

Syllabus and Curriculum for PGDM 2022-2024

A. Common First Year Courses

Term 1	Term 2	Term 3
111 Quantitative Methods	121 Programming in Python	131 Financial Econometrics
112 Financial Management	122 Finance I	132 Corporate Finance
113 Microeconomics	123 Macroeconomics	133 Big Data
114 Calculus and Differential Equations	124 Optimization	134 Supply Chain Management
115 Probability	125 Statistical Inference and Modeling	135 Advanced Macroeconomics
116 Analytics in Business	126 Machine Learning I	136 Stochastic Process

B. Second Year Courses

Term 4	Term 5	Term 6
241 Deep and Reinforcement Learning	251 AI Applications in Business	261 Information Theory and Cryptography
242 Financial Time Series Analysis	252 Applied Multivariate Statistics	262 Topics in Data Science
243 Asset Pricing I	253 Fixed Income Models	263 Topics in Financial Engineering
244 Derivatives and Options	254 Credit Risk Models	264 Computational Finance
245 Financial Risk Analytics in Banking and Financial Services 246 Stochastic Calculus 247 Programming in SQL	255 Visualization 256 Financial Market Microstructure 257 Algorithms and Data Structures	List of Special Electives 260 Advanced Visualization 265 Asset Pricing II 266 Medical Analytics 267 Robotics 268 Quantum Computing 269 Projects in R / Python 270 Algorithmic and High Frequency Trading 271 Marketing Concepts 272 Organization Behavior 273 Human Resources 274 Natural Language Processing and Text Analytics 275 Dissertation

111: Quantitative Methods

- 1. Differential Calculus :** Introduction to Functions and Real Analysis; Derivatives – partial and total, economic applications, marginal and elasticity concepts, functions of several variables, implicit function theorem, higher order derivatives and Young's theorem, Taylor's approximation, convex sets, convex and concave functions, properties of linear homogenous functions, Euler's theorem
- 2. Linear Algebra:** Vectors, matrices, inverse, simultaneous linear equations, Cramer's rule for solving system of linear equations, input-output model, Hawkin - Simon condition, open and closed models quadratic equation, characteristic (eigen) roots and vectors
- 3. Classical Optimization and Applications:** Introduction to quadratic forms, unconstrained optimization, constrained optimization with equality constraints, Lagrangian method, Hessian and Jacobian matrices, applications – utility maximization, cost minimization, profit – output maximization
- 4. Linear and Non-linear Optimization:** Duality theory, constrained optimization with inequality and non-negativity constraints, Kuhn-Tucker formulation, linear programming – formulation, primal and dual, solutions using graphical and Simplex methods, applications from economics and finance
- 5. Dynamics:** Definite and indefinite integrals, applications – measuring consumer and producer surplus, continuous interest – discount calculations, difference and differential equations, phase diagrams, Cobweb model, multiplier accelerator, Harrod-Domar and Solow model

BASIC TEXT BOOK:

1. Rosen, Kenneth H. Discrete mathematics and its applications. 7 th Ed. New York: McGraw-Hill, 2012
2. Lay, David C, McDonald, Judi J and Lay, Steven R. Linear Algebra and Its Applications, 5th Ed, Pearson, 2015.
3. Simon, Carl P. and Blume L., Mathematics for Economists, Viva-Norton Student Edition, 2010

REFERENCE BOOKS:

1. Golub, Gene H., and Charles F. Van Loan. Matrix computations. Vol. 3. JHU Press, 2012
2. Trefethen, Lloyd N., and David Bau III. Numerical linear algebra. Vol. 50. Siam, 1997

112: Financial Management

1. **Financial institutions and the financial system** : introduction, key terms
2. **Financial mathematics** : Time Value of Money, Compounding, EAR, Annuities
3. **Context of finance**: Introduction to the Companies Act, Forms of organisation, limited liability, forms of financing (long-term and short-term), techniques of financing, basics of taxation
4. **Financial accounting**: Financial accounting practices and their rationale and limitations, financial statements and their analysis, ratios and DuPont analysis, accounting manipulation
5. **Managerial accounting**: Introduction to cost and management accounting and their analysis

References:

Fundamentals of financial management (concise edition). Brigham, E. F.; Houston, J. F. 7th ed. South-Western, 2011. 384 pages. ISBN: 978-0538481526

Principles of corporate finance (Global edition). Brealey, R. A.; Myers, S. C.; Allen, F. 11th ed. McGraw-Hill, 2014. ISBN: 978-007151560

113: Microeconomics

1. Introduction

Why Study Microeconomics? Microeconomics Vs. Macroeconomics, Microeconomics as a tool to understand business and economic policy

2. Consumer Behavior and Preferences

Opportunity sets, optimum choices, indirect utility demand functions, income and substitution effects, Slutsky equation, normal versus inferior goods, types of demand functions, elasticity, welfare evaluation, consumer surplus, equivalent variation and compensating variation, revealed preference (weak and strong axioms)

3. Utility Function and Expected Utility Theorem

Contingent Consumption, Utility Functions and Probabilities, Expected Utility Function, risk aversion, diversification and risk spreading

4. Production and Cost

Production functions and its types, marginal products, rate of technical substitution, technical progress, cost functions, average and marginal costs, short run versus long run costs, economies of scale and scope, profit maximization, cost minimization, derivation of input demand

5. Market and Prices- I

Competitive Markets, profit maximization, Short Run Vs. Long Run, Application: tax incidence, price control

6. Market and Prices -II

Monopoly, Monopoly behavior and Price discrimination – first, second and third degree, Oligopoly, Cournot Model, Stackelberg model, Bertrand Model, Monopolistic Competition.

Reference Books

- Austan Goolsbee, Chad Syverson, and Steven Levitt, Microeconomics, 3rd Edition, Macmillan Learning
- Varian, H. R., Microeconomic Analysis, third edition, W.W. Norton and Co., 1992
- Mas-Collel, Whinston and Green, Micro-economic Theory, OUP, 1995
- Gravelle, H and R. Rees: Microeconomics, Pearson Education, 3rd Edition, 2004

114: Calculus and Differential Equations

COURSE DESCRIPTION:

The use of mathematical methods and data analysis, as the means to analyze and help make educated decisions about complex problems. Calculus is an intrinsic field of mathematics and especially in many machine learning algorithms that you cannot think of skipping this course to learn the essence of Data Science. Data Scientists use calculus for almost every model. The main goal of the course is to provide students with the relevant tools and techniques for solving managerial decision problems of a quantitative nature, all taught through practical scenarios and real-world applications. The course is aimed at teaching students to master comparative statics problems, using the acquired mathematical tools. Home assignments will be provided on a weekly basis. Quiz at regular basis would be conducted to evaluate the student's effort towards the subject content. The objective of the course is to acquire the students' knowledge in the field of mathematics and to make them ready to analyze simulated as well as real economic situations. Students learn how to use and apply mathematics by working with concrete examples and exercises. Moreover this course is aimed at showing what constitutes a solid proof. The ability to present proofs can be trained and improved and in that respect the course is helpful. It will be shown that how the deep knowledge of math concepts helps to understand real life situations.

