

Four Year Degree
Program of Financial Mathematics

BS (Financial Mathematics)

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF KARACHI

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF KARACHI
BS in Financial Mathematics

Total Credit Hours: 140

YEAR - 1	SEMESTER - I	Course No.	Course Title	Credit Hours	Course Type
		300.1 (E)	English - I	2+0	Gen Ed
300.1 (I. S)	Islamic Studies OR Ethics (Non-Muslim)	2+0	Gen Ed		
300.1 (Civ/Com)	Civics and Community Engagement	2+0	Gen Ed		
300.1 (N. Sc)	Everyday Science, Astronomy, Physics, Chemistry, Earth Science or Biology	3+0	Gen Ed		
FM301	Microeconomics	3+0	Int Disc		
FM303	Principles of Accounting	3+0	Int Disc		
FM305	Introductory Statistics for Business	2+1	Major		
Total Credit Hours				18	
YEAR - 1	SEMESTER - II	300.2	Ideology & Constitution of Pakistan/ Pakistan Studies	2+0/2+0	Gen Ed
		300.2	Functional English	3+0	Gen Ed
		300.2 (Entr)	Entrepreneurship	2+0	Gen Ed
		300.2 (Soc. Sc)	Intro to Soc. Sc. Urdu, Economics, History, Geography or Psychology	2+0	Gen Ed
		FM302	Macroeconomics	3+0	Int Disc
		FM304	Introduction to Business Finance	3+0	Int Disc
		FM306	Calculus with Applications	3+0	Major
		Total Credit Hours			

YEAR - 2	SEMESTER-III	Course No.	Course Title	Credit Hours	Course Type
		400.1 (Q. Reas)	Quantitative Reasoning-I	3+0	Gen Ed
400.1 (E. Writ)	Expository Writing	3+0	Gen Ed		
FM401	Data Structure & Algorithms	2+1	Int Disc		
FM403	Financial Accounting	3+0	Int Disc		
FM405	Multivariate Statistical Analysis	2+1	Major		
FM407	Multivariable Calculus and Geometry	3+0	Major		
Total Credit Hours				18	
YEAR - 2	SEMESTER-IV	400.2 (Q. Reas)	Quantitative Reasoning-II	3+0	Gen Ed
		400.2 (ICT)	Application of Inf. & Comm. Technologies	3+0	Gen Ed
		FM402	Introduction to Database	2+1	Sub
		FM404	Cost and Management Accounting	3+0	Sub
		FM406	Quantitative Methods in Business	2+1	Major
		FM408	Linear Algebra	3+0	Major
		Total Credit Hours			

YEAR - 3		Course No.	Course Title	Credit Hours	Course Type	
	SEMESTER-V	FM501	Real Analysis		3+0	Major
		FM503	Data Analytics		2+1	Major
		FM505	Numerical Analysis-I		3+0	Major
		FM507	Differential Equations-I		3+0	Major
		FM509	Programming Language-I		2+1	Major
		Total Credit Hours			15	
	SEMESTER-VI	FM502	Actuarial Mathematics		3+0	Major
		FM504	Discrete Mathematics		3+0	Major
		FM506	Numerical Analysis-II		3+0	Major
		FM508	Differential Equations-II		3+0	Major
		FM510	Programming Language-II		2+1	Major
		Total Credit Hours			15	

YEAR - 4		Course No.	Course Title	Credit Hours	Course Type	
	SEMESTER - VII	FM601	Operations Research		3+0	Major / (Opt)
		FM603	Financial Derivatives		3+0	Major / (Opt)
		FM605	Stochastic Processes		3+0	Major / (Opt)
			Optional-I		3+0	Major / (Opt)
			Optional-II		3+0	Major / (Opt)
		FM600.1	Field Experience / Internship		0+3	Major / (Opt)
	Total Credit Hours			18		
	SEMESTER - VIII	FM602	Financial Report Writing		3+0	Major / (Opt)
		FM604	Portfolio Theory & Management		3+0	Major / (Opt)
		FM606	Stochastic Calculus		3+0	Major / (Opt)
			Optional-I		3+0	Major / (Opt)
			Optional-II		3+0	Major / (Opt)
		FM600.2	Capstone Project		0+3	Major / (Opt)
Total Credit Hours			18			

Optional Courses

Sr. #.	Course No.	Optional Course Title	Credit Hours
01	FM-607	Corporate Finance	3+0
02	FM-608	Games, Markets and Information	3+0
03	FM-609	Management Information System	3+0
04	FM-610	Financial Modelling and Simulation	3+0
05	FM-611	Discrete time Modelling and Derivative Security	3+0
06	FM-612	Life Insurance and Institutional Investment	3+0
07	FM-613	Principles of Risk	3+0
08	FM-614	Global Financial Market	3+0
09	FM-615	Equities Foreign Exchange and Commodities Modelling	3+0
10	FM-616	Interest rate and Credit Modelling	3+0
11	FM-617	Financial Computer Simulation- I	2+1
12	FM-618	Financial Computer Simulation- II	2+1
13	FM-619	Analysis of Financial Time Series	3+0

BS- I Financial Mathematics

First Year

YEAR - 1			Course No.	Course Title	Credit Hours	Course Type
	SEMESTER - I	300.1 (E)	English - I	2+0	Gen Ed	
		300.1 (I. S)	Islamic Studies OR Ethics (Non-Muslim)	2+0	Gen Ed	
		300.1 (Civ/Com)	Civics and Community Engagement	2+0	Gen Ed	
		300.1 (N. Sc)	Everyday Science, Astronomy, Physics, Chemistry, Earth Science or Biology	3+0	Gen Ed	
		FM301	Microeconomics	3+0	Int Disc	
		FM303	Principles of Accounting	3+0	Int Disc	
		FM305	Introductory Statistics for Business	2+1	Major	
		Total Credit Hours			18	
	SEMESTER - II	300.2	Ideology & Constitution of Pakistan/Pakistan Studies	2+0/2+0	Gen Ed	
300.2		Functional English	3+0	Gen Ed		
300.2 (Entr)		Entrepreneurship	2+0	Gen Ed		
300.2 (Soc. Sc)		Intro to Soc. Sc, Urdu, Economics, History, Geography or Psychology	2+0	Gen Ed		
FM302		Macroeconomics	3+0	Int Disc		
FM304		Introduction to Business Finance	3+0	Int Disc		
FM306		Calculus with Applications	3+0	Major		
Total Credit Hours			20			

First Semester

FM-301 Microeconomics (3 + 0)

Introduction: An overview of the social system, Economy as integral part of the social system, Economic agents and economic problem, Economics as a science of choices between competing wants and limited resources, Classification of economics, Importance and scope of micro-economics, Basic concepts: Commodities, Income and Resources, Production and Consumption, Exchange and Distribution.

The Price Mechanism: The concept of a market economy, Laws of demand and supply, schedules & graphs of demand and supply, Market equilibrium and determination of price, Movement along and shifting of demand and supply curves, Concept of elasticity of demand and supply, Importance of elasticity.

Consumer's Behavior: Consumers/ households as economic agents, Problem of the consumers, The utility theory, Laws of diminishing marginal utility and equi-marginal utilities, Budget constraint and consumer's equilibrium, Individual demand and market demand, Introduction to demand elasticity.

Firms and Industries: Business enterprises, Forms of business organization: Proprietorship, Partnership, Joint stock companies, Multinational corporations, Classification of the firms, Production and supply of commodities (goods and services), Objectives of the firm: The profit motive, Output maximization and cost minimization, Industrial structure & market supply.

Production and Cost Functions: Production function, Primary inputs: factors of production, Secondary/intermediate inputs: Raw material and energy, The laws of returns, Revenues of the firm: total, average and marginal revenues, Cost function: Total, average and marginal costs, Short-run and Long-run costs, Equilibrium of the firm.

Market Structure: Classification of markets according to nature of commodity, extent, time and degree of competition, Perfect competition among buyers and sellers, Imperfect competition: Monopoly and Monopsony, Monopolistic competition, Price discrimination, The need for market regulation and role of the government, Public goods and their provision beyond the market.

Recommended Books:

1. D. Besanko, R. & Braeutigam, Microeconomics, 4th Edition, Wiley, 2014
2. M. Parkin, Microeconomics, 11th Edition, Prentice Hall, 2013
3. N.G. Mankiw, Principles of Microeconomics, 7th Edition, Cengage Learning, 2014
4. R. Frank, B., & Bernanke, Principles of Microeconomics, 5th Edition, McGraw-Hill/Irwin, 2012
5. R. Pindyck, & Rubinfeld.D, Microeconomics, 8th Edition, Prentice Hall, 2012

FM-303 Principles of Accounting (3 + 0)

Introduction to accounting concepts and conventions: Fundamental accounting equation, basic mechanics of recording using the general journal and the general ledger.

Adjusting the accounts: Preparing financial statements, Record, summarize, and analyse financial transactions, Accrual vs. cash basis of accounting, worksheets, closing entries

Merchandising accounting: Cost of goods sold (both perpetual and periodic), accounting for cash, petty cash, bank reconciliations and internal control systems, credit card sales

Accounting for Accounts Receivable: Income Statement and Balance Sheet Approach, Analysis and Aging of Accounts Receivable, Allowance Method for Making Provisions, Write Off and Recovery of Accounts Receivable, Advance from Customers.

Accounting for bad debts: Accounts and notes receivable, Inventories: periodic and perpetual systems, cost flow methods, effect of errors, estimated inventories, Special journals and subsidiary ledgers.

Depreciation: Methods Straight Line, Units of Output, Working Hours, Sum of the Years Digits and Fixed Percentage on Declining Balance, Addition, Revision of Life, Disposal and Exchange of Depreciated Asset.

Partnership Accounting: Formation, Plans of Profit/Loss Distribution, Admission, Retirement/Death, Liquidation.

Recommended Books:

1. Dupree.L, & Marder, Principles of Accounting, 1st Edition, Addison Wesley Publishing Company, 2010
2. Meigs & Meigs, Accounting the Basis for Business Decisions, 9th Edition, McGraw Hill Book Company, 1993
3. Needles.B, & Anderson.J, Principles of Accounting, Houghton Mifflin Company, 1992
4. Niswonger.Y, & Fess.A, Accounting Principles, South Western Company, 2012
5. Steven M. Bragg., Principles of Accounting, 1st Edition, Accounting Tools, Inc, 2021

FM-305 Introductory Statistics for Business (2+1)

Statistical Methods: Concepts of statistical population and sample from a population, quantitative and qualitative data, Nominal, ordinal and time series data, discrete and continuous data. Presentation of data by table and by diagrams, frequency distributions by histogram and frequency polygon, cumulative frequency distributions (inclusive and exclusive methods) and ogive. Bivariate data-scatter diagram, principle of least squares and fitting of polynomials and exponential curves. Measures of location (or central tendency) and dispersion. moments, measures of skewness and kurtosis, absolute moments and factorial moments, Inequalities concerning moments, Sheppard's corrections.

Probability Theory: Permutation, Combination, Random experiments, sample point and sample space, event, algebra of events. Definition of Probability – classical and relative frequency approach to probability; Richard Von-Mises, and Kolmogorov's approach to probability, merits and demerits of these approaches (only general ideas to be given), theorems on probability, conditional probability, independent events, Bayes theorem and its applications.

Random Variables: Discrete and continuous random variables, Illustrations of random variables and its properties. Univariate transformations. Expectation of random variable and its properties. Moments and cumulants, moment generating function. Cumulant generation function and characteristic function.

Lab/Practical: (Use any software Excel/ SPSS/ EViews)

- Identify and classify given data as qualitative or quantitative, nominal, ordinal, or time series.
- Conduct a small survey to collect data, classify it, and present it in a structured format.
- Create frequency distributions from given data sets.
- Construct histograms, frequency polygons, and ogives using statistical software (e.g., Excel, SPSS, R).
- Plot scatter diagrams and identify possible relationships. Apply the principle of least squares to fit linear, polynomial, and exponential curves.
- Interpret the results and assess the goodness of fit.
- Calculate the mean, median, mode, variance, and standard deviation for given data sets.
- Compare measures of central tendency for skewed and symmetrical distributions.
- Explore moments, skewness, and kurtosis using software tools.
- Calculate expected values, moments, and cumulative distribution functions.
- Explore univariate transformations of random variables using software tools.
- Calculate and interpret moment generating functions (MGFs) for different distributions.
- Apply these functions to solve problems related to business statistics.

