Quantitative Finance and Investment – Core Exam

Spring/Fall 2018

Important Exam Information:

Exam Registration	Candidates may register online or with an application.
Order Study Notes	Study notes are part of the required syllabus and are not available electronically but may be purchased through the online store.
Introductory Study Note	The Introductory Study Note has a complete listing of all study notes as well as errata and other important information.
Case Study	There is no case study for this examination.
Past Exams	Past Exams from 2000 - present are available on the SOA website.
Formula Package	A Formula Package will be provided with the exam. Please see the Introductory Study Note for more information.
Table	A cumulative normal distribution table will be provided with the exam.
Updates	Candidates should be sure to check the Updates page on the exam home page periodically for additional corrections or notices.

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1. **Topic: Stochastic Calculus**

Learning Objectives

The candidate will understand the fundamentals of stochastic calculus as they apply to option pricing.

Learning Outcomes

The Candidate will be able to:

a) Understand and apply concepts of probability and statistics important in mathematical finance.

b) Understand the importance of the no-arbitrage condition in asset pricing.

c) Understand Ito integral and stochastic differential equations.

d) Understand and apply Ito's Lemma.

e) Understand and apply Jensen's Inequality.

f) Demonstrate understanding of option pricing techniques and theory for equity and interest rate derivatives.

g) Demonstrate understanding of the differences and implications of real-world versus risk-neutral probability measures.

h) Define and apply the concepts of martingale, market price of risk and measures in single and multiple state variable contexts.

i) Understand and apply Girsanov's theorem in changing measures.

j) Understand the Black Scholes Merton PDE (partial differential equation).

Resources

- *Paul Wilmott Introduces Quantitative Finance,* Wilmott, Paul, 2nd Edition, 2007
  - Ch. 5 & 6
- *An Introduction to the Mathematics of Financial Derivatives,* Hirsa, Ali and Neftci, Salih N., 3rd Edition, 2014
  - Ch. 1-15 (excluding section 8.2.4)
- QFIC-113-17 *Frequently Asked Questions* in *Quantitative Finance*, Wilmott, Paul, 2nd Edition, 2009, Ch. 2, pp. 103-105, 109-115, 155-161 and 248-249

Continued on next page

- *Problems and Solutions in Mathematical Finance: Stochastic Calculus*, Chin, Eric, Nel, Dian and Olafsson, Sverrir, 2014

Candidates may study the assigned problems along with the relevant chapters of *An Introduction to the Mathematics of Financial Derivatives,* Hirsa, Ali and Neftci, Salih N., to reinforce the standard techniques used in stochastic calculus. Please note that formulas from this text are not included in the formula package.

- Ch. 1: corresponds to Hirsa & Neftci Ch. 5 & 14
- Ch. 2: corresponds to Hirsa & Neftci Ch. 6 & 8
- Ch. 3: corresponds to Hirsa & Neftci Ch. 11
- Ch. 4: corresponds to Hirsa & Neftci Ch. 14 & 15
- Ch. 5: corresponds to Hirsa & Neftci Ch. 11

Chapter	Pages	
1	1 to 3	Definitions 1.1 to 1.7 (Note that statement (b) of Definition 1.7 involves integration using a measure-theoretic approach. An equally valid statement can be made using a Riemann-Stieltjes integral for continuous distributions or a sum for discrete distributions.)
	4 to 5	Q3 to Q7
	18 to 19	Q7
	43 to 44	Q4, Q5
2	52 to 53	Definitions 2.1, 2.2, Theorems: 2.3 and 2.4, Definitions 2.5 and 2.6
	55 to 68	Q1 to Q13, except Q11
	68 to 71	Q1, Q2, Q3
	71 to 74	Q1 to Q5
	89 to 93	Q1 to Q4
3	96 to 100	Theorems 3.1, 3.2, and 3.3, Definition 3.6
	104 to 105	Q3
	110 to 119	Q8 to Q14
	123 to 149	Q1 to Q20
	155 to 158	Q1 to Q3
	175 to 178	Q10
4	186 to 187	Definitions 4.1(a) - (f)
	189	Theorem 4.6
	192 to 194	Q1, Q2
	194 to 197	Q1 to Q3
	221 to 242	Q1 to Q17
5	262 to 264	Q9 to Q11
	281 to 285	Q1, Q2

2. **Topic: Option Pricing and Hedging**

Learning Objectives

- The candidate will understand how to apply the fundamental theory underlying the standard models for pricing financial derivatives
- The candidate will understand the implications for option pricing when markets do not satisfy the common assumptions used in option pricing theory such as market completeness, bounded variation, perfect liquidity, etc.
- The candidate will understand how to evaluate situations associated with derivatives and hedging activities.

