Math 5760/6890: Introduction to Mathematical Finance I  
Fall 2020 Syllabus

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Zoom handle: https://utah.zoom.us/j/93540792219 (please see Canvas for the passcode)
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Accessibility and Support: The preferred methods for reaching me are (in order of preference/reactivity): a message on Canvas or via email. I answer email daily, usually in the mornings.

Office hours: MW 1-2 or by appointment using the Zoom handle above. Please check Canvas for any changes or cancellations.

Course Description:
This is the first part of a two-semester class on Mathematical finance. The Fall is devoted to discrete stochastic models with application to finance and the Spring to continuous stochastic models. The course makes heavy use of discrete probability spaces (hence the Math 5010 or equivalent prerequisite). We also require some very basic understanding of ODEs (hence the Math 2280 prerequisite). Both classes 5760 and 6890 meet at the same time. Graduate students can register for the 6000 level class. There is extra work involved including homework problems (or extra questions) that are more theoretical. Grading in Math 5760 and 6890 will be done independently.

Course Details:

Course Type: Interactive Video Conferencing (IVC)

Location & Meeting Times: Canvas. TuTh / 9:10am-10:30am. The Zoom link is above and the passcode will be given in Canvas.

Attendance & Punctuality: Attendance to the video lectures is expected but not mandatory. For those that cannot make it class notes and videos of the lectures will be regularly posted on Canvas. However to get the best learning experience, you are encouraged to attend and actively participate in the lectures. Examples of participation are to ask questions, ask to re-explain or review some concept etc... Lectures should not be a monologue, participating is relatively easy (via e.g. chat or audio) and makes the lecture more valuable for everyone involved.

COVID-19 Considerations: Students must self-report if they test positive for COVID-19 via coronavirus.utah.edu

Course Materials: All materials for this course (including class notes and problem assignments) are copyrighted. Do not distribute or share course resources without instructor permission. Class notes mainly based on the following textbooks will be posted on Canvas. You are not required to buy these books.


Technical Requirements

- Students are expected to be computer literate and Canvas and zoom navigation skills are expected. Knowledge and navigation of canvas and zoom is critical to access all features and resources of this course.
- This class includes synchronous components (live Zoom sessions). A stable connection and adequate bandwidth is needed. Lectures will be recorded for your convenience. Please do reach out to the instructor if you anticipate having problems attending the lectures in this fashion.
- Programming: Computer implementation is an essential component in this subject, and you will be required to do some of your coursework with computer programs. We will be using Python, which is one of the most used programming languages in finance and data science and is highly valued in the industry. You do not need any prior experience with Python, as we will be doing only elementary programming (i.e. if you understand what are variables, lists, loops and if statements you should be able to hit the ground running). You will be able to do all the programming
required for this class through your browser using a “Jupyter” service hosted by the Mathematics Department (with a few exceptions where Excel or another spreadsheet software will come handy). Using Jupyter does require a stable internet connection though. Python being open source, it should be relatively easy to install similar software in your computer.

Syllabus subject to change: This syllabus is meant to serve as an outline and guide for our course. Please note that I may modify it with reasonable notice to you. I may also modify the Course Schedule to accommodate the needs of our class. Any changes will be announced in class and posted on Canvas.

Content Overview: The class revolves around a very useful discrete model for pricing financial derivatives called the binomial model. We first will see how, under certain assumptions, we can use it to price option price contracts (starting with European style options for simplicity). The binomial model is then our gateway to stochastic processes. The culminating result is a motivation of the Black-Scholes model that can be seen as the limit of the binomial model as we take the time step to zero. This derivation will be revisited and expanded in the Spring, during the second part of this class. Please see the last page of this syllabus for more details.

Course expected learning outcomes: See last page for details.