BASIC TEXT BOOK:

1. Simon, C. and L. Blume, Mathematics for Economists, Norton, London, 1994
2. Chiang, A. C., Fundamental Methods of Mathematical Economics, McGraw-Hill, 1984
3. M.D. Intriligator, Mathematical Optimization and Economic Theory, Prentice-Hall, 1971

REFERENCE BOOKS:

1. Knut Sydsaeter and Peter J. Hammond, Mathematics for Economic Analysis, Pearson Education Asia, 1995
2. Anthony, M and N. Biggs, Mathematics for Economics and Finance, Cambridge University Press, Cambridge 2000
3. George F. Simmons, Differential Equations with Applications and Historical Notes, 3rd Edition, Chapman and Hall, CRC Press, 2016
4. Morris W. Hirsch, Stephen Smale and Robert L. Devaney, Differential Equations, Dynamical Systems, and an introduction to Chaos, Elsevier, 2004
5. Walter A. Strauss, Partial Differential Equations: An Introduction, 2nd Edition, Wiley, 2007

115: Probability

1. Probability

Basic concepts in the field of probability: event, sample space, counting, combinatorics, conditional probability and independence, Bayes's theorem, base rate fallacy

2. Random variables:

Random variable and cumulative distribution function, density function, Discrete and continuous, Expectations and Variance, Moments, moment generating functions, characteristic functions, quantiles

3. Special parametric families of univariate distributions

Discrete: Discrete Uniform distribution, Bernoulli distribution, Binomial distribution, Poisson, geometric and hyper-geometric uniform, negative binomial

Continuous: Uniform, Normal, Exponential, Gamma, Beta

4. Joint and conditional distributions

Joint, marginal and conditional distribution, Expectation, covariance, correlation, conditional Expectations, stochastic independence, Bivariate Normal distributions

5. Functions of Random variables and limit theorems

Method of Distribution function, Transformation Method, Law of Large numbers, Central Limit theorem

Books

- DeGroot, M.H. and M.J. Schervish, *Probability and Statistics*,
- Hogg, R. and A. Craig, J., *Introduction to Mathematical Statistics*, McGraw-Hill, 1965.
- Miller, I. and M. Miller, *Mathematical Statistics*, sixth edition, Prentice Hall International, 1999.
- Mood, A. M., R. A. Graybill and R.C. Boes, *Introduction to the Theory of Statistics*, McGraw-Hill, 1974.
- Ramachandran, K. M and C. P. Tsokos, *Mathematical Statistics with Applications*, 2009.

116: Analytics in Business

COURSE DESCRIPTION:

1. Introduction to Analytics

Defining Data science, Skills, Tools and technologies used in Analytics. Examples of Analytics projects

2. Managing Analytics Projects

Identifying opportunities, Data science Process and Design. Model Life Cycle Management.

3. Behavioral Factors

Perception, Learning, Memory, Motivation, Emotions, Decision making

4. Marketing Analytics

Defining Marketing and Marketing Analytics, Customer Analysis, Segmentation, Campaigns, Marketing Optimization. Measurements and Metrics

5. HR Analytics

HR Practices and Process, Employee Engagement, HR Metrics and Measurement

TEXT BOOK:

- Kotler, P. and Armstrong G, Principles of Marketing, 17th Edition, Pearson Education – [PDF Available]
- Stephen P Robbins and Timothy A Judge, Organizational Behavior 15th Edition, Pearson Education – [PDF Available]

REFERENCE BOOKS:

An Introduction To Statistical Learning Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirami

121: Programming in Python

1. Introduction

Evolution of Python, Advantages of Python, Installation and setting up environment, Jupyter notebook: Python IDE, Data Types. Lists, Loops and Tuples - Creating list, Indexing and slicing, Looping in to array elements using loops, List manipulations, List comprehension, Tuples. Dictionary – Introduction, Fetching keys and values, Deleting elements, Conditional Statements - If – else statements, Nested conditional statements, Single line conditional statements, Loops – For, While, Functions – Syntax, Passing parameters and returning values, Scope of variables

2. Numpy:

Arrays, Array indexing, Array Slicing, Data types, Array math, Broadcasting, Matplotlib: What does A Matplotlib python plot look like?, Data for Matplotlib plots, Create your plot, What is a subplot?

3. Pandas

Pandas Data Structures - Series & Data frames, Creating series & data frames from other objects, Creating data frames with random numbers, Reading data from flat files, Indexing & Selecting - Row indexing, Selecting rows based on conditions, Sorting data, Handling missing data - Selecting rows with missing values, Ignoring rows with missing values, Filling with average values, Forwarding & Backward filling, Column and row operations - Data Mutation, Apply functions, Descriptive statistics - Describe function, Finding average, min and max, Data Transformations – Aggregations

Text Book:

1. Python Cookbook: Recipes for Mastering Python 3, David Beazley, Brian K. Jones
2. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython
Wes McKinney

122: Finance I

1 Micro Foundation of Financial Economics:

Introduction to financial markets, capital markets, consumption and investments with and without capital markets, market places and transaction costs and the breakdown of separation; Fisher separation theorem, capital budgeting techniques.

2. Theory of Uncertainty

Axioms of choice under uncertainty; utility functions; expected utility theorem; certainty equivalence, measures of risk-absolute and relative risk aversions;

3. Stochastic dominance

First order, second order and third order; measures of investment risk-variance of return, Mean - Variance as choice criteria.

4. Mean-Variance Portfolio Theory

Measuring portfolio return and risks, effect of diversification, minimum variance portfolio, perfectly correlated assets, minimum variance opportunity set, optimal portfolio choice; mean-variance frontier of risky and risk-free asset, optimum portfolio weights choice.

5. CAPM & APT

Models of asset returns, single index model, systematic and specific risk, equilibrium models of capital asset pricing model, capital market line, security market line, estimation of beta, multi index models - arbitrage-pricing theory.

123: Macroeconomics

1. National Income Accounting

Accounting structure, key concepts in accounting for both closed and open economies – gross national product, gross domestic product, net national product, national income, savings and investment, balance of payments, circular flow of income, computational problems – expenditure approach, income approach and value added approach for measurement, input-output tables

2. Keynesian Models

Simple Keynesian Model, assumptions, concepts of involuntary unemployment, liquidity preference, paradox of thrift, investment function, IS-LM model – two sector model, goods and money market equilibrium, multiplier, liquidity trap, complete Keynesian model – three sector model, role of government in terms of monetary and fiscal policy

3. Keynesian Models versus Classical Models

Says Law, quantity theory of money, price flexibility and full employment, Clowers and Patinkin's money demand functions, equilibrium concept in classical model, synthesis between classical models and Keynesian models, interpretation and policy analysis

4. Expectations and Macroeconomic Adjustments

Expectations formations – Adaptive and rational expectations hypothesis, partial adjustment model, Lucas critique, Phillips curve, rules versus discretion, time consistency, inflation targeting, interest rate rules, effects of spending and taxes in models with flexible and sticky prices, perverse effects of fiscal expansion

5. Macroeconomics: Open Economy Aspects

Market for foreign exchange, devaluation and depreciation, real and nominal exchange rate, factors affecting exchange rate, Mundell-Fleming model, fixed versus floating exchange rate, price adjustment, role of fiscal and monetary policies under alternative exchange rate regimes, purchasing power parity concept

Books

- Scarth, W., *Macroeconomics: An Introduction to Advanced Methods*, third edition, Thomson, 2007
- Mankiw, N. G., *Macroeconomics*, fifth edition, Worth Publishers, 2002
- Hall, E. and Taylor, J. B. *Macroeconomics*. W. W. Norton and Company, 1986
- Barro, R.J. *Macroeconomics*, Fifth edition, MIT Press 1997

124: Optimization

1 Linear Programming (LP)

Geometry of Linear Algebra, concept of an Objective function and constraints, formulation of LP, graphical solution, Simplex algorithm, Pivoting, Basic and Non-basic variables, Primal LP.

