Math 418C   Financial Mathematics III

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Office Hours: 10:00-10:50 M-F e-mail or call to make appointment or ask questions. Students welcome when my office door is open! Check out http://www.cwu.edu/~chueh for my daily schedule.

Prerequisite: MATH 418B or Permission.

Text: 1. Mathematics of Investment and Credit, 4th Edition, Samuel A. Broverman, Actex Academic Series
2. Derivatives Markets, 2nd Edition, Robert L. McDonald, Pearson

Course Objectives:

This course is required for Actuarial Science majors. As the 3rd part of three-course sequence, it prepares students to pass SOA/CAS Exam FM. This exam is covered by the course sequence Math 418A,B,C (9 credits). It's followed by the new course Math 440 Financial Economics (5 credits) covering Exam MFE. After completing the entire sequence, students will be able to calculate present and future values of annuities determined by interest rates. They will be able to apply methods of pricing investment products such as bonds and annuities as well as analyze loans and sinking funds. Students will also be able to solve interest-related problems in the actuarial professional. Students will gain understanding of financial derivatives (forwards, options, futures, swaps) and their use in risk management.
For math 418C, students will be able to define as well as calculate duration, convexity and immunization, and the term structure of interest rates. Students will know the definitions of derivatives, forwards, futures, short and long positions, call and put options, spreads, collars, hedging, arbitrage, and swaps.

Learning Objectives:

The following <u>objectives</u> and <u>exam percentages</u> are excerpted from published SOA Exam Syllabus. Specific topics to be focused on in Math 418C course are in BOLD as follows:

I.   **Interest Theory (65-80%)**   **<u>(Using Textbook by Broverman "Mathematics of Investment and Credit")</u>**

      A. Time Value of Money (5-15%)
      1. The candidate will be able to define and recognize the definitions of the following terms:
        a. Interest rate (rate of interest)
        b. Simple interest
        c. Compound interest
        d. Accumulation function
        e. Future value
        f. Present value/net present value
        g. Discount factor
        h. Discount rate (rate of discount)
        i. Convertible m-thly

j. Nominal rate
k. Effective rate
l. Inflation and real rate of interest
m. Force of interest
n. Equation of value

2. The candidate will be able to:
   a. Given any two of interest rate, present value, or future value, calculate the third based on simple or compound interest.
   b. Given any one of the effective interest rate, the nominal interest rate convertible m-thly, the effective discount rate, the nominal discount rate convertible m-thly, or the force of interest, calculate all of the other items. c. Write the equation of value given a set of cash flows and an interest rate.

B. Annuities with payments that are not contingent (5-20%)
1. The candidate will be able to define and recognize the definitions of the following terms:
   a. Annuity-immediate
   b. Annuity-due
   c. Perpetuity
   d. Payable m-thly, or Payable continuously
   e. Level payment annuity
   f. Arithmetic increasing/decreasing payment annuity
   g. Geometric increasing/decreasing payment annuity
   h. Term of annuity

2. The candidate will be able to:
   a. Given an annuity with level payments, immediate (or due), payable m-thly, (or payable continuously), and any three of present value, future value, interest rate, payment, and term calculate the remaining two items.
   b. Given an annuity with non-level payments, immediate (or due), payable m-thly, (or payable continuously), the pattern of payment amounts, and any three of present value, future value, interest rate, payment amounts, and term of annuity calculate the remaining two items.

C. Loans (5-20%)
1. The candidate will be able to define and recognize the definitions of the following terms:
   a. Principal
   b. Interest
   c. Term of loan
   d. Outstanding balance
   e. Final payment (drop payment, balloon payment)
   f. Amortization
   g. Sinking fund

2. The candidate will be able to:
   a. Given any four of term of loan, interest rate, payment amount, payment period, principal, calculate the remaining items.
   b. Calculate the outstanding balance at any point in time.
   c. Calculate the amount of interest and principal repayment in a given payment.
   d. Given the quantities, except one, in a sinking fund arrangement calculate the missing quantity.

D. Bonds (5-20%)
1. The candidate will be able to define and recognize the definitions of the following terms:
   a. Price
   b. Redemption value
   c. Par Value/Face value
   d. Coupon, Coupon rate
   e. Term of bond
   f. Yield rate g. Callable/non-callable

h. Book value
i. Accumulation of discount

2. The candidate will be able to:
a. Given any four of price, redemption value, yield rate, coupon rate, and term of bond, calculate the remaining item.

