

F111: Financial Management

1. **Financial institutions and the financial system:** introduction and key terms
2. **Financial mathematics:** Time Value of Money, Compounding, EAR, Annuities, etc.
3. **Context of finance:** Introduction to the Companies Act, Forms of organization, 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.
- Principles of corporate finance (Global edition). Brealey, R. A.; Myers, S. C.; Allen, F. 11th ed. McGraw-Hill, 2014.

M112: Banking and Risk Management

1. **Financial System – Structure and Components:** Overview and importance of the financial system; financial institutions, assets, markets, and services; their features and interrelationships; graphic representation of the system; classification of institutions like banks, NBFCs, and cooperatives; and key markets including money, capital, and forex.
2. **Indian Banking System – Evolution and Operations:** History of Indian banking; nationalisation and reforms; PSB reorganisation; types of banks—private, foreign, cooperative, RRBs; banking ombudsman; banker-customer relationship; and legal aspects of lockers and custody.
3. **Banking Products, Services, and Technology:** Deposit and loan products; instruments like cheques, drafts, and remittances; electronic banking—IMPS, NEFT, RTGS, SWIFT, ATMs; international banking; and innovations in mobile and internet banking.
4. **Regulation, Supervision, and Risk in Banking:** RBI's functions and monetary tools—CRR, SLR, repo, OMO, LAF; principles of lending; capital and risk management; and practices adopted by banks like SBI, Citibank, and Standard Chartered.
5. **Global Regulations, Crises, and Specialized Banking:** Basel Accords; capital adequacy norms; asset-liability management with case studies; trade finance—domestic and international; global financial crises; and emerging challenges in banking regulation.

References:

- Modern Banking: Theory and Practice. Muraleedharan, D. Pearson Education.
- Management of Banking and Financial Services. Suresh, Padmalatha; Paul, Justin. 2nd ed. Pearson Education.
- Contemporary Banking in India. Kidwai, Naina Lal (Ed.). Business Standard Books.
- Banking on Basel: The Future of International Financial Regulation. Tarullo, Daniel K. Peterson Institute for International Economics.

E113: 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 their 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.

References:

- 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.

MA114: Quantitative Methods

1. **Differential & Integral 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, Integrals and Definite Integrals and their properties.
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. **Discrete Mathematics:** Various Proof Techniques, Logic, Existential and Universal Quantifiers, Mathematical Induction, Relations and Functions, Various number systems and their properties.
4. **Combinatorics and Graph Theory:** Permutations & Combinations, Counting Techniques, Graph Theory, Trees, Cycles, Coloring and Matchings, Adjacency Matrix
5. **Applications:** The topics covered in units 1 to 4 will be applied to Fields in Analytics, Economics, Finance and Management.

References:

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

MA115: Probability with MATLAB

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 hypergeometric 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

References:

- 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.

BA116: Analytics in Business

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

References:

- Kotler, P. and Armstrong G, Principles of Marketing, 17th Edition, Pearson Education.
- Stephen P Robbins and Timothy A Judge, Organizational Behavior 15th Edition, Pearson Education.
- An Introduction to Statistical Learning Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirami.

F121: 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, the 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.

References:

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

M122: Global Enterprise Risk Management

1. **Introduction to Risk and Risk Management:** This module introduces the foundational concepts of risk and enterprise risk management (ERM); people and behaviors in risk contexts; governance structures; organizational culture and risk-taking behavior; risk maturity levels; and a global perspective on emerging and systemic risks.
2. **Risk Culture and Organizational Processes:** Focuses on embedding risk thinking into business processes; understanding and assessing risk culture; practical approaches to improving risk management within existing organizational frameworks; strategies for shifting risk culture; and the cultural theory of risk and its implications for organizations.
3. **COSO Framework for ERM:** Explores the structure and approach of the COSO ERM framework; the COSO cube 2004 guidance; updates introduced in the COSO 2017 framework; comparison of COSO with Annex SL; and the relevance and applicability of COSO frameworks for modern risk professionals.
4. **Risk Management Process:** Covers the steps in the risk management process including risk identification; writing effective risk descriptions; creating and maintaining a risk register; analyzing and evaluating risks; understanding different types of risk rating; and linking risk and internal controls.
5. **Governance, Risk Appetite, and Strategic Decision-Making:** Examines advanced topics in ERM such as defining and measuring risk appetite and tolerance; aligning risk with organizational performance; developing a risk strategy approach; questions boards should ask about risk; building organizational risk competencies and capabilities; and integrating risk into governance and decision-making processes.