Recommended Books:

1. A.M. Goon.A.M, Gupta M.K. & Dasgupta.B, Fundamentals of Statistics, 8th Edition, World Press, 2005
2. A.M. Goon.A.M, Gupta M.K. & Dasgupta.B, An Outline of Statistical Theory, 4th Edition, World Press, 2003
3. M. Barrow, Statistics for Economics, Accounting and Business Studies, 6th Edition, Pearson Education, 2013
4. R. N. Landers, A Step-by-Step Introduction to Statistics for Business, SAGE Publishing, 2010
5. Wonnacott.T.H, & Wonnacott.R.J, Introductory Statistics for Business and Economics, 4th Edition, Wiley, 1990

Second Semester

FM-302 Macroeconomics (3 + 0)

Introduction to Macro Economics: What macroeconomics is about? Issues addressed by macroeconomists, Positive versus Normative analysis, Classical versus Keynesians.

Measurement and Structure of the National Economy: National Income Accounting: the measurement of Production, Income and Expenditure, Gross Domestic Product and Gross National Product, Saving and Wealth, Real GDP, Price Indices and Inflation, Interest rates.

Productivity, Output and Employment: The Production Function, The Demand for Labor, The Supply of Labor, Labor Market Equilibrium, Unemployment, Relating Output and Unemployment: Okun's Law.

Consumption, Saving and Investment in Closed and Open Economy: Consumption and Saving, Investment, Goods Market Equilibrium, Balance of Payment Accounting, Goods Market Equilibrium in an Open Economy, Saving and Investment in a Small Open Economy, Saving and Investment in Large Open Economies, Fiscal Policy and the Current Account.

The Assets Market, Money and Prices: Introduction to Money, Portfolio allocation and the Demand for Assets, The Demand for Money, Assets Market Equilibrium, Money Growth and Inflation.7

The IS-LM and the AD-AS Model: The FE Line: Equilibrium in the Labor Market Equilibrium, The IS Curve: Equilibrium in the Goods Market Equilibrium, The LM Curve: Equilibrium in the Assets Market Equilibrium, General Equilibrium in the complete IS-LM Model, Price adjustment and the Attainment of General Equilibrium, Aggregate Demand and the Aggregate Supply.

Money and Inflation: Inflation and its causes, Demand-pull Inflation, Cost-push Inflation, Stagflation and Hyperinflation, Inflation as a Monetary Phenomenon, The Philips Curve and Accelerating Inflation, Inflation in Pakistan: Sources and Managing Policies, Sources of Inflation in Pakistan, Policies to Combat Inflation in Pakistan.

Recommended Books:

1. A.B. Andrew, A.B. & Bernanke B. & Croushore.D, Macroeconomics, 8th Edition, Prentice Hall, 2013
2. Baumol.W.J. & Blinder A.S., Macroeconomics: Principles and Policy, 12th Edition, Cengage Learning, 2011
3. Krugman.P. & Wells.r, Macroeconomics, 3rd Edition, Worth Publishers, 2012
4. Mankiw.N.G, Principles of Macroeconomics, 6th Edition, South-Western Cengage Learning, 2011
5. McConnell.C, Brue.C, & Flynn.S, Macroeconomics, 10th Edition, McGraw-Hill/Irwin, 2011

FM-304 Introduction to Business Finance (3 + 0)

An Overview of Finance: Scope of Finance and its Career Opportunities, Alternative Form of Business Organization, Finance in the Organizational Structure of the Firm, Managerial Actions to Maximize Shareholders Wealth, Functions of a Finance Manager

The Financial Environment: Markets, Institutions, and Interest Rates: The Financial Market, Financial Institutions, The Stock Market, The Cost of Money, Interest Rate Level, The Determinants of Market Interest Rates

Time Value of Money: Future Value Concept, Present Value Concept, Future Value of an Annuity, Present Value of an Annuity

Risk and Return, Investment Return, The Trade–Off between Risk and Return, Risk in Portfolio Context

Analysis of Financial Statements, Ratio Analysis, Liquidity Ratio, Assets Management Ratios, Debt Management Ratios, Profitability Ratios, Market Value Ratio, Trend Analysis, Uses and Limitations of Ratio Analysis

The Impact of Operating and Financial Decisions on the Firm: Operating Leverage, Financial Leverage, Combined or Total Leverage

The Framework of Financial Planning: Short–Term Financial Planning, Long–Term Financial Planning

The Cost of Capital: Basic Definition, Cost of Debt, Cost of Preferred Stock, Cost of Retained Earning

The Basic Concept of Capital Budgeting, Importance of Capital Budgeting, Generating Ideas for Capital Budgeting, Project Classification, Capital Budgeting Decision Rules, Comparison of NPV and IRR Methods

Working Capital Management: The Importance of Working Capital, Short–Term Financial Decisions and Value Maximization, Why Current Assets and Current Liabilities are Required, Deciding on an Appropriate Working Capital Policy

Cash and Near–Cash Item Management: The Efficient Collection and Disbursement of Operating Cash, The Optimal Level of Operating Cash Balance, Investment Excess Cash in Marketable Securities, Evaluating Cash Management Strategies

Recommended Books

1. E. McLaney, Business Finance: Theory and Practice, Pearson Education 2009.
2. Houston, Brigham, Financial Management, Theory and Practice, 10th International Edition, Harcourt Brace College Publishers. 2004.
3. J. Madura, International Financial Management, 8th Edition (West Publishing Company) 2006.
4. K. S. R. Ramesh, Fundamentals of Financial Management, Latest International Edition Maxwell Macmillan. 1989.
5. P. P. Drake, F. J. Fabozzi, The Basics of Finance: An Introduction to Financial Markets, Business Finance, and Portfolio Management, John Wiley 2010

FM-306 Calculus with Applications (3 + 0)

Introduction: Real Numbers & its properties, Introduction to functions, domain, range, symmetry tests, Graph of functions

Limits & Continuity: Limits, Continuity, Tangent lines & Rate of Change,

Some especial types of Functions: Logarithmic & exponential functions, Inverse functions, hyperbolic functions, inverse trigonometric & hyperbolic functions

Introduction to derivatives: Techniques of differentiation, Chain rule and implicit differentiation, derivatives of Inverse functions, hyperbolic functions, inverse trigonometric & hyperbolic functions, Applications of differentiation, Maxima and Minima of a function of single variable, Marginal analysis and approximations using increments, Indeterminate forms and L' Hospital Rule

The Integration: Integration techniques, Integration by substitution, differentiation & integration of logarithmic & exponential function, Integrals of inverse trigonometric & hyperbolic function, Integration of Power of sine, cosine, secant and tangent, by parts, trigonometric substitution, Improper integrals, Beta and gamma integrals

Differential Equations: Differential equations, formation and solution, equations of first order, initial and boundary value problems, various methods of solving first order differential equations: Separable, Exact & Homogeneous equation, integration factor and orthogonal trajectories. Non-Linear First Order Equations, Envelopes and Singular solutions.

Recommended Books:

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley (9th Edition), 2005
2. H. Anton, Calculus and Analytic Geometry, Wiley (10th Edition), 2010
3. K. Hoffmann, Calculus for Business, Economics and the social and the life sciences, McGraw Hill (10th Edition), 2007
4. M. Tenenbaum, H. Pollard, Ordinary Differential Equations, Dover Publications, Incorporated, 2012
5. S. M. Yousuf, Mathematical Methods, Fourth Edition, Ilmi Kitab Khana, Lahore, 2003

Second Year

YEAR - 2	SEMESTER-III	Course No.	Course Title	Credit Hours	Course Type
		400.1 (Q. Reas)	Quantitative Reasoning-I	3+0	Gen Ed
		400.1 (E. Writ)	Expository Writing	3+0	Gen Ed
		FM401	Data Structure & Algorithms	2+1	Int Disc
		FM403	Financial Accounting	3+0	Int Disc
		FM405	Multivariate Statistical Analysis	2+1	Major
		FM407	Multivariable Calculus and Geometry	3+0	Major
	Total Credit Hours			18	
	SEMESTER-IV	400.2 (Q. Reas)	Quantitative Reasoning-II	3+0	Gen Ed
		400.2 (ICT)	Application of Inf. & Comm. Technologies	3+0	Gen Ed
		FM402	Introduction to Database	2+1	Sub
		FM404	Cost and Management Accounting	3+0	Sub
		FM406	Quantitative Methods in Business	2+1	Major
		FM408	Linear Algebra	3+0	Major
Total Credit Hours			18		

Third Semester

400.1 (Q.Reas) Quantitative Reasoning-I (3+0)

Numeric Reasoning: Number system, basic arithmetic equations, units and conversions, dimensions, rates, ratios, percentage, scientific notation, computation with real number, operations of integers, exponent, square root, measurement scales.

Algebraic and Geometric Reasoning: Basics of geometry, line, angle, circle, polygon, area, perimeter, volume, surface etc., introduction of set, properties and operation, functions, types of functions, graphical representation of functions, relations, types of relations, simplifying algebraic expressions exponents, factorization, algebraic solutions of linear and quadratic equations.

Logical and critical reasoning: Logic, proposition, propositional equivalence, truth table, Conjunction, disjunction, negation, propositions, logical fallacies, tautologies and contradictions, logical equivalence, Venn diagram, components of critical thinking, observation, analysis, interpretation, reflection, evaluation, inference, scientific reasoning.

Mathematical Modelling and Analysis: Introduction to deterministic models, linear and non-linear functions, system of linear equations, application of derivatives, linear and exponential growth decay model.

Recommended Books:

1. Alan F. Beardon. (2005). Algebra and Geometry, 1st edition, Cambridge University Press.
2. Eric Zaslow. (2020). Quantitative Reasoning, 1st edition, Cambridge University Press.
3. Forest Jim. (2020). Introduction to Statistics: An Intuitive Guide for Analyzing Data and Unlocking Discoveries, Jim Publishing.
4. Rosen, K. H. (2018). Discrete Mathematics and its Applications, 7th edition, McGraw Hill.
5. Sevilla. A & Somers K. (2008). Quantitative Reasoning: Tools for Today's Informed Citizen, 1st edition, Wiley.
6. Bennett.J & Briggs.W. (2018). Using & Understanding Mathematics: A Quantitative Reasoning Approach, 7th edition, Pearson.
7. Frank S Budnick. (1993). Applied Mathematics for Business, Economics, and the Social Sciences, 4th edition, McGraw Hill.
8. William Fox. (2017). Mathematical Modeling for Business Analytics, 1st edition, CRC Press.

FM-401 Data Structure & Algorithms (2+1)

Elementary Data Structures: Simple array-based data structures: arrays, matrices, stacks, queues, Linked lists, Introduction to Trees, Logical construction and traversing of Binary Trees, Implementation of Binary Trees (Insertion and Traversing), Searching and deletion in Binary Trees, Binary Search Tree, Introduction to Balanced and AVL Trees.

Algorithm Specification: The Role of Algorithms in Computing, Properties of Algorithm, examples, performance, complexity analysis, measurement, and Big Oh notation.

Abstract data types (ADTs): Array and Polynomial as an ADT, Sparse Matrices, and Representation of Arrays., Stack ADT, Linked lists and array implementations, Expressions, Postfix Notation, and Infix to postfix conversion.

Recursion and Queue: Recursive Definition and Processes, Writing Recursive Programs, analyzing recursive algorithms, Queue ADT, Linked and array implementations of queues, circular and double ended queue, dequeuer, priority queues.

Self Referencing Classes: Dynamic Memory Allocation, garbage collection. Linked List: Singly Linked Lists, Circular Lists, Linked Stacks and Queues (Double Ended List), Doubly Linked Lists.

Sorting and Order Statistics: Heaps and Heaps as Priority Queues, Double Ended Priority Queue. Searching: Linear Search, Binary Search, and Types of Indexing, Hash Functions, Division, Overflow Handling, Chaining. B-Trees, Generalized List, etc. Divide and conquer algorithms, Sorting, selection, insertion, merge, quick, bubble, heap, shell, radix, bucket.

Lab/Practical:

- Implement basic operations on arrays and matrices.
- Perform insertion, deletion, and traversal of array elements.
- Implement stacks and queues using arrays and linked lists.
- Perform stack operations: push, pop, and peek.
- Implement singly linked lists, circular linked lists, and doubly linked lists.
- Perform
- different sorting algorithms: selection sort, insertion sort, merge sort, quicksort, bubble sort, heap sort, shell sort, radix sort, and bucket sort.
- Analyze the time and space complexity of each sorting algorithm.
- Implement linear and binary insertion, deletion, and traversal of linked list elements.
- Implement binary trees and binary search trees.
- Perform insertion, deletion, and traversal (in-order, pre-order, post-order) of binary trees.
- Analyze the performance of recursive algorithms.
- Implement and compare search algorithms.
- Analyze the performance of different hash functions.
- Implement classic divide and conquer algorithms: merge sort, quicksort.
- Analyze the performance and efficiency of divide and conquer algorithms.