E. General Cash Flows and Portfolios (5-20%)
1. Students will be able to define and recognize the definitions of the following terms:
a. Yield rate/rate of return
b. Dollar-weighted rate of return/Time-weighted rate of return
c. Current value
d. Duration (Macaulay, modified and effective)
e. Convexity
f. Portfolio and investment year allocation methods
g. Spot rate
h. Forward rate
i. Yield curve
j. Stock price, stock dividend
2. Students will be able to:
a. Calculate the current value of a set of cash flows.
b. Calculate the portfolio yield rate.
c. Calculate the dollar-weighted and time-weighted rate of return.
d. Calculate the duration and convexity of a set of cash flows.
e. Calculate either Macaulay or modified duration given the other.
f. Use duration and convexity to approximate the change in present value due to a change in interest rate.
g. Calculate the price of a stock using the dividend discount model.

F. Immunization (5-15%)
1. Students will be able to define and recognize the definitions of the following terms:
a. Cash-flow matching;
b. Immunization (including full immunization);
c. Redington immunization.
2. Students will be able to:
a. Construct an investment portfolio to fully immunize a set of liability cash flows.
b. Construct an investment portfolio to match present value and duration of a set of liability cash flows.
c. Construct an investment portfolio to exactly match a set of liability cash flows.

II.   **Financial Economics (20-35%) (<u>Using Textbook by McDonald "Derivatives Markets"</u>)**

A. General Derivatives (0-5%)
1. Students will be able to define and recognize the definitions of the following terms:
a. Derivative, Underlying asset, Over-the-counter market
b. Ask price, Bid price, Bid-ask spread
c. Short selling, Short position, Long position
d. Stock index
e. Spot price
f. Net profit/payoff
g. Credit risk
h. Marking-to-market
i. Margin, Maintenance margin, Margin call
2. Students will be able to **evaluate an investor's margin position based on changes in asset values.**

B. Options (5-10%)
1. Students will be able to define and recognize the definitions of the following terms:
    a. Call option, Put option
    b. Expiration, Expiration date
    c. Strike price/Exercise price
    d. European option, American option, Bermudan option
    e. In-the-money, At-the-money, Out-of-the-money
    f. Covered call, Naked writing
    g. Dividends
    h. Put-call parity
2. Students will be able to **evaluate the payoff and profit of basic derivative contracts.**

C. Hedging and Investment Strategies (5-15%)
1. Students will be able to define and recognize the definitions of the following terms:
    a. Hedging, Arbitrage
    b. Diversifiable risk, Nondiversifiable risk
    c. Synthetic forwards
    c. Spreads (including bull, bear, box, and ratio spreads)
    d. Collars (including zero-cost collars), Paylater strategy
    e. Straddles (including strangles, written straddles and butterfly spreads)
    f. Convertible bond, Mandatorily convertible bond
    2. The candidate will be able to:
    a. Explain how derivative securities can be used as tools to manage financial risk.
    b. Explain the reasons to hedge and not to hedge.
    c. Evaluate the payoff and profit of hedging strategies.

D. Forwards and Futures (0-10%)
1. Students will be able to define and recognize the definitions of the following terms:
    a. Forward contract, Prepaid forward contract
    b. Outright purchase, Fully leveraged purchase
    c. Implied repo rate
    d. Cost of carry
    e. Lease rate
    f. Futures contract
2. Students will be able to:
    a. Determine forward price from prepaid forward price.
    b. Explain the relationship between forward price and futures price.
    c. Explain the relationship between forward price and future stock price.
    d. Use the concept of no-arbitrage to determine the theoretical value of futures and forwards.
    e. Given any four of call premium, put premium, forward price, strike price and interest rate, calculate the remaining item using the put-call parity formula.