References:

- James Lam, Enterprise Risk Management: From Incentives to Controls, Wiley, 2nd edition, 2014.
- Paul Hopkin, Fundamentals of Risk Management: Understanding, Evaluating and Implementing Effective Risk Management, Kogan Page, 6th edition, 2022.

E123: 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

References:

- 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.

MA124: Statistics inference with R

1. **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
2. **Estimations:** 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
3. **Hypothesis Testing:** 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
4. **Design of Experiments and Analysis of Variance:** Design of Experiments, one-way ANOVA, two-way ANOVA, Simple linear regression model, ANOVA approach to regression,
5. **Bayesian Estimation and Inference:** Bayesian point estimation, Bayesian confidence intervals, hypothesis testing, Bayesian decision theory

References:

- 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.

BA125: Linear Algebra in Business

1. **Different Pictures of Matrices:** The row and column picture, solutions of linear system of equations, Gaussian elimination
2. **Vector Spaces induced by matrices:** Row space, column space, null space, graph representation of matrices, Adjacency matrix, Rank of a matrix, Different conditions for solutions to equations, multiplicity of solutions, the linear least square problem and its geometric picture
3. **Decomposition of Matrices:** LU, QR, Cholesky, Polar, and singular value Decomposition and application to rank deficient least squares
4. **Eigen values and Eigen Vectors:** Spectral representation, Determinants, Applications to solutions of system of differential equations of Markov chain
5. **Classical Optimization and Applications:** Introduction to linear programming and quadratic forms, unconstrained optimization, constrained optimization with equality constraints, Lagrangian method, Hessian and Jacobian matrices, applications – utility maximization, cost minimization, profit – output maximization

References:

- Trefethen, Lloyd N., and David Bau III. Numerical linear algebra. Vol. 50. Siam, 1997.
- Golub, Gene H., and Charles F. Van Loan. Matrix computations. Vol. 3. JHU Press, 2012.
- Gill, Philip E., Walter Murray, and Margaret H. Wright. Numerical linear algebra and optimization. Vol. 1. Redwood City, CA: Addison-Wesley, 1991.

BA126: Introduction to Python

1. **Python:** Programming in Python, Algorithm design concepts illustrated with examples, use of built-in libraries and functions
2. **Searching and Sorting:** Linear Search, Binary Search, Insertion sort, Bubble sort, Heap sort, Quick sort, Radix sort, Merge sort, space and time complexity with different data structures
3. **Graph algorithms:** Shortest Path algorithms, Depth-first search, Breadth-first search, Graph colouring, Spanning Tree algorithms, Max Flow Min Cut, Euler circuit algorithm
4. **Numerical Algorithms:** Round off and Truncation errors, Ill Conditioned Matrices, Gaussian Elimination, Numerical differentiation and integration
5. **Intractable Problems:** Notion of NP and NP-complete, Various complexity classes, SAT problem, Cook's theorem, Reducibility among various NP-complete problems

References:

- T.H. Cormen, C.E. Leiserson, R.L. Rivest and C Stein, Introduction to Algorithms MIT Press, 3rd Edition 2009.
- Stormy Attaway, Matlab, A Practical Approach to Programming and Problem Solving, Elsevier 2009.
- Michael J Crawley, The R Book, John Wiley & Sons, Ltd, 2007.
- Allent Downey, Think Python, Green Tea Press 2012.

