Proposal Form For Addition And Revision Of Courses

1. Proposing College / School: College of Sciences and Mathematics
   Department: Department of Mathematics and Statistics

2. Course Prefix and Number: MATH 5870/6870
   3. Effective Term: Fall 2012

4. Course Title: Financial Mathematics
   Abbreviated Title (30 characters or less): Financial Mathematics

5. Requested Action:
   - [ ] Renumber a Course
   - [ ] Add a Course
   - [ ] Revise a Course

6. Course Credit:
   Contact/Group Hours: 3
   Scheduled Type: Lecture
   Weekly or Per Term?: Weekly
   Credit Hours: 3
   Anticipated Enrollment: 20
   Maximum Hours (Repeatability): 3
   Total Credit Hours: 3

7. Grading Type:
   - [ ] Regular (ABCDF)
   - [ ] Satisfactory/Unsatisfactory (S/U)
   - [ ] Audit

8. Prerequisites/Corequisites:
P: Calculus I (MATH1610), Calculus II (MATH1620), Linear Differential Equations (MATH 2650), Probability and Statistics (STAT3600) or equivalent

9. Restrictions:
   List specific restriction in space above.
   - [ ] College
   - [ ] Major
   - [ ] Standing
   - [ ] Degree

10. Course Description:
   Options and spreads, pricing of such options in accordance with the Black-Scholes Equation, and the binomial pricing model.

11. May Count Either:
    - [ ] Selective
    - [ ] or
    - [ ] Required

12. Affected Program(s):
    (Respond “N/A” if not included in any program; attach memorandum if more space is required)
    (e.g.: minor, major, etc.)
    (e.g.: MS in Chemistry, Performance Option, Minor in Art)
    Requirement or Elective?
    (required or optional?)
    N/A
    N/A
    N/A

13. Overlapping or Duplication of Other Units’ Offerings:
    (If course is included in any other degree program, is used as an elective frequently by other unit(s), or is in an area similar to that covered by another college/school, attach correspondence with relevant unit)
    - [ ] Applicable
    - [ ] Not Applicable
14. Justification:
Options pricing, including the Black-Scholes model and binomial pricing model, is relevant to the Actuarial Program, and likely to be of interest to students of mathematics and possibly other areas such as finance. These topics are not covered in any other mathematics course, or in any course at the level of mathematical rigor which we propose.

(Include a concise, yet adequate rationale for the addition/revision of the course, citing accreditation, assessments (faculty, graduate, and/or external) where applicable)

15. Resources:
No additional resources need. Existing faculties in Actuarial science program are going to teach this course.

(Indicate whether existing resources such as library materials, classroom/laboratory space, and faculty appointments are adequate to support the proposed addition/revision; if additional resources are required, indicate how such needs will be met, referencing the appropriate level of authorization -- i.e.: Dean -- where necessary; if no additional resources or shifting of resources will be necessary, respond “Not Applicable”)

16. Student Learning Outcomes:
Undergraduate Student Learning Outcomes - MATH 5870
1. determine the relationship between put and call options and identify arbitrage opportunities.
2. calculate value of differential types of options using different models.
3. explain the properties of a lognormal distribution and Black-Scholes formula.
4. apply Ito's lemma in the one-dimensional case.
5. understand delta-hedging risk management techniques.
6. use basic techniques to solve heat equation and Black-scholes partial differential equation.

Graduate Student Learning Outcomes - MATH 6870
1. determine the relationship between put and call options and identify arbitrage opportunities.
2. calculate payoff and profit of differential types of options/exotic options using different models.
3. understand the properties of a lognormal distribution and use programming to estimate the parameters of Lognormal distributions.
4. understand and apply binomial model and Black-Scholes formula to evaluate European and American options.
5. apply Ito's lemma in the one-dimensional and two-dimensional case.
6. understand delta-hedging risk management techniques.
7. use basic techniques to solve heat equation and Black-scholes partial differential equation.
8. use variance reduction techniques to accelerate convergence.

(State in measurable terms (reflective of course level) what students should be able to do when they have completed this course)

17. Course Content Outline:
Week 1
Review of Options: Option Terminology; Payoff and Profit for a purchased/written call/put option.
Assignment: Exercises on calculating and graphing the payoff and profit of options.

Week 2
American options / European options: Difference between American and European options.
Assignment: Identify the situations where the values of European and American options are the same.

Week 3
Put-call parity: Use put-call parity to determine the relationship between prices of European put and call options and to identify arbitrage opportunities.
Assignment: Exercises on using the put-call parity.

Week 4
Binomial model: Evaluate European and American options using the binomial model.
Assignment: Calculate the value of European and American options using the binomial model.

Week 5
Black-Scholes option pricing: Evaluate European and American options using the Black-Scholes option-pricing model.
Assignment: Calculate the value of European and American options using the Black-Scholes option-pricing model.

Week 6
Lognormal distribution: Explain the properties of a lognormal distribution and explain the Black-Scholes formula as a limited expected value for a lognormal distribution.
Assignment: Relation between lognormal and normal. Calculate the expectation of a lognormal variable.

Week 7
Delta-hedging: Explain and demonstrate how to control risk using the method of delta-hedging.
Assignment: Compute and graph the profit using delta-hedging.

Week 8
Exotic options: Introduce gap, Asian, barrier, compound, and exchange options.
Assignment: Use the spreadsheet of the exotic option functions to compute the prices of options.

Week 9
Cash-or-nothing options: Terminology and delta-hedging cash-or-nothing put and calls.
Assignment: project on COD (collect-on-delivery call).

