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

**ORIE 5581 Monte Carlo Simulation**

**Fall 2016**

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 deals with predicting certain aspects of the behavior of some system through approximate models. Manufacturers 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

Shane Henderson

Office: 230 Rhodes Hall

Email: [sgh9@cornell.edu](mailto:sgh9@cornell.edu)

Phone: 255-9126

Office hours: See the course website under Tools->Contacts

Teaching assistants. See the course website under Tools->Contacts for office hours etc.

Xiaoyang (Andrew) Lu (xl562), Lifan Wu (lw529), Bangrui Chen (bc496), Skylar Carfi (swc74), Stephen Jacobs (swj25), Anna Dong (nd292) and Zilong Wang (zw243).

### Class Schedule

The class meets in Hollister B14 on Tuesday and Thursday, 1:25-2:40. In addition, there are four recitation sessions:

1. Monday 12:20-2:15, 571 Rhodes Hall
2. Monday 2:30-4:25, 571 Rhodes Hall
3. Friday 11:15-1:10, 571 Rhodes Hall
4. Friday 2:30-4:25, 571 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. Recitations are not graded, but a strong attendance record can help in tie-breaking situations when I set course grades.

Attendance at both the lectures and one of the recitations is expected. You are responsible for being aware of announcements and content. Monday Sept 5 is Labor Day. For that week only we will run special recitations on Thursday Sept 1rd 10:10-12:05 and Tuesday Sept 6th 10:10-12:05, both in 453 Rhodes.

### VideoNote

Recorded lectures from the fall 2015 version of this class – which are very similar to those of this semester – are available online. These are a valuable study tool, and an excellent way to catch up on material (not announcements) from the lecture. See <http://www.videonote.com/cornell>

### Course Website

The course website can be reached via <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 & Analysis Henderson,S” 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. The initial part of the course includes a short review of probability and statistics, which is in essence the material in Chapter 4 – Review of Probability and Statistics - of the *suggested* (but not required) textbook by Law; see below. If this material is unfamiliar to you, then you might study Chapters 1 through 6 of Introduction to Probability and Statistics for Engineers and Scientists, 2nd ed., by Sheldon Ross, or Chapters 1-5 and Chapter 7 of Probability and Statistics for Engineering and the Sciences, 8th ed., by Devore. This material is very standard, and can be found in other books at a similar level. Some programming experience is useful in a few homework assignments but we will help you get started.

### Resources

* Course packet (Required) – We will follow the packet in class. It is required. Hardcopies are available at the Cornell Store. You may instead use a pdf version that can be downloaded from the course website.
* iClicker or iClicker App. (Required) See the description on the course webpage under Course Information for full details.
* Textbook (Suggested) – The textbook for the course is A.M. Law, *Simulation Modeling and Analysis*, McGraw-Hill, 2014, ISBN 978-0073401324. We will recommend reading 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 (first half of semester) and Simio (second half of semester), both of which only operate on PCs or Macs running Windows. They are available in 571 Rhodes Hall and 453 Rhodes Hall. For a student version of @Risk see <http://www.palisade.com/cart/products_EN.asp?cat=51&panel=0> - the cost is $50 (we’ll use @Risk only modestly, so I don’t recommend this purchase). 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. 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.

Other good books on simulation (on reserve at Uris) are

* J. Banks, J.S. Carson II, B.L. Nelson, D.M. Nicol, *Discrete-Event System Simulation,* 5th ed. Prentice Hall, 2010. (Similar level to this class.)
* B. L. Nelson. *Foundations and Methods of Stochastic Simulation: A First Course*, Springer-Verlag (2013). (Slightly higher level than this class, but very readable)
* J. Banks, *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*,Wiley-Interscience, 1998. (Slightly higher level than this class, but very readable.)
* S.M. Ross, *Simulation*, Academic Press, 2002. (Or later editions. Similar level to this class.)
* P. Glasserman, *Monte Carlo Methods in Financial Engineering,* Springer-Verlag, 2004. (This book is for advanced students, and while focused on financial engineering, is excellent reading in general.)

### Organization of the Lectures

You should bring your course packet to every class. It has gaps that you’ll fill in as we go. Occasionally, we will post extra material on the course website.

### Assignments

There will be approximately weekly 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 and neatness of your work. 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.

There will be no extension for homework for any reason, but you can skip **two** homework assignments without any penalty if taking the full-semester course, and you can skip one homework assignment without penalty if only taking the half-semester course.

### Grading

Your grade will be determined as follows.

|  |  |  |
| --- | --- | --- |
|  | **4580/5580** | **5581** |
| Clicker responses | 4 | 4 |
| Homework, equally weighted, lowest two (one for 5581) scores dropped | 19 | 35 |
| Project – Due near the end of the semester (includes 2/20 pts assigned to an early project-related homework to get you started). | 20 |  |
| Prelim – October 13, 7.30pm | 26 or 0\* | 61 |
| Final – TBD | 30 or 56\* |  |
| Fill out the course evaluation | 1 |  |

\* Computed automatically, whichever is to your advantage.

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

Your clicker response grade comes from responding to in-class clicker questions. Points are for participation, not correctness. Your clicker score is given by 4 min(1, 1.333 x / n), where n is the total number of clicker questions and x is the number to which you respond.

I will also take into account your participation on Piazza (responding to other students’ questions) when setting grades, by bumping up prolific (correct) answerers by a 1/3 letter grade (B+ to A-, for example).

For the prelim you may bring in one sheet of prepared notes. For the final you can bring in two sheets.

The project is completed in teams of 4 or 5 students (not less than 4 and not more than 5) that you select. More details on the project will follow later in the course.

You may request a regrade on any work within one week of the graded work being returned. Attach a written note that explains your request for a regrade. The entire homework/project/exam will be regraded.

### Policy on Academic Conduct

Every student is expected to abide by the Cornell University Code of Academic Integrity. All work you hand in should be your own, with the following exceptions. 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. Projects should be done in your teams, with no collaboration between different teams.

If you violate this policy, you risk having your entire homework/project grade set to 0 or even failing the course. If you have any questions about this policy, then 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.

### 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. The estimate on the number of lectures is just a rough guess.

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

\* Readings from Simio documentation may be assigned.

\*\* If time permits.