ACTS:4380
Mathematics of Finance II
Course Syllabus
Fall 2018

THE UNIVERSITY OF IOWA

CAE Center of Actuarial Excellence

SOCIETY OF ACTUARIES

University of Iowa

Aug 20, 2018 – Nov 7, 2018*
MWThF, 66 SH
3:30 p.m. – 4:20 p.m.

* This is an off-cycle course lasting for 11 weeks only. The drop date is October 11, 2018.

1 Contact Information

- **Instructor:** Professor Ambrose Lo, PhD, FSA, CERA

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  (Feel free to visit it from time to time for latest updates on my courses and books!)

  ▷ *Office hours:* 2:45 p.m. – 3:30 p.m. and 4:30 p.m. – 5:15 p.m., Monday and Wednesday, or by appointment

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2 Course Description and Objectives

Prerequisites: ACTS:3080 (Mathematics of Finance I) with a minimum grade of C+
and status as Actuarial Science major

Corequisite: STAT:4100 (Mathematical Statistics I) or STAT:5100 (Statistical Inference I)

Recommendation: Taking FIN:3300 (Corporate Finance) together with or before ACTS:4380

Building upon students' prior exposure to actuarial science and preparation in mathematical statistics, this intermediate course on mathematical finance for B.S. and M.S. in Actuarial Science students explores option pricing in a reasonably mathematical manner and prepares you adequately for the *derivatives portion* (i.e., Topics 6 to 10) of the **Investment and Financial Markets (IFM) Exam** offered by the Society of Actuaries (SOA). It consists of three interrelated parts of varying degrees of technical sophistication:

Part I.	Conceptual Foundation on Derivatives	(approx. 3.5 weeks)
Part II.	Pricing and Hedging of Derivatives	
II-A.	Discrete-time Option Pricing Models	(approx. 2 weeks)
II-B.	Continuous-time Option Pricing Models	(approx. 5 weeks)
Part III.	Epilogue: General Properties of Option Prices	(approx. 0.5 weeks)

Here is the synopsis of the course:

- Part I (Chapters 1 to 3) lays the conceptual groundwork of the whole course by setting up the terminology of derivatives commonly encountered in the literature and introducing the definition, mechanics, typical use, and payoff structures of the two primary groups of derivatives, namely, forwards and options, which bestow upon their holders an obligation and a right to trade an underlying asset at a fixed price on a fixed date, respectively. Particular emphasis is placed on how and why a derivative works in a given scenario of interest. In due course, we also present the all-important *no-arbitrage assumption* and the method of *pricing by replication*. Underlying the pricing and hedging of derivatives throughout this book, these two vehicles are applied in this part to determine the fair price of a forward, where "fair" is meant in the sense that the resulting price permits no free lunch opportunities.

- In Part II (Chapters 4 to 8), which is the centerpiece of this course, we build upon the background material in Part I and tackle option pricing in two stages—first in the discrete-time binomial tree model (Chapter 4), which is simple, intuitive, and easy to implement, then in the technically more challenging continuous-time Black-Scholes model (Chapters 5 to 8). In this part, the no-arbitrage assumption and the method of replication continue to play a vital role in valuing options and lead to the celebrated *risk-neutral pricing formula*. The implementation and far-reaching implications of the method of risk-neutral valuation for the pricing and hedging of derivatives are explored in Chapters 6 to 8.

- Finally, we end in Part III (Chapter 9) with a description of some general properties satisfied by option prices when no asset price model is prescribed. Even in this model-free framework setting, there is a rich theory describing the no-arbitrage properties universally satisfied by option prices. Although this part can be read prior to studying Part II, you will find that what you learn from Part II, especially the notion of an exchange option in Chapter 8, will provide you with some surprisingly useful insights into the connections between different options.

After taking this course, the successful student is expected to:

1. Understand the mechanics and typical use of different kinds of financial derivatives.

2. Price options on a wide variety of underlying assets using different pricing methodologies.

3. Realize the assumptions and limitations of each class of option pricing models.

4. Take and, most importantly, pass Exam IFM in November 2018 with considerable ease.

5. (For graduate students) Proceed to more advanced courses on mathematical finance with strong confidence.