Recommended Books

1. Adam B. Drozdek, Data Structure and Algorithm in C++, 4th Edition, Cengage Learning, 2012
2. Conger S., Hands-on Database: An Introduction to Database Design and Development, 2nd Edition, Springer, 2021
3. Horowitz.E, Sahni.S, & Mehta.D, Fundamentals of Data Structures in C++, 2nd Edition, Computer Science Press, 1995
4. Rocca.M.L., Advanced Algorithms and Data Structures, Manning Publication, 2021
5. Wengrow.J, A Common-Sense Guide to Data Structures and Algorithms, 2nd Edition, Pragmatic, 2020

FM-403 Financial Accounting (3 + 0)

Introduction of Financial Accounting and Principles The Impact of International Accounting Standards as Applicable in Pakistan for the Preparation of Financial Statements and their Disclosure Requirement, Forms of Business Enterprises such as Non-profit Organization, Sole Proprietorship, Partnerships and Corporation

Accounting for Receivables Accounting for Receivables Under Income Statement and Balance Sheet Approach, Notes Receivable and their Matters

Financial Statements–The Outputs of the System Objectives of Financial Reporting, Qualitative Characteristics of Financial Information, The Uses and Limitations of Classified Balance Sheets, The Uses and Limitations of Classified Income Statements, The Retained Earnings Statement or Statements of Changes in Stockholders Equity

Inventory Accounting Nature and Classes of Inventories, Periodic and Perpetual Inventory Valuation as per International Accounting Standard (IAS–2), LIFO, FIFO Methods, Weighted Average Method, Moving Average, Inventory Valuation at Cost or NRV Whichever is Lower

Cash Flow Statement Preparation of Cash Flow Statements According to the Requirement of IAS, Classification of Cash Flow Statements as Operating Activities, Investing Activities and Financial Activities by Using Direct and Indirect Methods

Interpreting Financial Statement Data, Users of Financial Statements and The Purposes of Financial Statement Analysis, The Techniques and Tools of Financial Analysis, Common Financial Ratios, Common Size Balance Sheet and Income Statement, Limitations of Financial Statement Analysis

Recommended Books

1. Horngren, Harrison, Robinson, Financial Accounting, Prentice Hall, 3rd Edition, 1995.
2. M. F. Robert, J. R. Williams, S. F. Haka, M. S. Bettner, Accounting, McGraw–Hill, 10th Edition, 1999.
3. Meigs & Meigs, Accounting the Basis for Business Decisions, 9th Edition, McGraw Hill Book Company, 1993
4. Niswonger.Y, & Fess.A, Accounting Principles, South Western Company, 2012
5. Weygandt, Kieso, Kimmel, Financial Accounting, John Wiley and Sons, Inc., 2nd Edition, 1998.

FM-405 Multivariate Statistical Analysis (2+1)

Standard probability distributions: Degenerate, Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric. Normal, uniform, exponential, beta, gamma, Cauchy, Laplace.

Bivariate and Multivariate Distributions: Discrete and continuous type, marginal and conditional distributions, independence, expectation and conditional expectation, characteristic function and its properties, Inversion Theorem (without proof), Multinomial Distribution. Bivariate Transformations-concept and examples in uniform, normal, exponential, beta, gamma and Cauchy distributions. Variance stabilizing transformations-sin-1, square root, log and Fisher's, Bivariate normal distribution and its properties, Multivariate normal distribution, its marginal and conditional distributions.

Correlation and regression: Karl Pearson's Coefficient of Correlation, lines of regression, Spearman's Rank Correlation Coefficient, Correlation Ratio. Multiple and partial correlation coefficients (for three variates only), Limit Laws: Convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution, Chebyshev's inequality, De-Moivre-Laplace theorem, central limit theorem (C.L.T.), Liapunov theorem (without proof) and applications of CLT.

Sampling Distribution: Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean and sample proportion. Sampling distributions of chi-square, t and F statistic. Distribution of sample correlation coefficient r when $\rho = 0$.

Tests of significance: Null and alternative hypotheses, level of significance and probabilities of Type I and Type II errors, critical region and p-value. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations. Tests of significance based on t, F and Chi-square distributions.

Lab/Practical: (Use any software/Language)

- Generate and plot probability mass functions (PMFs) for discrete distributions: Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric.
- Generate and plot probability density functions (PDFs) for continuous distributions: Normal, Uniform, .
- Generate and visualize bivariate distributions: normal, uniform, exponential, beta, gamma, and Cauchy.
- Calculate and interpret marginal and conditional distributions.
- Apply bivariate transformations to datasets following uniform, normal, exponential, beta, gamma, and Cauchy distributions.
- Perform variance stabilizing transformations (e.g., sine-inverse, square root, logarithm, Fisher's transformation) on given data.
- Calculate Karl Pearson's and Spearman's rank correlation coefficients for various datasets.
- Plot and interpret lines of regression for bivariate data.
- Analyze multiple and partial correlation coefficients for three variates, and understand their significance.
- Generate and analyze the sampling distributions of sample mean and sample proportion.
- Explore the sampling distributions of chi-square, t, and F statistics.
- Simulate and interpret the distribution of the sample correlation coefficient r when $\rho = 0$.
- Use large sample tests based on the CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation, and difference of standard deviations.
- Conduct tests of significance using t, F, and chi-square distributions, and interpret the p-value.

Recommended Books:

1. C. Alvin, Rencher, F. William, Christensen, Methods of Multivariate Analysis, (3rd Edition)
2. H. T. Neil, Applied Multivariate Analysis, 2002
3. H. Tinsley, S. Brown, Handbook of Applied Multivariate Statistics and Mathematical Modeling. Academic Press, 2000
4. J. Izenman, Modern Multivariate Statistical Techniques: Regression, Classification, and Manifold Learning, Springer
5. R. V. Hogg, E. A. Tanis, A Brief Course in Mathematical Statistics. Pearson Education, 2009

FM-407 Multivariable Calculus and Geometry (3 + 0)

Polar Coordinates: Polar Coordinate & Sketching the graph of polar coordinates, Slope of tangent line and arc length for parametric and polar curve, Area in polar Coordinates

Introduction to Vectors, Line and Plane: Product of vectors, Projection of vectors, Parametric equation of line, Plane in three spaces, Quadratic surfaces, Cylindrical & Spherical coordinate

Derivatives of function of two variables: Partial derivative, Tangent plane, Total differential for function of two variables, Directional derivatives and gradient for function of two variables, Maxima and minima for the function of two variables, Jacobians

The Integral: Introduction of double and triple integrals and their applications

Recommended Books:

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley (9th Edition), 2005
2. H. Anton, Calculus, Wiley (7th Edition), 2001
3. K. Hoffmann, Calculus for Business, Economics and the social and the life sciences, McGraw Hill (10th Edition), 2007
4. S. M. Yousuf, Mathematical Methods, Fourth Edition, Ilmi Kitab Khana, Lahore, 2003
5. Thomas, & Finney, Calculus and Analytic Geometry, Addison Wesley, 2005

Fourth Semester

400.2 (Q.Reas) Quantitative Reasoning-II (3+0)

Fundamental Statistical Concepts: Population and sample Interpretation of Tabular and Graphical form of data (Grouped and ungrouped). Summarizing data; Measures of central tendency, dispersion and Quantiles.

Combinatorial Analysis: Rules of counting (multiplicative, permutation and combination); Venn diagram

Basic concept of probability: Axioms of Probability. Introduction to probability models for continuous and discrete variables; Normal and Binomial distribution with simple applications.

Bivariate Data analysis: Scatter plots; Pearson correlation; Simple linear regression with simple application

Fundamental Concepts of Inference: Basic ideas of test of significance and testing of hypothesis. Concepts of level of significance and degree of freedom.

Quantitative reasoning exercises using fundamental statistical concepts

Recommended Books:

Bennett, J., & Briggs, W. (2019). Using & understanding mathematics: a quantitative reasoning approach. Pearson.

Mann, P. S. (2010). Introductory statistics. John Wiley & Sons.

Chatfield, C. (2018). Statistics for technology: a course in applied statistics. Routledge.

Lock, R. H., Lock, P. F., Morgan, K. L., Lock, E. F., & Lock, D. F. (2020). Statistics: Unlocking the power of data. John Wiley & Sons.

Peck, R., Short, T., & Olsen, C. (2020). Introduction to statistics and data analysis. Cengage Learning.

FM402 Introduction to Database (3+0)

Introduction to Basic Database Concepts: Importance of Databases, File Systems and Databases, A File system Critique, Shortcomings of Traditional File Processing System, Levels of Data, Different Types of Database Users, History of DBMSs, Advantages and Disadvantages of DBMSs

Database Architecture: Data Independence, Database Languages, Database, Data Model and DBMS, Functions and Components of a DBMS, Multi-user DBMS Architectures

Database Planning, Design, and Administration: The Information System Life Cycle, DBS Development Life Cycle, DB Planning, Requirements Collection and Analysis, DB Design, DBMS Selection, Application Design, Prototyping Implementation, Data Conversion and Loading Testing, Operational Maintenance, Fact-Finding Techniques

Entity-Relationship Modeling: Semantic Data Models, Introduction to Entity-Relationship Data Model, Different Constructs of E-R Data Model, Abstraction Process, Modeling different types of Entities and Attributes

Relational Model and Languages: Introduction to Relational Data Model, Relational Model Terminology, Mathematical Relations, Database Relations, Characteristics of Relations, Integrity Constraints Over Relations, Foreign Key Constraints.

Structured Query Language (SQL): Introduction, DDL Commands, DML Commands, DCL Commands, Complex Queries and SQL Functions, Procedural SQL; Triggers, Stored procedures.

Recommended Books:

1. C. J. Date, An Introduction to Database Systems, 8th Edition, Pearson, 2004.
2. Jeffrey A. Hoffer, Ramesh Venkataraman, Heikki Topi, Modern Database Management, 12th Edition, Pearson, 2015.
3. Michael McLaughlin, Oracle Database 11g PL/SQL Programming (Oracle Press) 1st Edition, McGraw-Hill Education, 2008,
4. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, 7th Edition, Pearson, 2016.
5. Thomas Connolly, Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation and Management, 6th Edition, Pearson, 2015.

FM-404 Cost and Management Accounting (3+0)

Introduction to Cost and Management Accounting: Financial Accounting, Management Accounting, and Cost Accounting, Different Costs for Different Purposes, Cost for Decision Making, Planning, and Control: The Five-Step Decision-Making Process

Cost and Cost Terms: Direct Costs and Indirect Costs, Fixed and Variable cost, Semi-variable and step fixed cost, Prime Costs and Conversion Costs, Total Costs and Unit Costs, Classifications of Manufacturing Costs; Direct Materials, Direct Labor & Manufacturing Overhead, Cost Drivers, Calculating the Cost of Products, Services, and Other Cost Objects, Statement of cost of goods manufactured, manufacturing cost accounting cycle.

Job order Costing and Process Costing: Job Costing, Batch Costing, Service Costing, process costing, Losses in process costing, Valuing work in process: Opening and closing, Cost Flows in Process Costing, Equivalent Units of Production, Operation Costing, Comparison of Job-Order and Process Costing.

Absorption and Marginal costing: Difference between marginal and absorption costing, calculation of profit and inventory under both the methods, Reconciliation of profit.

Cost Volume Profit (CVP): Essentials of CVP Analysis, Contribution Margins, Expressing CVP Relationships, Cost-Volume-Profit Assumptions, Breakeven Point, Target Operating Income, Target Net Income and Income Taxes, Using CVP Analysis for Decision Making, Sensitivity Analysis and Margin of Safety

Activity-Based Costing (ABC): Nonmanufacturing Costs and Activity-Based Costing, Manufacturing Costs and Activity-Based Costing, Cost Pools, Allocation Bases, and Activity-Based, Designing an Activity-Based Costing (ABC) System, Comparison of Traditional and ABC Product Costs,

Budgeting: The Basic Framework of Budgeting, Preparing the Master Budget; Sales Budget, The Production Budget, Direct Materials Budget, Direct Labor Budget, Manufacturing Overhead Budget, Ending Finished Goods Inventory Budget, Selling and Administrative Expense Budget, Cash Budget, The Budgeted Income Statement, The Budgeted Balance Sheet

Standard Cost and Variance Analysis: Standard costing, Preparation of standard, Uses of standard costing, Purpose and Limitations of standard costing, Variances; Direct material variances, Direct labor variances, Variable overhead variances, Fixed overhead variances, Reasons for cost variances.