Learning Outcomes

The Candidate will be able to:

a) Identify limitations of the Black-Scholes pricing formula.

b) Compare and contrast the various kinds of volatility, (e.g. actual, realized, implied, forward, etc.)

c) Compare and contrast various approaches for setting volatility assumptions in hedging.

d) Understand the different approaches to hedging.

e) Understand how to delta hedge and the interplay between hedging assumptions and hedging outcomes.

f) Appreciate how hedge strategies may go awry.

g) Describe and explain some approaches for relaxing the assumptions used in the Black-Scholes formula.

Resources

- *Paul Wilmott Introduces Quantitative Finance,* Wilmott, Paul, 2nd Edition, 2007
    - Ch. 2 (background only), 8 and 10
- QFIC-102-13: Current Issues: Options - What Does An Option Pricing Model Tell Us About Option Prices?
- QFIC-103-13: How to Use the Holes in Black-Scholes
- QFIC-104-13: Chapter 3 of *The Known, the Unknown, and the Unknowable in Financial Risk Management: Measurement and Theory Advancing Practice*
- QFIC-114-17: *Frequently Asked Questions* in *Quantitative Finance*, Wilmott, Paul, 2nd Edition, 2009, Ch. 2, pp. 162-173 and 223-225
- QFIC-115-17: Which Free Lunch Would You Like Today, Sir?: Delta Hedging, Volatility Arbitrage and Optimal Portfolios

3. **Topic: Interest Rate Models**

Learning Objectives

The candidate will understand the quantitative tools and techniques for modelling the term structure of interest rates and pricing interest rate derivatives.

Learning Outcomes

The Candidate will be able to:

a) Understand and apply the concepts of risk-neutral measure, forward measure, normalization, and the market price of risk, in the pricing of interest rate derivatives.

b) Apply the models to price common interest sensitive instruments including: callable bonds, bond options, caps, floors and swaptions.

c) Understand and apply popular one-factor interest rate models including Vasicek, Cox-Ingersoll-Ross, Hull-White, Ho-Lee, Black-Derman-Toy and Black-Karasinski.

d) Understand the concept of calibration and describe the issues related to calibration, including yield curve fitting.

e) Understand and differentiate between the classical approach to interest rate modelling and the HJM modelling approach, including the basic philosophy, arbitrage conditions, assumptions, and practical implementations.

f) Understand and apply the HJM and BGM/Libor Market model.

Resources

- *Paul Wilmott Introduces Quantitative Finance,* Wilmott, Paul, 2nd Edition, 2007
  - Ch. 16-19
- *An Introduction to the Mathematics of Financial Derivatives,* Hirsa, Ali and Neftci, Salih N., 3rd Edition, 2014
  - Ch. 16-19
- QFIC-116-17: Low Yield Curves and Absolute/Normal Volatilities

4. **Topic: Volatility**
Learning Objectives
The candidate will understand the concept of volatility and some basic models of it.
Learning Outcomes
The Candidate will be able to: a) Compare and contrast the various kinds of volatility, (e.g. actual, realized, implied and forward, etc.). b) Understand and apply various techniques for analyzing conditional heteroscedastic models including ARCH and GARCH.
Resources
• *Paul Wilmott Introduces Quantitative Finance,* Wilmott, Paul, 2nd Edition, 2007 o Ch. 9, Sections 9.5-9.7 • *Analysis of Financial Time Series,* Tsay, Ruey S., 3rd Edition, 2010 o Ch. 1, 2 (background only) o Ch. 3, Sections 3.1–3.8, 3.14 • QFIC-109-15: Chapter 9 of *Risk Management and Financial Institutions,* Hull, 2nd Edition

5. **Topic: Fixed Income Portfolio Management**

Learning Objectives

The candidate will understand and identify the variety of fixed instruments available for portfolio management.

This section deals with fixed income securities. As the name implies the cash flow is often predictable, however, there are various risks that affect cash flows of these instruments. In general candidates should be able to identify the cash flow pattern and the factors affecting cash flow for commonly available fixed income securities. Candidates should be comfortable using various interest rate risk quantification measures in the valuation and managing of investment portfolios; Candidates should also understand various strategies of managing the portfolio against a given benchmark.

