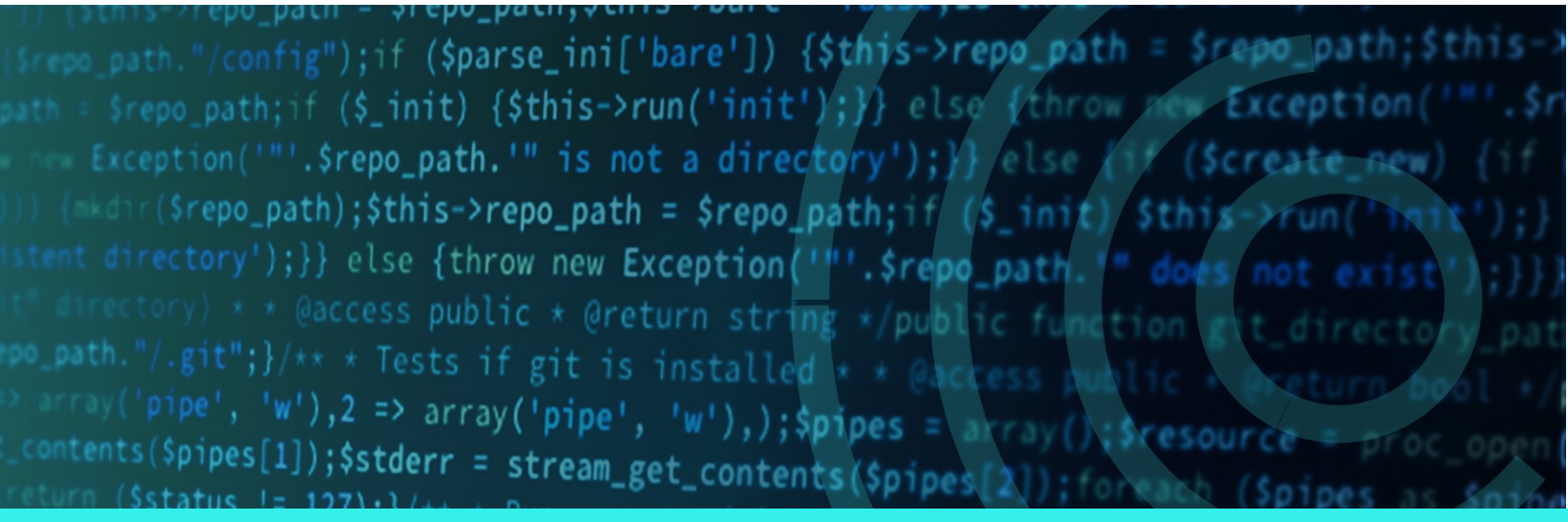
WORLDQUANT UNIVERSITY

Course Syllabus

MScFE 622

Continuous-time Stochastic Processes



Revised: 1/3/2022

Table of Contents

Course Overview

General

MScFE 622: Continuous-time Stochastic Processes

This course covers key stochastic processes such as Brownian Motion, Stochastic Calculus including the Ito integral, the Black-Scholes Model, and Levy processes. The course expands the student knowledge on quadratic variations, proving martingale property, deriving and proving Ito-Doeblin, and understanding the first and second fundamental theorems of finance. In the last module of the course, some of the most important interest rate models are addressed in detail.

Credits	4 Semester Credit Hours
Course Materials	Lecture notes and optional references posted in the online course room; free online resources to amplify existing course content as indicated by your faculty
Methods of Instruction	Video lectures, live sessions, guest lectures, reading assignments embedded in the online course room, posted references
Methods of Assessment	Quizzes, collaborative review assignments, group work project
Curriculum Revision Date	October 7, 2019
Prerequisites	MSFE 620: Discrete-time Stochastic Processes
Faculty Contact	Faculty contact information is posted in the "Course Announcements" section of your online course room.