Recommended Books:

1. C. Suematsu, Transaction Cost Management, Springer International Publishing, 2014
2. D. R. Hansen, M. M. Mowen, L. Guan, Cost Management: Accounting and Control, South-Western, Cengage Learning (6th Edition), 2006
3. J. Rains, Target Cost Management: The Ladder to Global Survival and Success, CRC Press, 2010
4. L. G. Eldenburg, S. Wolcott, L-H. Chen, G. Cook, Cost Management: Measuring, Monitoring, and Motivating Performance, Second Canadian Edition, Wiley, 2005,
5. S. Seuring, Maria Goldbach, Cost Management in Supply Chains, Physica-Verlag Heidelberg, 2002

FM-406 Quantitative Methods in Business (2 + 1)

Index Numbers: Definition, construction of index numbers by different methods, Problems faced in their construction, criterion of a good index number-Test Theory-unit, time reversal, factor reversal and circular tests. Errors in the construction of index numbers. Chain and Fixed base index numbers. Base Shifting, Splicing and Deflating of index numbers. Cost of Living Index numbers- construction and uses. Wholesale Price Index and Index of Industrial Production.

Demand Analysis: Demand function, price and income elasticity of demand, nature of commodities, laws of supply and demand, Income distributions, Pareto – curves of concentration. Utility and Production Functions: utility function, constrained utility maximization, indifference curves, derivation of demand curve, production function, homogeneous production functions, Isoquant and Iso cost curves, Elasticity of substitution, C.E.S. functions, Multiple production by monopolist, discriminating monopolistic form, multiplant form.

Time Series: Introduction, decomposition of a time series, different components with illustrations. Measurement of trend- Graphical Method, Method of Semi-averages, Method of fitting curves (straight line, polynomials, growth curves-modified exponential curve, Gompertz curve and logistic curve). Method of Moving Averages. Measurement of seasonal variation- Method of Simple Averages, Ratio to Trend Method, Ratio to Moving Average Method and Link Relative Method. Measurement of cyclical variation residual method. Random component-estimation of its variance by Variate Difference Method.

Methods of estimation: Maximum likelihood, moments, minimum chi-square, least squares and minimum variance. Properties of maximum likelihood estimators (without proof).

Lab/Practical: (Use any software Excel/ SPSS/ EViews)

- Construct index numbers using the Laspeyres, Paasche, and Fisher methods.
- Apply the unit test, time reversal test, factor reversal test, and circular test to evaluate the index numbers.
- Identify and analyze errors in the construction of index numbers.
- Construct chain and fixed base index numbers for a given dataset.
- Perform base shifting and splicing on index numbers.
- Deflate index numbers to adjust for price changes over time.
- Construct cost of living index numbers using the Family Budget method.
- Analyze the uses and implications of cost of living indices.
- Construct and interpret the Wholesale Price Index and Index of Industrial Production.
- Calculate and interpret price and income elasticity of demand.
- Derive demand curves from utility functions using constrained utility maximization and indifference curves.
- Decompose a time series into its components: trend, seasonal, cyclical, and random.
- Measure trends using graphical methods, semi-averages, and curve fitting (e.g., straight line, polynomials, growth curves).
- Measure seasonal variations using methods such as simple averages, ratio to trend, ratio to moving average, and link relative methods.
- Estimate the variance of the random component using the Variate Difference Method.
- Interpret the significance of cyclical and random components in time series data.
- Estimate parameters using the method of maximum likelihood and evaluate its properties (without proof).
- Apply the method of moments and minimum chi-square to estimate parameters from sample data.
- Use the least squares method for parameter estimation in linear regression models and interpret the results.

Recommended Books:

1. A.M. Goon, M. K. Gupta, B. Dasgupta, An Outline of Statistical Theory, Vol. II, World Press (3rd Edition), Kolkata, 2005
2. G. Casella, R.L. Berger, Statistical Inference, Thomson Duxbury (2nd Edition), 2002
3. H. M. Reid, Introduction to Statistics: Fundamental Concepts and Procedures of Data Analysis, 1st Edition
4. M. Orús Lacort, Descriptive and Inferential Statistics - Summaries of theory and Exercises solved

FM-408 Linear Algebra (3 + 0)

Vector spaces and subspaces: Vector Spaces, Subspaces, Null spaces, column spaces, Linear combination, Spanning, Linearly independent sets

Basis and Dimensions: basis, The dimension of a vector space, Rank and Nullity Change of basis

Inner Product Spaces: General inner products, weighted Euclidean inner product, Norm and Distance, angle between vectors

Orthogonality: orthogonal vectors, Orthonormal basis, Orthogonal projections, orthogonal matrices

Eigenvectors and eigenvalues: The characteristic equation, Eigenvectors and linear transformations

Linear transformations: Matrix of a linear transformation, composition of two transformations, Linear models in business, science, and engineering, Kernel and Range, Rank and Nullity of Transformation, Inverse linear transformation

Applications: Differential equations, Cubic Spline Interpolation, Markove Chains, Games of Strategy, Leontief Economic Model, Age-Specific population growth

Recommended Books:

1. D. C. Lay, Steven R. Lay, and Judi J. McDonald, Linear Algebra and Its Applications, Pearson Education (5th Edition), 2014
2. E. W. Cheney, David Ronald Kincaid, Linear Algebra: Theory and Applications, Jones & Bartlett Publishers, 2009
3. H. Anton, C. Rorres, Elementary Linear Algebra: Applications Version, Wiley (11th Edition), 2013
4. L. W. Johnson, R. D. Riess, Jimmy Thomas Arnold, Introduction to Linear Algebra, Pearson Education (6th Edition), 2015
5. T. W. Körner, Vectors, Pure and Applied: A General Introduction to Linear Algebra, Cambridge University Press, 2013

Third Year

YEAR - 3		Course No.	Course Title	Credit Hours	Course Type
	SEMESTER-V	FM501	Real Analysis	3+0	Major
		FM503	Data Analytics	2+1	Major
		FM505	Numerical Analysis-I	3+0	Major
		FM507	Differential Equations-I	3+0	Major
		FM509	Programming Language-I	2+1	Major
				Total Credit Hours	15
	SEMESTER-VI	FM502	Actuarial Mathematics	3+0	Major
		FM504	Discrete Mathematics	3+0	Major
		FM506	Numerical Analysis-II	3+0	Major
		FM508	Differential Equations-II	3+0	Major
		FM510	Programming Language-II	2+1	Major
				0+1	Compulsory
				Total Credit Hours	15

Fifth Semester

FM-501 Real Analysis (3 + 0)

The Spaces \mathbf{R} , \mathbf{R}^k , and \mathbf{C} : The Real Numbers \mathbf{R} , The Real Spaces \mathbf{R}^k , The Complex Numbers \mathbf{C}

Point-Set Topology: Bounded Sets, Classification of Points, Open and Closed Sets, Nested Intervals and the Bolzano–Weierstrass

Limits and Convergence: Definitions and First Properties, Convergence Results for Sequences, Topological Results for Sequences, Properties of Infinite Series, Manipulations of Series in \mathbf{R}

Functions; Continuity and Convergence: Continuity, Uniform Continuity, Sequences and Series of Functions

The Derivative: The Derivative for $f: D^1 \rightarrow \mathbf{R}$, The Derivative for $f: D^k \rightarrow \mathbf{R}$, The Derivative for $f: D^k \rightarrow \mathbf{R}^p$, The Derivative for $f: D \rightarrow \mathbf{C}$, The Inverse and Implicit Function Theorems

Real Integration: The Integral of $f[a, b] \rightarrow \mathbf{R}$, Properties of the Riemann Integral, Further Development of Integration Theory, Vector-Valued and Line Integrals

Recommended Books:

1. C. C. Pugh, , Real Mathematical Analysis, Springer, 2015
2. H. D. Junghenn, A Course in Real Analysis, CRC Press, 2015
3. M.A. Al-Gwaiz, S.A. Elsanousi, Elements of Real Analysis, CRC Press, 2006
4. R. L. Wheeden, Measure and Integral: An Introduction to Real Analysis, Second Edition, CRC Press, 2015
5. S. G. Krantz, Real Analysis and Foundations, Third Edition, CRC Press, 2013

FM-503 Data Analytics (2+1)

Introduction to Data Analytics: Definition of Data Analytics, Importance and Applications, Types of Data Analytics: Descriptive, Diagnostic, Predictive, Prescriptive, Data Sources, Data Warehousing, Data Cleaning and Preprocessing, Data Integration.

Exploratory Data Analysis (EDA): Descriptive Statistics, Data Visualization Techniques, Identifying Patterns and Trends, Handling Missing Data.

Machine Learning Basics: Introduction to Machine Learning, Supervised vs Unsupervised Learning, Model Evaluation Metrics, Overfitting and Underfitting, Supervised Learning Techniques, Linear Regression, Logistic Regression, Decision Trees, Neural Networks, Unsupervised Learning Techniques, Clustering Methods: K-Means, Hierarchical Clustering, Dimensionality Reduction: PCA.

Time Series Analysis: Introduction to Time Series Data, Time Series Decomposition, Forecasting Methods: ARIMA, Exponential Smoothing, Seasonality and Trend Analysis, Advanced Analytics Techniques, Data Visualization, Principles of Effective Data Visualization, Visualization Tools: Matplotlib, Seaborn, Tableau, Power BI, Interactive Dashboards.

Ethical and Legal Considerations: Data Privacy and Security, Ethical Issues in Data Analytics, Data Governance, Compliance and Regulations.

Lab/Practical: (Use any software)

- Define and explore different types of data analytics: Descriptive, Diagnostic, Predictive, and Prescriptive.
- Discuss the importance and applications of data analytics in various industries.
- Identify and analyze various data sources (structured, unstructured).
- Introduction to data warehousing concepts and architecture.
- Use MATLAB, Python or R to perform data cleaning, handling missing values, outliers, and normalization.
- Introduction to data integration techniques.
- Compute measures of central tendency (mean, median, mode) and dispersion (variance, standard deviation).
- Use Python (Pandas) to summarize and describe data sets.
- Create visualizations using Matplotlib and Seaborn.
- Identify patterns and trends through visual analysis.
- Implement Linear Regression and Logistic Regression models in Python.
- Evaluate model performance using metrics like R-squared, accuracy, precision, recall.
- Basic implementation of a neural network using TensorFlow or Keras.
- Understand overfitting and underfitting by experimenting with model complexity.
- Decompose time series data into trend, seasonality, and residual components using Python.
- Visualize decomposed components and analyze patterns.
- Implement ARIMA and Exponential Smoothing models for forecasting.
- Compare model performance and accuracy.
- Implement a simple deep learning model using TensorFlow or Keras.
- Explore basic reinforcement learning concepts and implement a simple RL agent.

Recommended Books:

1. EMC Education Services, Data science and big data analytics: discovering, analyzing, visualizing and presenting data, Wiley, 2015
2. Ghavami, P., Big data analytics methods. In Big Data Analytics Methods, 1stEdition, DeGruyter, 2019
3. Hair, J. F., Multivariate data analysis: An overview. International encyclopedia of statistical science, 7th Edition, Pearson, 2011
4. Wilks, D. S., Statistical methods in the atmospheric sciences (Vol. 100), Academic press, 2011
5. Zhang, Y., New advances in machine learning. Pearson, 2010

FM-505 Numerical Analysis-I (3 + 0)

Fundamentals: Floating Point Arithmetic, Overflow and Underflow, Absolute, Relative Error, Machine Epsilon, Forward and Backward Error Analysis, Loss of Significance, Robustness, Error Testing and Order of Convergence, Computational Complexity Condition, Solution of nonlinear algebraic equations, Newton-Raphson, Secant method, Bisection, Regula Falsi.

Linear Systems: LU Factorization, Cholesky Factorization, QR Factorization, The Gram–Schmidt Algorithm Givens Rotations, Householder Reflections, Linear Least Squares, Singular Value Decomposition, Iterative Schemes and Splitting, Jacobi and Gauss–Seidel Iterations Relaxation, Steepest Descent Method, Conjugate Gradients, Eigenvalues and Eigenvectors, The Power Method, Inverse Iteration, Deflation

Interpolation and Approximation Theory: Lagrange Form of Polynomial Interpolation, Newton Form of Polynomial Interpolation, Polynomial Best Approximations, Orthogonal polynomials, Least-Squares Polynomial Fitting, The Peano Kernel Theorem, Splines, B-Spline,

Numerical Differentiation: Finite Differences, Differentiation of Incomplete or Inexact Data

Numerical Integration: Mid-Point and Trapezium Rule, The Peano Kernel Theorem, Simpson’s Rule, Newton–Cotes Rules, Gaussian Quadrature, Composite Rules, Multi-Dimensional Integration.

