UNSW SCIENCE

SCHOOL OF MATHS AND STATISTICS

MATH 5816

Continuous Time Financial Modelling

Term 3, 2019

Cricos Provider Code: 00098G

MATH 5816 Continuous Time Financial Modelling

Information about the course

Course Authority and Lecturer:

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Regular consultation times will be announced on Moodle and in lectures. Other times may be arranged by appointment. Please use email to arrange an appointment and make sure you use your UNSW email account.

Credit, Prerequisites, Exclusions:

This course counts for 6 Units of Credits (6UOC)

Prerequisites

MATH5965 Discrete Time Financial Modelling

MATH5975 Introduction to Stochastic Analysis

Location and Times

Lectures: There will be two blocks of two hour lectures:

Day	**Place**	**Weeks**
Mondays 10am-12pm	OMB G32	1-3, 5-9,11
Wednesday 4-6 pm	OMB G32	1-9

Lectures will start in Week 1 and continue until Week 9 , and one Monday lecture in Week 11 to make up for a holiday in Week 4. **There will be no lectures in Week 10**.

Course Aims

The main goal of the course is a detailed study of the classical Black-Scholes model, its variants and current topics in continuous time financial modelling. We introduce the concept of a continuously rebalanced portfolio, and we examine the arbitrage free property of the model by examining the existence and uniqueness of a martingale probability measure. We provide two alternative proofs of the Black-Scholes option pricing formula. The first relies on the calculation of the replicating strategy; it thus requires solving the Black-Scholes partial differential equation. The second method is based on probabilistic considerations and it makes direct use of the risk neutral valuation formula. We introduce and study the concepts of historical and implied volatilities. Subsequently, we present the approach known as the implied local volatility modelling. In this approach, the observed market prices at a given date (and thus the observed smiles and skews) are taken as inputs. In the second part of the course, we study contingent claims of American style in the Black-Scholes set up. We explain that the valuation of American claims is closely related to specific optimal stopping problems. We show that for the purpose of arbitrage valuation, the maximization of the expected discounted payoff should be done under the martingale measure. The last part of the course is devoted to cross-currency derivatives, stochastic volatility models and recent developments in continuous time financial modelling. Finally, we will look at stochastic optimal control based on the book of Pham (2009).

Course structure

- *Black-Scholes model and its extensions*: self-financing strategies, arbitrage opportunities, martingale measures, option pricing formula, replication of European contingent claims. Black-Scholes partial differential equation, completeness, Black's model for futures.
- *American claims*: American call and put option, rational exercise time, early exercise premium representation, optimal exercise boundary.
- *Volatilities*: historical volatility, implied volatility, volatility surface, risk-neutral marginal distributions, local volatility models.
- *Cross-currency derivatives*: domestic and foreign martingale measures, currency forward contracts and options.
- *Non-semimartingale models*
- Stochastic Volatility models
- Levy Models used in Finance
- Stochastic Optimal Control

The aim of MATH5816 is that at the end of session you should be able to understand the concepts and techniques discussed in the syllabus and be able to apply these concepts and techniques to appropriate problems in mathematical finance.

Relation to other mathematics courses

This is a compulsory course for the Master in Financial Mathematics. It builds on foundation knowledge of probability and stochastic analysis and will provide a solid background to the other core courses in the Master of Financial Mathematics, for example Math5985 and Math5925, Math 5005 and Math 5006.

Student Learning Outcomes

A student should be able

- Learn how Black Scholes is the building stone to most financial mathematics products
- Learn the fundamental principles of European, American, Asian and other Exotic Options
- Master the concepts and techniques of mathematical finance to solve appropriate problems in mathematical finance
- Able to apply specific and general results with specified assumptions to a variety of financial problems
- Able to use terminology and reporting styles appropriately and successfully to communicate information and understanding to both a mathematician and layperson.

I do not record the lectures so attending the class is strongly recommended.

Relation to Graduate Attributes

These outcomes are closely related to th graduate attributes "Research, inquiry, and analytical thinking abilities", "Communication" and "Information Literacy".

Teaching Strategies Underpinning the Course

Lecture notes provide a brief reference source to this course. These notes are heavily based on Shreve's book for the geometric Brownian motion case, Jeanblanc's book for the Levy processes and Pham for stochastic optimal control. At this stage, these are skeleton lecture notes only and sometimes, other materials and textbooks will be used for deeper understanding. New ideas and skills are first introduced and demonstrated in lectures, then students develop these skills by applying them to specific taks in tutorials and assessments.