Course Design: The instructor will deliver online lectures via Zoom during the usual class times. Expect 4-6 homework assignments. Although it may be possible to find solutions online, you will not learn anything from it. It is better figure the problems out on your own or with a group of other students. It may be unpleasant and frustrating to hit dead-ends, make mistakes and spend a lot of time on this, but it is the only effective way I know to learn mathematics. To help you, there will be two regularly scheduled virtual office hours per week. The instructor is also available for virtual meetings with prior notice. There will be two exams: a midterm and a final, and both will evaluate how well you know the concepts learned in class, and how well you can apply them.

Evaluation: All assignments (homeworks, midterm and final exam) are to be submitted electronically using Gradescope. Please check Canvas for the details. In particular, this means you need a means of scanning your assignment (such as a scanner or smartphone) OR you may also handwrite your assignments on a tablet. Typing up your assignments is also acceptable but NOT necessary. Since the midterm and final exam are time-limited, you should not attempt to typeset these assignments. If the assignment involves coding, your code and sufficient output/ plots to show that it is working as intended is to be included in the submission. Please check Canvas for the details.

Homework – 50% 4-6 HW assignments. At least one of the assignments is a “mini-project” (most likely using the binomial model to price options using market data)

Midterm – 25%: 80min, open book/notes, Tue Oct 6 9:10am-10:30am (tentative). The exam will be proctored remotely using Zoom.

Final – 30% 120min, open book/notes, comprehensive exam. Tue Dec 8 2020 8am-10am (fixed by the university). The exam will be proctored remotely using Zoom.

Remote proctoring: The exams in this class will proctored remotely over a Zoom video call. This means that you will need a quiet room for the duration of the exam, a stable internet connection and a device with webcam that is able to run Zoom so that the instructor can see you and your work area while taking the exam. Please contact the instructor if you anticipate any problems with this or if you need any special accommodations.

Academic Code of Conduct: Students are encouraged to review the Student Code for the University of Utah: [https://regulations.utah.edu/academics/6-400.php](https://regulations.utah.edu/academics/6-400.php). In order to ensure that the highest standards of academic conduct are promoted and supported at the University, students must adhere to generally accepted standards of academic honesty, including but not limited to refraining from cheating, plagiarizing, research misconduct, misrepresenting one’s work, and/or inappropriately collaborating. A student who engages in academic misconduct as defined in Part I.B. may be subject to academic sanctions including but not limited to a grade reduction, failing grade, probation, suspension or dismissal from the program or the University, or revocation of the student’s degree or certificate. Sanctions may also include community service, a written reprimand, and/or a written statement of misconduct that can be put into an appropriate record maintained for purposes of the profession or discipline for which the student is preparing.

Grade scale: If $X$ is your percentage grade, then \( \{ X \geq 93 \% \Rightarrow A, X \geq 90 \% \Rightarrow A-, X \geq 87 \% \Rightarrow B+, X \geq 83 \% \Rightarrow B, X \geq 80 \% \Rightarrow B-, X \geq 77 \% \Rightarrow C+, X \geq 73 \% \Rightarrow C, X \geq 70 \% \Rightarrow C-, X \geq 67 \% \Rightarrow D+, X \geq 63 \% \Rightarrow D, X \geq 60 \% \Rightarrow D-, X < 60 \% \Rightarrow E \} \). Letter grade assignments can be changed at the discretion of the instructor.

Communication

All course materials, such as lecture videos, lecture notes, assignments, solutions, grades, etc. will be posted on the Course Canvas site. Class announcements will be done via email through the Canvas server. You will be responsible for any information contained in them as well as the information announced in class.
It is your responsibility to also regularly check your Umail (make sure you set up forwarding if you do not check it regularly), your Umail is the only way for me to communicate privately with you, there will be occasions during the semester that we may need to reach out to you individually (e.g. regarding a grade or assignment) and it is in your best interest to respond promptly.

Feel free to contact me by email for questions at fguevara@math.utah.edu. I will do my best to answer emails promptly. I would like to encourage you to email me only if it is something personal that requires individual attention, if instead you have questions about logistics of the class, course material and assignments, and anything else your classmates may wonder as well, please post a question on the Discussions Board instead. This way the information is shared quickly to the entire class, and each of you can benefit from seeing other classmates’ questions.