Recommended Books:

1. C. Faul, A Concise Introduction to Numerical Analysis, CRC Press, 2016
2. S. Ackleh, E. J. Allen, R. B. Kearfott, P. Seshaiyer, Classical and Modern Numerical Analysis: Theory, Methods and Practice, CRC Press, 2009
3. J. C. Butcher, Numerical Methods for Ordinary Differential Equations, Wiley (3rd Edition), 2016
4. M. Al-Baali, (Ed), L. Grandinetti, (Ed), A. Purnama, Numerical Analysis and Optimization, Springer, 2015
5. W. Gautschi, Numerical Analysis, Springer, 2012

FM-507 Differential Equation-I (3 + 0)

Introduction: Definitions and Terminology, A Taste of Ordinary Differential Equations, The Nature of Solutions

The Initial Value Problem: Direction Fields, Fundamental Theorems, Solution of Simple First-Order Differential Equations, Review of first order equations.

Applications of the Initial Value Problem: Population Models, Simple Epidemic Models, Falling Bodies, Mixture Problems, Curves of Pursuit, Chemical Reactions.

N-th Order Linear Differential Equations: Basic Theory, Roots of Polynomials, Homogeneous Linear Equations with Constant Coefficients, Nonhomogeneous Linear Equations with Constant Coefficients, Higher order Homogeneous Differential equations with constant coefficients, superposition of solutions, Cauchy-Euler’s equations, Variation of parameter, Reduction of order, systems of two first order linear homogenous equations.

The Laplace Transform Method: The Laplace Transform and Its Properties, Using the Laplace Transform and Its Inverse to Solve Initial Value Problems, Convolution and the Laplace Transform, The Unit Function and Time-Delay Functions, Impulse Functions

Applications of Systems of Equations: Richardson’s Arms Race Model, Phase-Plane Portraits Modified Richardson’s Arms Race Models, Lanchester’s Combat Model, Models for Interacting Species, Epidemics, Pendulums, Duffing’s Equation, Van der Pol’s Equation, Mixture Problems.

Recommended Books:

1. C. Roberts, Ordinary Differential Equations: Applications, Models, and Computing, Chapman and Hall/CRC, 2010
2. H. Ulrich, H. Weber, Laplace, Fourier and z-Transformation, Springer, 2017.
3. J. Cronin, Ordinary Differential Equations: Introduction and Qualitative Theory, Third Edition, CRC Press, 2007
4. S. A. Wirkus, Randall J. Swift, A Course in Ordinary Differential Equations, Second Edition, Chapman and Hall/CRC, 2014
5. W. E. Boyce, R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, Wiley (10th Edition International Student Version), 2013

FM-509 Programming Language-I (2 + 1)

Introduction: Introduction to Computer Programming, Principles of Structured and Modular Programming, Overview of Structured Programming Languages

Algorithms and Problem Solving: Program Development: Analyzing Problem, Designing Algorithm/Solution, Testing Designed Solution, Translating Algorithms into Programs, Fundamental Programming Constructs

Data Types: Basics of Input and Output

Selection and Decision structures: Operators (If, If-Else, Nested If-Else, Switch Statement and Condition Operator), Repetition (While and For Loop, Do-While Loops), Break Statement, Continue Statement, Control Structures, Functions, Arrays, Pointers Records, Files (Input-Output), Testing & Debugging.

Lab/Practical:

- Explore the basic structure of a program (e.g., include statements, main function, etc.).
 - Discuss and implement principles of structured and modular programming by creating simple functions.
 - Analyze a simple problem, design an algorithm, and then translate it into a program.
 - Test the designed solution by running different test cases.
 - Discuss common programming constructs like loops, conditionals, and functions in the context of problem-solving.
 - Write programs that demonstrate the use of different data types (e.g., integers, floats, characters).
 - Implement basic input and output operations (e.g., reading from the keyboard and displaying results).
 - Write programs that use if, if-else, and nested if-else statements for decision-making.
 - Implement a program that uses the switch statement to perform different actions based on user input.
 - Explore the use of the conditional (ternary) operator in simplifying decision-making.
 - Write programs that use while, do-while, and for loops to solve repetitive tasks.
 - Implement break and continue statements within loops to control the flow of execution.
 - Write programs that define and call functions to perform specific tasks.
 - Explore the concept of function parameters, return values, and scope of variables.
 - Write programs that declare and initialize arrays, and perform basic operations (e.g., searching, sorting).
 - Implement pointer variables and demonstrate pointer arithmetic. □ Introduce basic debugging tools and techniques (e.g., setting breakpoints, stepping through code).
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- Write test cases for existing programs and identify possible errors.

Recommended Books:

1. B. W. Kernighan, Dennis M. Ritchie, The C Programming Language, Prentice Hall (2nd Edition), 2005
2. B. W. Kernighan, The C programming language, Prentice Hall (2nd Ed), 2005
3. G. Perry, The Absolute Beginner's Guide to C", Pearson Education Inc (3rd Edition), 2013
4. P. Deitel, H. Deitel, C How to Program, Prentice Hall (7th Edition), 2012
5. S. G. Kochan, Programming in C, Addison-Wesley Professional (4th Edition), 2013

Sixth Semester

FM-502 Actuarial Mathematics (3 + 0)

Introduction: The economics of insurance, the future lifetime random variables (discrete and continuous), force of mortality, Life Tables: Select, Ultimate and Select and Ultimate, Annuities and Assurance in both discrete and continuous case, Commutation Functions

Function: Straightforward functions, Estimation in straightforward function, Main variables, benefit, disability, long term care contract, Calculation of net premiums and reserves. Future expenses, Bonus influence of inflation. Equation of value for fixed benefits and variable benefits. Techniques of discounted emerging costs, pricing, reserving and assessing of profitability.

Decision theory: Fundamental concepts of Bayesian statistics and its use. Probabilities and moments of loss distributions, Construction of risk models. Concepts of credibility theory, rating systems, techniques for analyzing delay (or run off) triangle and projecting the ultimate position

Survival distributions: age at death, life tables, fractional ages, mortality laws, select and ultimate life tables. Life insurance: actuarial present value function (apv), moments of apv, basic life insurance contracts, portfolio. Life annuities: actuarial accumulation function, moments of apv, basic life annuities. Net annual premiums: actuarial equivalence principle, loss function, accumulation type benefits.

Actuarial reserves: Prospective loss function, basic contracts, recursive equations, fractional durations.

Recommended Books:

1. A.K. Gupta, Tamas Varga, An Introduction to Actuarial Mathematics, Springer Netherlands, 2002
2. M. Micocci, G. N. Gregoriou, Giovanni Batista Masala, Pension Fund Risk Management: Financial and Actuarial Modeling, Chapman and Hall/CRC, 2010
3. M. V. Wüthrich, M. Merz, Financial Modeling, Actuarial Valuation and Solvency in Insurance, Springer-Verlag Berlin Heidelberg, 2013
4. P. J. Boland, Statistical and Probabilistic Methods in Actuarial Science, Chapman and Hall/CRC, 2007
5. V. I. Rotar, Actuarial Models: The Mathematics of Insurance, Second Edition, Chapman and Hall/CRC, 2014

FM-504 Discrete Mathematics (3 + 0)

Logic: Propositions and Truth Values, Logical Connectives and Truth Tables, Tautologies and Contradictions, Logical Equivalence and Logical Implication, The Algebra of Propositions, Arguments, Formal Proof of the Validity of Arguments, Predicate Logic, Arguments in Predicate Logic

Mathematical Proof: The Nature of Proof, Axioms and Axiom Systems, Methods of Proof.

Sets: Sets and Membership, Subsets, Operations on Sets, Counting Techniques, The Algebra of Sets, Families of Sets, The Cartesian Product.

Relations: Relations and Their Representations, Properties of Relations, Intersections and Unions of Relations, Equivalence Relations and Partitions, Order Relations, Hasse Diagrams, Relational Databases

Functions: Functions, Composite Functions, Injections and Surjections, Bijections and Inverse Functions, More on Cardinality, Functional Dependence and Normal Forms

Boolean Algebra: Introduction, Properties of Boolean Algebras, Boolean Functions, Switching Circuits, Logic Networks, Minimization of Boolean Expressions

Graph Theory: Introductions and types, Paths and Cycles, Isomorphism of Graphs, Planar Graphs, Directed Graphs, Trees and applications of trees

Applications of Graph Theory: Rooted Trees, Sorting, Searching Strategies, Weighted Graphs, The Shortest Path and Traveling Salesman Problems, graph colouring, Networks and Flows

Recommended Books:

1. J. Gallier, Discrete Mathematics, Springer, 2011
2. K. H. Rosen, Handbook of Discrete and Combinatorial Mathematics, 1999 Chapman and Hall/CRC
3. R. Garnier, J. Taylor, Discrete Mathematics: Proofs, Structures and Applications, CRC Press (3rd Edition), 2009
4. S. Govindarajan, A. Maheshwari, Algorithms and Discrete Applied Mathematics, Springer, 2016
5. W. Conradie, V. Goranko, Logic and Discrete Mathematics: A Concise Introduction, Wiley, 2015

FM-506 Numerical Analysis-II (3 + 0)

Approximations: Difference Equations (Homogeneous and non-homogeneous): Formation, Solutions directly.

Ordinary Differential Equations: One-Step Methods, Multistep Methods, Order, and Consistency, Order Conditions, Stiffness and A-Stability, Adams Methods, Backward Differentiation Formulae, Rational Methods, Runge–Kutta Methods

Partial Differential Equations: Classification of PDEs, Parabolic PDEs, Elliptic PDEs, Parabolic PDEs in Two Dimensions, Hyperbolic PDEs, Spectral Methods

Two-Point Boundary Value Problem: The Maximum Principle, Green’s Function, Variational Formulation.

Elliptic Equations: A Maximum Principle, Dirichlet’s Problem for a Disc. Poisson’s Integral, Fundamental Solutions. Green’s Function, Variational Formulation of the Dirichlet Problem, A Neumann Problem, Regularity

Finite Difference Methods for Elliptic Equations: A Two-Point Boundary Value Problem, Poisson’s Equation Theory, Error Estimates, A Posteriori Error Estimate,

Parabolic Equations: The Pure Initial Value Problem, Solution by Eigenfunction Expansion, Variational Formulation. Energy Estimates, A Maximum Principle

Finite Difference Methods for Parabolic Problems: The Pure Initial Value Problem, The Mixed Initial-Boundary Value Problem

Hyperbolic Equations: Characteristic Directions and Surfaces, The Wave Equation, First Order Scalar Equations, Symmetric Hyperbolic Systems

Finite Difference Methods for Hyperbolic Equations: First Order Scalar Equations, Symmetric Hyperbolic Systems, The Wendroff Box Scheme

Recommended Books:

1. J. D. Faires, Richard L. Burden, Numerical Methods, Cengage Learning (4th Edition), 2013
2. N. Nassif, D. K. Fayyad, Introduction to Numerical Analysis and Scientific Computing, CRC Press, 2013
3. R. Li, Z. Chen, W. Wu, Generalized Difference Methods for Differential Equations: Numerical Analysis of Finite Volume Methods, CRC Press, 2000
4. S. Rout-Hoolash, C-H Lai, Computing Financial Derivatives: A Finite-Difference Approach, CRC Press, 2017
5. S. S. Ray, Numerical Analysis with Algorithms and Programming, CRC Press, 2016

FM-508 Differential Equations-II (3 + 0)

One-Dimensional Hyperbolic Equations: Derivation of the Basic Equations, Boundary and Initial Conditions, Other Boundary Value Problems: Longitudinal Vibrations of a Thin Rod, Torsional Oscillations of an Elastic Cylinder, D’Alembert Method, Semi-infinite String Oscillations and the Use of Symmetry Properties, Finite Intervals: The Fourier Method for One-Dimensional Wave Equations, Generalized Fourier Solutions, Energy of the String

One-Dimensional Parabolic Equations: Physical Problems Described by Parabolic Equations, Boundary Value Problems, The Principle of the Maximum, Correctness, and the Generalized Solution, The Fourier Method of Separation of Variables for the Heat, Conduction Equation, Heat Conduction in an Infinite Bar, Heat Equation for a Semi-infinite Bar.

Elliptic Equations: Elliptic Partial Differential Equations, The Dirichlet Boundary Value Problem for Laplace’s Equation in a Rectangular Domain, Laplace’s and Poisson’s Equations for Two-Dimensional Domains with Circular Symmetry, Laplace’s Equation in Cylindrical Coordinates

Bessel Functions: Boundary Value Problems Leading to Bessel Functions, Bessel Functions of the First Kind, Properties of Bessel Functions of the First Kind, Bessel Functions of the Second Kind.

