QFI – Quantitative Finance Exam

Spring 2019/Fall 2019

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	A case study will not be used for this examination.
Past Exams	Past Exams from 2000-present are available on SOA website.
Updates	Candidates should be sure to check the Updates page on the exam home page periodically for additional corrections or notices.
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.

Recognized by the Canadian Institute of Actuaries

1. **Topic: Stochastic Calculus**

Learning Objectives

The candidate will understand the foundations of quantitative finance.

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 the Ito integral and stochastic differential equations

d) Understand and apply Ito's Lemma

e) Understand the Black Scholes Merton PDE (partial differential equation)

f) Understand and apply Jensen's Inequality

g) Understand the distinction between complete and incomplete markets

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

i) Demonstrate understanding of the differences and implications of real-world versus risk-neutral probability measures, and when the use of each is appropriate

j) Understand and apply Girsanov's theorem in changing measures

k) Understand the importance of the Feynman-Kac Theorem

Resources

- *An Introduction to the Mathematics of Financial Derivatives,* Hirsa, Ali and Neftci, Salih N., 3rd Edition 2nd Printing, 2014
    - Ch. 1-15 (excluding section 8.2.4)

  ***Note**:* Candidates should verify that their copy of the Hirsa & Neftci textbook is the 3rd edition, second printing by checking that page iv, *Notices* section, begins with "Knowledge and best practice in this field…". If the *Notices* section begins "No responsibility is assumed…" it is the first printing and should be replaced.
- QFIQ-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
- *Problems and Solutions in Mathematical Finance: Stochastic Calculus*, Chin, Eric, Nel, Dian and Olafsson, Sverrir, 2014

  Note: Candidates should study the following problems in Chin, Nel, and Ólafsson alongside the matching chapters of *An Introduction to the Mathematics of Financial Derivatives,* Hirsa and Neftci to reinforce the standard techniques used in stochastic calculus. Please note that formulas from Chin, Nel, and Ólafsson are not included in the formula package.

Chin et al. Chapter	Pages	Item	Corresponding Hirsa & Neftci Chapter
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.)	5, 14
	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	6 & 8
	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	11
	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)	14 & 15
	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	11
	281 to 285	Q1, Q2	

2. **Topic: Fixed Income Markets**

Learning Objectives

The candidate will understand the fundamentals of fixed income markets and traded securities.

Learning Outcomes

The Candidate will be able to:

a) Understand the characteristics of fixed rate, floating rate, and zero-coupon bonds

b) Bootstrap a yield curve

c) Understand measures of interest rate risk including duration, convexity, slope, and curvature

d) Understand the characteristics and uses of interest rate forwards, swaps, futures, and options

e) Describe the issues in modeling low to negative interest rates

Resources

- *Fixed Income Securities: Valuation, Risk, and Risk Management*, Veronesi, Pietro, 2010
  - Ch. 1
  - Ch. 2 (including Appendix)
  - Ch. 3 (excluding Appendix)
  - Ch. 4
  - Ch. 5.1-5.7 (excluding Case Study)
  - Ch. 6 (including Appendix)
- QFIQ-116-17: Low Yield Curves and Absolute/Normal Volatilities

3. **Topic: Interest Rate Models and Hedging**

Learning Objectives

The candidate will understand:

- The quantitative tools and techniques for modeling the term structure of interest rates.
- The standard yield curve models.
- The tools and techniques for managing interest rate risk.