3 Exam IFM

Exam IFM is a new three-hour computer-based exam that consists of 30 multiple-choice questions, each of which includes 5 answer choices identified by (A), (B), (C), (D), and (E). It was offered for the first time in July 2018 and replaced its predecessor, Exam MFE (Models for Financial Economics), which was exclusively about the use and pricing of derivatives. Exam IFM encompasses much of the MFE derivatives material, but with a lot of corporate finance added. Roughly speaking, 50% of IFM is about derivatives (Topics 6 to 10) and the other 50% is about corporate finance (Topics 1 to 5). There are two released MFE past exams (Spring 2007 and Spring 2009), 60 sample questions on introductory derivatives, and 40 sample questions on advanced derivatives, all with detailed solutions. More information about Exam IFM can be found at `https://www.soa.org/education/exam-req/edu-exam-ifm-detail.aspx`.

Note that because of time constraints, this course is largely dedicated to the *derivatives portion* (i.e., Topics 6 to 10) of the IFM exam syllabus. To help you learn the *corporate finance portion* (i.e., Topics 1 to 5), it is strongly suggested that you also take **FIN:3300 (Corporate Finance)**, in addition to ACTS:4380, in the same semester. The reasons are two-fold:

1. While FIN:3300 may not use the same corporate finance text as in the IFM exam syllabus, the course has a significant overlap with the required IFM corporate finance topics (e.g., risk-return trade-off, asset pricing models, market efficiency, capital structure) and will be highly conducive to you mastering the IFM exam material and, by extension, taking Exam IFM in November 2018.

2. Getting a B- or above in FIN:3300 before July 2019 allows you to receive the VEE credit in Accounting and Finance (an accounting course is also required effective from July 2019). In other words, you have to take FIN:3300 no matter for IFM exam preparation or for fulfilling the VEE credit.

Exam IFM is offered three times every year (March, July, and November). In Fall 2018, Exam IFM will be offered via computer-based testing (CBT) from November 15 to November 21. The registration deadline is October 9 (please refer to `https://www.soa.org/Education/Exam-Req/Exam-Day-Info/edu-2018-cbt-test-schedule.aspx`). It is strongly suggested that you take the exam in November as you learn the material, do the homework, and study for the quizzes and exams in this course (as the old saying goes, *strike while the iron is hot*!). In fact, the off-cycle arrangement of this course is made so that it will end well before you take the November 2018

IFM exam. In the "unlikely" event that you cannot pass the exam in November, you should retake it in March 2019 when your memory is still fresh. The bottom line is: *You should aim to have (at least) three professional exams under your belt, namely, P, FM, and IFM, before the Career Fair of 2019, in order to be a competitive candidate for a permanent actuarial job.*

4 Textbook

The required textbook for this course is

> *Derivative Pricing: A Problem-Based Primer*, 2018, by **Lo, A.** (yours truly), Chapman & Hall/CRC Press Financial Mathematics Series. ISBN: 9781138033351.

All registered students in this course are expected to purchase this text, which not only addresses all important topics required in the derivatives portion of Exam IFM, but also presents lots of intuition for you to understand the subject matter deeply, and a wide variety of examples and practice problems for exam preparation. During lectures, you will put down additional details, work out examples together with the instructor, and take supplementary notes to better understand concepts. *You are strongly encouraged to bring the book to class.*

The optional text for this course is

> *Derivatives Markets* (Third Edition), 2013, by McDonald, R.L., Pearson Education, ISBN: 978-0-32154-308-0.

This is the official textbook for the derivatives portion of Exam IFM. We shall cover, in a different but more cohesive order, the following required sections in McDonald (2013):

- Chapter 1: Introduction to Derivatives, Sections 1, 2, 4, 5

- Chapter 2: An Introduction to Forwards and Options, Sections 1-4

- Chapter 3: Insurance, Collars, and Other Strategies, Sections 1-4

- Chapter 5: Financial Forwards and Futures, Sections 1, 2, 3 (through the middle of p. 136), 4 (through the top of p. 143)

- Chapter 9: Parity and Other Option Relationships, Sections 1 (through the bottom of p.269), 3

- Chapter 10: Binomial Option Pricing, Sections 1-5, 6 (through the middle of p. 315)

- Chapter 11: Binomial Option Pricing, Section 1

- Chapter 12: The Black-Scholes Formula, Sections 1-3, Appendices A, B

- Chapter 13: Market-Making and Delta-Hedging, Sections 1-4, 5 (beginning at the bottom of p.398), 6

