TO: Undergraduate Curriculum Committee
FROM: Dr. Uğur Abdulla, Head, Department of Mathematical Sciences
CC: Dr. Hamid Rassoul, Dean, College of Science
DATE: November 12, 2014
RE: Adding a course – MTH 4202 – Stochastic Modeling

The Department of Mathematical Sciences intended to introduce a new course, MTH 4202, Stochastic Modeling. The course will replace the degree requirement in programs 7076 and 7077 of MTH 4201 with MTH 4201 OR MTH 4202.
Florida Institute of Technology

ADDING A NEW COURSE TO THE CURRICULUM

This course is available for student registration only after the approval process has been completed.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>COURSE NO.*</th>
<th>CREDIT HOURS</th>
<th>TERM TO BE ADDED TO THE FILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g., CSE)</td>
<td>4202</td>
<td>3</td>
<td>Spring 2015</td>
</tr>
</tbody>
</table>

*Justify level (1000 level+ and no co- or prerequisites) (e.g., Fall 2010)

<table>
<thead>
<tr>
<th>CLASS HOURS</th>
<th>LECTURE HOURS</th>
<th>LAB HOURS</th>
<th>CONTACT HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>45/semester</td>
<td>45/semester</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DEPARTMENT Mathematical Sciences (e.g., Computer Sciences)

SCHEDULE TYPE Lecture (e.g., Lecture, Lab or Special Topics/Project)

☐ COLLEGE OF AERONAUTICS - 23
☐ COLLEGE OF PSYCHOLOGY AND LIBERAL ARTS - 25
☐ NATHAN M. BISK COLLEGE OF BUSINESS - 24
☐ COLLEGE OF SCIENCE - 26
☐ COLLEGE OF ENGINEERING - 1
☐ EXTENDED STUDIES / NATHAN M. BISK COLLEGE OF BUSINESS - 90

COMPUTER TITLE Restricted to 25 characters, including spaces
Stochastic Modeling

Stochastic Modeling

CATALOG TITLE Restricted to 250 characters, including spaces

Includes discrete and continuous time parameter Markov processes and their applications to genetics, biology, ecology, Polsson and renewal processes and applications to reliability and queueing, time series, Brownian motion, martingales, Ito calculus and applications to finance. Prerequisites: MTH 2001, MTH 2201 and MTH 2401.

This description has been approved by the catalog office.

Catalog Director

10/20/2014

In addition, please attach a course syllabus and/or more detailed description.

<table>
<thead>
<tr>
<th>RESTRICTIONS</th>
<th>Course Number</th>
<th>Course Number</th>
<th>Course Number</th>
<th>Course Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Prerequisite MTH 2001</td>
<td>☐ Corequisite</td>
<td>☐ and ☐ or</td>
<td>GRADES TO BE ISSUED</td>
<td></td>
</tr>
<tr>
<td>☐ Prerequisite MTH 2201</td>
<td>☐ Corequisite</td>
<td>☐ and ☐ or</td>
<td>A, B, C, D, F</td>
<td></td>
</tr>
<tr>
<td>☐ Prerequisite MTH 2401</td>
<td>☐ Corequisite</td>
<td>☐ and ☐ or</td>
<td>☐ and ☐ or</td>
<td></td>
</tr>
</tbody>
</table>

ADDITIONAL RESTRICTION (e.g., Major, Class Level, Department Head Approval)

If this course replaces a course currently offered in BANNER, please indicate old course information and the date/term the course may be removed from the system.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>COURSE NO. (e.g., CSE)</th>
<th>TERM TO INACTIVATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Yes</td>
<td>☐ No</td>
<td>Will this course be used to measure program-level student learning outcomes? If yes, review and signature required.*</td>
</tr>
<tr>
<td>☐ Yes</td>
<td>☐ No</td>
<td>Will this course be used to satisfy the scholarly inquiry requirement? If yes, attach “Q” materials for review.</td>
</tr>
<tr>
<td>☐ Yes</td>
<td>☐ No</td>
<td>Will this course impact any existing program? If yes, attach “Changing Graduation Requirements” form for each program that is impacted.</td>
</tr>
</tbody>
</table>

APPROVALS: On completion of description and course number verification, affix appropriate signatures as indicated, and submit completed form to Chair, Graduate Council, or Chair, Undergraduate Curriculum Committee for approval.

