



Institute of Actuaries of India

Statutory body established under an Act of Parliament

Unit No. F-206, 2nd Floor, F Wing, Tower II, Seawoods Grand Central,
Plot no R-1, Sector 40, Nerul Road, Navi Mumbai - 400706
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Subject

B1 - Quantitative Finance and Financial Engineering



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COURSE STRUCTURE

SECTION	TOPIC	WEIGHTING
I	Intertemporal preference of money and theory of interest rates	15-20%
II	Application of principle of economic equivalence	10-15%
III	Measurement and management of investment risk	10%
IV	Financial markets and portfolio management	15-20%
V	Asset price and investment return models	10-15%
VI	Stochastic calculus and theory of option pricing	15-20%

TENTATIVE CHAPTER NAMES UNDER EACH SECTION WITH EXPECTED LEARNING OUTCOMES:

Section I: Intertemporal preference of money and theory of interest rates

- 1) **Investment and Insurance cashflows**
 - a) Describe nature and timing of cashflow for various investment classes
 - b) Describe nature and timing of cashflow for various insurance contracts
- 2) **Time value of money**
 - a) Describe concepts of simple interest, compound interest and discounting
 - b) Define and calculate present value of future payment
 - c) How rate of interest relates with time period
- 3) **Interest rates and inflation**
 - a) Describe concepts of effective interest rate, nominal interest rate and force of interest and carry out calculations
 - b) Explain the concept of real interest rate as against money interest rates and carry out calculations
 - c) Understand the actuarial notation of interest rates
- 4) **Present value and Future value**
 - a) Calculate present value and future value of a stream of cashflows under various scenarios viz., varying lengths of time, varying interest rates, varying cashflows, commencement of the first cashflow
- 5) **Annuities - level and variable**
 - a) Define various annuity functions and actuarial notation of annuity functions
 - b) Derive formulae for, and calculate, present and future values of immediate annuities, annuities due, deferred annuities, continuous annuities, annuities payable at regular intervals, perpetuities, Increasing and decreasing immediate annuities and deferred annuities

Section II: Application of principle of economic equivalence

- 6) **Equation of value**
 - a) Define equation of value for cashflows
 - b) Apply equation of value concept to calculate unknown quantities like interest rate or time period or cashflow amounts



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- c) Apply equation of value concept differentiating between actual cashflows and expected cashflows
- 7) Capital budgeting and investment appraisal**
 - a) Define and calculate net present value, internal rate of return, payback period and discounted payback period in assessing the viability of a capital project
- 8) Loan repayment and amortisation schedule**
 - a) Understand different methods of loan repayment
 - b) Construct loan schedules under EMI method and derive formulae for calculation of interest or principal quantities at a particular time period
- 9) Fair price and yields of key asset classes**
 - a) Define asset classes and their returns in terms of coupons, dividends or rents
 - b) Define and calculate nominal yield, real yield, running yield, gross and net redemption yield for various asset classes
 - c) Calculate the price of an asset given the cashflow patterns under various asset classes

Section III: Measurement and management of investment risk

- 10) Measures of investment risk**
 - a) Define and calculate risk measurement quantities using various measures like variance, semi-variance, shortfall probabilities, Value at Risk, Tail Value at Risk
 - b) Explain how risk measures can determine utility function and vice-versa
- 11) Role of insurance**
 - a) Describe how insurance is used in managing risks and explain concepts of moral hazard and adverse selection in insurance

Section IV: Financial markets and portfolio management

- 12) Efficient Market hypothesis**
 - a) Understand and discuss the forms of efficient market hypothesis in terms of rational investor behaviour based on empirical evidence
- 13) Modern Portfolio Theory and portfolio optimisation**
 - a) Demonstrate understanding and application of mean variance portfolio theory for portfolio optimisation
 - b) Using the principles of mean variance portfolio theory calculate mean and variance of investment returns of a basket of assets given statistical measures of investment returns for each individual asset in the basket
 - c) Describe concepts of specific risk, systematic risk and diversification in the context of mean variance portfolio theory
- 14) Expected utility theory and investor behaviour**



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- a) Define utility function and mathematically express investor risk and reward appetite in terms of non-satiation, absolute and relative risk aversion, risk neutrality and risk-seeking
- b) Describe utility theory and expected utility theorem
- c) Apply concepts of utility theory and utility functions real life investment and insurance scenarios