- Chapter 14: Exotic Options: I, Sections 1, 2 (through the bottom of p.413), 3 (through the bottom of p.416), 4 (through the bottom of p. 419), 5 (through Figure 14.4 on p.423), 6, Exercises 14.20 and 14.21 on p.429

- Chapter 18: The Lognormal Distribution, Sections 1-4

- Appendices A (The Greek Alphabet), B.1 (The Language of Interest Rates), and C (Jensen's Inequality)

- IFM-22-18: Supplementary Material for Derivatives: "Actuarial-Specific Applications of Options and other derivatives, and Expanded Coverage on Exotic Options"

Unless otherwise stated, chapter appendices are not included in the required readings. Pearson has published *Student Solutions Manual to Derivatives Markets*, which provides solutions to all even-numbered end-of-chapter problems in the text.

5 Grading System

Assessment in this course comprises the following items:

- **Attendance and Attitude:** $\pm \varepsilon \%$[i]

  You may choose to attend or not to attend classes, but everyone needs to be aware that absence from classes without a valid reason can adversely affect your final grade. It is also impossible for absentees to get a copy of course material they miss, inquire about announcements made in class, or seek out-of-class help from the instructor. Likewise, your participation, preparedness, and work ethic may affect your final grade (positively or negatively).

- **Homework Assignments: 20%**

  There will be weekly assignments each consisting of about 4 to 6 end-of-chapter problems in the textbook, usually assigned on Wednesday and due the next Wednesday. Refer to the course schedule on pages 7 and 8. Any exceptions will be announced in class or in ICON. Late homework will be severely penalized (see the instructions on ICON). For students' guidance, illustrative solutions will be posted on ICON shortly after each homework is due. The homework with the lowest score will be dropped when it comes to computing the final grade.

  A note on collaboration: Discussion with other students on homework problems is encouraged. However, you should always write up your own solutions.

- **Short Quizzes: 15%**

  There will be a total of five 15-minute quizzes held on Fridays. These quizzes are intended to motivate you to study regularly (not just cram before the Midterm and Final Exams!) and will consist of relatively straightforward questions. The quiz with the lowest score will be dropped when it comes to computing the final grade.

- **Midterm Examination: 25%**

  There will be a 90-minute written Midterm Examination to be held in the evening (6:30 p.m. – 8:00 p.m.) of **October 5, 2018 (Friday)** at 106 GILH testing the material in Chapters 1 to 5 of this course. It will consist mainly of a series of short computational questions similar in style to IFM problems and/or end-of-chapter problems in the textbook. You will therefore

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[i]In mathematics, ε usually denotes a small positive number.

find that problems from released MFE/IFM past/sample exams and the textbook are useful in preparing for the Midterm Exam.

- **Final Examination: 40%**

  A two-hour comprehensive written Final Examination will take place in the evening (6:30 p.m. – 8:30 p.m.) of **November 7, 2018 (Wednesday)** at 106 GILH testing the material in the whole course, with an emphasis on Chapters 6 to 9. As an immediate precursor of the November 2018 IFM Exam, the Final Exam serves as a mock exam and gives you a rough picture of how you will perform in the real exam. Like the Midterm Exam, the Final Exam will comprise mainly short computational questions similar in style to MFE/IFM problems and/or problems in the textbook.

All quizzes and exams in this course are closed-book. The IFM formulas and tables (posted on ICON) will be provided if needed, and you are not allowed to bring your own formula sheets (the same applies to the real IFM exam as well!). Only SOA/CAS-approved calculators listed on Point 9 of `https://www.soa.org/Files/Edu/edu-rules-reg-instructions.pdf` are permitted.

A note on absences from exams. If, because of illness, you are unable to take any exams in this course as scheduled, you should inform the course instructor *within 24 hours* of the exam, and submit original documentation as soon as possible. Approval for absences for other reasons such as mandatory religious obligations, certain University activities, or unavoidable circumstances should be sought well in advance with documentation provided. Otherwise, a zero score will be awarded.