Legendre Functions: Boundary Value Problems Leading to Legendre Polynomials, Generating Function for Legendre Polynomials, Recurrence Relations, Orthogonality of Legendre Polynomials.

Recommended Books:

1. Jungel, R. Manasevich, P.A. Markowich, H. Shahgholian, Nonlinear Differential Equation Models, Springer-Verlag Wien, 2004
2. V. Dobrushkin, Applied Differential Equations: The Primary Course, Chapman and Hall/CRC, 2014
3. J. S. Petrovic, Advanced Calculus: Theory and Practice, Chapman and Hall/CRC, 2013
4. M. W. Wong, Partial Differential Equations: Topics in Fourier Analysis, CRC Press, 2013
5. P. Dyke, An Introduction to Laplace Transforms and Fourier Series, Springer, 2014

FM-510 Programming Language-II (2 + 1)

Introduction: Evolution of Object Oriented Programming (OOP), Object Oriented concepts and principles, problem solving in Object Oriented paradigm

Operators and Process: OOP design process, classes, functions/methods, objects and encapsulation; constructors and destructors, operator and function/method overloading, association, aggregation, composition, generalization, inheritance and its types, derived classes, abstract and concrete classes, virtual functions, polymorphism, exception handling.

Lab/Practical:

- Write a simple program demonstrating the basic principles of OOP (e.g., creating a class and objects).
- Discuss and implement encapsulation by creating a class with private attributes and public methods.
- Compare and contrast OOP with procedural programming through examples.
- Define classes with attributes and methods, and create objects of those classes.
- Explore the concept of constructors and destructors by initializing objects and managing memory.
- Implement a program demonstrating the use of multiple objects interacting with each other.
- Implement single and multiple inheritance in programs, and explore their advantages.
- Create abstract and concrete classes, and demonstrate their usage.
- Write a program that uses virtual functions to achieve polymorphism. Overload basic operators (e.g., +, -, *) for user-defined classes.

- Implement function overloading by creating multiple functions with the same name but different parameters.
- Discuss and explore the practical use cases of overloading in real-world scenarios.
- Create a program that demonstrates association between classes (e.g., a Person class associated with an Address class).
- Implement aggregation and composition by building classes that represent complex objects composed of simpler objects.
- Discuss the differences between these relationships and their significance in OOP design.
- Implement a hierarchy of classes using generalization (e.g., creating a base Shape class and derived classes like Circle and Rectangle).
- Discuss and implement abstract classes and interfaces, and their role in achieving abstraction in OOP.
- Design a program that showcases the use of both concrete and abstract classes.
- Write programs that handle runtime errors using try, catch, and throw statements.

Recommended Books:

1. G. Perry, The Absolute Beginner's Guide to C", Pearson Education Inc (3rd Edition), 2013
2. P. Deitel, H. Deitel, C++: How to Programme, , Pearson (5th Edition)
3. P. Deitel, H. Deitel, C How to Program, Prentice Hall (7th Edition), 2012
4. R. Lafore, Object Oriented Programming in C++, (3rd Edition),
5. S. G. Kochan Programming in C, Addison-Wesley Professional (4th Edition), 2013

Fourth Year

YEAR - 4		Course No.	Course Title	Credit Hours	Course Type	
	SEMESTER - VII	FM601	Operations Research	3+0	Major / (Opt)	
		FM603	Financial Derivatives	3+0	Major / (Opt)	
		FM605	Stochastic Processes	3+0	Major / (Opt)	
			Optional-I	3+0	Major / (Opt)	
			Optional-II	3+0	Major / (Opt)	
		FM600.1	Field Experience / Internship	0+3	Major / (Opt)	
		Total Credit Hours			18	
	SEMESTER - VIII	FM602	Financial Report Writing	3+0	Major / (Opt)	
		FM604	Portfolio Theory & Management	3+0	Major / (Opt)	
		FM606	Stochastic Calculus	3+0	Major / (Opt)	
			Optional-I	3+0	Major / (Opt)	
			Optional-II	3+0	Major / (Opt)	
		FM600.2	Capstone Project	0+1 3	Major / (Opt)	
		Total Credit Hours			18	

Seventh Semester

FM-601 Operations Research (3 + 0)

Introduction: Characteristic of Operations Research (OR), Scope of OR, Objective of OR, Models in OR

Transportation Problems: Definition of transportation model, North-west corner method, Least cost or matrix minima method, Vogel's approximation method, Degeneracy in transportations problem, test for optimality.

Assignment Problem: Introduction, Hungarian method, Non-square matrix, Restriction on assignments

Goal Programming: Goal Programming (Pre-emptive, Non pre-emptive), Integer Programming, Binary Integer Programming (BIP) Applications

Sequencing Models: Introduction, Basic assumptions, Travelling salesman problem

Inventory Management: Definition, Inventory classification, Objective of inventory control, Deterministic inventory models, Probabilistic models

Pert and CPM: Introduction, Definition, Rules for network construction, Fulkerson's rule for numbering the events, Float or slack values, PERT computations, Probability of meeting the scheduled dates, Time-cost relationships and project crashing, Updating (PERT and CPM)

Recommended Books:

1. Emrouznejad, W. Ho, Applied Operational Research with SAS, Chapman & Hall/CRC, 2011
2. A.R. Ravindran, Operations Research Applications, CRC Press, 2008
3. E. Grigoroudis, M. Doumpos, Operational Research in Business and Economics, Springer, 2017
4. G.S.R. Murthy, Applications of Operations Research and Management Science, Springer, 2015
5. J.H. Greenberg, Tutorials on Emerging Methodologies and Applications in Operations Research, Springer, 2005

FM-603 Financial Derivatives (3 + 0)

Fundamental derivatives concept, Analysis of derivative securities, Pricing of options and futures contracts, Arbitrage, Hedging, Spreads, Portfolio insurance, Derivatives for financial risk management, Applications of futures and forwards, Volatility, Volatility products, Interest rate derivatives, Mortgages, Credit risk, Blockchain and Bitcoins, Principles of Swaps, Structural models of Credit Risk, Market operations on stock index, Foreign Currencies

Recommended Books:

1. D. M. Chance, R. Brooks, An Introduction to Derivatives and Risk Management, Southwestern Cengage Learning (10th Edition), 2014
2. J.C. Hull, Options, Futures, and Derivative Securities, Prentice Hall (9th Edition), 2014
3. R. McDonald, Derivative Markets, Addison Wesley (2nd Edition), 2006
4. R. Whaley, Derivatives: Markets, Valuation, and Risk Management, John Wiley (1st Edition), 2006
5. Sundaram, Das, Derivatives Principles and Practice, McGraw-Hill Irwin (2nd Edition), 2015

FM-605 Stochastic Processes (3 + 0)

Fundamentals of probability, Laplace transform, Stochastic process, Poisson process with different types of events, Compound and nonhomogeneous Poisson process, Renewal reward process, Renewal equation, Regenerative process, Queuing systems and PASTA, Discrete and continuous time Markov chains, Multi-step transition and reaching probabilities, Stationary distribution, Exponential Queuing systems, Standard Brownian motion, Single stock market model

Recommended Books:

1. Papoulis & S.U. Pillai, Probability, Random Variables and Stochastic Processes, McGraw-Hill (4th Edition), 2002
2. G.F. Lawler, Introduction to Stochastic Processes, Chapman and Hall/CRC Probability Series (2nd Edition), 2006
3. M. Liao, Applied Stochastic Processes, Chapman and Hall/CRC Press, 2013
4. S.M. Ross, Introduction to Probability Models, Academic Press (11th Edition), 2014
5. U. Hassler, Stochastic Process and Calculus, Springer, 2016

Eighth Semester

FM-602 Financial Report Writing (3+0)

Overview of Financial Reporting and Financial Statement Analysis: Overview of Financial Statement Analysis, Industry Analysis, Porter's Five Forces Classification, Economic Attributes Framework, Company Strategic framework, Assessing the Quality of the Financial Statements, Balance Sheet, Measuring Financial Position.

Asset and Liability Valuation and Income Measurement: Asset and Liability Valuation, Historical Value: Acquisition Cost, Adjusted Acquisition Cost, Present Value of Cash Flows, Historical Interest Rates, Current Values: replacement Cost, Net Realizable Value, Present Value of Cash Flows, Using Current Interest rates, GAAP Valuations

Income Flows Versus Cash Flows: Key Relationships in the Dynamic of a Business, Income Flows, Cash Flows and Life Cycle relations, Net Income and Cash Flow from Operations, Investing and Financing Activities, Illustrations of Cash Flow Relations, Preparing the Statement of Cash Flows, Algebraic Formulation

Profitability and Risk Analysis: Profitability Analysis, Rate of Return on Assets, Disaggregating ROA, Analyzing Total Assets Turnover, Rate of Return on Common Shareholders' Equity, Calculating EPS, Framework for Risk Analysis, Analyzing Short-term Liquidity Risk, Analyzing Long-term Solvency Risk, Analyzing Credit Risk, Analyzing Bankruptcy Risk, Market Equity Beta Risk, Financial reporting manipulation Risk, Motivation for Earnings.

Forecasting Pro-Forma Financial Statements: Overview, Introduction to Forecasting, Preparing Pro-Forma Financial Statements, Forecasting financial statements, Using FSAP to Prepare Pro-Forma Financial Statements, Projecting Financial statements, Shortcut Approaches to Forecasting, Analyzing Pro-Forma Financial Statements and Sensitivity Analysis

Ratios and Financial Analysis: Purpose and Use of Ratios, Common-Size Statements, Activity Analysis, Liquidity Analysis, and Long term Debt and Solvency Analysis, Ratios: An Integrated Analysis, Analysis of Firm Performance, Economics Characteristics and Strategies, Classification and Partitioning of Ratios.

Analysis of Inventories: Inventory and Cost of Goods Sold: Stable Prices and Fluctuating Prices, Cost of Goods Sold, LIFO Versus FIFO: Income, Cash Flow and Working Capital Effects, Adjustment from LIFO to FIFO, Adjustment of Inventory Balances, Adjustment of Cost of Goods Sold, Adjustment of Income to Current Cost Income, Changes in Financial Ratios: FIFO Versus LIFO.

Analysis of Long Lived Assets: Acquiring the Asset: The Capitalization Decision, Financial Statement Effects, and Need for Analytic Adjustments, Valuation Implications, Other Valuation and Economic Consequences.

Analysis of Financing Liabilities and Income taxes : Balance Sheets Debt, Current Liabilities, Long Term Debt, Debt with Equity Features, Effect of Changes in Interest Rates, Retirement of Debt Prior to Maturity. Accounting for Income Taxes, Basic Issues, Deferred taxes: Alternative Approaches.

Recommended Books:

1. C. Gibson, Financial Reporting and Analysis: Using Financial Accounting Information, Cengage Learning (13th Edition), 2013
2. D. Young, J. Cohen, Corporate Financial Reporting and Analysis, John Wiley & Sons (3rd Edition), 2013
3. F. Mittelstaedt, L. Revsine, B. Johnson, L. Soffer, D. Collins, Financial Reporting and Analysis, McGraw-Hill Education (7th Edition), 2017
4. J. Wild, K. R. Subramanyam, Financial Statement Analysis, McGraw-Hill Education (11th Edition), 2013
5. M. J. Sandretto, Cases in Financial Reporting, Cengage Learning, 2012

FM-604 Portfolio theory and Management (3 + 0)

Portfolio mathematics, Risk and Return, Utility theory, Optimal portfolio selection and allocation, Markowitz mean-variance portfolio analysis, Models of risk and Expected returns, Capital asset pricing model, Arbitrage pricing theory, Market efficiency, Global portfolio diversification, Applied portfolio strategies and performance evaluation, The Black-Litterman model, Portfolio decision quality, Multicriteria methods in Portfolio decision analysis

Recommended Books:

1. Salo, J. Keisler, A. Morton, Portfolio Decision Analysis, Springer, 2011
2. H. Hult, F. Lindskog, O. Hammarlid, C.J. Rehn, Risk and Portfolio Analysis, Springer, 2012
3. O. Yu, Technology Portfolio Planning and Management, Springer Us, 2006
4. P. Xidonas, G. Mavrotas, T. Krintas, J. Psarras, C. Zopounidis, Multicriteria Portfolio Management, 2012
5. W. Marty, Portfolio Analytics, Springer, 2015

FM-606 Stochastic Calculus (3 + 0)

Introduction: Brownian motion, Stochastic Integration, Itô's formulas, Recurrence and transience, Lévy's Theorem, Burkholder Davis Gundy Inequalities, Martingales Adapted to Brownian Filtrations

