**ORIE 4580 / 5580 Simulation Modeling and Analysis**

**ORIE 5581 Monte Carlo Simulation**

**Fall 2015**

There are many different analysis techniques that are called simulation. The primary focus of ORIE 4580/5580 is *Monte Carlo* simulation and *discrete-event* simulation. The first part of the course is on Monte Carlo simulation, where we consider systems in which time does not play a substantive role. In the second part of the course, we model systems that evolve over time, primarily using Simio – a widely used simulation package.

Monte Carlo and discrete-event simulation deal with predicting aspects of the behavior of a system through approximate models. Manufacturers and companies like Amazon use simulation to model work cells, conveyors, automated guided vehicles, storage and retrieval systems. Airlines and trucking companies use simulation to model fleet logistics, distribution centers and traffic. Designers of communications networks and computer systems use simulation to model data transmission and switching systems. Health care providers use simulation to model resource levels and placement in health care systems. Epidemiologists use simulation to model spread of diseases. The defense community uses simulation to model aircraft readiness and combat strategy. In public services, simulation is used to model police, fire fighting, ambulance and judicial systems. Many aspects of financial, marketing and information systems can be studied using simulation.

### Staff

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Office hours: Please see the website under Tools/Contacts

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| --- | --- | --- | --- |
| Teaching assistants | Email | Office | Office hours |
| TBD |  | \* | \* |

 \* See the course website for missing information – look under Tools -> Contacts.

### Class Schedule

The class meets on Tuesday and Thursday, 1:25-2:40. In addition, there are four recitation sessions:

1. Monday 12:20-2:15, 471 Rhodes Hall
2. Monday 2:30-4:25, 471 Rhodes Hall
3. Friday 11:15-1:10, 471 Rhodes Hall
4. Friday 2:30-4:25, 471 Rhodes Hall

You are free to attend whichever recitation you desire for the time being. If one of the sessions gets too crowded, then we will ask you to attend the session for which you registered.

Attendance at both the lectures and one of the recitations is expected. You are responsible for being aware of the announcements and content of each class.

### Course Website

The course website can be reached through logging into blackboard at <http://blackboard.cornell.edu/>, by clicking on “Course Search” at the top and searching “ORIE 4580.” You should use the course website titled “ORIE 4580 Simulation Modeling and Analysis, Fall 2015, Henderson” even if you are taking ORIE 5580/5581. Please check the course website regularly for announcements.

### Prerequisites

Familiarity with the topics covered in ENGRD 2700 and ORIE 3500/5500 is required, but ORIE 3500/5500 may be taken concurrently with the permission of the instructor. The initial part of the course includes a short review of probability and statistics. If any of the topics covered in this part of the course are not familiar, then you should see the instructor. Some programming will be useful in a few homework assignments in the second half of the course, but we will help you get started.

### Resources

We will use three primary resources in this course.

* Course packet (Required) – We will follow the course packet in class. It is required and available at the Cornell Store. You may instead use a pdf version that can be downloaded from the course website.
* Textbook (Suggested) – The textbook for the course is A.M. Law, *Simulation Modeling and Analysis*, McGraw-Hill, 2014, ISBN 978-0073401324. We will post reading material from the textbook so that you will know which section to read if you buy the book. Feel free to purchase older editions of the textbook if you can find a more reasonably priced copy. The contents of the textbook change very little from one edition to the next.
* Software (Suggested) – We will use two software products: @Risk and Simio. They are available in 471 Rhodes Hall and 453 Rhodes Hall. ORIE 4580/5580 students may consider obtaining the student version of Simio ($25) from a link on the course website, which will enable you to do the homework assignments at home on a PC or a Mac running Parallels or similar. The student version of Simio imposes limits on the size of the models. These should not be a problem for the homework or project. The Simio software includes documentation from which you will have reading assignments in the later part of the course.

Other good books on simulation are

* J. Banks, J.S. Carson II, B.L. Nelson, D.M. Nicol, *Discrete-Event System Simulation,* Prentice Hall, 2001, ISBN 0130887021.
* J. Banks, *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*,Wiley-Interscience, 1998, ISBN 0471134031.
* S.M. Ross, *Simulation*, Academic Press, 2002.
* P. Bratley, B.L. Fox, L.E.E. Schrage, *A Guide to Simulation,* Springer-Verlag, 1987, ISBN 0387964673. (This book is a bit advanced.)