Grading scheme. Plus/minus grades will be given in this course, and undergraduate and graduate students will be treated as two separate groups when it comes to assigning final grades. An *approximate* guide is as follows:

Undergraduate students					
A-	$[83.5, 89)$	A	$[89, 94.5)$	A+	$[94.5, 100]$
B-	$[67, 72.5)$	B	$[72.5, 78)$	B+	$[78, 83.5)$
C-	$[50.5, 56)$	C	$[56, 61.5)$	C+	$[61.5, 67)$
D-	$[34, 39.5)$	D	$[39.5, 45)$	D+	$[45, 50.5)$
F	$[0, 34)$				

Graduate students					
A-	$[85, 90)$	A	$[90, 95)$	A+	$[95, 100]$
B-	$[70, 75)$	B	$[75, 80)$	B+	$[80, 85)$
C-	$[55, 60)$	C	$[60, 65)$	C+	$[\underline{\textbf{65}}, 70)$
D-	$[40, 45)$	D	$[45, 50)$	D+	$[50, 55)$
F	$[0, 40)$				

These are not completely absolute scales and the instructor reserves the "option" to adjust the cutoffs, depending on the difficulty of the exams. Note that with this grading scheme you are not "graded on a curve," and so you are not competing with fellow students. Therefore, you are not penalized in any way for working together to understand concepts and perform better in this course.

6 Tentative Teaching, Assignment, and Quiz Schedule

This approximate schedule will be updated as needed as the semester unfolds.

Teaching Week	Lecture	Date	Topic (Refer to Lo (2018))
Part I. Conceptual Foundation on Derivatives			
1	1	August 20, 2018 (Mon)	Introduction and Chapter 1
	2	August 22, 2018 (Wed)	Chapter 2, **Assignment 1**
	3	August 23, 2018 (Thur)	Chapter 2
	4	August 24, 2018 (Fri)	Chapter 2, **Quiz 1**
2	5	August 27, 2018 (Mon)	Chapter 2
	6	August 29, 2018 (Wed)	Chapter 2, **Assignment 2**
	7	August 30, 2018 (Thur)	Chapter 3
	8	August 31, 2018 (Fri)	Chapter 3
3	—	September 3, 2018 (Mon)	(University Holiday)
	9	September 5, 2018 (Wed)	Chapter 3, **Assignment 3**
	10	September 6, 2018 (Thur)	Chapter 3
	11	September 7, 2018 (Fri)	Chapter 3, **Quiz 2**
Part II. Pricing and Hedging of Derivatives			
4	12	September 10, 2018 (Mon)	Chapter 3
	13	September 12, 2018 (Wed)	Chapter 3, **Assignment 4**
	14	September 13, 2018 (Thur)	Chapter 4
	15	September 14, 2018 (Fri)	Chapter 4
5	16	September 17, 2018 (Mon)	Chapter 4
	17	September 19, 2018 (Wed)	Chapter 4, **Assignment 5**
	—	September 20, 2018 (Thur)	(No class due to Actuarial Job Fair)
	18	September 21, 2018 (Fri)	Chapter 4, **Quiz 3**
6	19	September 24, 2018 (Mon)	Chapter 4
	20	September 26, 2018 (Wed)	Chapter 4, **Assignment 6**
	21	September 27, 2018 (Thur)	Chapter 5
	22	September 28, 2018 (Fri)	Chapter 5
7	23	October 1, 2018 (Mon)	Chapter 5
	24	October 3, 2018 (Wed)	Chapter 6, **Assignment 7**

	25	October 4, 2018 (Thur)	Chapter 6
	—	October 5, 2018 (Fri)	**(No class. Midterm in evening!)**
8	26	October 8, 2018 (Mon)	Chapter 6
	27	October 10, 2018 (Wed)	Chapter 6, **Assignment 8**
	28	October 11, 2018 (Thur)[ii]	Chapter 6
	29	October 12, 2018 (Fri)	Chapter 6
9	30	October 15, 2018 (Mon)	Chapter 7
	31	October 17, 2018 (Wed)	Chapter 7, **Assignment 9**
	32	October 18, 2018 (Thur)	Chapter 7
	33	October 19, 2018 (Fri)	Chapter 8, **Quiz 4**
10	34	October 22, 2018 (Mon)	Chapter 8
	35	October 24, 2018 (Wed)	Chapter 8, **Assignment 10**
	36	October 25, 2018 (Thur)	Chapter 8
	37	October 26, 2018 (Fri)	Chapter 8, **Quiz 5**
Part III. Epilogue: General Properties of Option Prices			
11	38	October 29, 2018 (Mon)	Chapter 8
	39	October 31, 2018 (Wed)	Chapter 8
	40	November 1, 2018 (Thur)	Chapter 9
	41	November 2, 2018 (Fri)	Chapter 9 / Final review
12	—	November 7, 2018 (Wed)	**Final Examination**
—	—	November 15–21, 2018	**November 2018 Exam IFM**

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More about the Instructor ("Shameless" Self-introduction...)