2. Dual LP

Concept of Duality, Formulation of dual LP, Duality theorems, Complementary slackness, Sensitivity analysis, Matrix representation of LP, Network flow and Graph problems, Interior point algorithms

3. Integer Programming (IP)

Introduction to Hard Problems, Complexity of IP, Cutting Plane methods, Branch and bound algorithms, Unimodular matrices

4. Nonlinear Optimization

Newton's method, Line searches, Gradient descent, Conjugate gradient method, Quadratic Programming, Lagrangean methods, KKT conditions, Convex sets and functions, different algorithms and their applications

5. Dynamic Programming (DP)

Bellman's principle of optimality, formulation of a DP, application of DP to different fields

Books

- G.B. Dantzig, Linear Programming and Extensions, Princeton Landmarks in Mathematics, Princeton University Press, 1963
- Practical Optimization P. E. Gill, W. Murray and M. H. Wright, Academic Press, 1981.
- D. Bertsekas and J. Tsitsiklis Introduction to Linear Optimization, Athena Scientific, 1997
- Nonlinear Programming, D. Bertsekas, Athena Scientific, 2nd Edition, 1999
R Bellman, Dynamic Programming, Dover, 2003

125: Statistical Inference and Modeling

Sampling Methods and Sampling distributions

Simple random sampling: with and without replacement, statistic and sample moments, sampling distributions: Student's-t, Chi-square and F-distribution, determinants of sample size

Estimation^[1]_{SEP}

The Method of Moments, Maximum likelihood, properties of good estimators: unbiasedness, consistency, efficiency, Interval estimation, confidence intervals based on Normal data, confidence intervals for non-Normal data

Hypothesis Testing^[1]_{SEP}

Statistical hypothesis, simple versus composite hypothesis, critical region, types and size of error – type-I and type-II error, power of a test, p-value, Hypothesis test for single parameter, testing of hypotheses for two samples, Chi-square tests for count data

Design of Experiments and Analysis of Variance

Design of Experiments, one-way ANOVA, two-way ANOVA, Simple linear regression model, ANOVA approach to regression,

Bayesian Estimation and Inference

Bayesian point estimation, Bayesian confidence intervals, hypothesis testing, Bayesian decision theory

Books

- DeGroot, M.H. and M.J. Schervish, Probability and Statistics,
- Hogg, R. and A. Craig, J., Introduction to Mathematical Statistics, McGraw-Hill, 1965.
- Miller, I. and M. Miller, Mathematical Statistics, sixth edition, Prentice Hall International, 1999.
- Mood, A. M., R. A. Graybill and R.C. Boes, Introduction to the Theory of Statistics, McGraw-Hill, 1974.
- Ramachandran, K. M and C. P. Tsokos, Mathematical Statistics with Applications, 2009.

126: Machine Learning I

1. Supervised Learning

Basic framework, concept of training, test and validation data, building a machine learning model

2. Linear Regression

Motivation, Probabilistic Model, Multivariate Gaussian, Matrix Calculus, Maximum likelihood approach, Weighted Least Squares, Gradient descent algorithm

3. Classification

Formulation of the classification problem, Confusion Matrix, Precision and Recall, Binary and Multiclass Logistic Regression, Weight update equation, Gaussian Discriminant Analysis, Naïve Bayes algorithm

4. Neural Networks

Different types of Neural Networks, Concept of a Neuron, Input, Output and Hidden Layers, Function approximation, Loss functions and weights, loss minimization algorithms, forward and backward propagation

5. Decision Trees

Review of entropy, mutual information, Various inputs to the decision tree, classification and regression trees, Learning a decision tree, decision tree construction algorithm

Books

- Mitchell T, *Machine Learning*, McGraw Hill 1997
- Bishop C.M., *Pattern Recognition and Machine Learning*, Springer, 2006

131: Financial Econometrics

1. Regression Analysis

Linear regression model; two variables mode and Matrix Approach to Regression; BLUE property, general and confidence approach to hypothesis testing, goodness of fit, Applications; Specification and Functional Forms; model evaluation

2. Extension of Linear Regression Models

Consequences and detection of multicollinearity, heteroskedasticity, and autocorrelation; and remedial measures

3. Dummy Variables and Models

Regression on qualitative and quantitative variables, dummy variable trap, structural stability of regression models, Chow test, piecewise linear regression model, logit and probit models.

4. Simultaneous Equation Models

Simultaneity bias, structural versus reduced form, identification: rank versus order condition, exact and over identifications, triangular model, methods of estimation including indirect least squares, SURE, two-stage least squares and three-stage least squares.

5. Static Panel Data Models

Advantage of Panel data; Balanced and Unbalanced Panel; One way and Two way Effects; Pooled OLS; Fixed Effects, within and between estimates; Random Effects; Chow test, Hausman test and Lagrangian Multiple test.

BASIC TEXT BOOK:

1. Introductory Econometrics for Finance by Chris Brooks, 2nd edition, Cambridge University Press, 2008.
2. *Basic Econometrics* 4e by Damodar N. Gujarati & Sangeetha. Mc-Graw Hill.

REFERENCE BOOKS:

1. *Econometric Methods* by Johnston J. and J. Dinardo, fourth Edition, McGraw-Hill, 2010.
2. *Econometric Analysis of Panel Data* by Baltagi, B.H., John Wiley & sons Ltd., 2015
3. *Introduction to Econometrics* by G.S. Maddala and KLahiri, , 4th Edition, Wiley, 2009.

132: Corporate Finance

1. **Capital Structure:**

Choices in financing, Modigliani-Miller propositions, tax shields, agency and bankruptcy costs, static tradeoff and pecking order theories, valuation and capital budgeting for the levered firm

2. **Dividend Policy:**

Dividend policy irrelevance, effect of taxes, optimal dividend policies and practices, repurchases and stock dividends

3. **Long term financial management:**

Financing needs and growth rates, raising capital, leasing

4. **Short term financial management:**

Managing working capital, cash and credit

5. **Special topics:**

M&A , bankruptcy

References:

Brealey, R. and S. Myers, Principles of Corporate Finance, tenth edition, New York, McGraw Hill, 2018.

Ross, Westerfield and Jaffe, 12/e, Corporate Finance, TMH, 2019

133: Big Data

Introduction to Big Data

What is Big Data? What are the real world applications of Big Data Analytics? The V's that govern Big Data Architecture. Important tools & programming languages used in Big Data environments.

Components of Hadoop Ecosystem

Understanding the HDFS, Map Reduce functionalities in Hadoop. Actions & Transformations that are applicable. Immutability as a concept explored.

Introduction to Spark

What is Spark? Basics of PySpark. Managing Spark clusters & understanding concepts of RDD management. The core strength of Spark environment is studied in depth.

Spark Clusters on Cloud

Learn how to deploy Spark clusters on cloud using Databricks. Learn the ways to handle data I/O for the same. A strong understanding of Cloud architecture with the components within the same.

Pyspark for Data Handling

Learn how to handle data using lazy immutable actions and transformation functions. Practice on real world examples with code along sessions on the Databricks environment.

ML using Pyspark

Deploy ML models on the Spark cloud and learn how to solve Supervised, Unsupervised Learning techniques with practical Business Problems and datasets.

Reference Books:

1. Machine Learning with PySpark – Pramod Singh
2. Data Analytics with Spark Using Python – Aven Jeffrey
3. Spark for Python Developers – Amit Nandi
4. Frank Kane's Taming Big Data with Apache Spark and Python – Frank Kane

134: Supply Chain Management

1. Forecasting, Facility layout and location

Need for forecasting, quantitative methods, Qualitative aspects, quantitative models for layout decisions, Product, process fixed position, group layout, Location decisions-quantitative models.

2. Capacity and aggregate planning, Inventory management

Capacity measurement, Long-term and short term strategies, Various costs in inventory management and need, Deterministic models and discounts, Probabilistic inventory management

3. Scheduling models and applications

Scheduling in MRP system, Sequencing rules and applications, Batch production sequencing and scheduling.

4. Introduction to supply chain, Value of information and supply chain integration

Definition, complexity, key issues, Centralized vs. decentralized systems, Bullwhip effect, Push-based, pull based systems.

5. Outsourcing, Transportation decision

Make or buy decisions, Drivers of the decision, Network design decisions, Cross-docking, transshipment

Books

- Collier D. A, Evans J. R., *Operations Management*, Student Edition, Cengage Learning, 2009
- Janat Shah, *Supply Chain Management*, 2nd Edition, Pearson Education India, 2016
- Chopra, S., Meindl, P., and Kalra, D.V., *Supply Chain Management*, 6th Edition, Pearson, 2016.