F131: 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

M132: Marketing Management

1. **Segmentation, targeting, and positioning:** Principles and bases of market segmentation, including demographic, psychographic, geographic, and behavioral dimensions; tools and methods for analyzing customer needs, preferences, and buying behavior; evaluation of market potential and the competitive landscape; and the design and implementation of positioning strategies to achieve sustainable competitive advantage.
2. **Branding:** Fundamentals of brand creation and identity development; measuring and managing brand equity using qualitative and quantitative methods; strategies for brand extension, co-branding, and brand revitalization; and approaches to leveraging brand equity for long-term customer loyalty and firm profitability.
3. **Marketing communications:** Elements of the integrated marketing communications (IMC) mix, including advertising, sales promotion, personal selling, public relations, direct and digital marketing; the design of effective communication strategies aligned with consumer decision-making; media planning, message design, and budgeting for communication campaigns; and the measurement of communication effectiveness and return on marketing investments.
4. **Distribution channels:** Role and importance of marketing channels in value delivery networks; the functions and structures of intermediaries such as wholesalers, retailers, distributors, and logistics providers; channel design, conflict management, and relationship strategies; and emerging trends such as e-commerce platforms, Omni-channel retailing, and digital distribution models.
5. **Pricing:** Pricing objectives and their alignment with overall marketing and business strategy; cost-based, competition-based, and value-based pricing methods; approaches such as price discrimination, dynamic pricing, and psychological pricing; and the management of pricing decisions in global markets and across different stages of the product life cycle.

References:

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

E133: 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.

References:

- Introductory Econometrics for Finance by Chris Brooks, 2nd edition, Cambridge University Press, 2008.
- Basic Econometrics 4e by Damodar N. Gujarati & Sangeetha. Mc-Graw Hill.
- Econometric Methods by Johnston J. and J. Dinardo, fourth Edition, McGraw-Hill, 2010.
- Econometric Analysis of Panel Data by Baltagi, B.H., John Wiley & sons Ltd., 2015.
- Introduction to Econometrics by G.S. Maddala and K. Lahiri, 4th Edition, Wiley, 2009.

MA134: 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
5. **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

References:

- To be updated Ross, S.M., An Introduction to Mathematical Finance, Cambridge University Press, 2003.
- Parzen, E. Stochastic Processes, Society for Industrial and Applied Mathematics, 1999.
- Kulkarni, V. Modeling and Analysis of Stochastic Systems, G. Thomson Science and Professional, 1995.
- Bhat U.N.and G.K.Miller, Elements of Applied Stochastic Processes, Wiley, 2002.

BA135: Big Data

1. **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.
2. **Components of Hadoop Ecosystem:** Understanding the HDFS, Map Reduce functionalities in Hadoop. Actions & Transformations that are applicable. Immutability as a concept explored.
3. **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.
4. **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.
5. **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.
6. **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.

References:

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

BA136: Fundamentals of Machine Learning

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

References:

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

FE0: 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 Vasicekmodel, 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 Wiggin's model, ARCH and GARCH models and their suitable extensions in diffusion.

References:

- 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.

FE1: 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

References

- 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.

FE2: Derivatives and Options

1. **Pricing of Options:** Law of One Price, Concept of Replicating portfolio, Complete and Incomplete 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

References:

- 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.

FE3: 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 modelling, 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 drift condition 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

References:

- Bjork T, Arbitrage Theory in Continuous Time, OUP, 3rd ed. 2009.
- Filipovic D, Term-structure models, Springer Finance, Springer-Verlag, Berlin 2009.

FE4: 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, and securitization.
5. **Managing credit portfolios:** Basel-3 and RBI norms, regulatory reporting and accounting.

References:

- 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.

FE5: 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

References:

- 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.

FE6: 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

References:

- Dynamic Hedging, Taleb Paul Wilmott Introduces Quantitative Finance, Second Edition, Wiley 2007.
- Financial Instruments and Markets: A Casebook, Chacko et al.

FE7: 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, and 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.

FE8: Asset Pricing II

1. **Equity Return Predictability and Cross-Section of Stock Returns:** Dividend dynamics, term structure of dividend strips; term structures of asset price 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.

References:

- 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 Markets.
- 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

FE9: Financial Time Series Analysis

1. **Introduction to Time Series and ARIMA Forecasting Models:** Introduction to Financial Time Series and their Characteristics; Trend, Seasonality, Cyclicity, 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

References:

- Chris Brooks, “Introductory Econometrics for Finance”, Cambridge University Press.
- Ruey S Tsay, “Analysis of Financial Time Series, Wiley India Edition.
- Johanson, J. and Dinardo, “Econometric Methods”, McGraw-Hill.
- Walter Enders, Applied Econometric Time Series, Third Edition, Wiley India Edition.
- Damodar N Gujarati and Sangeetha, “Basic Econometrics, McGraw-Hill.

FE10: 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, the concept of the value function, Weightage average price, the 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

References:

- 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.