Additional Policies and Resources

**The Americans with Disabilities Act:** The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability & Access, 162 Olpin Union Building, 801-581-5020. CDA will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability & Access.

**Addressing Sexual Misconduct:** Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a Civil Rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran’s status or genetic information. If you or someone you know has been harassed or assaulted on the basis of your sex, including sexual orientation or gender identity/expression, you are encouraged to report it to the University’s Title IX Coordinator; Director, Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or to the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to police, contact the Department of Public Safety, 801-585-2677(COPS).

**Campus Safety:** The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit safe.utah.edu

**University Counseling Center:** The University Counseling Center (UCC) provides developmental, preventive, and therapeutic services and programs that promote the intellectual, emotional, cultural, and social development of University of Utah students. They advocate a philosophy of acceptance, compassion, and support for those they serve, as well as for each other. They aspire to respect cultural, individual and role differences as they continually work toward creating a safe and affirming climate for individuals of all ages, cultures, ethnicities, genders, gender identities, languages, mental and physical abilities, national origins, races, religions, sexual orientations, sizes and socioeconomic statuses.

**Office of the Dean of Students:** The Office of the Dean of Students is dedicated to being a resource to students through support, advocacy, involvement, and accountability. It serves as a support for students facing challenges to their success as students, and assists with the interpretation of University policy and regulations. Please consider reaching out to the Office of Dean of Students for any questions, issues and concerns. 200 South Central Campus Dr., Suite 270. Monday-Friday 8 am-5 pm.
**Expected Learning Outcomes**: Understanding probability, discrete stochastic calculus and numerical methods necessary for pricing derivative securities under no-arbitrage assumption. Specific objectives include:

- Understand the fundamental concepts of investment return and risk, and their quantifications.
- Fully understand the concept of time value of money, and be able to calculate bond prices from bond yields and vice versa.
- Quantify and model the return and risk from an investment in financial assets.
- Explain the basic stock valuation and the no-arbitrage principle.
- Analyze a portfolio of financial assets and use mathematical tools to optimize the portfolio performance according to a set of criteria.
- Characterize a financial derivative according to its payoff and other parameters, and decompose into a collection of known instruments in some cases.
- Build a discrete time model to explain the pricing of a financial derivative.
- Establish the price of a derivative as a conditional expectation of the payoff at a future time, and specify the probability measure for this conditional expectation.
- Justify the binomial tree model for pricing derivatives via a self-financing strategy, and demonstrate the replication of a derivative on such a model.
- Demonstrate the Black-Scholes formula for an option price as a limit in the binomial model as the number of steps becomes infinitely large.

**Schedule**: The following schedule is tentative. ($J_n$) $\equiv$ Joshi book, chapter $n$. ($S_n$) $\equiv$ Shreve book, chapter $n$.

- **Week 1**: Financial risk ($J_1$)
- **Week 2**: Hedging and Arbitrage ($J_2$)
- **Week 3**: Binomial no-arbitrage pricing model ($S_1$)
- **Week 4**: Finite Probability Spaces, Conditional Expectations ($S_2$)
- **Week 5**: Martingales, Markov processes ($S_2$)
- **Week 6**: State Prices, change of measure ($S_3$)
- **Week 7**: Capital asset pricing model ($S_3$)
- **Week 8**: American derivatives ($S_4$)
- **Week 9**: Random Walks, first passage time ($S_5$)
- **Week 10**: reflection principle, Perpetual American Put ($S_5$)
- **Week 11**: From binomial model to log-normal model ($J_3$)
- **Week 12**: Volatility, Greeks ($J_4$)
- **Week 13**: Brownian motion, stochastic processes ($J_5$)
- **Week 14**: Itô calculus, Black-Scholes equation derivation ($J_5$)
- **Week 15**: Risk neutrality and martingale measures ($J_6$)