MA6627: STOCHASTIC INTEREST RATE MODELS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Stochastic Interest Rate Models

Subject Code
MA - Mathematics
Course Number
6627

Academic Unit
Mathematics (MA)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MA5616 Financial Mathematics in Derivative Markets

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course aims to
- examine quantitative aspects of interest rate models and pricing of associated derivatives, such as caps and swaps;
- present calibration methods to stochastic interest rate models, including short rate and forward rate models; and
- introduce modeling of stochastic term structure models and hedging from an infinite-dimensional viewpoint.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe short rate models by Itô stochastic processes and derive governing equations of bond prices with no-arbitrage argument.	40	x	x	
2	Model stochastic movement of forward rates with HJM model.	20	x	x	
3	Formulate LIBOR market model (BGM model) of interest rate derivatives under the Gaussian HJM framework.	20	x	x	
4	Apply the technique of forward measure to price interest rate derivatives and to examine expectation of the short rate and the LIBOR process.	10	x	x	x
5	Present an infinite-dimensional analysis to interest rate term structure and hedging derivatives.	10	x	x	x

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Students will engage in lecture activities about various stochastic interest rate models.	1, 2, 3, 4, 5	39 hours in total

2	Assignments	Students are required to finish take-home assignments which helps them characterize and analyze various interest rate models with stochastic techniques, as well as apply these models in pricing traded interest rate derivatives.	1, 2, 3, 4, 5	after-class

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Test	1, 2, 3	20	Questions are designed for the first part of the course to see how well students have learned stochastic analysis of interest rate models, such as HJM and LIBOR models.	No
2	Hand-in assignments	1, 2, 3, 4, 5	10	These are skills-based assessment which enables students to model interest rate and forward rate with stochastic methods, as well as to formulate HJM framework and LIBOR processes.	Yes

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)

3

Minimum Examination Passing Requirement (%)

30

Additional Information for ATs

- For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

- Examination questions are designed to see how far students have achieved their intended learning outcomes. Questions will primarily be skills and understanding based to assess the student's versatility in mathematical methods underlying stochastic interest rate models and associated derivatives pricing.

Assessment Rubrics (AR)

Assessment Task

Test (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Independent problem-solving skills on stochastic analysis of interest rate models, including HJM and LIBOR models

Excellent

(A+, A, A-) Demonstrates a thorough understanding of the concepts and techniques in the stochastic interest rate theory and can always apply the techniques to solve HJM and LIBOR models.

Good

(B+, B, B-) Demonstrates a substantial understanding of the concepts and techniques in the stochastic interest rate theory and can usually apply the techniques to solve HJM and LIBOR models.

Fair

(C+, C, C-) Demonstrates a general understanding of the concepts and techniques in the stochastic interest rate theory and can sometimes apply the techniques to solve HJM and LIBOR models.

Marginal

(D) Demonstrates a partial understanding of the concepts and techniques in the stochastic interest rate theory and can seldom apply the techniques to solve HJM and LIBOR models.

Failure

(F) Demonstrates a little understanding of the concepts and techniques in the stochastic interest rate theory and can rarely or never apply the techniques to solve HJM and LIBOR models.

Assessment Task

Hand-in assignments (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Understanding of the stochastic method to model interest rate and forward rate, as well as to formulate HJM framework and LIBOR processes

Excellent

(A+, A, A-) Demonstrates a thorough understanding of the stochastic method to model interest rate and forward rate and can always apply the method to formulate HJM framework and LIBOR processes.

Good

(B+, B, B-) Demonstrates a substantial understanding of the stochastic method to model interest rate and forward rate and can usually apply the method to formulate HJM framework and LIBOR processes.

Fair

(C+, C, C-) Demonstrates a substantial understanding of the stochastic method to model interest rate and forward rate and can usually apply the method to formulate HJM framework and LIBOR processes.

Marginal

(D) Demonstrates a partial understanding of the stochastic method to model interest rate and forward rate and can seldom apply the method to formulate HJM framework and LIBOR processes.

Failure

(F) Demonstrates a little understanding of the stochastic method to model interest rate and forward rate and can rarely or never apply the method to formulate HJM framework and LIBOR processes.

Assessment Task

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Comprehensive problem-solving skills on mathematical methods underlying stochastic interest rate models and associated derivatives pricing

Excellent

(A+, A, A-) Demonstrates a thorough understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can always apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Good

(B+, B, B-) Demonstrates a substantial understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can usually apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Fair

(C+, C, C-) Demonstrates a substantial understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can usually apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Marginal

(D) Demonstrates a partial understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can seldom apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Failure

(F) Demonstrates a little understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can rarely or never apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Assessment Task

Test (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Independent problem-solving skills on stochastic analysis of interest rate models, including HJM and LIBOR models

Excellent

(A+, A, A-) Demonstrates a thorough understanding of the concepts and techniques in the stochastic interest rate theory and can always apply the techniques to solve HJM and LIBOR models.

Good

(B+, B) Demonstrates a substantial understanding of the concepts and techniques in the stochastic interest rate theory and can usually apply the techniques to solve HJM and LIBOR models.

Marginal

(B-, C+, C) Demonstrates a general understanding of the concepts and techniques in the stochastic interest rate theory and can sometimes apply the techniques to solve HJM and LIBOR models.

Failure

(F) Demonstrates a little understanding of the concepts and techniques in the stochastic interest rate theory and can rarely or never apply the techniques to solve HJM and LIBOR models.

Assessment Task

Hand-in assignments (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Understanding of the stochastic method to model interest rate and forward rate, as well as to formulate HJM framework and LIBOR processes

Excellent

(A+, A, A-) Demonstrates a thorough understanding of the stochastic method to model interest rate and forward rate and can always apply the method to formulate HJM framework and LIBOR processes.

Good

(B+, B) Demonstrates a substantial understanding of the stochastic method to model interest rate and forward rate and can usually apply the method to formulate HJM framework and LIBOR processes.

Marginal

(B-, C+, C) Demonstrates a general understanding of the stochastic method to model interest rate and forward rate and can sometimes apply the method to formulate HJM framework and LIBOR processes.

Failure

(F) Demonstrates a little understanding of the stochastic method to model interest rate and forward rate and can rarely or never apply the method to formulate HJM framework and LIBOR processes.

Assessment Task

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Comprehensive problem-solving skills on mathematical methods underlying stochastic interest rate models and associated derivatives pricing

Excellent

(A+, A, A-) Demonstrates a thorough understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can always apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Good

(B+, B) Demonstrates a substantial understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can usually apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Marginal

(B-, C+, C) Demonstrates a general understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can sometimes apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Failure

(F) Demonstrates a little understanding of the mathematical theory on stochastic interest rate models and associated derivatives pricing and can rarely or never apply the theory to solve problems on stochastic interest rate models and associated derivatives pricing.

Part III Other Information

Keyword Syllabus

Short term interest rate models. Zero-coupon bonds. Forward rates. Term structure dynamics-HJM model. Arbitrage and change of numeraire. LIBOR market-BGM model. Interest rate derivatives. Pricing of caps and swaps. Infinite dimensional approach to hedging. Calibration issues.

Reading List

Compulsory Readings

	Title
1	Steven E. Shreve, Stochastic Calculus for Finance I: The Binomial Asset Pricing Model, Springer; 2004th edition
2	Steven E. Shreve, Stochastic Calculus for Finance II: Continuous-Time Models, Springer, 2010

Additional Readings

	Title
1	Nil