Course Learning Outcomes

Upon successful completion of the course, you will be able to:

CLO 1	Solve stochastic differential equations
CLO 2	Apply Ito's formula for continuous semimartingales and Girsanov's theorem to the construction of equivalent local martingale measures
CLO 3	Derive the Black-Scholes partial differential equation, and use the Black-Scholes model to price and hedge derivatives

Module Objectives

Upon completion of each module in the course, you will be able to:

Module 1: Brownian Motion and Continuous-time Martingales	○ Define σ-algebra, probability space, and filtration ○ Compare and contrast various types of convergence of a sequence of random variables ○ Define Brownian motion and identify Brownian motion processes in multiple dimensions ○ Discuss continuous-time stochastic processes examples such as martingales, Markov processes, and Levy processes
Module 2: Stochastic Calculus I: Ito Process	○ Define the Stieltjes integral with respect to a finite variation process ○ Evaluate simple Ito integrals and apply Ito's Lemma ○ State and apply the Martingale Representation Theorem (MRT)
Module 3: Stochastic Calculus II: Semimartingales	○ Define the stochastic integral with respect to a square integrable martingale and a continuous martingale ○ Define local martingales and apply the localization procedure ○ Define semimartingales and apply Ito's formula and processes to solve problems on continuous semimartingales
Module 4: Continuous Trading	○ Discuss trading in continuous time and define arbitrage and completeness of a market model in continuous time ○ Use admissible and self-financing strategies to solve continuous time trading problems ○ Price and hedge derivatives in continuous time

Module 5: The Black-Scholes Model	○ Use the Black-Scholes model to price a call option and a put option ○ Derive the Black-Scholes partial differential equation ○ Price options in the generalized Black-Scholes model
Module 6: An Introduction to Levy Processes	○ Discuss the properties of a Poisson process ○ Demonstrate the properties of Lévy processes ○ Apply exponential Lévy models to financial modeling
Module 7: An Introduction to Interest Rate Modeling	○ Describe stochastic interest rate assets ○ Derive common short interest rate models such as Ho-Lee, Vasicek, Cox-Ingersoll-Ross, and Hull-White models ○ Solve the bond pricing equation to calculate bond prices in common short rate interest models

Credit Hour Policy

WorldQuant University awards semester credit hours. A 4-semester credit hour course requires students to spend approximately 180 hours engaged in coursework over 7 weeks (**ca. 25 h/week**). Coursework includes 60 hours of academic engagement (i.e., instructor-led activities such as watching video lectures, participate to interactive discussions via online) and 120 hours of preparation (i.e., completing reading assignments, conducting research, completing projects). Note that these are average times, derived from generally accepted average standards.

	Activity	Average hours	Est. hours/course
Academic Engagement	Watching video lectures and guest lectures	2 h/week	14
	Seeking clarification about course content	2 h/week	14
	Interacting with/watching online multimedia content	1 h/week	7
	Interacting in Q&A sessions with faculty and classmates via live sessions or discussion forums	2 h/week	14
	Taking quizzes	2 h/week	14
		Total	**63 hours** (60 hours target)
Preparation	Completing required reading in published course notes and mastering concepts	4 h/week	28
	Completing and mastering further reading from free resources as indicated by faculty	2 h/week	14
	Preparing for 7 quizzes (one quiz/week)	3 h/quiz	21
	Completing 3 collaborative review assignments	3 h/essay	9
	Reviewing 6 assignments from peers	1 h/essay	6
	Completing research and development for 3 Group Work Projects	12 h/project	36
	Collaborating with teammates via discussion forums to complete the Group Work Projects	1 h/week	7
		Total	**121 hours** (120 hours target)

Graded Assessments and Grading Policies

Assessments and Deadlines

The chart below lists the graded assessments that are required for completion, and the deadlines for submission. Keep in mind that in each week of this 7-week course you will complete 1 module, for a total of 7 modules. "M" in the table below stands for 'Module' (e.g., M1 is Module 1).

Submission Deadlines		
Week	**Assessment**	**Deadline**
Week 1*	Quiz M1	End of Week 1**
	Collaborative Review Task M1 (Submission)	
Week 2	Quiz M2	End of Week 2
	Collaborative Review Task M2 (Submission) and M1 (Assessment)	
Week 3	Quiz M3	End of Week 3
	Group Work Project - Submission 1	
	Collaborative Review Task M2 (Assessment)	
Week 4	Quiz M4	End of Week 4
	Collaborative Review Task M4 (Submission)	
Week 5	Quiz M5	End of Week 5
	Group Work Project - Submission 2	
	Collaborative Review Task M4 (Assessment)	
Week 6	Quiz M6	End of Week 6
Week 7	Quiz M7	End of Week 7
	Group Work Project - Submission 3	

The week starts on a **Tuesday (Day 1) and ends on a **Monday (Day 7)***

***Deadlines are on Mondays at 11:50 pm UTC+2 (23:50 UTC+2)*

Proctored Quiz M4

As a means of authentication and identity verification, WQU requires students to complete two proctored Quizzes over the course of the MScFE program. Quiz M4 of this course is going to be the first proctored Quiz in the Program. For this purpose, WQU uses a third-party online proctoring service, Examity, which utilizes a machine learning algorithm to monitor students throughout the Quiz and to identify them through their keystrokes. Before you can take your Quiz M4, you must visit Examity, create a profile, and schedule an appointment. More details about how to use Examity will be published in the Course Announcements forum.

