

STUDY GUIDE

NUMERICAL METHODS FOR COMPUTATIONAL FINANCE: PRICING DERIVATIVES WITH MATLAB

**Organised by
University of Cantabria**

1. IDENTIFYING DATA.		
• Course Name.	Numerical Methods for Computational Finance: Pricing Derivatives with MATLAB	
• Coordinating University.	University of Cantabria	
• Partners Involved.	University of Vaasa	
• Course Field(s).	Economy and Business, Applied Mathematics	
• Related Study Programme.	N/A	
• ISCED Code.	0541 (0412)	
• SDG.	SDG4 – Quality Education SDG8 – Decent Work and Economic Growth	
• Study Level.	Master and Doctoral level, and practising professionals. Accessible to strong Bachelor students who have completed calculus and probability.	
• EUNICE Key Competencies	Problem solving	Strongly
	Teamworking	N/A
	Communication	Partially
	Self-management	Strongly
	Cognitive flexibility	Partially
	Digital competence	Strongly
	Technical competence	Strongly
	Global intercultural competence	Partially

• Number of ECTS credits allocated.	1 credit ECTS
• Mode of Delivery.	Online asynchronous self-study
• Language of Instruction.	English
• Course Dates.	04 January 2027 – 31 January 2027
• Precise Schedule of the Lectures.	N/A

• Key Words.	Computational Finance; Option pricing; Markov processes; Numerical methods; MATLAB
• Catchy Phrase.	Markets do not come with magic formulas. That is what computational finance is for.
• Main Targeted Audience.	Economists, financial analysts, quantitative risk, and Bachelor's, Master's or doctoral students in economics, finance, mathematics or engineering.

• Prerequisites and co-requisites.	Knowledge: differential and integral calculus, basic probability. Programming: some previous programming in any language. No MATLAB experience is assumed. Study levels: Bachelor, Master and Doctoral, and practising professionals. Language: English, level B2 or above.
• Number of students that can attend the course.	Unlimited

2. CONTACT DETAILS.

• Department.	Department of Applied Mathematics and Computer Science
• Name of Lecturer.	Vera Egorova
• E-mail.	egorovav@unican.es
• Other Lecturers.	Tommi Sottinen (tommi.sottinen@uwasa.fi , University of Vaasa)

3. COURSE CONTENT.

The Black-Scholes formula prices a European option in one line. Almost nothing else in a real book of derivatives has a formula at all. This course is about what you do then.

In fifteen hours, you go from the pricing problem to working, tested code in MATLAB. Module 1 sets up derivatives, the Black-Scholes model and the partial differential equation behind it. Module 2 supplies the probabilistic foundation: We study stochastics differential equations with Brownian noise and end with the celebrated Black-Scholes formula. Module 3 is the technical core: finite difference schemes for the Black-Scholes equation, stability and convergence; how to treat American options; extension to jumps and to several assets. Module 4 is the practice: you implement, analyse and validate your own pricers by completing three assessed case studies.

4. LEARNING OUTCOMES.

On completing the course, the participant will be able to:

1. Identify the main families of derivative contracts and their payoff structures, and state the Black-Scholes model with its assumptions and its limitations.
2. Derive the Black-Scholes partial differential equation, recognise it as a degenerate parabolic problem.
3. Compute expectations and variances by conditioning, using the laws of total expectation and total variance, and recognise a price as a conditional expectation.
4. Model financial derivatives as stochastic differential equations driven by a Brownian motion and to discretize such equations.
5. Price by Monte Carlo and quantify the error.
6. Discretise the Black-Scholes operator by finite differences and analyse consistency, stability and convergence.
7. Recognise the Crank-Nicolson oscillation in Gamma near the strike and cure it.
8. Price American options by penalty, by front fixing and by projected SOR.
9. Extend a pricer to jump-diffusion and multi-asset settings, and estimate when a grid becomes infeasible.
10. Implement pricing code in MATLAB.
11. Validate a computed price.

5. OBJECTIVES.

1. The course aims to introduce students to the pricing of financial derivatives, from the Black-Scholes model to the numerical methods required when no formula exists.
2. The course provides students with practical experience of finite difference methods for the Black-Scholes equation, ensuring that every scheme discussed is also implemented, measured and tested by the student.
3. The course enables students to recognise the limits of grid-based methods, and to judge when a partial differential equation approach becomes infeasible and simulation is required instead.
4. The course prepares students to bridge academic mathematical finance and industry computational practice through three case studies.

6. COURSE ORGANISATION.

UNITS/MODULES

1.	[3 hours] Introduction: Financial Derivatives and the Pricing Problem
2.	[4 hours] Stochastic Modeling with Stochastic Differential Equations and Simulation
3.	[4 hours] Numerical Methods for PDE-Based Pricing

4.	[4 hours] MATLAB Implementation and Case Studies
LEARNING RESOURCES AND TOOLS.	
All learning materials for the course are provided on the course page on the Moodle platform: • MATLAB Online, used in a browser. • Short video lessons. • Lecture notes by T. Sottinen • Interactive MATLAB live scripts combining explanation, codes, examples and exercises. • A library of documented pricing functions. • Automatically graded MATLAB exercises with immediate feedback. • Self-assessment quizzes. • Discussion forums for questions, method-choice debates and comparison of results.	
PLANNED LEARNING ACTIVITIES AND TEACHING METHODS.	
It is a self-paced course, with different learning materials available.	

7. ASSESSMENT METHODS, CRITERIA AND PERIOD.	
The course is graded. To pass the course, students need to complete the online the following assesments: • Self-assessment quizzes: 30%. • Case Study 1 (European option pricer): 20%. • Case Study 2(American option pricer): 25% • Case Study 3(Jump-diffusion model): 25%. Pass mark: 50% overall. Period and retakes: assessment runs throughout the enrolment window, with no time limit. Quizzes allow unlimited attempts and the best attempt counts. Case studies may be resubmitted at any point within the window.	
OBSERVATIONS.	

8. BIBLIOGRAPHY AND TEACHING MATERIALS.	
1. Lecture notes: Sottinen, T. A Gentle Introduction to Stochastic Differential Equations with Brownian Noise , University of Vaasa, 2023. 2. Schumacher, J. M. Introduction to Financial Derivatives: Modeling, Pricing and Hedging. Open Press TiU, 2020. [https://dare.uva.nl/id/b9acb0ac-2b21-45b9-9c08-b7a87b1290c4]	

3. Seydel, R. U. Tools for Computational Finance. Springer, 2017.
4. in 't Hout, K. Numerical Partial Differential Equations in Finance Explained: An Introduction to Computational Finance. Palgrave Macmillan, Financial Engineering Explained series, 2017.

9. OTHER COMMENTS (IF ANY).