135: Advanced Macroeconomics

1. Growth Theory

Economic growth and economic development, Harrod-Domar model, Solow model, empirics of economic growth, technological progress, growth accounting and total factor productivity

2. Neoclassical Model of Economic Growth

Foundation of neoclassical growth, dynamic programming and optimum growth, the Ramsey-Cass-Koopmans model, growth with overlapping generations, applications of neoclassical growth model, social security: pay-as-you-go and unfunded, models with bequest motives

3. Endogenous Growth Theory

Basics of endogenous growth, the AK-Model, Putty-Clay model, human capital and economic growth, product variety and innovation, learning by doing, role of R&D and economic growth

4. Rational Expectations and Economic Policy

Policy Invariance result, Lucas Critique, Overlapping wage contracts models, New Keynesian Phillips curve (Menu cost models etc), supply-side distortions and the equilibrium unemployment, Time Inconsistency problem, Barro-Gordon model, Central Bank Independence, Inflation Targeting and Unconventional monetary policy (QE, forward guidance etc)

5. Government Solvency and Constraints on Fiscal Policy

Government Solvency condition, Debt Dynamics, Barro-Ricardo equivalence result, OLG models and pay-as-you-go pension system, Unpleasant monetarist arithmetic etc.

Books

- Romer, D., *Advanced Macroeconomics*, second edition, McGraw-Hill, 2001
- Blanchard and Fischer, *Lectures on Macroeconomics*, MIT Press, 1989
- Barro, R.J., *Macroeconomics*, Fifth edition, MIT Press 1997
- Sargent, T., *Macroeconomic Theory*, Academic Press, 1987.
- Pandit, V.N. and K. Krishnamurty, *Macroeconometric Models for India*, Oxford University Press, 2005

136: Stochastic Process

1. Stochastic Process and Simple Markov Processes

Principles of actuarial modeling, stochastic vs. deterministic models; short run and long-run properties; stochastic process and counting process; analyzing the output of a model; sensitivity testing; types of stochastic processes: discrete state spaces with discrete and continuous time changes, continuous state space, sample paths, stationary, increments, Markov property, filtrations, white noise, general random walk, Poisson process and compound Poisson process

2. Markov Chains +

Chapman-Kolmogorov equations; time homogeneous Markov chains, time-inhomogeneous Markov chains; Models- no claims discount policy model, NCD model, simple random walk on $Z=\{\dots-2,-1,0,1,2,\dots\}$ and on $\{0,1,2,\dots,b\}$; accident proneness model; long-term distribution and behaviours of a Markov chain, stationary probability distribution, modelling using Markov chains; estimating transition probabilities, assessing the fit and simulation

3. Two-State Markov Model

Assumptions, probabilities, joint density function, ML estimator; alternative approach, applications, two state model of a single decrement and comparison with those of a random lifetime model

4. General Properties of Markov Process

Poisson processes, deriving and solving the Kolmogorov equations for Markov process-time and age dependent and time independent transition intensities; birth and death problems; simple survival models, sickness and marriage models in terms of Markov process and duration dependent Markov process; Kolmogorov's backward differential equations, Markov jump process, the jump chain, simple two decrement model, calculation of total waiting time

Time-inhomogeneous Markov Jump Process

Chapman-Kolmogorov equations, transition rates, time inhomogeneous HSD model, Kolmogorov' backward and forward differential equations; a two state survival model; integrated form of Kolmogorov equations, applications-marriage, sickness and death; time homogeneous Poisson process models, time homogeneous and inhomogeneous Markov models

241: Deep and Reinforcement Learning

1. Deep FeedForward Neural Networks

Multilayer perceptrons, hidden layers, activation functions, ML vs DL for Neural Networks, back propagation, loss functions, learning parameters, regularization

2. Convolutional Neural Networks (CNN) and Deep Learning

Convolution operation on images, different types of filters, concept of a stride and pooling, different types of activation functions, RELU, Sigmoid, Tanh, cross entropy loss function, sampling, transfer learning, various descent algorithms, regularization techniques

3. Recurrent Neural Networks (RNN)

RNN architectures and their motivation, zero gradient and gradient blow up problem, LSTM, RNN update equations and algorithms, Deep RNNs and applications to time series prediction

4. Autoencoders

Undercomplete, regularized, sparse, Representational Power, Layer Size and Depth

5. Deep Generative models

Boltzmann machines, Restricted Boltzmann machines, Deep Belief Networks, Learning, layer interpretation

Books

- Ian Goodfellow, Yoshua Bengio and Aaron Courville. *Deep Learning*, MIT press, 2016
- Michael A. Nielsen, *Neural Network and Deep Learning*, Determination Press, 2015

242 Financial Time Series

1. Introduction to Time Series and ARIMA Forecasting Models

Introduction to Financial Time Series and their Characteristics; Trend, Seasonality, Cyclical, random components; Autocorrelation and partial autocorrelation, Stationarity and Non-stationarity; Unit Root test; auto-regressive and moving average models; ARIMA (Box-Jenkins) and Seasonal ARIMA models and forecasting

2. Univariate and Multi Variate GARCH Models

Characteristics of high frequency data; Volatility clustering and leverage effect; Univariate ARCH; GARCH and its Extensions (TGARCH, EGARCH, PGARCH etc.); forecasting; limitations of univariate GARCH models; Mutli variate GARCH Models-VECH, Diagonal VECH and BEKK models.

3. Multi Variate Time Series Models

Vector Auto-regressive Model, impulse response function, variance decomposition, VAR forecasting; introduction to cointegration, Engle Granger method and Johansen test, error correction model.

4. Long Memory Models

Long memory and long term dependence, fractionally difference series, ARFIMA model, non linearity tests-parametric and non-parametric tests; R/S Analysis;

5. Non-Linear Time Series Models

Non-linearity and modeling, Seasonality, Regime shifts, piece wise linear function; Threshold AR models; SETAR model; STAR model; Markov Switching Models

BASIC TEXT BOOK:

1. Chris Brooks, "Introductory Econometrics for Finance", Cambridge University Press.
2. Ruey S Tsay, "Analysis of Financial Time Series, Wiley India Edition

REFERENCE BOOKS:

1. Johanson, J. and Dinardo, "Econometric Methods", McGraw-Hill.
2. Walter Enders, Applied Econometric Time Series, Third Edition, Wiley India Edition.
3. Damodar N Gujarati and Sangeetha, "Basic Econometrics, McGraw-Hill.

243: Asset Pricing I

1. Asset Pricing Models and the No-Arbitrage Principle

Stock returns, Bond prices and interest rates under certainty; portfolio mathematics; return distributions; Market Model, Portfolio Theory: and the Capital Asset Pricing Model. Review of probability theory and stochastic processes.

2. Estimation and evaluation of asset pricing models

Consumption asset pricing, Cross-Sectional and Time-Series Asset Pricing Tests, Market Efficiency, Inefficiency, and Limits to Arbitrage

3. Return Predictability and Market Efficiency

Return Predictability, Evaluating Portfolio Managers, Alphas and Betas, Value, Momentum and Anomalies

4. Investor behavior and Heterogeneity

Limited stock participation and consumption risk, belief formation, investor sentiment

5. Imperfect markets and liquidity

Limited arbitrage and liquidity supply, liquidity, liquidity risk and expected returns

Books

- Campbell, J., A. Lo, and A. C. MacKinlay, The Econometrics of Financial Markets, Princeton University Press, 1997
- Cochrane, John H., Asset Pricing, Princeton, NJ: Princeton University Press 2nd Edition, 2005
- Singleton, Kenneth J, Empirical Dynamic Asset Pricing. Princeton NJ: Princeton University Press, 2006

244: Derivatives and Options

1. Pricing of Options

Law of One Price, Concept of Replicating portfolio, Complete and In-complete markets, AD securities

2. Discrete Time Financial Market Model

Binomial Model, Risk Neutral Probability, Martingale Measure, Conditions for no Arbitrage

3. Continuous Time Financial Market Model

Pricing by the probabilistic approach, Feynman Kac Approach, Self Financing Portfolio

4. Black-Scholes (BS) Model

Derivation and Solution of the BS PDE, Hedging, Greeks, Implied Volatility, Pricing European Options, Call, Put

5. American and Exotic Options

Pricing American Options, Path dependent options, Asian Options, Multi-stage Options, Pricing Barrier, Lookback and Exchange options Books

Books

- Hull, J. Options, futures, and other derivatives. Upper Saddle River, N.J: Pearson/Prentice Hall. 2006.
- Paul Wilmott, Sam Howison, Jeff Dewynne The Mathematics of Financial Derivatives; Cambridge University Press, 1995.