Addititional resources and support to the lecture notes are

- Steven Shreve: Stochastic Calculus for Finance II. Continuous Time Models. Springer, 2004.
- Marek Musiela and Marek Rutkowski: Martingale Methods in Finan- cial Modelling. 2nd ed. Springer, 2005.
- Robert J. Elliott and Peter E. Kopp: Mathematics of Financial Mar- kets. Springer, 1999.
- Alison Etheridge: A Course in Financial Calculus, Cambridge Uni-x versity Press, 2002.
- Rose-Anne Dana and Monique Jeanblanc: Financial Markets in Con- tinuous Time. Springer, 2003.
- Huyèn Pham, Continuous Time Stochastic Control and Optimization with Financial Applications, 2009. This is an ebook in the our library. Course structure
- Monique Jeanblanc, Marc Yor and Marc Chesney, *Mathematical Methods for Financial Markets.* Springer, 2009
- Albert N. Shiryaev, *Essential of Stochastic Finance: Facts, Models, Theory.* World Scientific, 2000

Rationale for Learning and Teaching Strategies

We believe that effective learning is best supported by a climate of inquiry, in which students are actively engaged in the learning process. Hence this course is structured with a strong emphasis on problem solving task in class, given problem sets, and in assessment tasks. Students are expected to devote the majority of their study time to solving of such tasks.

Effectively learning is achieved when students attend all classes, have prepared effectively for classes by reading through previous lecture notes and by having made a serious attempt at doing for themselves the problem sets.

Furthermore, lectures should be viewed by students as an opportunity to learn, rather than just copy down or skim over lecture notes.

Assessment

Knowledge and abilities assessed: All assessment tasks will assess the learning outcomes outlined above.

Assessment in this course will use problem solving tasks of a similar from to those practiced in lectures and problem sets, to encourage the development of the core skills underpinning this course and the development of analytical thinking. Assessment in this course will consist of

- 1 Online Quiz (given in Moodle) worth 5% (Week 3)
- 1 Midsession Test, worth 25% (Week 6)
- 1 group assignment, worth 10% due in Week 9
- Final exam (2 hours - scheduled by UNSW) worth 60%

In all assessments, marks will be awarded for correct working and appropriate explanations and not just the final answer.

Attendance at lectures is recommended. If you choose not to attend classes, then you will may miss out on important information and you will certainly not get the most of the course. Note that I do not record the lectures.

One Online Quiz

Rationale: The online quiz will give you an opportunity for students to test their understanding of Stochastic Calculus and material given in the class. Stochastic Calculus is required for the course. This quiz will consist of both short answer and multiple choice questions. You will only have one hour to complete the quiz. The quiz will be available on Moodle on the following date:

- Friday, 4th October 2019

The quiz will just be available on Moodle for 48 hour. You can take the quiz only once, so please arrange for an appropriate time for yourself to do it.

Mid-session Test

Rationale: The Midsession Test will give students feedback on their progress and mastery of the material.

Both short answers and some longer questions requiring clear and logical presentation

Duration: 90 minutes.

It will be held in Week 6, Wednesday 23rd October 2019 at 4:00 pm. You will need to bring your own calculator that has an UNSW approved sticker.

Assignment

Rationale: The assignment will give an opportunity for students to try their hand at more difficult problems requiring more than one line of argument and also introduce to aspects of the subject which are not explicitly covered in lectures.

The assignment must be YOUR OWN WORK, or severe penalties will be incurred, but you can work in GROUPS OF UP TO 5 people. Hand in one hard copy of the assignment with **ALL the names and student ID numbers at the right hand corner of each page of your assignment and individually each of you must submit your assignment in Turnitin Moodle**.

The aims of the assignment are stated in the course aims.

You should consult the University webpage on plagiarism

`https://student.unsw.edu.au/plagiarism`

The schedule for assignment is as follows:

TASK	Week Available	Date Due	Worth
Assignment	Week 7	Week 9	10 %

Both a hard copy form and soft copy form on Turnitin Moodle must be submitted on Friday 1st November 2019. Late assignments will not be accepted.

Final Examination - scheduled by UNSW Sydney

Duration: Two hours.

Rationale: The final examination will assess student mastery of the mate- rial covered in the lectures.

NOTE: You will need to pass the final examination to pass the course.

Weighting: 60% of your final mark.

Further details about the final examination will be available in class closer to the time and also on Moodle.

Every class is different and to accomodate this some variations from the above schedule may occur. Hence the above schedule should be considered as a guide only, as it will not be strictly adhered to. In the case of assessment dates, no changes will be made without consultation with the class nor without confirmation being posted as an announcement on Moodle.

Moodle

All course materials will be available on Moodle. The course material on Moodle are not a substitute for attendance to lectures and tutorials. You should check regularly for new materials.

Course Evaluation and Development

The School of Mathematics and Statistics evaluates each course each time it runs. We carefully consider the student responses and their implications for course development. It is common practice to discuss informally with students how the course and their mastery of it are progressing.

Administrative Matters

School Rules and Regulations

Full details of the general rules regarding attendance, release of marks, special consideration, addition assessment etc are available via the School of Mathematics and Statistics Web page at

`https:// www.maths.unsw.edu.au/currentstudents/assessment-policies`

Plagiarism and Academic Honesty

Plagiarism is the presentation of the thoughts or work of another as one's own. Issues that you must be aware of regarding plagiarism and the University's policies on academic honesty and plagiarism can be found

`https://student.unsw.edu.au/ plagiarism`