BAE1: Natural Language Processing and Text Analytics

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

References:

- Dan Jurafsky and James H Martin, Speech and Language Processing, 3rd Edition.
- 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.

BAE2: 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, and 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.

References:

- Head First SQL - Your Brain on SQL -- A Learner's Guide - Lynn Beighley, O'Reilly
- SQL Cookbook - Anthony Molinaro, O'Reilly
- SQL Primer_ An Accelerated Introduction to SQL Basics – Rahul Batra, Apress.

BAE3: Deep and Reinforcement Learning

1. **Deep Feed Forward Neural Networks:** Multilayer perceptron, 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

References:

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

BAE4: Algorithms and Data Structures

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

References:

- 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.

BAE5: 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 T^2 , ANOVA and MANOVA
3. **Analysis of covariance structure:** Principal 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, Correspondence analysis, Structural Equation Modeling, tree-based methods, support vector machines

References:

- 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.

BAE6: Advanced Analytical Models for Decision-Making

1. **Revenue Management and Pricing Models:** Overview, Demand Functions, Solving the basic pricing models with capacity constraints. Customer segmentation, Pricing to multiple segments, Pricing under uncertainty, Models for Perishable Assets, Seasonal demand, Mark up/down, Price Trajectory, Dynamic Pricing.
2. **Queuing Models:** Waiting line analysis, Elements and Characteristics of a waiting line system, Queue discipline, Finite and Infinite source, Single server, Multiple server waiting line, Measures of waiting-line performance, Monte Carlo process, Simulation of a Queuing system
3. **Decision Theory:** Decision processes, decision making under certainty, uncertainty and risk. Decision criteria (Maximin, Maximax, Laplace, Minimax regret, Hurwicz) Decision tree analysis, Posterior probability, Expected value of perfect information, Sensitivity analysis
4. **Transportation Models:** Location decisions and models, Gravity location models, Transportation model, Assignment model, Transshipment problem, Distribution network design, Network optimization models
5. **Applications:** Predictive analytics and Decision models for data-driven real-world applications, Application of Mathematical models for designing strategies supporting policy-making, business decisions and evaluating performance and risk, Analytical case studies in Healthcare, E-commerce, Internet, Retail, Airlines, Finance etc.

References:

- Dimitris Bertsimas and Robert Freund, Data, Models, and Decisions: The fundamentals of Management Science, South-Western College Publishing, 2000
- Robert Phillips, Pricing and Revenue Optimization, Stanford University Press, 2004
- D Gross, J.F. Shortle, J.M. Thompson and C.M. Harris, Fundamentals of Queueing Theory, 4th Edition, Hoboken, Wiley, 2008
- Averill M. Law and W. David Kelton, Simulation Modeling and Analysis, 2nd Edition, McGraw-Hill, 1991

BAE7: Information Theory & Cryptography

1. **Introduction:** Entropy, Shannon games, HMMs, maximum entropy principle and maximum conditional entropy, applications to statistics and Machine learning. 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

References:

6. T.M. Cover and J.A. Thomas, Elements of Information Theory, John Wiley, 1991.
7. R.B. Ash, Information Theory, Dover, 1990.
8. J Katz and Y Lindell, Introduction to Modern Cryptography, Chapman & Hall/CRC Press, 2nd Edition 2014.
9. Carmit Hazay and Yehuda Lindell, Efficient Secure Two-Party Protocols: Techniques and Constructions, Springer-Verlag 2010.

BAE8: 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.

References:

10. Aaron R. Bradley and Zohar Manna, The Calculus of Computation: Decision Procedures with Applications to Verification, Springer 2007.
11. William K. Pratt, Introduction to Digital Image Processing, CRC Press, 2013.
12. Yao Wang, Joern Ostermann, and Ya-Qin Zhang, Video Processing and Communications, Prentice Hall, 2002.
13. 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.
14. Manning, Christopher D., and Hinrich Schütze. Foundations of Statistical Natural Language Processing. Cambridge, MA: MIT Press, 1999.
15. L.C. Washington, Elliptic Curves: Number Theory and Cryptography, 2nd Edition, CRC Press, 2008.

BAE9: 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

References:

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

BAE10: 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

References:

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

BAE11: 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

References:

- 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.

BAE12: 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

References:

- 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).