245: Visualization

1. **Understand cognitive perception:**

Understand and leverage the strength of the human brain. Also understand the weaknesses of the human brain and avoid pitfalls upon presenting data.

2. **Eliminate Visual clutter:**

- Focus is on the business insight. Develop an eye to stress emphasis on data ink versus non-data components

3. **Choose an appropriate display mechanism:**

- Tables / Graphs/Maps/Glyphs types to match the message

4. **Design dashboards:**

- Understand the science behind the idea of dashboarding and solve a business question effectively

5. **Create storyboards:**

- Transform complex data into information and communicate it as a story

6. **Explore Visually:**

- Systematic process to generate insights

7. **Analyze Visually:**

Techniques to extract meaning from large data sets

Suggested Readings:

- The Visual Display of Quantitative Information (Edward R Tufte)
- Visual Thinking: for Design (Colin Ware)
- Sketching User Experiences: Getting the Design Right and the Right Design (Bill Buxton)
- The Elements of Graphing Data (William Cleveland)
- Visualization of Time-Oriented Data (Wolfgang Aigner, Silvia Miksch, Heidrun Schumann and Christian Tominski)

246: Stochastic Calculus

1. Basics

Basics of stochastic processes, Poisson process, Brownian motion process and its varied generalizations, Geometric Brownian motion, Analysis of second order processes, Ito integral and Ito lemma with applications, Kolmogorov equations, Jump process, Calculus for jump processes, change of measure, basics of Levy stochastic calculus.

2. Stochastic Tool-kit for finance

Martingales, Martingale representation theorem, stopping time, stopped process, first passage time, Doob's optimal stopping theorem, Girsanov theory, Arc-sine law, pricing kernel as a Martingale, Risk neutral analysis, Sharpe ratio.

3. Valuation of asset prices

Stochastic characterization of complete and incomplete markets, Forward and future contracts, binomial tree model, Black-Schole's theory and applications, Put-call parity, Implied volatility, Exchange options, Currency options, American options, Sensitivity analysis(Greeks)

4. Interest rate models and derivatives

Mean-reverting processes, O-U process, Square root process, Factor models-the Merton model, The Vasicek model, The Cox Ingersoll-Ross model, Heath-Jarrow-Merton model, Pricing of Bonds, Stochastic interest rate, Rate of return and yield curve.

5. Further option theory

Swaps, Caps, Floors, Swaptions, Forward LIBOR models, Barrier options, Look back option, Calibration, Levy process as stock price model, Stochastic volatility models, Heston model and Wiggins's model, ARCH and GARCH models and their suitable extensions in diffusion.

Books

- Shreve S.E.: Stochastic calculus for finance volume 2-continuous time models, Springer, 2004
- Hull, John C., and Sankarshan Basu. *Options, futures, and other derivatives*. Pearson Education India, 2016.
- Baz, Jamil, and George Chacko. *Financial derivatives: pricing, applications, and mathematics*. Cambridge University Press, 2004.
- Wilmott, Paul, Sam Howison, and Jeff Dewynne. *The mathematics of financial derivatives: a student introduction*. Cambridge University Press, 1995. Applebaum, David.
- *Lévy processes and stochastic calculus*. Cambridge university press, 2009.

247: Programming in SQL

1. Introduction to SQL.

What is SQL? What is ANSI SQL? Basics of the RDBMS: relational databases, database normalization. Types of SQL commands: DDL, DML. What is Data? What are database objects? What is a schema? Create a simple table: naming a table or other object, CREATE TABLE. Review the table structure. Data types for columns: character, numeric, date. Creating CONSTRAINTS in the CREATE TABLE statement, The types of CONSTRAINTS. ALTER TABLE and DROP TABLE commands. Creating a table from an existing table.

2. Manipulating Data - DML.

Insert rows into a table: default column list, enumerated column list. Update rows in a table. Delete rows from a table. Control transactions: COMMIT, ROLLBACK, SAVEPOINT. Inserting data from another table. Retrieving Data Using the SQL Select Statement. Restricting and Sorting Data. Execute a basic SELECT statement. List the capabilities of SQL SELECT statements. The WHERE clause, Boolean logic, additional WHERE clause features (IN, BETWEEN, IS NULL/IS NOT NULL).

3. Using Single-Row Functions.

Functions in SQL: character functions, number functions, date functions, conversion functions, other functions. Use character, number, and date functions in SELECT statements. Nesting functions. Conversion functions: automatic datatype conversions. Aggregated Data - Group Functions: COUNT, SUM, MIN/MAX, AVG. Group data by using the GROUP BY clause: multiple columns, ORDER BY, nesting functions. Include or exclude grouped rows using the HAVING clause.

4. Displaying Data from Multiple Tables.

SELECT statements to access data from more than one table using equijoins and non-equijoins, table aliases. Types of joins: inner joins, outer joins, Self-join. Subqueries: single-row subqueries, multiple-row subqueries, multiple-column subquery, scalar subqueries, correlated subqueries. Set operator to combine multiple queries into a single query: UNION, UNION ALL, INTERSECT, EXCEPT (MINUS), Window Functions.

5. Creating Other Schema Objects. Database Tuning.

Utilizing views. Create and use simple and complex views. Performance impact of using nested views. Create and maintain indexes: implicit index creation, single column, composite, unique, dropping. When should indexes be considered/avoided? Database tuning vs. SQL statement tuning. Formatting SQL statements for readability, the order of tables in the FROM clause the placement of the most restrictive conditions in the WHERE clause, the placement of join conditions in the WHERE clause.

BASIC TEXT BOOK:

3. Head First SQL - Your Brain on SQL -- A Learner's Guide - Lynn Beighley, O'Reilly
4. SQL Cookbook - Anthony Molinaro, O'Reilly

REFERENCE BOOKS:

1. SQL Primer_ An Accelerated Introduction to SQL Basics – Rahul Batra, Apress.
2. <https://docs.microsoft.com/en-us/sql/sql-server/?view=sql-server-ver15>
3. <https://www.sql-server-performance.com/>

251: AI Applications in Business

1. **Recommender Systems - 1**

Similarity metrics, sparse vs dense data structures, Popularity based, Association Analysis/ Market Basket, Analysis using confidence and support, Content based recommendations

2. **Recommender Systems – 2**

collaborative systems, User Based similarities, Item based similarities, Singular Value Decomposition, hybrid recommenders

1. **Markov Decision Process and Reinforcement Learning**

Review of Markov Chains, State Space, Actions, Goals, Rewards and Returns, Policy and Value functions

2. **Dynamic Programming**

Bellman's principle of Optimality, Policy prediction and Improvement, Policy and Value Iteration, Examples and Applications

3. **Approximate Methods**

Value function approximation, Stochastic Gradient Methods, Feature construction for linear methods, least squares

Books

- Richard S Sutton and Andrew G Barto, *Reinforcement Learning: An Introduction*, MIT Press 2nd edition 2017
- Csaba Szepesvari, *Algorithms for Reinforcement Learning*, Morgan and Claypool Publishers

252: Applied Multivariate Statistics

1. Introduction to Multivariate Statistics

Univariate descriptive Statistics, Multivariate descriptive Statistics, Multivariate data visualization, Multivariate Normal Distribution theory

2. Multivariate inferential statistics

sample mean vectors and sample correlation in multivariate data contexts, conditional distribution and partial correlation in multivariate contexts, inferential statistics, Hotelling's T², ANOVA and MANOVA

3. Analysis of covariance structure

Principle components analysis, Exploratory Factor analysis – Estimation and Rotation, Canonical Correlation analysis,

4. Classification and clustering

Bayes rule and classification problem, Discriminant analysis (Linear and Quadratic), Cluster analysis,

5. Special Topics (can vary year to year)

Multidimensional scaling, Correspondance analysis, Structural Equation Modeling, tree-based methods, support vector machines

Books :

Johnson, R.A., Wichern, D.W., 2007. Applied Multivariate Statistical Analysis (6th edition), Pearson Prentice Hall.