Grading Criteria: Points Distribution and Grading Scale

You can view your progress (points earned and percentage towards final grade) by clicking 'Grades" on top left of your online course room. To successfully pass this course, you must earn a final grade of **70%** or above.

Graded assessments are reflected in your final course grade as follows:

Points Distribution		
Graded Assessment	**Points**	**Percentage**
Quiz M1	20	
Quiz M2	20	
Quiz M3	20	
Quiz M4	20	
Quiz M5	20	
Quiz M6	20	
Quiz M7	20	
Quiz Assignments Total	**140**	**35%**
Collaborative Review Task M1 (Submission)	20	
Collaborative Review Task M1 (Assessment)	6	
Collaborative Review Task M2 (Submission)	21	
Collaborative Review Task M2 (Assessment)	6	
Collaborative Review Task M4 (Submission)	21	
Collaborative Review Task M4 (Assessment)	6	
Collaborative Review Total	**80**	**20%**
Group Work Project – Submission 1	45	
Group Work Project – Submission 2	45	
Group Work Project – Submission 3	90	
Group Work Project Total	**180**	**45%**
Course Total	**400**	**100%**

The table below shows how your final grade percentage will be evaluated:

Grading Scale	
Grade Percentage	**Designation**
90-100	Excellent
80-89	Proficient
70-79	Satisfactory
0-69	Unsatisfactory
Withdrawal*	W

** Students may withdraw from a course before the end of Week 3*

Satisfactory Academic Progress

In order to earn the Master of Science in Financial Engineering, you must:

- Maintain a cumulative average score of **80%** or above
- Complete the program within the **Maximum Time Frame (MTF)** of 150% (3 years) of the scheduled program length of two (2) years.

Course Structure, Expectations, and Requirements

The content for each week-long module is released on a **Tuesday** (**Day 1**) and ends with the weekly live session on the following **Monday** (**Day 7**). Make sure you plan your studies carefully to maintain a manageable amount of learning each day. The course materials in each module are organized into five (5) Units.

Attendance

Regular attendance and participation are crucial elements for a successful learning experience. You must access the online course room at least once each week, complete all of the activities listed in the "Graded Assessments and Deadlines" table, and participate in discussion forums.

Multi-media Content and Reading Assignments

Learning materials are published in the online course room and consist of recorded video lectures, supplementary notes, and short case studies. Text-based notes are downloadable for offline studying. You may also be directed to additional videos and articles elsewhere on the web by faculty. You should use these materials to master the topics and complete the graded assessments.

Practice Quizzes (Ungraded)

To test your knowledge of the new concepts that are introduced each week, an ungraded practice quiz is available in Unit 4 of each module. You can take this ungraded quiz multiple times to prepare for your graded quiz assignment. Practice quizzes do not affect your final grade.

Quiz Assignments (Graded)

Every week, you are required to complete one (1) graded quiz consisting of fifteen (15) multiple choice questions. The goal of these quizzes is to assess your understanding and mastery of each week's content. Quiz assignments are automatically graded, and the grade is made available to you in your online gradebook. You are granted one (1) timed attempt per quiz (3 hours length), so we encourage you to complete some ungraded practice quizzes before taking the graded quiz.

To help you manage your time, the deadline for **all** graded quizzes is the last day of the course (end of Week 7); however, we strongly recommend that you complete each quiz within its respective week to avoid the accumulation of homework at the end of the course.

Your grades for the graded quiz assignments will comprise **35% of your final grade**.

Collaborative Review

In Week 1, 2, and 4, you are required to complete a short assessment for collaborative review based on the current week's work. After submitting it online by the end of **Sunday** (**Day 6**), you are required to assess two of your peers' assignments as well as your own. Your review is based on four criteria included in the rubric posted online. For each criterion, select one of the four levels of evaluation as follows: "*Excellent*", "*Proficient*", "*Satisfactory*", or "*Unsatisfactory*".

You will have until the following Sunday to assess these assignments. The grade you obtain for your collaborative-reviewed assignments will comprise **20% of your final grade**.