Week 10
Brownian motion: Definition and properties of standard, arithmetic and geometric Brownian motions.
Assignment: Case study on how L. Bachelier attempted to describe fluctuations in stock prices mathematically in 1900.

Week 11
Ito's Lemma: Function of an Ito Process and multivariate Ito's Lemma.
Assignment: Apply Ito's Lemma in the one-dimensional case.

Week 12
Black-Scholes Partial Differential Equations: Verifying the formula for a derivative.
Assignment: Verify solutions to the Black-Scholes PDEs.

Week 13
Reduction to heat equation: Explain how to reduce Black-Scholes PDE to heat equations.
Assignment: Explain what it means to say that stock prices follow and diffusion process.

Week 14
Heat Equations: Method to solve basic heat equations.
Assignment: Solve basic heat equations analytically and numerically.

Week 15
Simulation I: Lognormal stock prices.
Assignment: Use program to estimate the parameters of a lognormal distribution.
Week 16
Simulation II: Variance reduction.
Assignment: Use variance reduction techniques to accelerate convergence.

(Provide a comprehensive, week-by-week breakdown of course content, including assignment due dates)

18. Assignments / Projects:

1. Weekly assignment will be assigned during each lecture and collected every two weeks. Assignment problems will include exercises from textbooks as well as problems made up by the instructor.
2. Reading Assignment: Research report or publication related to the course content will be assigned to graduate students as required assignment, and to undergraduate students as optional reading assignment. Discussion or report will be followed by the reading assignment.
3. Programming Assignment: The last part of the course will involve some simulation problems which need to be done via computer programming. Multi software will be allowed, depend on students preference.
4. Exam: There will be one midterm exam covering first part of the course around the 35th class day. There will be one cumulative final exams during the final exam week.

(List all quizzes, projects, reports, activities and other components of the course grade -- including a brief description of each assignment that clarifies its contribution to the course's learning objectives)

19. Rubric and Grading Scale:

Grade Breakdown:
- Homework Assignments 20% for MATH 5870, 15% for MATH 6870;
- Reading Assignments: 0% for MATH 6870, 5% for MATH 6870;
- Projects: 10% for MATH 5870 and MATH 6870;
- Midterm Exam: 30% for MATH 5870 and MATH 6870;
- Final Exam: 40% for MATH 5870 and MATH 6870.
(Note: The number of problems of homework assignments, midterm exam, and final exam for MATH 6870 will be 1.2 times that of MATH 5870).

Grading Scale:
- 90%-100% A; 80% - 89% B; 70% - 79% C; 60%-69% D; 0 - 59% F

(List all components of the course grade -- including attendance and/or participation if relevant -- with point totals for each; indicate point totals and ranges or percentages for grading scale; for S/U grading, detail performance expectations for a passing grade)

20. Justification for Graduate Credit:

The Black-Scholes partial differential equation will be derived using elementary stochastic calculus, and solved using standard diffusion methods. Much of the course is grounded upon basic probability theory, so although it is not rigorous enough to have a 7000 number, a 5000/6000 piggy-back number is appropriate.

Graduate students will be required to do more course work ---- more problems in homework assignments, and more problems in both mid and final exams. They will be required to conduct a review or short presentation for each of the reading assignment. They will also be required to lead the group if there is any group work (e.g. programming projects).

(Include a brief statement explaining how the course meets graduate educational standards (i.e.: rigorous standards for evaluation, development of critical thinking and analytical skills, etc.))

(Included below are standard statements regarding course policies. If necessary, a statement may be altered to reflect the academic policies of individual faculty members and/or the academic unit or department, provided that there is no conflict with the Tiger Cub, Faculty Handbook, or any existing university policy.)

POLICY STATEMENTS

Attendance: Although attendance is not required, students are expected to attend all classes, and will be held responsible for any content covered in the event of an absence.
**Excused Absences:** Students are granted excused absences from class for the following reasons: illness of the student, serious illness of a member of the student's immediate family, the death of a member of the student's immediate family, trips for student organizations sponsored by an academic unit, trips for university classes, trips for participation in intercollegiate athletic events, subpoena for a court appearance, and religious holidays. Students who wish to have an excused absence from class for any other reason must contact the instructor in advance of the absence to request permission. The instructor will weigh the merits of the request, and render a decision. When feasible, the student must notify the instructor prior to the occurrence of any excused absences, but in no case shall such notification occur more than one week after the absence. Appropriate documentation for all excused absences is required. Please see the Tiger Cub for more information on excused absences.

**Make-Up Policy:** Arrangement to make up a missed major examination (e.g., hour exams, mid-term exams) due to properly authorized excused absences must be initiated by the student within one week of the end of the period of the excused absence(s). Except in unusual circumstances, such as the continued absence of the student or the advent of university holidays, a make-up exam will take place within two weeks of the date that the student initiates arrangements for it. Except in extraordinary circumstances, no make-up exams will be arranged during the last three days before the final exam period begins.

**Academic Honesty Policy:** All portions of the Auburn University student academic honesty code (Title XII) found in the Tiger Cub will apply to university courses. All academic honesty violations or alleged violations of the SGA Code of Laws will be reported to the Office of the Provost, which will then refer the case to the Academic Honesty Committee.

**Disability Accommodations:** Students who need special accommodations in class, as provided for by the Americans With Disabilities Act, should arrange for a confidential meeting with the instructor during office hours in the first week of classes (or as soon as possible if accommodations are needed immediately). The student must bring a copy of their Accommodation Letter and an Instructor Verification Form to the meeting. If the student does not have these forms, they should make an appointment with the Program for Students with Disabilities, 1288 Haley Center, 844-2096 (VTT).