems of linear equations
    - Linear Regression and fitting of functions
    - Numerical Solution of Ordinary Differential Equations
    - Quadrature and Numerical Integration
- Solution of Linear Programming Problem
- Fitting Probability Distribution given a random sequence, Gaussian and Mixed Gaussian
- Time Series Analysis
- Using Financial Tool Boxes for
    - Portfolio optimization by mean-variance Method
    - Volatility Estimation using ARCH and GARCH modelling
- Monte Carlo and Quasi Monte Carlo simulation

Advanced Mathematics for Finance

1. Review of Prerequisites

- Review of elementary probability
- Conditional expectation
- Martingales
    - Properties of martingales
- Stochastic processes
    - Brownian Motion

2 Elementary Asset Pricing Model

- The one step binomial asset pricing model
- The multi-step binomial asset pricing mode

3. Stochastic Calculus

- Basics Concepts
- Continuous time financial models
- Stochastic Integration
- Stochastic Differential Equations and Associated Equations
    - Fakker-Plank and Kolmogorov Equations
- Itos Lemma.
- The Girsanov theorem

4. Statistics of real prices: basic results

- Second-order statistics
  - Price increments vs. returns
  - Autocorrelation and power spectrum
- Distribution of returns over different time scales
  - Presentation of the data
  - The distribution of returns
  - Convolutions
- Tail probability and its use

1. Capital Asset Pricing Models

2. Concepts of Volatility and its Estimation

- Elementary Volatility Concepts
  - Estimation of Volatility
  - Application to VAR Computation
- The GARCH and Arch Model
- Stochastic Volatility Model
  - Estimation of Stochastic Volatility

3. Quality of VAR Estimation

- Comparison of Methods of VAR Estimations
- Simulation and back testing
  - Stochastic Modelling
  - Time series-Autocorrelation Analysis
  - Spectral Analysis
  - Parametric Modelling
- Historical simulation, based on Empirical Distribution
- Skewness and price-volatility correlations

7. Extreme Value Theory and Copula

- Need for Extreme Value Theory
- Univariate Tail Estimation
  - Tail dependence
  - Tail covariance
- Multivariate Dependence
- Generalized Extreme Value (GEV) and Generalized Pareto Distribution (GPD), Block maxima, GPD and Hill methods.
  - Quantile estimation
- Copulas and dependence modelling

8. Options: hedging and residual risk

- Options: definition and valuation
  - Quantitative analysis – option price
  - Real option prices, volatility smile and 'implied' kurtosis
  - The case of an infinite kurtosis
- Residual risk
  - The Black–Scholes Models
    - Ito calculus and the Black-Scholes equation
    - The Gaussian Bachelier model
    - Solution and Martingale
    - Time value and the cost of hedging
    - The Log-normal Black–Scholes model
    - General pricing and hedging in a Brownian world
    - The Greeks

Financial Optimisation and Risk Decisions

1. Overview of decision models and descriptive models

2. Deterministic decision making
- Linear Programming
- Integer Programming
- Non linear Programming

3. Decision making under uncertainty
- Mean Variance model
- Utility theory
- Stochastic dominance
- Stochastic Programming with recourse
- Chanced constraint Programming

4. Portfolio planning
- Markowitz MV model
- Capital Asset Pricing model (CAPM)
- Index tracking models
- Arbitrage pricing theory and factor model
- Cardinality restrictions
- Rebalancing model

5. Asset and liability management
- Asset and liability matching using deterministic model
- Asset price scenarios- stocks and bonds
- Liability scenarios- Mortality and Insurance claims
- Combined model using stochastic Programming
- Equilibrium asset pricing: The Capital Asset Pricing Model, continued. Excel example: CAPM
- Equity valuation Arbitrage.

9. Optimal portfolios
- Portfolios of uncorrelated assets
  - Uncorrelated Gaussian assets
  - Uncorrelated 'power-law' assets
  - 'Exponential' assets
  - General case: optimal portfolio and VaR
- Portfolios of correlated assets
  - Correlated Gaussian fluctuations
  - Optimal portfolios with non-linear constraints
  - 'Power-law' fluctuations – linear model
  - 'Power-law' fluctuations – Student model
- Optimized trading
- Value-at-risk – general non-linear portfolios
  - Outline of the method: identifying worst cases
  - Numerical test of the method

Corporate Governance, Regulations and Operational Risk

1. **Overview and need for regulatory regime**
   - International perspectives
   - National perspectives
   - Relationship between national and international regulations

2. **Regulations in the finance sector**
   - Basel Accord I
   - Basel Accord II
   - Adoption of Basel Accord by RBI
   - Regulations in other financial domains

3. **Regulations for corporate governance.**
   - US corporate governance SOX
   - UK and European regulations
   - Indian corporate regulation by SEBI

4. **Operational Risks and Mitigation**
   - Definition
   - Operational Risks of Financial Institutions
   - Operational Risks of non-Financial Institutions
   - Risks from IT infrastructure
   - Credit Risk and Operational risk

5. **Regulations in other domains**
   - Environment
   - Health
   - Transport

Project

Participants will be assigned individual projects. The credit will be equivalent to three theoretical subjects. Evaluation will be based on work-in-progress (25% by supervisor), Dissertation (50%), Viva and Presentation (25%)