Posting Questions for Live Sessions

Throughout the week, if you have any questions regarding the core learning content or assessments, you can post them on the **Question to Faculty** forum located on top of each Module section of your online course room. Key topics will be addressed in the live session every **Monday** (**Day 7**) in addition of being answered in the forum. All live sessions are recorded and will be made available on the WQU platform for you to access at any time.

Group Work Project and Grading Rubric

For the duration of each course, you will be required to work on a group project together with up to four of your peers. The topic will encapsulate the relevant coursework, and your group will be required to submit three drafts – in weeks 3, 5, and 7 – for your instructor's assessment. Once submitted as a "draft", the group work project drafts are run through Turnitin's plagiarism detection software (see the Academic Integrity section of this syllabus for more details).

Within a week of each submission, your group will receive feedback from the instructor, enabling you to implement changes ahead of the second and final submission. The instructor will use the grading rubric in the following page to evaluate the three submissions (drafts) of the group work project.

You will use a group discussion forum open only to your group members to collaborate in the project. Your grades for the three submitted drafts will comprise **45% of your final grade**.

Assessment Criteria	Excellent	Proficient	Satisfactory	Unsatisfactory	Percentage of Overall Grade	Points Possible (Drafts 1 - 2)	Points Possible (Draft 3)
	85-100%	70-84%	65-69%	0-64%			
Knowledge of the Content	The group presents a clear, coherent and noteworthy paper that demonstrates full understanding of their subject matter. They have answered most of the questions applying critical thinking. Their chosen evidence is thorough, relevant and clearly presented.	The group produces a strong paper that demonstrates that they understand the subject matter. They have answered most of the questions applying critical thinking. The group demonstrates awareness of the literature they refer to.	The group has produced an adequate paper, reflecting some knowledge of the subject matter. The paper has some content, and some critical thinking has been applied to answer the questions. The group may struggle in relating references to their argument.	The group has produced a weak paper that needs considerable revision. The paper lacks in content, and not all the questions have been answered. Overall, the paper reflects a poor understanding of the topic.	30%	14	27
Research	The group has demonstrated strong skills in their selection and use of peer-reviewed resources to present original ideas in the context of the selected references.	The group has referenced reliable peer-reviewed resources to support their argument.	The group has used some peer-reviewed resources however the selected resources have only been partially incorporated in their argument.	The group has only used Internet resources (i.e., Wikipedia) or similar non-academic resources to support their argument. Referencing is scant.	20%	9	18
Methods and Analysis	The group has demonstrated to be able to analyze their argument and draw logical and valid conclusions based on their research. If applicable: the code accompanying the paper is very well commented and easy to follow. The executed program provides the expected results and meets all the given specifications.	The group has demonstrated to be able to analyze their argument and draw logical conclusions for the most part. Their analysis may be somewhat derivative and/or may lack deeper insight. If applicable: the code accompanying the paper is commented and is fairly easy to follow. The executed program provides acceptable results and meets most of the specifications.	The group has demonstrated poor ability to analyze their argument and draw logical conclusions. Their analysis is weakly supported by their research. If applicable; the code accompanying the paper is poorly commented and is not easy to follow. The program provides results however it does not meet most of the specifications.	The group has not been able to analyze their argument. Their analysis is vaguely connected to their research. If applicable: the code accompanying the paper is not sufficiently commented and it is difficult to follow. The program does not provide the expected results and does not meet the specifications.	20%	9	18
Argument and Conclusions	The group has structured a clear and coherent argument, including introduction, body, and conclusion.	The group has structured an argument and included an introduction, a body, and a conclusion.	The group has included the main elements of an argument: introduction, body and conclusion; however, they make a weak/unclear argument.	The group has nominal introduction and conclusion, but this does not build to a coherent, logical argument. The paper may be contradictory.	20%	9	18
Writing Components and Formatting	The group has presented their assignment in a clear and coherent manner, with consistent formatting and clear referencing. The work is free of grammar errors and typos.	The group has presented their assignment in a clear and coherent manner, with sufficient formatting and clear referencing. The work may have a few grammar errors and typos.	The group has presented their assignment adequately, with some consideration of formatting and referencing. There are some grammar errors and typos.	The group has presented their assignment with poor formatting and inadequate referencing. There are several grammar errors and typos.	10%	4	9
				Total	**100%**	**45**	**90**

Academic Integrity and Student Responsibilities

Commitment to the principles of academic honesty and integrity is essential to the mission of WQU. All work submitted in a course must be the student's own work.