Applications: Stochastic differential equations, Applications to Brownian Motion, Feller's Test, Greens function, Harris Chains, Girsanov's Theorem, Radon-Nikodym derivative, Prokhorov's Theorem, Skorohod's Existence theorem for Stochastic differential equation, Donsker's Theorem, Feynman-Kac formula, Diffusion equations, Black-Scholes models, Option pricing, Interest rate models

Recommended Books:

1. B. Oksendal, Stochastic Differential Equations, 6th Ed. Universitext, Springer-Verlag, Berlin, 2003
2. D. Lamberton, B. Lapeyre, Introduction to Stochastic Calculus Applied to Finance, Chapman and Hall/CRC Financial Mathematics Series, 2007
3. J. Le Gall, Brownian Motion, Martingales, and Stochastic Calculus, Springer, 2016
4. J.M. Steele, Stochastic Calculus and Financial Applications, Springer, 2003
5. R. Durrett, Stochastic Calculus: A Practical Introduction

Optional Courses for 7th & 8th Semesters

	Course No.	Optional Course Title	Credit Hours
1	FM-607	Corporate Finance	3+0
2	FM-608	Games, Markets and Information	3+0
3	FM-609	Management Information System	3+0
4	FM-610	Financial Modelling and Simulation	3+0
5	FM-611	Discrete time Modelling and Derivative Security	3+0
6	FM-612	Life Insurance and Institutional Investment	3+0
7	FM-613	Principles of Risk	3+0
8	FM-614	Global Financial Market	3+0
9	FM-615	Equities Foreign Exchange and Commodities Modelling	3+0
10	FM-616	Interest rate and Credit Modelling	3+0
11	FM-617	Financial Computer Simulation- I	2+1
12	FM-618	Financial Computer Simulation- II	2+1
13	FM-619	Analysis of Financial Time Series	3+0

FM-607 Corporate Finance (3 + 0)

Goals of Financial Management, Conflicts between Company Stakeholders, Financial Markets, FV/PV of Cash Flows and Cash Flow Streams, Compounding/Discounting, Multiple Compounding and Discounting, Different compounding periods, Amortized Loans, Terminology and characteristics of bonds, Bond valuation, Bond yields, Terminology and characteristics of stocks, Stock valuation models, Growth opportunities & PVGO model, Expected Rate of Return, Standard Deviation of Returns, Relationship between Risk and Return, Measuring Portfolio Risk, Diversification, The Capital Asset Pricing Model (CAPM), Cost of Debt, Cost of Equity, Weighted Average Cost of Capital, Capital budgeting decision rules, NPV versus IRR, Independent and Mutually exclusive Projects, Cash Flow Estimation, Identifying Relevant Cash Flows, Evaluating Capital Budgeting Projects, Sensitivity Analysis, Scenario Analysis, Real Options, Decision Trees, Financial Leverage and Firm Value, Financial Distress Costs, Estimating the Optimal Capital Structure, Capital Structure Theory

Recommended Books:

1. J. Berk, P. DeMarzo, Corporate Finance, 2nd Edition, Pearson, Boston, 2010
2. Ross, Westfield, Jordon, Fundamentals of Corporate Finance, 9th Edition, The McGraw-Hill Companies, 2009
3. Brealey, Myers, Allen, Principles of Corporate Finance, 9th Edition, The McGraw-Hill Companies, 2007
4. Brigham, Ehrhardt, Financial Management: Theory and Practice, 10th Edition, Cengage Learning, 2002
5. Horne, Wachowicz, Fundamentals of Financial Management, 12th Edition, Pearson Education, 2005

FM-608 Games, Markets and Information (3 + 0)

Combinatorial Optimisation: The Shortest Path Problem, The Minimal Spanning Tree Problem, Flows in Networks, Scheduling Theory, Computational Complexity, Game Theory: Definition and explanation of some important terms, Two person zero-sum game, Games without saddle points, Theory of Games: Matrix Games – Pure Strategies, Matrix Games – Mixed Strategies, Bimatrix Games, N-person Games, Multi-criteria Decision Theory, AHP and TOPSIS methods.

Recommended Books:

1. F.M. Garcia, D.T. Gonzalez, Strategy and Game Theory, Springer, 2016
2. El Rhalibi, F. Tian, Z. Pan, B. Liu, E-Learnings and Games, Springer, 2016
3. H. Peters, Game Theory, Springer, 2015
4. M. Gairing, R. Savani, Algorithm Game Theory, Springer, 2016
5. T. Ichiishi, T. Marschak, Markets, Games, and Organization, Springer, 2003

FM-609 Management Information System (3 + 0)

Foundations of Information Systems in Business, Competing with Information Technology, The Interneted E-Business Enterprise, Electronic Business Systems, Electronic Commerce Systems, E-Business Decision Support, Developing E-Business Strategies, Developing E-Business Solutions, Security and Ethical Challenges of E-Business, Enterprise and Global Management of E-Business Technology, Computer Hardware, Computer Software, Data Resources Management, Telecommunications and Networks

Recommended Books:

1. J.A. O'Brien, Management Information Systems: Managing Information Technology in the E-Business Enterprise, 5th Edition, McGraw-Hill/Irwin, 2002
2. J. N. Morgan, Application Cases in MIS: Using the Internet and Spreadsheet and Database Software, 4th Edition, McGraw-Hill/Irwin, 2002
3. K.C. Laudon, J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Edition, Pearson/Prentice-Hall, New Jersey, 2007
4. C.K. Laudon, J.P. Laudon, Essentials of Management Information Systems, 10th Edition, Pearson Prentice-Hall, 2012
5. T. Lucey, Management Information Systems, 9th Edition, Thompson, 2005

FM-610 Financial Modelling and Simulation (3 + 0)

Difference equations, Homogenous and non-homogenous equations, Prey-Predator Equation (discrete form), Applications in Finance, Logistic Equation, Logistic Yeast Culture.

Stationary Time Series: Autoregressive moving average (ARMA) process, Nonstationary Processes: ARIMA Model Building and Testing: Estimation, Box Jenkins, Criteria for choosing between models, Diagnostic tests. Forecasting: Box-Jenkins, Prediction bounds. Testing for Trends and Unit Roots: Dickey-Fuller, ADF, Structural change, Trend-stationarity vs difference stationarity, Seasonality and Volatility: ARCH, GARCH, ML estimation, Multi equation Time Series Models: Spectral Analysis, Generation of pseudo – random numbers, simulation methods: Generation of Uniform Random Numbers, Generation of Gaussian White Noise, Simulation Using a State-Space Model, inverse transform and acceptance-rejection, design issues and sensitivity analysis.

Recommended Books:

1. G. Kitagawa, Introduction to Time Series Modelling, Chapman & Hall/CRC, 2010
2. G.B. Louis, A. Gilbert, Modelling and Simulation, Springer-Verlag London, 2013
3. W. Andrzej, L. Henrik, Modelling Foundations and Applications, Springer International Publishing, 2016
4. I.C. Dima, M. Man, Modelling and Simulation in Management, Springer, 2015
5. R. Prado, M. West, Time Series: Modelling, Computation and Inference, Chapman & Hall/CRC, 2010
6. K. Koyamada, S. Tamura, O. Ono, Systems Modelling and Simulation, Springer Japan, 2007
7. L. Bernard, U. Nyambuu, Dynamic Modeling, Empirical Macroeconomics, and Finance, Springer, 2016

FM-611 Discrete time Modelling and Derivative Security (3 + 0)

Building Blocks, Ito's Lemma, Stochastic Differential Equations, The Factor Model Approach to Arbitrage Pricing, Constructing A Factor Pricing Framework, Equity Derivatives, Derivatives securities, Interest and Credit Derivatives, Hedging, Fair Pricing, The Road to Risk Neutrality, Stock price Evolution, European Puts and Calls, Cox-Ross-Rubinstein model, American call and Put options, Stochastic interest rates, Transaction Costs

Recommended Books:

1. C. Chiarella, X.Z. He, C.S. Nikitopoulos, Derivative Security Pricing, Springer US, 2015
2. D. Furihata, T. Matsuo, Discrete Variational Derivative Method: A Structure-Preserving Numerical Method for Partial Differential Equations, Chapman and Hall/CRC, 2010
3. J.A. Primbs, A factor Model Approach to Derivative Pricing, Chapman & Hall/CRC, 2016
4. K. Back, A Course in Derivative Securities, Springer US, 2005
5. R. Stewart, R. Brooks, K. Kotiaids, D.J. Van Der Zee, Conceptual Modelling for Discrete-Event Simulation, CRC Press, 2010
6. S.R. Pliska, Introduction to Mathematical Finance, Blackwell, 2001

FM-612 Life Insurance and Institutional Investment (3 + 0)

Introduction to Insurance, Introduction to pension savings, Calculation of pensions, Life Insurance, Legal Principles of Life Insurance, Life Insurance Products, Types of Insurance, Applications of Life Insurance, Pricing and Valuation in Life Insurance, Provident Funds and education Funds, Pension-new funds, older funds, LTC, Distribution Channels (the Bachelor reform-insurance agents and pension advisers, Property and Liability Loss Exposures, Introduction to Capital market, Capital Market and financial institution-investment principles, The stock market crisis, Market reforms Bachar Reform, Hodak Committee

Recommended Books:

1. C. d'Aspremont, V.A. Ginsburgh, H.R. Sneessens, F. Spinnewyn, Institutional and Financial Incentives for Social Insurance, Springer, 2002
2. F.J. Fabozzi, Institutional Investment Management: Equity and Bond Portfolio strategies and Applications, Wiley, 2009
3. J. Laurent, R. Norberg, F. Planchet, Modelling in Life Insurance- A Management Perspective, Springer, 2016
4. M. Koller, Life Insurance Risk Management Essentials, Springer, 2011
5. P. Parodi, Pricing in General Insurance, Chapman & Hall/CRC, 2014

FM-613 Principles of Risk (3 + 0)

Concepts of Risk: Subjective and objective risks, Static and dynamic risks, Pure and speculative risks, Fundamental and particular risk, Operational and strategic risk, Economic and social cost of risk, Economic Theory of Risk: Expected Utility Hypothesis, Risk preferences, Risk premium, Measurement of risk attitudes, Risk aversion coefficient, Risk Measurement: Loss frequency and severity, Expected value and variance, Degree of risk, Loss distributions, Stochastic dominance, Value at risk, Corporate Risks & Rationale of Corporate Risk Management: Overview of key pure risks, Overview of key financial risks, Rationales of corporate risk management, Holistic/integrated risk management, Risk Management Organization and Process: Objectives of risk management and risk management policy statement, Risk manager and responsibility, Risk management decisions, Ethical aspects of risk management decisions, Identification and evaluation of risks, Risk Mapping, Choosing risk management methods, Implementation, monitoring & review of the chosen methods, Major Tools of Risk Management: Risk avoidance, Risk reduction & loss control, Risk retention & self-insurance, Risk transfer via insurance, Concept of financial risks hedging, Alternative risk transfer.