<table>
<thead>
<tr>
<th>Originator</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Yes</td>
<td>☐ No</td>
</tr>
</tbody>
</table>

Chair, Graduate Council

10/21/2014

<table>
<thead>
<tr>
<th>Date</th>
</tr>
</thead>
</table>

Chair, Undergraduate Curriculum Committee

10/23/2014

**Vice President for Institutional Effectiveness

11/16/2014

CATALOG DIRECTOR

These changes/additions have been made for the University Catalog and entered into the BANNER term named above.

Catalog Director

<table>
<thead>
<tr>
<th>Date</th>
</tr>
</thead>
</table>

REGISTRAR’S USE ONLY

SCARSE
SCADETL
SCAPRO
SCARBASE

SCARRES
Operator Init.

Date
Florida Institute of Technology

CHANGING GRADUATION REQUIREMENTS IN A MAJOR/MINOR

The addition or removal of any graduation requirement in a major or minor requires that this form, accompanied by supporting documentation, be completed and approved as indicated below. Incomplete or incorrect forms will not be processed.

COLLEGE: Science

DEPARTMENT: Mathematical Science

DEGREE LEVEL: Undergraduate

PROGRAM TITLE: Mathematical Science - Applied Mathematics

TO BE INITIATED WITH CATALOG YEAR: 2015/2016

CHANGE REQUESTED FOR: X major program □ minor program

Major/Minor Code: 7077

Date change to be initiated must be for a future academic year.

DESCRIPTION OF REQUESTED CHANGES: Attach a more detailed description and any supporting documentation

Replace requirement of MTH 4201 with requirement of MTH 4201 OR MTH 4202.

Approvals: On completion of appropriate department approvals, submit form to Chair, Graduate Council, or Chair, Undergraduate Curriculum Committee, for approval below and forward to the Office of the Registrar

Chair, Graduate Council: 10/21/2014

Date

Department Head / Minor Program Chair: 10/21/14

Date

Chair, Undergraduate Curriculum Committee: 10/22/14

Date

Dean or Associate Dean

REGISTRAR'S USE ONLY

University Catalog

□ Yes □ No Update completed [ ] Date [ ] Initials

CAPP / Degree Evaluation

□ Yes □ No Update completed [ ] Date [ ] Initials

Catalog / Policy Mgmt. System

□ Yes □ No Update completed [ ] Date [ ] Initials
The addition or removal of any graduation requirement in a major or minor requires that this form, accompanied by supporting documentation, be completed and approved as indicated below. Incomplete or incorrect forms will not be processed.

COLLEGE: Science

DEPARTMENT: Mathematical Science

DEGREE LEVEL: Undergraduate

PROGRAM TITLE: Mathematical Science

TO BE INITIATED WITH CATALOG YEAR 2015/2016

CHANGE REQUESTED FOR: ☑ major program ☐ minor program 7076

Major/Minor Code

Date change to be initiated must be for a future academic year.

DESCRIPTION OF REQUESTED CHANGES: Attach a more detailed description and any supporting documentation

Replace requirement of MTH 4201 with requirement of MTH 4201 OR MTH 4202.

Approvals: On completion of appropriate department approvals, submit form to Chair, Graduate Council, or Chair, Undergraduate Curriculum Committee, for approval below and forward to the Office of the Registrar

Date: 10/21/2014

Chair, Graduate Council

Date: 10/21/2014

Department Head / Major Program Chair

Date: 10/22/14

Department Head / Minor Program Chair

Date: 10/22/14

Dean or Associate Dean

REGISTRAR'S USE ONLY

University Catalog

☐ Yes ☐ No Update completed Date Initials

☐ Yes ☐ No Update completed Date Initials

☐ Yes ☐ No Update completed Date Initials

DISTRIBUTION

Original - Registrar

Copy - Academic Unit

Florida Institute of Technology • Office of the Registrar
150 West University Boulevard, Melbourne, FL 32901-6975 • (321) 674-7399 • Fax (321) 674-7827
MTH 4202 – Stochastic Modeling

The proposed undergraduate level MTH 4202 – Stochastic Modeling course will be added to the list of assessment courses for Applied Math – B.S. and Mathematical Sciences – B.S. programs. The related PLOs and measures are outlined below.