Plagiarism is the act of presenting another person's ideas, research, or writing, as your own. You commit plagiarism when you:

- copy a statement or paragraph created by another person without using quotation marks and a reference to the source and the author;
- present the ideas of another person in your own words without giving credit;
- use information that is not considered common knowledge without giving credit to the source;
- purchase a paper from the Internet or a vendor and submit it as a personal paper.

To plagiarize or to copy the work of another person and to present it as your own is a violation of academic integrity. Penalties for the first violation is course failure; a second violation may result in being terminated from the program. Refer to the University Catalog for a detailed list of consequences to academic integrity violation. To gain a deeper understanding of plagiarism and how to avoid it, watch this video tutorial; further information can be found at Purdue Online Writing Lab.

Below you find tips on what you should and should not do to avoid plagiarism:

DO	○ Include statements (1-2 lines at most) from books or articles published by others, as long as you use quotation marks (" "), and the source is cited properly. The statement should be used to boost or amplify your own personal opinion or argument. ○ Paraphrase the idea of another person as long as it is used to emphasize your own ideas, and the other person is cited.
DON'T	○ Copy and paste from articles, books, or other sources without proper citations. ○ Extensively cite or paraphrase entire paragraphs, even if the paragraph is within quotation marks and cited. ○ Include a graph or a table with data from a work published by others.

Use of Turnitin

At the time of submission, all group work assignments are run through Turnitin, a plagiarism detection software. Turnitin creates a similarity report that matches the submitted paper against

its database (peer reviewed journals, textbook, internet resources, etc.) as well as papers created by other students at WQU or in other institutions. Students can make use of Turnitin while their assignment is in the "draft" status and download the Turnitin similarity report prior to submitting their paper for grading. The similarity report shows a similarity score equal to the percentage of matching found with the resources described above.

Students are responsible to:

- Inform themselves about what constitutes plagiarism. In addition to the tips provided above to avoid plagiarism, extensive information and tutorials are provided in the Student Resource Center, Student Orientation course, and in the Course Overview section of the course;
- Review the Turnitin similarity report for each assignment while in "draft" status;
- Edit the work prior to the due date. to ensure that any statement copied from another author is properly quoted, cited, and is mindfully used to support your original work. **The point of using a quotation from a source is to support the argument you are making and should NOT become the argument itself.**

Based on the Turnitin similarity report, the Instructional Team will evaluate whether you have committed plagiarism and may decide to give you a failing grade for the assignment or for the entire course (see WQU Academic Integrity Policy in the University Catalog).

Keep in mind that when you commit plagiarism, **your Academic Integrity status is changed to 'Probation' and a note is added in your records describing the violation**. This note may prevent you from receiving recommendation letters or alumni opportunities.

Student Code of Conduct

The Student Code of Conduct sets forth the standards of conduct expected of students at WQU. This code is not exhaustive, and you may be subject to disciplinary actions for other behavior and/or activities deemed unacceptable or disruptive to the goals and mission of WQU and the expectation of professionalism in the online learning environment.

If you violate the Student Code of Conduct, you will be subject to disciplinary actions including issuance of a warning, probation, termination, or permanent dismissal from the University. Any and all disciplinary actions will be recorded in your student academic record.

Violations of the Student Code of Conduct*

- All forms of violation of academic integrity including: cheating; fabrication; plagiarism; engaging in or facilitating academic dishonesty; republishing or redistributing any course materials, student's own work, or another student's work; uploading WQU content to websites or linking to it through services
- Sharing personal account information to access the online platform with anyone
- Use of any religious, inflammatory or flagrant language in the online learning environment or public social media
- Use of any religious, inflammatory, or flagrant language related to WQU on social media or on WQU social media accounts.
- Endangering, threatening, or causing harm to any member of the WQU community, causing reasonable apprehension of such harm or engaging in conduct or communications that a reasonable person would interpret as a serious expression of intent to harm.
- Unauthorized use of University property and/or resources.
- Engaging in retaliation, harassment or repeated contact that a reasonable person would understand to be unwanted, including stalking and/or sexual harassment.
- Engaging in any discriminatory activities as prohibited by applicable law or University policy.
- Engaging in any illegal sexual offense, including, but not limited to, sexual assault, public sexual indecency, or indecent exposure.
- Violation of any other University policy.
- Conduct that is illegal under state or local law.

**Refer to the University's Catalog for a complete list of actions constituting violation of the Academic Integrity and Student Code of Conduct.*