Recommended Books:

1. E. Baranoff, Risk Management and Insurance, John Wiley, 2004
2. E.R. George, Principles of Risk Management and Insurance, latest Edition, Person Education.
3. J.S. Trieschmann, R.E. Hoyt, D. Sommer, Risk Management and Insurance, 12th Edition, South-Western College Publishing, 2005
4. S. Roeser, R. Hillerbrand, P. Sandin, M. Peterson, Essentials of Risk Theory, Springer, 2013
5. S.E. Harrington, G.R. Niehaus, Risk Management and Insurance, 2nd Edition, McGraw-Hill, 2003
6. V. Huynh, V. Kreinovich, S. Sriboonchitta, K. Suriya, Econometrics of Risk, Springer, 2015

FM-614 Global Financial Market (3 + 0)

Introduction Financial Market, Asset pricing, Security, Investment companies and investment process, Performance of securities, Asset Backed securities, Risk and return, Diversification, Index models and the capital Asset pricing model (CAPM), Market Indexes, Fama-French Factors, Arbitrage pricing theory, Portfolio Evaluation, Alpha, Market efficiency, Behavioural Finance, Bubbles and Market crashes, Equity valuation, Dividend discount models, Price earnings ratios, Equity trading, margins, Short Sales, Bond prices and Yields, Bond Portfolios, Default risk, Credit default swaps, The credit crisis, Dimensional Fund Advisors, Money Management Industry, Derivatives markets, Option pricing, Bonds with embedded options, Black-Scholes formula, Future basics, Future pricing and commodities, Hedge Funds and crashes, Macroeconomics analysis

Recommended Books:

1. Bodie, Zvi, A. Kane, A. Marcus, Investments, McGraw-Hill, 7th Edition
2. Chakrabarti, C. Sen, Anatomy of Global Stock Market Crashes, Springer, 2012
3. G. Bekaert, R.J. Hodrick, International Financial Management, Prentice Hall, 2008
4. Malkiel, Burton, A Random Walk Down Wall Street, Norton, 8th Edition, 2004
5. S. Nayak, The Global Financial Crisis, Springer, 2013

FM-615 Equities Foreign Exchange and Commodities Modelling (3 + 0)

Arbitrage-free pricing theory and equity markets: Replication strategies, risk-neutral Pricing, Brownian motion, Ito calculus, First and Second Fundamental Theorems of Asset Pricing, examples from equity markets, Foreign Exchange Markets: Modelling of FX markets, foreign and domestic risk-neutral measures, forward measures, triangular arbitrage and the carry trade, Commodity Markets: Modelling of electricity, gas and metal prices, jump diffusion processes, pricing of energy derivatives

Recommended Books:

1. C. Ullrich, Forecasting and Hedging in the Foreign Exchange Markets, Springer, 2009
 - A. Eydeland, K. Wolyniec, Energy and Power Risk Management: New Development in Modelling, Pricing and Hedging, Wiley, 2000.
2. F.J. Fabozzi, Institutional Investment Management: Equity and Bond Portfolio strategies and Applications, Wiley, 2009
3. R. Francione, R.A. Schwartz, Equity Markets in Transition, Springer, 2017
4. S. Shreve, Stochastic Calculus for Finance II: Continuous Time Models, Springer Finance, 2004.
5. U. Lossen, Portfolio Strategies of Private Equity Firms, Springer, 2007
6. Z. Vukanovic, Foreign Direct Investment Inflows into the South East European Media Market, Springer, 2016

FM-616 Interest rate and Credit Modelling (3 + 0)

Basics of interest rates and bond markets, Vasicek and Cox-Ingersoll-Ross bond price models, Black-Derman-Toy binomial model, Short-rate models, Heath-Jarrow-Morton models, Rational valuation of derivative securities, Structural models of default: Black-Scholes-Merton model, First-passage models of default, Hazard function approach: hazard function and hazard rate, bond pricing with recovery at maturity or at the default-time, Pricing of simple default able claims

Recommended Books:

1. D. Filipovic, Term-Structure Models: A graduate Course, Springer, 2009
2. L. Wu, Interest Rate Modelling: Theory and Practice, Chapman & Hall/CRC, 2009
 - I. Beyna, Interest Rate Derivatives, Springer, 2013
3. D. Brigo, F. Mercurio, Interest Rate Models-Theory and Practice, Springer, 2006
4. Z. Grbac, W.J. Runggaldier, Interest Rate Modeling: Post-Crisis Challenges and Approaches, Springer, 2015
5. C. Bluhm, L. Overbeck, C. Wagner, Introduction to Credit Risk Modeling, 2nd Edition, Chapman & Hall/CRC, 2010
6. N. Wagner, Credit Risk: Models, Derivatives, and Management, Chapman & Hall/CRC, 2008

FM-617 Financial Computer Simulation- I (2 + 1)

Analytical Thinking What Is Financial Analytics? Laboratory for Data Science, Professional Analytics World, Language Features: Functions, Assignment, Arguments, and Types, Language Features: Binding and Arrays, Error Handling, Numeric, statistical, and Character Functions, Data Frames and Input–Output.

Financial Statistics Probability, Combinatorics, Mathematical Expectation, Sample Mean, Standard Deviation, and Variance, Sample Skewness and Kurtosis, Financial Returns, Capital Asset Pricing Model

Financial Securities, Bond Investments, The Housing Crisis, The Euro Crisis, Securities Datasets and Visualization, Adjusting for Stock Splits, Adjusting for Mergers, Plotting Multiple Series, Securities Data Importing, Securities Data Cleansing, Securities Quoting

Dataset Analytics and Risk Measurement Generating Prices from Log Returns, Normal Mixture Models of Price Movements, Sudden Currency Price Movement

The Sharpe Ratio Sharpe Ratio Formula, Time Periods and Annualizing, Ranking Investment Candidates, The Quantmod Package, Measuring Income Statement Growth, Sharpe Ratios for Income Statement Growth

All the contents may be cover with software (e.g **R**, **PYTHON** etc.)

Lab/Practical:

- Introduction to financial analytics and its importance in decision-making.
- Install and configure R/Python for financial simulations.
- Explore basic language features like functions, assignment, arguments, and data types in R/Python.
- Implement and manipulate arrays and data frames.
- Write programs that include error handling mechanisms for robust financial simulations.
- Explore numeric, statistical, and character functions for data analysis.
- Calculate probability, combinatorics, and mathematical expectations in financial contexts.
- Write scripts to compute sample mean, standard deviation, variance, skewness, and kurtosis of financial data.
- Analyze financial returns and explore their distribution using statistical functions.
- Write a program to calculate expected returns using the CAPM formula.
- Analyze real-world financial data to evaluate the risk and return of different assets.
- Visualize the relationship between risk and return for a portfolio of assets.
- Import and cleanse securities data from various sources.
- Adjust stock prices for splits and mergers, and plot multiple time series for visualization.
- Discuss and simulate scenarios related to the Housing Crisis and the Euro Crisis using historical data.
- Generate price data from log returns and analyze price movements using normal mixture models.
- Simulate sudden currency price movements and assess their impact on financial portfolios.
- Visualize and interpret the results of risk measurements through graphical outputs.
- Implement the Sharpe Ratio formula and calculate it for different financial instruments.
- Rank investment candidates based on their Sharpe Ratios and time-period adjustments.
- Import financial datasets from different formats (CSV, Excel, APIs) into R/Python.
- Clean and preprocess the data to handle missing values and anomalies.
- Create comprehensive visualizations of financial data, including plotting multiple series and customizing charts.
- Simulate price movements, financial returns, and risk metrics using Monte Carlo simulations.
- Conduct scenario analyses for different economic conditions and their impact on financial portfolios.

Recommended Books:

1. D. Eddelbuettel, Seamless R and C++ Integration with Rcpp. New York: Springer, 2013, ISBN 978-1461468677
2. D. Ruppert, Statistics and Data Analysis for Financial Engineering, Springer Texts in Statistics. New York: Springer, ISBN 9781441977861, 2011
3. J. Ledolter, Data Mining and Business Analytics with R. John Wiley, May. ISBN: 978-1-118-44714-7, 2013
4. J. Ledolter, Data Mining and Business Analytics with R. John Wiley, May. ISBN: 978-1-118-44714-7, 2013
5. M. J. Bennett, D. L. Hugen, Financial Analytics with R: Building a Laptop Laboratory for Data Science, Cambridge University Press, 2016

FM-618 Financial Computer Simulation- II (2 + 1)

Time Series Analysis Examining Time Series, Stationary Time Series, Auto-Regressive Moving Average Processes, Power Transformations, The TSA Package, Auto-Regressive Integrated Moving Average Processes, Case Study: Earnings of Johnson & Johnson, Case Study: Monthly Airline Passengers, Case Study: Electricity Production, Generalized Auto-Regressive Conditional Heteroskedasticity, Case Study: Volatility of Google Stock Returns

Markowitz Mean-Variance Optimization Optimal Portfolio of Two Risky Assets, Quadratic Programming, Data Mining with Portfolio Optimization, Constraints, Penalization, and the Lasso Extending to High Dimensions, Case Study: Surviving Stocks of the S&P 500 Index

Cluster Analysis K-Means Clustering, Dissecting the K-Means Algorithm, Sparsity and Connectedness of Undirected Graphs, Covariance and Precision Matrices, Visualizing Covariance, The Wishart Distribution, Glasso: Penalization for Undirected Graphs, Running the Glasso Algorithm, Tracking a Value Stock through the Years

Simulating Trading Strategies Foreign Exchange Markets, Chart Analytics, Initialization and Finalization, Momentum Indicators, Bayesian Reasoning within Positions, Entries, Exits, Profitability, Short-Term Volatility, The State Machine

Data Exploration Using Fundamentals The RSQLite Package, Finding Market-to-Book Ratios, The Reshape2 Package, Value Investing

All the contents may be cover with any software (e.g **R, PYTHON** etc.)

Lab/Practical:

- Import and visualize different time series datasets (e.g., stock prices, economic indicators).
- Identify and differentiate between stationary and non-stationary time series.
- Implement ARMA models to capture the dependencies in time series data.
- Use the TSA package (or equivalent) to fit ARMA models and evaluate their performance.
- Apply ARMA modeling to case studies such as the earnings of Johnson & Johnson and monthly airline passengers.
- Implement ARIMA models for non-stationary time series and analyze their performance.
- Explore Generalized Auto-Regressive Conditional Heteroskedasticity (GARCH) models to capture volatility clustering.
- Apply GARCH modeling to analyze the volatility of Google stock returns.
- Calculate the optimal portfolio of two risky assets using quadratic programming.
- Implement K-means clustering to segment financial data (e.g., stocks, portfolios).
- Analyze the algorithm's performance and visualize the clustering results.
- Explore advanced topics like the sparsity and connectedness of undirected graphs, covariance, and precision matrices, using the Glasso algorithm.
- Implement and backtest trading strategies in foreign exchange markets.
- Explore chart analytics, momentum indicators, and Bayesian reasoning within trading positions.
- Simulate entries, exits, and profitability using short-term volatility measures and a state machine framework.
- Use the RSQLite package (or equivalent) to manage and query financial datasets.
- Calculate and analyze market-to-book ratios and other fundamental indicators.

Recommended Books:

1. D. Eddelbuettel, Seamless R and C++ Integration with Rcpp. New York: Springer, 2013, ISBN 978-1461468677
2. D. Ruppert, Statistics and Data Analysis for Financial Engineering, Springer Texts in Statistics. New York: Springer, ISBN 9781441977861, 2011
3. J. Ledolter, Data Mining and Business Analytics with R. John Wiley, May. ISBN: 978-1-118-44714-7, 2013
4. J. Ledolter, Data Mining and Business Analytics with R. John Wiley, May. ISBN: 978-1-118-44714-7, 2013
5. M. J. Bennett, D. L. Hugen, Financial Analytics with R: Building a Laptop Laboratory for Data Science, Cambridge University Press, 2016

FM-619 Analysis of Financial Time series (3+0)

Stochastic process and its main characteristics Stochastic process, Time series as a discrete stochastic process, Stationarity, Main Characteristics of stochastic processes (means, auto-covariation and autocorrelation functions), Stationary stochastic processes, Stationarity as the main characteristic of stochastic component of time series, World decomposition, Lag operator, Autoregressive-moving average models ARMA (p,q) Moving average models MA(q), Condition of invertability, Autoregressive models AR(p), Yull-Worker equations, Stationarity conditions, Autoregressive-moving average models ARMA(p,q), Coefficient estimation in ARMA (p,q) processes, Box-Jenkins' approach, Coefficients estimation in autoregressive models, Coefficient estimation in ARMA (p) processes, Quality of adjustment of time series models, AIC information criterion, BIC information criterion, "Portmanto"-statistics, Box-Jenkins methodology to identification of stationary time series models, Forecasting in the framework of Box-Jenkins model Forecasting, trend and seasonality in Box-Jenkins mode, Non-stationary time series Non-stationary time series, Time series with non-stationary variance, Non-stationary mean, ARIMA (p,d,q) models, The use of Box-Jenkins methodology to determination of order of integration, The unit root problem The unit root problem, Spurious trends and regressions, Unit root tests (Dickey-Fuller).

ADF test and the choice of the number of lags, Other unit root tests. Unit root and structure changes Non-stationary time series, TSP or DSP: methodology of research. Segmented trends and structure changes, Regressive dynamic models Regressive dynamic models, Autoregressive models with distributed lags (ADL), Vector auto regression model and co-integration Time series co-integration, Co-integration regression, Testing of co-integration, Vector auto regression and co-integration, Co-integration and error correction model, Causality in time series Granger causality, Hypothesis testing on rational expectations, Hypothesis testing on market efficiency

Recommended Books:

1. Banerjee, J.J. Dolado, D.V. Hendry. Co-Integration, Error Correction, and Econometric Analysis of Non-Stationary Data. Oxford University Press, 1993
2. G. Kitagawa, Introduction to Time Series Modelling, Chapman & Hall/CRC, 2010
3. G.B. Louis, A. Gilbert, Modelling and Simulation, Springer-Verlag London, 2013
4. R. Prado, M. West, Time Series: Modelling, Computation and Inference, Chapman & Hall/CRC, 2010
5. R. S. Tsay, Analysis of Financial Time Series. Wiley, 2014