Measure 3: Projects in Certain Courses

Projects will be assigned to the students in the courses MTH 4311 – Numerical Analysis, MTH 4201 – Math Modeling, and MTH 4202 – Stochastic Modeling. These projects will be written and the selected ones will be presented in class.

PLO 1: Learn Mathematical Methods Relevant to Modern Applied Mathematics

Target: All students working on a project will learn mathematical methods relevant to their project problem; this is essential to successfully carry out the project.

PLO 2: Formulate and Solve Problems

Target: All students working on a project will develop skills to formulate and solve the project problem.

PLO 3: Use Technology Effectively in Mathematics

Target: All students working on applied and computational project will develop skills to effectively use technology. 90% of the students in MTH 4201 will demonstrate proficiency in coding algorithms and using computer algebra systems for solving problems related to their projects.

PLO 5: Understand and Develop Competence in the Application of Mathematics to Other Areas

Target: All students working on a project involving applications of mathematics to other areas will develop competence in the related area to successfully carry out the project.

PLO 6: Develop Mathematical Intuition

Target: All students working on a specific project problem will develop mathematical intuition to successfully carry out their project.

PLO 7: Demonstrate Skills for Communication in Modern Mathematics

Target: All students working on projects will demonstrate skills to communicate in modern mathematics through in class presentations and seminars.

PLO 8: Communicate and Interact Effectively with Audiences

Target: All students working on interdisciplinary projects will develop skills to communicate and interact effectively with audiences coming from different background.
**Measure 4: Written Assignments in the Designated Classes**

In addition to the projects and exams, specifically designed written assignments in the courses such as MTH 4311-Numerical Analysis, MTH 4101-Intro to Analysis, MTH 4201-Mathematical Modeling, and **MTH 4202 -- Stochastic Modeling** will measure the outcomes selected below.

**PLO 1: Learn Mathematical Methods Relevant to Modern Applied Mathematics**

**Target:** 90% of the students who complete specifically constructed assignments will learn mathematical methods relevant to modern applied mathematics.

**PLO 2: Formulate and Solve Problems**

**Target:** 90% of the students who complete specifically constructed assignments will develop skills to formulate and solve problems.

**PLO 4: Develop Skills for Abstract Thinking, Mathematical Rigor, and Logic**

**Target:** 80% of the students who complete specifically constructed assignments will develop skills for abstract thinking, mathematical rigor and logic.

**PLO 5: Understand and Develop Competence in the Application of Mathematics to Other Areas**

**Target:** 80% of the students who complete specifically constructed assignments will master applications of mathematics to other disciplines and develop competence in these interdisciplinary applications.

**PLO 6: Develop Mathematical Intuition**

**Target:** 90% of the students who complete specifically constructed assignments will develop mathematical intuition.
STOCHASTIC MODELING, MTH 4202, Spring 2015
Instructor: Eugene Dshalalow

and Instructor’s Notes.

Course Information. This course presents an introduction to stochastic models and their applications to physics, finance, electrical and computer engineering, and biological sciences. Probability and Statistics, MTH 2401 Calculus III, MTH 2001, and Differential Equations/Linear Algebra MTH 2201 are the prerequisites for the course. Students enrolled in the course will be periodically tested by means of homework assignments, projects, case studies, and exams. For projects, in which programming skills will be required, students can use any programming language they are most familiar with (such as MATLAB, Mathematica, and R). If a student wants to consult a specialized text on any particular topic, a supplementary bibliography is attached, along with underlying citations. This bibliography also includes some pertinent books on programming in MATLAB, Mathematica, and R.