### Organization of the Lectures

You should bring your course packet to every class. Occasionally, we will post extra material on the course website. If that happens then you will receive an email from us reminding you to print this material and bring it to class.

### Assignments

There will be periodic homework assignments. You should expect to have approximately 10 assignments throughout the semester. The assignments will be due in class on Thursdays. You may do the homework individually or in pairs. If doing it as a pair, write both of your names and netids on one homework. Do not hand in two solutions. You will receive the same grade. You may have a different homework partner for each homework if you wish.

Please pay attention to the organization of the assignments you turn in. If you include computer outputs, clearly label them and mark your answers. You should put one recitation session number on your homework assignments. This is the session in which you can pick up your graded homework assignment.

*If you would like your homework to be re-graded, then you should contact us within* ***one*** *week after the homework is returned. The entire homework will be regraded. There will be no extension for homework for any reason, but you can skip* ***two*** *homework assignments without any penalty.*

### Grading

Your grade will be based on class homework assignments, a project and two exams. They will be weighed according to the following scale:

|  |  |
| --- | --- |
| Homework | 20 |
| Project – Tentatively due Dec. 5, 12:00 pm | 15 |
| Prelim – date is TBD | 30 or 0\* |
| Final – TBD | 35 or 65\* |

 \* Computed automatically, whichever is to your advantage.

*You must get a certain minimum grade in the exam to pass this course. That grade depends on how hard the final exam is, but is usually around 50%.*

The project is completed in teams of up to 4 students that you select. More details on the project will follow later in the course.

If you are not officially enrolled in the course, your work is unlikely to be graded.

### Policy on Academic Conduct

Every student is expected to abide by the Cornell University Code of Academic Integrity. You may discuss the homework assignments with other students, but only at the level of a discussion in a corridor. When you are writing down or typing your homework assignment, please make sure you are by yourself (or with your homework partner if working in a pair). Sharing computer code or spreadsheet calculations is not allowed. You cannot get help in any way from students that have completed this course in the past. We believe that homework is a learning experience, and will grade as easily as possible, as long as you put in an honest effort.

If you violate this policy, you risk having your entire homework grade set to 0 or even failing the course. If you have any hesitation as to whether certain actions violate the policy or not, please contact the instructor beforehand. Please see <http://cuinfo.cornell.edu/Academic/AIC.html> for more information on the university code of academic integrity.

### Note for ORIE Affiliates

If you are an ORIE major, then you must get a grade of C– or better in this course. If you fail to meet this requirement, then you will have to repeat the course to graduate, even if that means staying for another year. There will be no follow-up exams and no extra work for credit offered after the course.

### Note for ORIE 5581

If you are taking ORIE 5581, then your grade will be based on the prelim and homework assignments (dropping the lowest homework score) and will be weighed according to the following scale:

|  |  |
| --- | --- |
| Homework | 35 |
| Prelim – Date is TBD | 65 |

### Topics Covered

Below is a list of topics that we will cover throughout the semester, along with the approximate number of lectures we are going to spend on each topic and the corresponding chapter in the textbook. For some of the topics, we will post supplementary reading assignments on the course website.

|  |  |  |
| --- | --- | --- |
| Topic | No. of Lectures | Chapter No. inthe Book |
| Introduction to simulation | 1 | Ch. 1 |
| Review of probability and statistics | 3-6 | Ch. 4 |
| Simulation in Excel | 2 |  |
| Uniform random variable generation | 2-3 | Ch. 7 |
| Non-uniform random variable generation | 4-6 | Ch. 8 |
| Estimation and input modeling | 4-6 | Ch. 6 |
| Variance reduction | 3-5 | Ch. 11 |
| Prelim – ?? |  |  |
| Introduction to discrete-event system simulation | 1 | Ch. 1 |
| Building models in Simio | 6-9 | \* |
| Output analysis | 2-3 | Ch. 9 |
| Comparing alternative systems | 2 | Ch. 10 |
| Verification, validation, implementation | 1 | Ch. 5 |
| Building complex simulation models\*\* | 3-6 | Ch. 2 |
| Review | 1 |  |
| Final Exam – TBD |  |  |

 \* Readings from Simio documentation will be assigned.

 \*\* If time permits.