15) Stochastic dominance and behavioural economics

- a) Define the concept of dominance and first and second order stochastic dominance
- b) Describe the concept of Kahneman and Tversky's Prospect Theory as a counterintuition to expected utility theory
- c) Explain concepts of heuristics, framing and bias and characterise investor behaviour under various types of bias
- d) Define equity premium puzzle and explain Bernartzi-Thaler solution to the same

Section V: Asset price and investment return models

16) Statistical distribution of investment returns

- a) Define and compare stochastic models with deterministic models
- b) Demonstrate understanding and application of fixed rate and varying rate models for single payments and payment streams
- c) Explain the use of lognormal distribution for modelling investment returns and its limitations
- d) Derive mathematically or by intuition, and apply, lognormal formulae for varying rate models

17) Factor models of investment returns

- a) Describe single index models of investment returns and perform calculations using these models
- b) Describe following multi-factor models of investments returns, understand how these are formulated and perform calculations using the following models:
 - i) Macroeconomic models
 - ii) Fundamental models
 - iii) Statistical models

18) Equilibrium models of asset pricing

- a) Discuss process of parameter estimation in asset pricing models and its challenges
- b) Describe the founding principles and assumptions of CAPM (Capital Asset Pricing Model) and apply the CAPM in calculating asset prices
- c) Discuss the limitations of CAPM and how they may be addressed
- d) Arbitrage Pricing Model- Principles, Assumptions Applications and Limitations

19) The term structure of interest rates

- a) Define and calculate spot rates and forward rates



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- b) Explain and demonstrate the concepts of duration, discounted mean term, convexity and immunization of a series of cashflows
- c) Explain how Redington immunization of portfolio of liabilities may be achieved using duration and convexity

Section VI: Stochastic calculus and theory of option pricing

20) Stochastic processes - Martingales and Brownian motion (Weiner Process)

- a) Define the statistical properties of Martingales and Brownian motion and how they are appropriate models for stock pricing

21) Stochastic calculus and Ito's lemma

- a) Demonstrate basic understanding of stochastic calculus
- b) State Ito's lemma and apply it for simple problems
- c) Find the solution of stochastic differential equation of a Geometric Brownian Motion and Ornstein-Uhlenbeck process
- d) Understand and apply the continuous lognormal model of security returns and discuss its suitability and limitations

22) Derivatives' pricing and theory of no-arbitrage

- a) Define, explain and apply the concept of no-arbitrage theory in valuation of forward contracts and options
- b) Define American and European put and call options and derive by logical reasoning or otherwise the lower and upper bounds of option premium
- c) Explain the concept of put-call parity

23) The binomial model

- a) Use binomial trees in option pricing
- b) Discuss concept of risk neutral measure as against real world measure
- c) Compare equivalence of risk neutral approach to state price deflator approach to option pricing in the binomial model

24) Black-Scholes option pricing model

- a) Derive Black-Scholes and Garman-Kolhagan partial differential equations
- b) Apply Black-Scholes formula for valuing call and put options and discuss its limitations
- c) Compare equivalence of risk neutral approach to state price deflator approach to option pricing in the Black-Scholes model

25) Option price sensitivity analyses using the Greeks

- a) Understand and apply in simple situations the first and second order partial derivatives Delta and Vega in evaluating an option price

26) Risk neutral and portfolio replication strategy for asset pricing - discrete time

- a) Define complete market, replicating portfolio, previsible process and hedging
- b) Explain equivalence of risk neutral approach to martingale approach
- c) Demonstrate pricing and hedging a simple derivative using martingale approach



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27) Risk neutral and portfolio replication strategy for asset pricing - continuous time

- a) Demonstrate pricing and hedging a simple derivate using martingale approach

28) Interest rate models

- a) Characteristics of an effective model of term structure of interest rates
- b) Describe risk neutral approach to pricing simple bonds and interest rate derivatives under a one-factor model of risk free rate
- c) Describe price deflator approach to pricing simple bonds and interest rate derivatives under a one-factor model of risk free rate
- d) Demonstrate understanding and application in simple situations of the following one-factor models of instantaneous risk free rate:
 - i) Cox-Ingersoll-Ross model
 - ii) Vasicek model
 - iii) Hull-White model