Tacq, Jacques. Multivariate Analysis Techniques in Social Science Research: From Problem to Analysis Sage International, 1997.

253: Fixed income models

1. Bonds and Interest Rates:

Fixed Income markets and products, Zero-coupon bonds, Interest rates, LIBOR rates and ZCB prices, Forward rates, spot rates and short rates, Introduction to continuous time models and arbitrage free pricing of interest rate derivatives

2. Valuation and Numeraire invariance:

Numeraire pairs, Change of Numeraire, Forward Prices and forward measure, Interest rate derivatives, coupon-bearing bonds, interest rate swaps and options

3. Term Structure Modelling:

Structural relationships, Short rate modeling, Short rate models, Affine short rate models, Calibration of short rate models, multi factor short rate models, Yield Curve models and construction of yield curves

4. Forward Rate Models:

Forward rate dynamics under physical measure, Heath Jarrow Morton (HJM) framework, HJM driftcondition under different measures, relation to affine yield models

5. Market Models:

Black formula compatibility, LIBOR market model, Forward LIBOR and ZCB volatilities, Forward LIBOR term structure model, Implicit forward volatility term structure, implied flat volatility term structure, construction of forward LIBOR processes.

Books:

Bjork T, Arbitrage Theory in Continuous Time, OUP, 3rd ed. 2009

Filipovic D, Term-structure models, Springer Finance, Springer-Verlag, Berlin 2009

254: Credit Risk Models

1. Basic models:

Traditional approach, liabilities as Contingent Claims, Merton Model, KMV model

2. Approaches to Credit Risk Modelling:

Stochastic Approach, Macro-simulation approach, Risk Neutral Valuation. Industry approaches such as the McKinsey model and the KPMG Loan Analysis system.

3. Internal models and Credit scoring:

Actuarial approaches, internal model approaches, back testing and stress testing, credit scoring using logistic regression and Discriminant Analysis, Survival Analysis methods, Hazard Regression

4. Credit derivatives:

Instruments, hedging credit risk, valuation, correlated defaults, securitization

5. Managing credit portfolios:

Basel-3 and RBI norms, regulatory reporting and accounting

Books

- David Lando, Credit Risk Modeling Theory and Applications, Princeton University Press, 2004
- Christian Bluhm, Ludger Overbeck, Christoph Wagner, An Introduction to Credit Risk Modeling, Chapman& Hall/CRC 2003

256: Financial Market Microstructure

1. Institutions and Market Structure:

The nature of markets, prices and markets, the investigation of the economic forces affecting trades, quotes and prices, trading mechanisms, order data, quote data

2. Inventory Models:

Sources for Short-run Price Deviation from Fundamentals, transaction costs, order handling costs, Roll's model, inventory models, the dealers problem, prices and inventories in competitive markets, market maker behaviour

3. Information Based Models:

Informed traders and uninformed traders, the information content, the Glosten-Milgrom model, trade quantities and price behaviour, sequential trade models and price behaviour, long-lived information

4. Strategic Trader Models:

Strategic behaviour of informed and uninformed traders, price behaviour and multiple informed traders, trading mechanism and strategic trading, strategic behaviour and security returns, the robustness of strategic models

5. Price Discovery and Market:

Stability, Information and sequence of prices, the volume critique, the role of time in price adjustment, information and market viability, order form and price behaviour, market transparency, trader anonymity, market design, market structure policies

Books:

- Maureen O'Hara, Market Microstructure Theory, Blackwell, 1995
- Frank de Jong and Barbara Rindi, The Microstructure of Financial Markets, Cambridge University Press, 2009
- Joel Hasbrouck, Empirical Market Microstructure, Oxford University Press, 2007

257: Algorithms and Data Structures (RB)

1. Data Structures

Stacks, Queues, Hashing, Graphs, Trees, Choice of Data Structures on the complexity of algorithms

2. Algorithmic Complexity

Big oh notation, solving recurrence equations to analyze running time of algorithms, sorting and searching algorithms, recursive formulation of algorithms, difference between space and time complexity, graph algorithms

3. Approximation Algorithms

Introduction to Hard Problems, Various relaxation and randomized algorithms used in the solution of hard problems, sampling based algorithms, Google Page rank algorithm

4. Numerical Algorithms

Interpolation, Condition number of matrix, round off and truncation errors, numerical differentiation and integration, finding roots of equation and application to find implied volatility, solution of nonlinear equations

5. Applications

Kalman filter, Algorithms for finding Haplotypes, Lemke Howson Algorithm, RSA algorithm

Books

- T.H. Cormen, C.E. Leiserson, R.L. Rivest and C Stein, *Introduction to Algorithms* MIT Press, 3rd Edition 2009
- J.D. Ullman and J. Widom, *A First Course in Database Systems*, Prentice Hall, *Third Edition* 2008
- Vijay Vazirani, *Approximation Algorithms* Springer-Verlag 2004
- Mitzenmacher and Upfal. *Probability and Computing: Randomized Algorithms and Probabilistic Analysis*, Cambridge University Press, 1995

260: Advanced Visualization

Infographics are some of the best techniques that a **business** can **use** to start viral campaigns – be it internal or external campaigns. Our audiences today want to feel informed, and yet they shy away from a direct communication pitch. That's why BI professionals have a great opportunity to communicate their information using infographics. An effective infographic gives the viewer all the information he or she needs to make an informed decision. Just a simple call-to-action at the end of your piece should be more than enough. This builds trust with the consumer and boosts the thought leadership of the company that produced the infographic.

Infographics help cover “heavy” topics in an enjoyable way. **People** rather look at an **infographic** than read a complex dashboard or lengthy text containing the same content.

Infographics can often be combined with advanced visualization practices by incorporating dynamic visuals , motion charts , advanced cartography methods etc.

- Overview to info graphics
- Understand target audience and create customized info graphic views. Tune communications to specific business processes for organizations
- Define KPI's to approach the required business problem.
- Gather data and represent KPI's using advanced infographic components.
- Sketch low fidelity wire frame works(Blue prints)
- Create Interactive working prototypes using cutting edge tools communicate stories using data to your audiences.
- Create Reusable info graphic templates (Advanced dashboard processes & story boards) and automate information flow for real time usage
- Custom visuals using motion charts
- Visualizing multi-dimensional data
- Advanced cartography techniques

Infographics can often be combined with advanced visualization practices by incorporating dynamic visuals , motion charts , advanced cartography methods etc.

BASIC TEXT BOOK:

Teaching notes, Info graphic paraphernalia & data sets to be provided by instructor.

REFERENCE BOOKS:

Teaching notes, Info graphic paraphernalia & data sets to be provided by instructor.

261 : Information Theory & Cryptography

Information Theory: Entropy, Shannon games, HMMs, maximum entropy principle and maximum conditional entropy, applications to statistics and Machine learning.

Books

- T.M. Cover and J.A. Thomas, *Elements of Information Theory*, John Wiley, 1991
- R.B. Ash, *Information Theory*, Dover, 1990

Cryptography

1. Introduction to Cryptography

History of Cryptography, stream cipher, one time pad, Attacks, , Secure ciphers, PRG and Semantic security

2. Block Ciphers

Basics of block ciphers, the data encryption standard, attacks on block ciphers, AES block cipher, PRP and PR, one time key, many time key

3. Message Integrity

Introduction to message integrity, CBC-MAC, Collision resistant Hashing, Merkle-Damgard, SHA, HMAC, Authenticated encryption, Session set up using a key distribution center

4. Public key Cryptography

Arithmetic modulo primes, Key exchange protocols, Diffie-Hellman, Discrete log problem, ElGamal encryption, Trapdoor permutations, RSA

5. Digital Signatures

Signing using RSA, Hash based signatures, certificates, password protocols, salts, authenticated key exchange SSL/TLS session setup

Books

- J Katz and Y Lindell, *Introduction to Modern Cryptography*, Chapman & Hall/CRC Press, 2nd Edition 2014
- Carmit Hazay and Yehuda Lindell, *Efficient Secure Two-Party Protocols : Techniques and Constructions*, Springer-Verlag 2010

262: Topics in Data Science

The topics of this course vary from year to year and are given by visiting experts from industry or abroad. The topics are of current interest in industry or academia. They could, for example range from computational advertising, static analysis of programs, applications of deep learning in medicine, image and video processing, natural language processing, new algorithms to handle big data, advances in cryptography and data privacy.

