City University of Hong Kong
Course Syllabus

offered by College/School/Department of Mathematics
with effect from Semester B 2024/25

Part I Course Overview

Course Title:	**Stochastic Interest Rate Models**
Course Code:	**MA6627**
Course Duration:	**One Semester**
Credit Units:	**3 CUs**
Level:	**P6**
Medium of Instruction:	**English**
Medium of Assessment:	**English**
Prerequisites: *(Course Code and Title)*	**MA5616 Financial Mathematics in Derivative Markets**
Precursors: *(Course Code and Title)*	**Nil**
Equivalent Courses: *(Course Code and Title)*	**Nil**
Exclusive Courses: *(Course Code and Title)*	**Nil**

Part II Course Details

1. 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.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Describe short rate models by Itô stochastic processes and derive governing equations of bond prices with no-arbitrage argument.	40%	✓	✓	
2.	Model stochastic movement of forward rates with HJM model.	20%	✓	✓	
3.	Formulate LIBOR market model (BGM model) of interest rate derivatives under the Gaussian HJM framework.	20%	✓	✓	
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%	✓	✓	✓
5.	Present an infinite-dimensional analysis to interest rate term structure and hedging derivatives.	10%	✓	✓	✓
		100%			

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.

3. Learning and Teaching Activities (LTAs)

(LTAs designed to facilitate students' achievement of the CILOs.)

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

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

30% Coursework
70% Examination (Duration: 3 hours, at the end of the semester)

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

Assessment Tasks/Activities	CILO No.						Weighting	Remarks
	1	2	3	4	5	6		
Continuous Assessment: __30__%								
Test	✓	✓	✓				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.
Hand-in assignments	✓	✓	✓	✓	✓		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.
Examination: 70% (duration: 3 hrs, if applicable)								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.
							100%	

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Test	Independent problem-solving skills on stochastic analysis of interest rate models, including HJM and LIBOR models	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.	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.	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.	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.	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.
2. Hand-in assignments	Understanding of the stochastic method to model interest rate and forward rate, as well as to formulate HJM framework and LIBOR processes	Demonstrates a thorough understanding of the stochastic method to model interest rate and forward rate and can always apply the method to formulate HJM	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.	Demonstrates a substantial understanding of the stochastic method to model interest rate and forward rate and can usually apply the method to formulate HJM	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.	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.

		framework and LIBOR processes.		framework and LIBOR processes.		
3. Examination	Comprehensive problem-solving skills on mathematical methods underlying stochastic interest rate models and associated derivatives pricing	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.	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.	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.	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.	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.

Applicable to students admitted from Semester A 2022/23 to Summer Term 2024

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Test	Independent problem-solving skills on stochastic analysis of interest rate models, including HJM and LIBOR models	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.	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.	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.	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.
2. Hand-in assignments	Understanding of the stochastic method to model interest rate and forward rate, as well as to formulate HJM framework and LIBOR processes	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.	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.	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.	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.
3. Examination	Comprehensive problem-solving skills on mathematical methods underlying stochastic interest rate models and associated derivatives pricing	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.	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.	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.	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 (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

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.

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

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
3.	
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2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

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