

MATH 86: MATHEMATICAL FINANCE

Syllabus: Winter 2023
Location: TBD
Tue/Thu: 2:25 – 4:15 PM
Wed X-Hour: 5:30 – 6:20 PM

Instructor: John W. Welborn
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Office Hours: By Request

COURSE DESCRIPTION

Financial derivatives can be thought of as wagers on uncertain future financial events. This course will take a mathematically rigorous approach to understanding the Black-Scholes-Merton model and its applications to pricing financial derivatives and risk management. Topics will include arbitrage-free pricing, binomial tree models, measure theory, Ito calculus, the Black-Scholes analysis, derivatives pricing, volatility modeling, and hedging.

PREREQUISITES

MATH 20 and MATH 40, or MATH 60; MATH 23; and COSC 1 or the equivalent.

COURSE TEXTBOOKS

1. Baxter, Martin., and Andrew Rennie. *Financial Calculus: An Introduction to Derivative Pricing*. Cambridge: Cambridge University Press, 1996. [Available online](#).
2. Wilmott, Paul. *Paul Wilmott Introduces Quantitative Finance*. 2nd ed. Chichester, West Sussex, England: J. Wiley & Sons Ltd., 2007. [Available online](#).

GRADING:

- Problem Sets: 20%
- Midterm Exam: 25% (2/7/23 @ 10:10 AM)
- Final Project: 20%
- Final Exam: 35% (3/10/23 @ 3:00 PM)

EXAMS

The midterm (25%) and final exam (35%) will be open book and open note. Students must do their own work and adhere to the [Academic Honor Principle](#). Students who require testing accommodations must contact me as soon as possible and provide the appropriate documentation.

FINAL PROJECT

Your final project (20%) may be on any topic related to mathematical finance. Students are encouraged to consider either an empirical or theoretical project. Potential topics include local volatility modeling, exotic options pricing formulae, numerical methods, and jump diffusion processes. Projects will be graded on novelty, quality, technical proficiency, and research.

PROBLEM SETS

There will be 4 problem sets due throughout the term. Each assignment is worth 5% of your final grade. For each assignment, you may work in groups of up to 3-4 other students. To complete the assignment, upload a single, clear, and legible PDF document to Canvas.

COURSE SCHEDULE

Week	Date	Topic	Day	Reading(s)
1	1/5/2023	Introduction	Thu	Baxter
2	1/10/2023	Products, Markets, and Derivatives	Tue	Wilmott 1,2
	1/12/2023	The Binomial Branch and Tree Models	Thu	Baxter 2.1, 2.2
3	1/17/2023	Binomial Representation Theorem	Tue	Baxter 2.3, 2.4
	1/19/2023	The Random Behavior of Assets	Thu	Wilmott 4, Baxter 3.1
4	1/24/2023	Elementary Stochastic Calculus	Tue	Wilmott 5
	1/26/2023	The Black-Scholes Model	Thu	Wilmott 6
5	1/31/2023	Partial Differential Equations	Tue	Wilmott 7
	2/2/2023	Review	Thu	
6	2/7/2023	MIDTERM EXAM @ 1020AM	Tue	
	2/9/2023	The Black-Scholes formulae	Thu	Wilmott 8
7	2/14/2023	The Greeks	Tue	Wilmott 8
	2/15/2023	Exotic, Path-Dependent and Multi-Asset Options	Wed	Wilmott 11, 12
	2/16/2023	Barrier Options and their PDEs	Thu	Wilmott 13, (1995) 12
8	2/21/2023	Change of Measure	Tue	Baxter 3.4
	2/23/2023	Martingale Representation Theorem	Thu	Baxter 3.5, 3.6
9	2/28/2023	Black-Scholes Model and Practice	Tue	Baxter 3.7, 3.8
	3/2/2023	Project Presentations	Thu	
10	3/7/2023	Review	Tue	
	3/10/2023	FINAL EXAM @ 300PM	Fri	

FOUNDATIONAL READING

- Bachelier, Louis et al. *Louis Bachelier's Theory of Speculation: The Origins of Modern Finance*. Princeton: Princeton University Press, 2006. [Online](#).
- Black, E. and M. Scholes. 1973. The valuation of options and corporate liabilities. *Journal of Political Economy*. 81: 637-54.
- Einstein, Albert, R. Fürth, and A. D. Cowper. *Investigations on the Theory of the Brownian Movement*. London: Methuen & co. ltd., 1926. [Print](#).
- Harrison, J. M. and D. M. Kreps. 1979. Martingales and arbitrage in the multi-period securities markets. *Journal of Economic Theory* 20: 381-408.
- Harrison, J. M. and S. R. Pliska. 1981. Martingales and stochastic integration in the theory of continuous trading. *Stochastic Processes and Applications*. 11: 215-60.
- Markowitz, H. 1952. Portfolio selection. *Journal of Finance* 19: 425-42.
- Merton, R. C. 1973. Theory of rational option pricing. *Bell Journal of Economics* 4.
- Sharpe, W. 1964. Capital asset prices: a theory of market equilibrium under conditions of risk. *Journal of Finance* 19: 425-42.
- Thorpe, E.O. 1969. Optimal Gambling Systems for Favorable Games. *Review of the International Statistics Institute* 37(3).

ACADEMIC HONOR PRINCIPLE

Fundamental to the principle of independent learning are the requirements of honesty and integrity in the performance of academic assignments, both in and out of the classroom. Dartmouth operates on the principle of academic honor, without proctoring of examinations. Any student who submits work which is not his or her own, or commits other acts of academic dishonesty, violates the purposes of the college and is subject to disciplinary actions, up to and including suspension or separation. All students must follow the [Academic Honor Principle](#).

MENTAL HEALTH

The academic environment at Dartmouth is challenging, our terms are intensive, and classes are not the only demanding part of your life. There are a number of resources available to you on campus to support your wellness, including your undergraduate dean (<http://www.dartmouth.edu/~upperde/>), Counseling and Human Development (<http://www.dartmouth.edu/~chd/>), and the Student Wellness Center (<http://www.dartmouth.edu/~healthed/>).

STUDENT ACCESSIBILITY NEEDS

Students requesting disability-related accommodations and services for this course must notify me as early in the term as possible. This conversation will help to establish what supports are built into my online course. In order for accommodations to be authorized, students are required to consult with Student Accessibility Services (SAS; student.accessibility.services@dartmouth.edu; SAS website; 603-646-9900) and to email me their SAS accommodation form. We will then work together with SAS if accommodations need to be modified based on the online learning environment. If students have questions about whether they are eligible for accommodations, they should contact the SAS office. All inquiries and discussions will remain confidential.

RELIGIOUS OBSERVANCES

Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please contact me before the end of the second week of the term to discuss accommodations.