Learning Outcomes

The Candidate will be able to:

a) Demonstrate an understanding of par yield curves, spot curves, and forward curves and their relationship to traded security prices; and understanding of bootstrapping and interpolation.

b) Describe the cash flow of various corporate bonds considering underlying risks such as interest rate, credit and event risks.

c) Demonstrate an understanding of the characteristics of leveraged loans.

d) Demonstrate an understanding of cash flow pattern and underlying drivers and risks of non-agency mortgage-backed securities, and commercial mortgage-backed securities.

e) Demonstrate an understanding of the characteristics and mechanics of fixed income ETFs.

f) Construct and manage portfolios of fixed income securities using the following broad categories:

    a. Managing funds against a target return

    b. Managing funds against liabilities

Resources

- *The Handbook of Fixed Income Securities,* Fabozzi, Frank, 8th Edition, 2012
    - Ch. 1, 2 and 9 (all background only)
    - Ch. 12, 13, 18, 21, 24, 31, 32
- *Managing Investment Portfolios: A Dynamic Process*, Maginn, John L. & Tuttle, Donald L., 3rd Edition, 2007
    - Ch. 6: Fixed Income Portfolio Management
- *Paul Wilmott Introduces Quantitative Finance,* Wilmott, Paul, 2nd Edition, 2007
    - Ch. 14
- QFIC-117-17: High-Yield Bond Market Primer

6. **Topic: Equities**

Learning Objectives

The candidate will understand the variety of equity investments and strategies available for portfolio management.

Learning Outcomes

The Candidate will be able to:

a) Explain the nature and role of equity investments within portfolios that may include other asset classes.

b) Demonstrate an understanding of the basic concepts surrounding passive, active, and semi active (enhanced index) equity investing, including managing exposures.

c) Explain the basic active equity selection strategies including value, growth and combination approaches.

d) Demonstrate an understanding of equity indices and their construction, including distinguishing among the weighting schemes and their biases.

e) Identify methods for establishing passive exposure to an equity market;

f) Compare techniques for characterizing investment style of an investor;

g) Recommend and justify, in a risk–return framework, the optimal portfolio allocations to a group of investment managers;

h) Describe the core-satellite approach to portfolio construction with a completeness fund to control overall risk exposures;

i) Explain alpha and beta separation as an approach to active management and demonstrate the use of portable alpha;

j) Describe the process of identifying, selecting, and contracting with equity managers.

Resources

- *Managing Investment Portfolios: A Dynamic Process*, Maginn, John L. & Tuttle, Donald L., 3rd Edition, 2007
    - Ch. 7: Equity Portfolio Management
- QFIC-110-15: Liquidity as an Investment Style

7. **Topic: Investment Policy**
Learning Objectives
The candidate will understand how to develop an investment policy including governance for institutional investors and financial intermediaries.
Learning Outcomes
The Candidate will be able to: a) Explain how investment policies and strategies can manage risk and create value. b) Identify a fiduciary's obligations and explain how they apply in managing portfolios. c) Determine how a client's objectives, needs and constraints affect investment strategy and portfolio construction. Include capital, funding objectives, risk appetite and risk-return trade-off, tax, accounting considerations and constraints such as regulators, rating agencies, and liquidity. d) Incorporate financial and non-financial risks into an investment policy, including currency, credit, spread, liquidity, interest rate, equity, insurance product, operational, legal and political risks.
Resources
• *Managing Investment Portfolios: A Dynamic Process*, Maginn, John L. & Tuttle, Donald L., 3rd Edition, 2007   o Ch. 1 & 3 • QFIC-108-13: Managing your Advisor: A Guide to Getting the Most Out of the Portfolio Management Process

8. **Topic: Asset Allocation**
Learning Objectives
The candidate will understand the theory and techniques of portfolio asset allocation.
Learning Outcomes
The Candidate will be able to: a) Explain the impact of asset allocation, relative to various investor goals and constraints. b) Propose and critique asset allocation strategies. c) Evaluate the significance of liabilities in the allocation of assets. d) Incorporate risk management principles in investment policy and strategy, including asset allocation. e) Understand and apply the concept of risk factors in the context of asset allocation.
Resources
• *Managing Investment Portfolios: A Dynamic Process*, Maginn, John L. & Tuttle, Donald L., 3rd Edition, 2007 o Ch. 5 • QFIC-111-16: Stop Playing With Your Optimizer • QFIC-112-16: Risk Factors as Building Blocks for Portfolio Diversification: The Chemistry of Asset Allocation