Expected Outcomes. Upon the completion of the course students will learn theoretical aspects of random processes, such as Poisson and Poisson type processes, Brownian motion, martingales, Markov and Galton–Watson processes, queueing processes, renewal and regenerative processes, and Itô processes, to name a few. They will also be able to recognize and utilize these processes in real-world situations. Among different skills the students are expected to acquire are modeling computer networks and mobile communication systems using Markov and queueing processes, use of stochastic estimators in determination of mutation rates of microorganisms, stochastic analysis of ecological systems (e.g., extinction and saturation of various populations), hedging options and future contracts using Black-Scholes-Merton algorithm (based on case studies of real stocks), understanding how stocks and stock markets operate (using Itô calculus and martingale dynamics), application of renewal and regenerative processes in the analysis of reliability and inventory systems. Not only will the students be able to identify stochastic phenomena and model various practical situations analytically, but they are also expected to fluently operate with learned-to numerical tools ranging from simulation of processes and algorithmization to numerical solution of stochastic differential equations. They will also learn how to collect statistical data of stochastic processes (not previously taught in statistics courses) and how to use the results of such sampling analysis to calculate mutation rates of bacteria, use stochastic estimators to calculate drift and volatility parameters of stocks, and calculate fair prices of stock options and other contracts, to name a few.

In a nutshell,

- Students will learn stochastic analysis in a rigorous way so that they will understand the true anatomy of underlying random processes.
- Students will learn how to model stochastic situations and employ theoretical and practical skills in various branches of industry including technology, biology, biotechnology, engineering, computer science, and finance. Using their skills acquired through intense training (via case studies and projects) they should be able to identify and solve stochastic problems they encounter at their forthcoming working places.
- The course will teach students simulation techniques and utilize methods of numerical analysis in situations closest to the real world.
• The students are expected to further enhance their programming skills applied to simulation (of processes) and computation.

• Both theoretical and practical knowledge should stimulate students to continue with advanced studies in stochastics and inspire them to do senior research using stochastic methods.

Course Description and Schedule


**Week 3. Discrete Branching Processes** and their applications to biology, determination of mutation rates of microorganisms using stochastic estimators. Case study and project: determination of mutation rates by simulation. Text: Instructor’s Notes. [JonO].

**Midterm Exam 1**

**Week 4. The Poisson Process**: filtered probability spaces, Poisson counting process, random telegraph signal process, the Poisson point process, the compound Poisson process. M/G/1 queue and embedded Markov chains. Text: Borovkov, Chapter 5, pp. 155-170 and Instructor’s Notes. [Jon].

**Weeks 5-6. Jump Markov Processes and Markovian Queues**. The sample path anatomy, infinitesimal generator, finite Q-matrices and Q-exponentials, the birth-death process. The PASTA property, M/M/1/infinity, M/M/n/infinity, M/M/n/N systems, the machine repair problem. Case study: numerical solutions of systems of Kolmogorov’s differential equations. Text: Borovkov, Chapters 6-7, pp. 171-216. [Nor].

**Week 7. Absorbing states and phase-type distributions** (Markov modulated processes), extinction and saturation applied to ecology dynamics; queueing applications. Case study: computation of absorption probabilities and times until absorption (extinction and saturation). Text: Instructor’s Notes. [Jain].

**Week 8. Renewal and Regenerative Processes**. Key renewal theorems and applications to queueing and reliability. Regenerative processes. Text: Borovkov, Chapter 8, pp. 227-236. [Jon].

**Midterm Exam 2**


**Week 11. The Brownian Motion Process; an Introduction**. Simulation of Brownian motion, statistics of Brownian motion, statistical data analysis from the stock market, log returns. Case Study: simulation of Brownian motion and a stock by geometric Brownian motion, calculation of statistical estimates of its drift and volatility parameters. Text: Instructor’s Notes. [Shreve], [Sto].
**Weeks 12-13. Stochastic Calculus.** Continuous martingales. The Brownian motion process revisited. The Itô integral, the Itô integral of general processes, SDE’s (stochastic differential equations). The Itô process and Itô formula, Ornstein-Uhlenbeck process, the martingale representation through a stochastic integral. Text: Borovkov, Chapter 11, pp. 303-348, and Instructor’s Notes. [Shreve].

**Midterm Exam 3**

**Weeks 14-15. Stochastic Finance.** The SDE representation of the geometric Brownian motion, interest rate models, numerical solutions of SDE’s, Black-Schole-Merton equation applied to European option trading. Case study: hedging long positions in financial contracts. Text: Borovkov, Chapter 13, pp. 385-430, and Instructor’s Notes. [Iac], [Sey], [Shreve].

**Final Exam**

**Grading Policy.** The average grade will be based on 25% of homework and projects, 45% midterm exams, and 30% of the final exam.

**BIBLIOGRAPHY**