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) Understand and apply various one-factor interest rate models

c) Calibrate a model to observed prices of traded securities

d) Describe the practical issues related to calibration, including yield curve fitting

e) Demonstrate understanding of option pricing theory and techniques for interest rate derivatives

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

g) Understand and apply the techniques of interest rate risk hedging

h) Understand the application of Monte Carlo simulation to risk neutral pricing of interest rate securities

i) Understand and apply the Heath-Jarrow-Morton approach including the Libor Market model

j) Understand and apply multifactor interest rate models including the two-factor Hull-White model

Resources

- *An Introduction to the Mathematics of Financial Derivatives,* Hirsa, Ali and Neftci, Salih N., 3rd Edition 2nd Printing, 2014
    - Ch. 16-21
- *Fixed Income Securities: Valuation, Risk, and Risk Management*, Veronesi, Pietro, 2010
    - Ch. 14
    - Ch. 15.1-15.6 (excluding Appendices)
    - Ch. 16.1-16.8 (excluding Appendix)
    - Ch. 17 (including Case Study)
    - Ch. 18.1-18.6 (excluding Appendix)
    - Ch. 19.1-19.8 (excluding Appendix)
    - Ch. 20
    - Ch. 21.1-21.10 (excluding Appendix)
    - Ch. 22.1-22.4

4. **Topic: Equity Option Pricing and Hedging**

Learning Objectives

The candidate will understand:

- How to apply the standard models for pricing financial derivatives.
- The implications for option pricing when markets do not satisfy the common assumptions used in option pricing theory.
- How to evaluate risk exposures and the issues in hedging them.

Learning Outcomes

The Candidate will be able to:

a) Demonstrate an understanding of option pricing techniques and theory for equity derivatives

b) Identify limitations of the Black-Scholes-Merton pricing formula

c) Demonstrate an understanding of the different approaches to hedging – static and dynamic

d) Demonstrate an understanding of how to delta hedge, and the interplay between hedging assumptions and hedging outcomes

e) Analyze the Greeks of common option strategies

f) Appreciate how hedge strategies may go awry

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

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

i) Define and explain the concept of volatility smile and some arguments for its existence

j) Compare and contrast "floating" and "sticky" smiles

k) Describe and contrast several approaches for modeling smiles, including: stochastic volatility, local-volatility, jump-diffusions, variance-gamma, and mixture models

l) Explain various issues and approaches for fitting a volatility surface

Resources

- *The Volatility Smile*, Derman, Emanuel and Miller, Michael B., 2016
  - Ch. 1 (background)
  - Ch. 2-7
  - Ch. 8-10
  - Ch. 14
  - Ch. 17-19
- QFIQ-114-17: Chapter 2, pp. 162-173 and 223-225 of *Frequently Asked Questions* in *Quantitative Finance*, Wilmott, Paul, 2nd Edition, 2009

- QFIQ-115-17: Which Free Lunch Would You Like Today, Sir?: Delta Hedging, Volatility Arbitrage and Optimal Portfolios
- QFIQ-120-19: Chapters 6 and 7 of *Pricing and Hedging Financial Derivatives*, Marroni, Leonardo and Perdomo, Irene, 2014

5. Topic: Additional Quantitative Techniques

Learning Objectives

The candidate will understand important quantitative techniques relating to financial time series, volatility modeling, and stochastic modeling.

Learning Outcomes

The Candidate will be able to:

a) Understand and apply various techniques for analyzing conditional heteroscedastic models including ARCH and GARCH

b) Demonstrate an understanding of the concept of a factor model in the context of financial time series

c) Apply various techniques for analyzing factor models including principal component analysis (PCA) and statistical factor analysis

d) Compare and contrast various approaches for setting volatility assumptions for a hedging model

e) Demonstrate an understanding of the general uses and techniques of stochastic modeling

Resources

- *Analysis of Financial Time Series,* Tsay, Ruey S., 3rd Edition, 2010
  - Ch. 1, 2 (background only)
  - Ch. 3, Sections 3.1–3.8, 3.14
- *Fixed Income Securities: Valuation, Risk, and Risk Management*, Veronesi, Pietro, 2010
  - Ch. 4.6
- QFIQ-109-15: Chapter 9 of *Risk Management and Financial Institutions,* Hull, 2nd Edition
- QFIQ-119-19: Chapter 6 - Principal Component Analysis of *Market Models: A Guide for Financial Data Analysis*, Alexander, Carol, 2001
- Economic Scenario Generators: A Practical Guide, SOA, 2016, Ch. 1, 5-7, 9, 10