E. Swaps (0-5%)
1. Students will be able to define and recognize the definitions of the following terms:
    a. Swap, Prepaid swap b. Swap term, Swap spread, Notional Amount
    c. Simple commodity swap, Interest rate swap
    d. Deferred swap
2. Students will be able to **use the concept of no-arbitrage to determine the theoretical values of swaps.**

Topical Outline:

Topic to cover	Hours
	(3 hours meetings will be a week study)

I.   Cash Flows and Immunization
  1. Asset Liability Cash Flow Matching
  2. Durations
  3. Full Immunization   5

II.   Outline Objectives A, B   10
  1. General derivatives
  2. Options

III.   Outline Objectives C, D, E
  1. Hedging and Investment Strategies   10
  2. Forwards and Futures
  3. Swaps

    TESTING/PRESENTATION   5

    TOTAL   30

Class format

Mixture of lectures, slide show and discussion, in-class problem solving, Students are encouraged to present their solutions of the assigned problems and answer questions raised by the instructor and students.
Lecture followed by in-class problem solving with students' input and textbook reading as expected. Students are expected to spend extra time on their own to solve related problems presented. Instructor and students present their understanding of the assigned problems and chapter readings.

Attendance

To achieve success in *any* mathematics class, **regular attendance is almost imperative**. Unlike most subjects, new topics in Financial Mathematics build on previous knowledge; failure to learn something early may haunt you throughout the course. We will do work in class occasionally, so if you missed a class you missed in-class credit.

IF YOU MISS CLASS, IT IS YOUR RESPONSIBILITY TO FIND OUT THE MATERIAL COVERED, ANNOUNCED, OR ASSIGNED, AND TO ARRANGE TO PICK UP ANY ASSIGNMENTS THAT MAY BE HANDED OUT OR RETURNED!

Homework policy

Homework has been assigned on the syllabus and will also be given in class. The due date will be every Friday by noon. Working on homework is the only way most of us learn to critically analyze and "solve" problems.

Some class time will be devoted to questions on the homework. Office hours are also scheduled to provide

opportunities for more in-depth discussion of homework problems.

There may be problems to be worked during class to turn in. Poor attendance regularly will affect your homework grade.

Grading policy

- ➢ Textbook Assignments and in-class work/quizzes   (200 points)
- ➢ Two Learning Experience   (200 points)
- ➢ Final Learning Experience   (100 points)

  Total   500 points

Tentative Schedule (Any change will be announced in class.)

Week	Reading Assignment	Homework
1. 3/26-3/30	6.1, 6.3, 6.4	6.1 #1,2,5; 6.3 #4,6; 6.4 # 1-5 Due Friday: 6.1, 6.3
2. 4/2-4/6	7.1, 7.2	7.1 #1-3,5,6,10; 7.2 #1,2,5-7, 10,12,13 Due Friday: 6.4, 7.1
3. 4/9-4/13	**Review**	Due Friday: 7.2
4. 4/6-4/20	**Learning Experience I** 8.1, 8.3.1, 8.4.1, 8.4.2	 Reading
5. 4/23-4/27	1.1-1.4; 2.1-2.6, 2.A	page 17-18 #1-#12 page 54-56 #1-#16
6. 4/30-5/4	**Learning Experience II.**	
7. 5/7-5/11	3.1-3.5	page 87-90 #1-20
8. 5/14-5/18	4.1-4.4	page 121-124 #1-#25
9. 5/21-5/25	5.1-5.4, 5.B	page 162-164 #1-10
10. 5/28-6/1	8.1-8.2	page 275-276 #1-#14
11. 6/4-6/8	**Final Learning Experience**	

Academic Integrity

Actuarial professionals in general, and Credential Actuaries in particular, have reputations for working hard, being objective, and having integrity. Aspiring actuaries (i.e., actuarial students) must:

- Accept these as the Facts of Professional Life and

- Understand that **when one person compromises, all suffer**.

This is especially true with respect to integrity. Consequently, any student guilty of committing a proscribed action under the Student Judicial Code (WAC §106-120-027) will receive **a grade of F** in this course and be subject to further disciplinary action in accordance with University Policy (WAC §106-72-005).

The grading policy for all actuarial courses is based on strict compliance with WAC 106-120---STUDENT JUDICIAL CODE, especially Part II, Sub-part B, regarding ACADEMIC DISHONESTY. A student who violates this Code WILL RECEIVE A GRADE OF F IN THIS CLASS, and will be subject to further disciplinary action in accordance with University Policy (WAC 106-72-005).