Professor Ambrose Lo was born (in 19X9), raised, and educated in Hong Kong. He earned his B.S. in Actuarial Science (first class honors) and Ph.D. in Actuarial Science from The University of Hong Kong in 2010 and 2014, respectively. He joined the Department of Statistics and Actuarial Science at The University of Iowa in August 2014 as an Assistant Professor of Actuarial Science. He is a Fellow of the Society of Actuaries (FSA) and a Chartered Enterprise Risk Analyst (CERA). His research interests lie in dependence structures, quantitative risk management as well as optimal (re)insurance. His research papers have been published in top-tier actuarial journals, such as *ASTIN Bulletin: The Journal of the International Actuarial Association*, *Insurance: Mathematics and Economics*, and *Scandinavian Actuarial Journal*.

Besides dedicating himself to actuarial research, Ambrose attaches equal importance to teaching, through which he nurtures the next generation of actuaries and serves the actuarial profession. He has taught courses on financial derivatives, mathematical finance, life contingencies, credibility theory, advanced probability theory, and regression and time series analysis. His emphasis in teaching is always placed on the development of a thorough understanding of the subject matter complemented by concrete problem-solving skills. He is a coauthor of the *ACTEX Study Manual for SOA Exam SRM* (September 2018 edition) and the sole author of the *ACTEX Study Manual*

[ii]Drop date for undergraduates.

for CAS Exam MAS-I (Fall 2018 Edition) and the textbook *Derivative Pricing: A Problem-Based Primer* published by Chapman & Hall/CRC press.

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College of Liberal Arts & Sciences: Policies and Procedures

Administrative Home

The College of Liberal Arts and Sciences (CLAS) is the administrative home of this course and governs its add/drop deadlines, the second-grade-only option, and other policies. These policies vary by college.

Electronic Communication

Students are responsible for official correspondences sent to their UI email address (uiowa.edu) and must use this address for all communication within UI (Operations Manual, III.15.2).

Accommodations for Disabilities

UI is committed to an educational experience that is accessible to all students. A student may request academic accommodations for a disability (such as mental health, attention, learning, vision, and physical or health-related condition) by registering with Student Disability Services (SDS). The student should then discuss accommodations with the course instructor (`https://sds.studentlife.uiowa.edu/`).

Nondiscrimination in the Classroom

UI is committed to making the classroom a respectful and inclusive space for all people irrespective of their gender, sexual, racial, religious or other identities. Toward this goal, students are invited to optionally share their preferred names and pronouns with their instructors and classmates. The University of Iowa prohibits discrimination and harassment against individuals on the basis of race, class, gender, sexual orientation, national origin, and other identity categories set forth in the University's Human Rights policy. For more information, contact the Office of Equal Opportunity and Diversity at diversity@uiowa.edu or `diversity.uiowa.edu`.

Academic Honesty

All undergraduates enrolled in courses offered by CLAS have, in essence, agreed to the College's Code of Academic Honesty. Misconduct is reported to the College, resulting in suspension or other sanctions, with sanctions communicated with the student through the UI email address.

CLAS Final Examination Policies

The final exam schedule for each semester is announced around the fifth week of classes; students are responsible for knowing the date, time, and place of a final exam. Students should not make travel plans until knowing this final exam information. No exams of any kind are allowed the week before finals.

Making a Suggestion or a Complaint

Students with a complaint should first visit with the instructor or course supervisor and then with the departmental executive officer (DEO), also known as the Chair. Students may then bring the concern to CLAS.

Understanding Sexual Harassment

Sexual harassment subverts the mission of the University and threatens the well-being of students, faculty, and staff. All members of the UI community must uphold the UI mission and contribute to a safe environment that enhances learning. Incidents of sexual harassment must be reported immediately. For assistance, definitions, and the full University policy, see `https://osmrc.uiowa.edu/`.

END OF COURSE SYLLABUS