ME1: Banking Management & Financial Services

1. **Financial Regulation:** Asymmetric information and the rationale for regulation of securities market, financial market fragility, review of regulatory policies in US, UK, Japan and Asian emerging markets.
2. **Indian Capital Markets:** Structure of primary and secondary markets, dematerialization, depositories, credit rating of financial instruments, financial institutions: development financial institutions, non-banking financial intermediaries, LIC of India and UTI, mutual funds, venture capital, bank-assurance
3. **Financial Sector Reforms:** Indian capital market integration, foreign institutional investors, impact of exchange rate variability in a liberalized regime, Issues of GDRs, ADRs
4. **Banking Regulation:** Banking regulation act 1949, financial stability, basics of public debt management issue of government securities conduct of monetary policy- role of gilt market
5. **Bank of International Settlement:** Capital adequacy regulations Basel accord I & II. accounting standard, disclosure and relationship banking mark-to-market accounting, liquidity risk and contagion market discipline: issues and evidence market discipline in emerging economies: beyond bank fundamentals

References

- Houthakker, H.S. and Williamson, P.J. The Economics of Financial Markets, Oxford University Press, 1996.
- Krugman, P. and Obstfeld, M. International Economics, Theory and Policy, sixth edition, Addison - Wesley, 2003.
- Herring, R. and Litan, R.E. Financial Regulation in the Global Economy, Brookings Institution Press, 1995.
- Howells, P. and Bain, K. Financial Markets and Institutions, Fifth Edition, Pearson Education, 2007.

ME2: 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
3. **Markov Decision Process and Reinforcement Learning:** Review of Markov Chains, State Space, Actions, Goals, Rewards and Returns, Policy and Value functions
4. **Dynamic Programming:** Bellman's principle of Optimality, Policy prediction and Improvement, Policy and Value Iteration, Examples and Applications
5. **Approximate Methods:** Value function approximation, Stochastic Gradient Methods, Feature construction for linear methods, least squares

References:

- 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.

ME3: Strategic Management

1. Introduce the concept of Brand and associated concepts like Brand Identity, Brand Personality, Brand Equity, and Brand Extension.
2. Understand how to leverage a brand and the need to do so. Understand the role of brand management in marketing strategies.
3. Understand branding as a communication process and the stages of a brand launch.
4. Introduction to concept writing. Understand the role of corporate brands and branding in new technology platforms.
5. Understand brand attitudes, need for revitalization, and co-branding, Discuss applications of brand management strategies with case studies.

References

- Strategic Brand Management - Kevin Lane Keller Pearson.
- Building Strong Brands - David A. Aaker, The Free Press.
- The New Strategic Brand Management - Jean-Noel Kapferer, Kogan Page Limited.
- Brand Relevance - Making Competitors Irrelevant- David A. Aaker, Printed by Jossey-Bass.

ME4: Taxation Management

1. **Tax Incidence:** Definition, Partial and General Equilibrium Incidence, Economic vs Statutory Incidence, Partial Equilibrium model, Tax incidence Formula, Parallel Trends assumption, fixed effects
2. **Efficiency Cost of Taxation:** Introduction, Excess Burden of Taxation, Efficiency cost, Tax policy implications, Marginal excess burden of Tax increase, Government revenue leakage, Excess burden with Taxes on multiple goods, Goulder and Williams formula
3. **Optimal Taxation:** Commodity Taxation, Ramsey Tax Problem and Model, Government's problem, Ramsey Optimal Tax formula, Perturbation analysis, Optimal Capital Income Tax Rate, Optimal Income Tax with no Behavioral Responses
4. **Income Taxation:** Labor-Leisure Choice model, Non-Hours Responses, Progressive Taxes and Labor supply, Negative Income tax, Elasticity estimation using varying tax rate, Taxable income elasticities
5. **Corporate Taxation:** Corporate decisions and Tax policies, Model of Firm behavior, cash rich and cash constrained firms, evidence on dividend taxation, impacts on investment, corporate taxation in an agency model

References

- Atkinson and J. Stiglitz. Lectures on Public Economics, New York: McGraw Hill, 1980
- B. Salanie. The Economics of Taxation, Cambridge: MIT Press, 2003
- C. Ballard, D. Fullerton, J. Shoven, and J. Whalley, A General Equilibrium Model for Tax Policy Evaluation, Chicago: University of Chicago Press, 1985