Books

- Aaron R. Bradley and Zohar Manna, The Calculus of Computation: Decision Procedures with Applications to Verification, Springer 2007
- William K. Pratt, Introduction to Digital Image Processing, CRC Press, 2013
- Yao Wang, Joern Ostermann, and Ya-Qin Zhang, Video Processing and Communications, Prentice Hall, 2002
- Jurafsky, David, and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition. Upper Saddle River, NJ: Prentice-Hall, 2000
- Manning, Christopher D., and Hinrich Schütze. Foundations of Statistical Natural Language Processing. Cambridge, MA: MIT Press, 1999
- L.C. Washington, Elliptic Curves : Number Theory and Cryptography, 2 nd Edition, CRC Press, 2008

263: Topics in Financial Engineering

This course's contents vary from year to year. Topics may include

1. Diffusions with varying volatility:

Local Volatility models, Dupire approach; stochastic volatility models

2. Jumps:

Extreme value theory, large deviations, jump diffusions, Ito's lemma for jumps, Pricing with jump diffusions

3. Exotic options:

Pricing and hedging exotic and multi-asset options, path dependent options, barrier options

4. Interest rate models (in continuous time):

Bond price processes under different short rate models, equilibrium models of term structure, forward rate models, Heath-Jarrow-Morton modelling approach

5. Product Innovation:

Structuring new products, tax and regulatory considerations, understanding history and which products succeed; explaining how new products work to clients

Books:

- Dynamic Hedging, Taleb
- Paul Wilmott Introduces Quantitative Finance, Second Edition, Wiley 2007 (ISBN 978-0-470-31958-1)
- Financial Instruments and Markets: A Casebook, Chacko et al

264: Computational Finance

1. Numerical Programming in Python:

introduction to numerical methods – computational issues, introduction to python scientific computation libraries, exercises (root finding, linear systems, ODEs, optimisations)

2. Tree-based approaches and replicating strategies:

Recombining and non-recombining trees

3. Solving PDEs:

Discretizing the BS equation, explicit and implicit differencing, solving boundary value problems, techniques to improve precision and reduce computation time

4. Simulation Methods:

Pseudorandom generators, generating paths, variance reduction techniques

5. Calibration:

Incorporating skews and smiles, calibrating interest rate models (HJM)

References:

[PTVF] Numerical Recipes (3/e) : Press et al.

[JC] Introduction to Derivative Securities, Jarrow and Chatterjea

265: Asset Pricing II (Empirical Asset Pricing)

1. Equity Return Predictability and Cross-Section of Stock Returns

Dividend dynamics, term structure of dividend strips; term structures of asset prices and returns; predictive regressions; timing and pricing of dividends; discount Rates; systematic risk and betas; cross-section of risk and return; detecting anomalies.

2. Intermediary-based Asset Pricing and Production-based Asset Pricing Models

Financial intermediaries and cross-section of asset returns; leverage and value-at-risk; Market liquidity and funding liquidity; Intermediary asset pricing; long-run consumption risk and asset returns; investment shocks and asset prices; value premium.

3. Hedge Funds and Mutual Funds

Scale and skill in active management; time-varying fund manager skill; managerial ability, incentives, and risk preferences; economics of hedge funds.

4. Volatility

Variance premium; Uncertainty, time-varying fear, and asset prices; Overreaction and Excess volatility, idiosyncratic volatility

5. Corporate Bonds and CDS, Fixed Income and Currencies, and Commodities

Quality and corporate bond returns; cross-section of credit spreads; currency risk factors; economic momentum and currency returns; carry trade; currency premium and global imbalances; fundamentals of commodity futures returns; financialization of commodity markets; cryptocurrency.

Books

- Campbell, John Y., 2018, Financial Decisions and Markets: A Course in Asset Pricing, Princeton, NJ: Princeton University Press
- Campbell, John Y., Andrew W. Lo, and A. Craig MacKinlay, 1997, The Econometrics of Financial
- Duffie, Darrell, 2001, Dynamic Asset Pricing Theory, 3rd Edition, Princeton, NJ: Princeton University Press
- Singleton, Kenneth J., 2006, Empirical Dynamic Asset Pricing, Princeton, NJ: Princeton University Press
- Hamilton, James D., 1994, Time Series Analysis, Princeton, NJ: Princeton University Press

266: Medical Analytics

1. Introduction to Molecular Biology

DNA, RNA and Proteins, Cell, Basics of Transcription, Translation, Genes, Codons, Amino Acids, Genomes, Protein Structure

2. Genomics

Alignment algorithms for sequence alignment, Local Alignment Blast algorithm and its statistics, Global alignment for protein sequences PAM and BLOSUM matrices, comparative genomics, Hidden Markov Models to identify genes, CpG islands and other genomic signatures, SNPs, Haplotypes

3. Imaging Modalities

Basics of Anatomy and Physiology and various organ systems, Anatomical Planes, X-ray, CT scan, MRI, PET scan, Image formation and Resolution

4. Time Series

Electrical Properties of Heart and Brain, EEG, ECG, Echo, Ultrasound, Application of machine learning to classify images and medical video

5. Biological Networks

Modeling Metabolic Networks, Flux Balance analysis, Application to medicine

Books

- Uri Alon, *An introduction to Systems Biology: Design principles of Biological Circuits*, Chapman and Hall 2013
- Dan Gusfield, *Algorithms on Strings, Trees and Sequences*, Cambridge University Press, 1997
- Gray's Anatomy International Edition: The Anatomical Basis of Clinical Practice
- Prince and Links, *Medical Imaging, Signals and Systems*, Pearson Prentice Hall, 2006
- Guyton and Hall, *Textbook of Medical Physiology*
- Durbin, Eddy, Krogh and Mitchison, *Biological Sequence Analysis : Probabilistic Models of Proteins and nucleic acids*, Cambridge University Press, 2013

267: Robotics

1. Kinematics and Dynamics

Introduction to velocity, acceleration, force, frames of reference, work and energy, equations of motion and conservation laws, Rotation, torque, Euler Angles

2. Spatial Descriptions

Positions, Orientations and Frames, Changing descriptions from frame to frame, Rotation matrix, Operators for translation and rotation Stationary Markov Chains, Codes, Kraft's Inequality

3. Manipulator Kinematics

Link connection description, convention for fixing frames to links, concept of the actuator and joint space, DH parameters

4. Inverse Manipulator Kinematics and Jacobians

Notion of manipulator subspace, Algebraic and Peper's solution, examples of inverse manipulator kinematics, Time varying position and orientation, Angular Velocity, Velocity propagation from link to link, Jacobians and singularities, computational aspects

5. Dynamics of the Manipulator and Trajectory generation

Newton's and Euler's equation, Mass distribution, Inertia Tensor, Lagrangian formulation of manipulator dynamics, joint space schemes and geometric problems with Cartesian paths

Books

- John. J. Craig, *Introduction to Robotics Mechanics and Control*, 3rd Edition, Pearson Prentice Hall, 2005
- R. Paul, *Robotic Manipulators*, MIT Press, 1981

268: Quantum Computing

1. Classical Computation

Turing Machine, Church-Turing Thesis, Circuit model of Computation, Computational Complexity, Energy and Information

2. Quantum Mechanics

Stern Gerlach and Young's Double slit experiments, Linear Vector space, postulates of quantum mechanics, matrix formulation, Entanglement, EPR paradox, Bell's Inequalities

3. Quantum Computation

The Qbit, Bloch sphere, measurement of state of qbit, Bell basis, rotations of Bloch Sphere, circuit model of quantum computation, Function evaluation, Quantum adder

4. Quantum Algorithms

Deutsch-Jozsa algorithm, Quantum Search algorithms, Grover's algorithm, Quantum Fourier Transform, Shor's algorithm

5. Adiabatic Quantum Computing

Challenges of Quantum Computing, Noise and Decoherence, Quantum Adiabatic Optimization

Books

- Michael A. Nielsen and Isaac L. Chuang, *Quantum Computation and Quantum Information*, Cambridge University Press, 2010
- P Kok and B Lovett, *Introduction to Optical Quantum Information Processing*, Cambridge University Press, 2010
- Scott Aaronson, *Quantum Computing since Democritus*, Cambridge University Press, 2013

269 Projects in R Python

In the project course students will follow a case study approach.

