

CS 476/676: Numeric Computation for Financial Modelling

Winter 2021

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Lecture Times:	Tues and Fri	Online
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Calendar Description: <http://www.ucalendar.uwaterloo.ca/1112/COURSE/course-CS.html#CS476>

Schedule of Classes: <http://www.adm.uwaterloo.ca/infocour/CIR/SA/under.html>

Course Description

The interaction of financial models, numerical methods, and computing environments. Basic computational aspects of option pricing and hedging. Numerical methods for stochastic differential equations, strong and weak convergence. Generating correlated random numbers. Time-stepping methods. Finite difference methods for the Black-Scholes equation. Discretization, stability, convergence. Computational optimization, portfolio optimization and model calibration, data driven optimization.

Course Objectives

To provide students with an overview of modern numerical algorithms for use in financial applications.

Jan 11	Introduction to Options Random Walks on a Lattice	
Jan 18	No Arbitrage Pricing Lattice Construction	
Jan 25	Pricing European and American Option on Lattice Convergence and Black-Scholes Model	
Feb 1	Ito's Lemma Risk Neutral Valuation	Assignment 1 Due Feb 1
Feb 8	MC Method I Hedging, Delta, Gamma and Greeks	
Feb 15	Reading Week	
Feb 22	VaR and CVaR Risk Measures Implied Volatility, Volatility Smile	Assignment 2 Due Feb 22
Mar 1	MC Method II: Correlated Assets BS PDE	
Mar 8	American Options: Complementarity PDE Finite Difference Method	
Mar 15	Mar 14-15, additional break Explicit Finite Difference Method	Assignment 3 Due Mar 17
Mar 22	Implicit Finite Difference Method, Stability, Convergence Penalty Method	
Mar 29	Option Model Calibration. CVaR Portfolio Optimization	
April 5	Nonlinear Optimization Optimality	
April 12	Review	Assignment 4 Due April 14

- **Reference Material** Course notes can be downloaded in LEARN. The notes also have a list of reference books.
- **Background Assumed** You should have taken
 - An introductory course in numerical computation, similar to CS370.
 - An introductory course in statistics.
 - Basic calculus and linear algebra.
 - Ability to program in Matlab

The course assumes some mathematics as well as computing maturity from students. No finance background is assumed.

- **Course Accounts** You will need to register in the course to obtain a computing account on the CS student computing environment. You should register in CS476/676. If you use a research machine, you may not have a license for matlab (depending on your supervisor).
- **Assignments** Assignments will be posted in LEARN. Make sure that you check for announcements in LEARN frequently. Assignments must be submitted on the due date to **Crowdmark**. A link will be sent to you for submission. Please check Crowdmark website for information, If you need further assistance, please contact TA.
- **Assignment Marking.** The assignments will consist of programming problems and analytic work. **IMPORTANT:** most of the marks for the programming problems will be given for your description of your algorithms (i.e. pseudo-code) and explanation of the results. Simply handing in “raw code” will get very few marks.

Assignment figures and graphs should be carefully thought out to present the data and your conclusions in an effective and clear manner. Poor presentation of your work will result in a poor mark.

In all cases, I expect you to explain your algorithms, and describe what you see in detail. You should also submit hard copies of your code, along with some documentation. Matlab has good plotting facilities. Create figures with Matlab to include in your assignments.

Assignment solutions will be discussed in online recording. Assignment solutions will not be posted.

- **Late Policy** On the due date of an assignment, the work done to date should be submitted via Crowdmark; further material may be submitted for one-half credit 24 hours after the due date.
- **Grade** There are 4 assignments with their weights in the final grade as follows:
 - Assignment 1: 20%
 - Assignment 2: 20%
 - Assignment 3: 30%
 - Assignment 4: 30%
- **Graduate Students** To obtain credit for CS676, graduate students will have to complete extra questions.
- **Programming Languages** There are many sources of Matlab information on the Web. There are also many reference books available. You are responsible for getting up to speed on Matlab.
- **Final Examination:** No final exam.
- **Assignment Retention** Unclaimed assignments will be retained for one month after term grades become official in quest. After that time, they will be destroyed in compliance with UW’s confidential shredding procedures:

[http://www.adm.uwaterloo.ca/infostor/Confidential Shredding procedures 2008.htm](http://www.adm.uwaterloo.ca/infostor/Confidential%20Shredding%20procedures%202008.htm)

- **Collaboration** *We encourage you to discuss general concepts and problems with classmates, TAs, and instructors. However, the solution that you submit must be worked through by yourself and written in your own words. It is not acceptable to work on an assignment with somebody else and write it up individually. When discussing course matters, do not take notes, and do not look at another person's partial solutions, or show them yours.*

Note that current Math faculty policy is that a mark of -100% can be recorded for the assignment in question in the case of cheating/copying.

- **Academic Integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]
- **Grievance:** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.
- **Discipline:** A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/ to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about 'rules' for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.
- **Appeals:** A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities: Note for Students with Disabilities: AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

- **Intellectual Property:**

Students should be aware that this course contains the intellectual property of their instructor, TA, and/or the University of Waterloo. Intellectual property includes items such as:

- Lecture content, spoken and written (and any audio/video recording thereof);
- Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides);
- Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and
- Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein, are used to enhance a student's educational experience. However, sharing this intellectual property without the intellectual property owner's permission is a violation of intellectual property rights. For this reason, it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository). Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of intellectual property rights.