Several topical and important case studies will be assigned to the class for them to work on them and discuss their results. Examples of representative case studies include:

- Predicting Insurance Fraud
- Predicting and Preventing Customer Attrition
- Optimizing Retail Product Mix
- Estimating Flight Delays
- Forecasting Baseline and Incremental Sales

After the completion of the case studies, student teams will be free to work on a project of their choice. They may use data available from the public domain or collect their own data. This project will cover all the steps in the data science process: data acquisition, cleansing, labelling, feature engineering, model building, selection, model optimization and finally strategies for deployment and operationalization

270: Algorithmic and High Frequency Trading

1. Algorithmic Trading

Example of Algorithmic trading. Exchanges, Quote and Order driven markets, Evolution of markets, Limit order Book, Order Imbalance, High frequency data

2. Optimal Betting and Execution Strategies

Optimal Execution and Liquidation and their impact, Optimal acquisition with temporary impact, inventory path formulation, Permanent price, Quantitative investment and trading framework

3. Order Flow

Temporary and Permanent Impact, Parameters of the market impact model, concept of value function, Weightage average price, volume traded, Optimal liquidation speed and its interpretation, Strategy performance,

4. Dark Pools

Full Execution in Dark Pools, Riccati ODE and its solution, Optimal liquidation and inventory model, simulations and back-testing strategies, Performance measurement

5. Market Making

Mathematical formulation of Market Maker's control problem, Symmetric fill probability, Optimal postings, Mean reversion in inventory, Market Making with no terminal penalty

Books

- Cartea A, Jaimungal S and Penalva J *Algorithmic and High-Frequency Trading*, Cambridge University Press 2015
- Chan E *Algorithmic Trading: Winning Strategies and Their Rationale*, Wiley Trading 2013

271: Marketing Concepts

6. Segmentation, targeting, and positioning

How to assess market potential, understand and analyze customer behavior, and focus resources on specific customer segments and against specific competitors.

7. Branding

How to develop, measure, and capitalize on brand equity.

8. Marketing communications

How to develop an effective mix of marketing communication efforts.

9. Distribution channels

How to understand the role of distributors, retailers, and other intermediaries in delivering products, services and information to customers.

10. Pricing

How to set prices that capitalize on value to the customer and capture value for the firm.

Reference Books

- Chernev A., *Strategic Marketing Management*, 8th Edition, Cerebellum Press, 2012
- Kotler, P. and Keller K. L., *Marketing Management*, 13th Edition, Pearson Education, 2013

272: Organization Behaviour

1) Basics of Organizational Behavior

Ethical Values and the importance of organizational behavior, study of personality and the reason for individual differences, Study of Employee Work attitudes and the role of job satisfaction

2) Stress and Happiness at Work

Factors influencing personality and its influence on stress, causes and consequences of job related stress, managing stress, Emotions, Organizational programs of wellness and stress management, Job insecurity

3) Group Behavior and Motivation

Organization structure, Groups in organizations and their Influence and motivation, cultural differences in motivation, Promoting Employee productivity, interpersonal skills and communication

4) Leadership and Organizational Control

Leadership styles and Values, Leadership qualities, Leader vs Boss, Power and Politics, Goal Setting, Performance Appraisals and Rewards, Reward Systems

5) Organizational Dynamics

Factors influencing organizational dynamics, Organizational objectives and effectiveness, Deficiencies in the Work place, Team approach to work, Composition and Cohesiveness of Teams, Importance of a Collaborative Culture

References

- Stephen P. Robins, Organisational Behavior, PHI Learning / Pearson Education, 11th edition, 2008.
- Fred Luthans, Organisational Behavior, McGraw Hill, 11th Edition, 2001.
- Champoux, J. (2011) *Organizational Behavior: Integrating Individuals, Groups, and Organizations* (4th edn). New York, NY: Routledge.

273: Human Resources

1. Introduction to Human Resource Management, Human Resource Planning

Introduction, Concept of Human Resource Management, Scope of Human Resource Management, History of Human Resource Management, Function of Human Resource Management, Role of HR Executives, Process of Human Resource Planning, Need for Human Resource Planning, HR Forecasting Techniques, Successful Human Resource Planning

2. Recruitment and Selection, Training and Management Development

Concept of Recruitment, Factors Affecting Recruitment, Sources of Recruitment, Recruitment Policy, Selection, Selection Process, Application Forms, Selection Test, Interviews, Evaluation, Placement, Induction, Meaning of Training, Area of Training, Methods of Training, Concept of Management Development, Management Development Methods, Differences Between Training and Development, Evaluation of Training and Management Development

3. Employee Career Planning and Growth, Performance Appraisal

Concept of Employee Growth, Managing Career Planning, Elements of a Career Planning Programme, Succession Planning, Concept and Need for Performance, Reviews, Overview of Performance Appraisal, Types of Appraisal Methods, 360 degree appraisal, Benefits

4. Compensation Management, Job Evaluation

Wage and Salary Administration, Managing Wages, Concept of Rewards and Incentives, Managing Benefits in Organisations, Concept of Job Evaluation, Objectives, Techniques, Advantages and Limitations, Introduction to Competency

5. Human Resource Information System, Job Analysis and Design

Introduction, Concept, Components, Types, Application, Implementation, Benefits, Impact, Concept of Job Analysis and Design, Process of Job Analysis, Methods of Job Analysis, Job Analysis Information, Concept of Job Design

Books

- Dessler, G., *Human Resource Management*, 13th Edition, Pearson, 2012.
- Robert N. Lussier and John R. Hendon, *Human Resource Management: Functions, Applications, and Skill Development*, 3rd Edition, SAGE, 2018.

274: Natural Language Processing and Text Analytics(RB)

1. Language Modeling

Language Modeling with N-grams, Text Normalization, Part of speech tagging, Edit distance, Statistical Language modeling, Linguistic structure, Parsing, Regular Expressions

2. Text processing and Information Retrieval

Different models for Text Retrieval, RSJ model, Model based feedback, Text encoding, Tokenization, stemming, vector space scoring, random projection, approximate vector retrieval

3. Sentiment Analysis

Semantics of Text, Summarization, Question Answering, Lexicons for Sentiment, Connotation, Information extraction, Word Senses, Representation of Sentence meaning, Argument Structure

4. Natural Language Processing (NLP) and Deep Learning

Word window, classification, Recurrent Neural Networks and models of language, machine translation of text and language, Convolutional Neural Networks for sentence classification, subword models, modeling contextual representations

5. Relation Discovery and Topic Mining

Topic Extraction, Latent Semantic Analysis (LSA), Probabilistic LSA (PLSA) and its extensions, Latent Dirichlet Allocation (LDA), Hidden Markov Models (HMM), Mixture Language Models

Books

- Dan Jurafsky and James H Martin, *Speech and Language Processing*, 3rd Edition, Draft
- Christopher Manning and Hinrich Schutze, *Foundations of Statistical Natural Language Processing*, MIT Press, 1999
- Christopher Manning, Prabhakar Raghavan and Hinrich Schutze, *Introduction to Information Retrieval*, Cambridge University Press, 2008
- Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press 2016