IE 522 – Discrete Event Systems Simulation

Harold and Inge Marcus Department of Industrial and Manufacturing Engineering
The Pennsylvania State University, University PA

INSTRUCTOR: Dr. Hui Yang

PHONE: 814-865-7397

EMAIL: All emails must be sent through **Canvas** to ensure that I receive all of your emails and for you to receive a reply timely. This ensures that your email does not get mixed with my general emails.

OFFICE: 221 Leonhard Building

OFFICE HOURS: *Monday Wednesday 2:30pm - 4:00pm*
Or by appointment

CLASS TIME & PLACE: MoWe 9:05AM - 10:20AM   Leonhard Bldg 203

PREREQUISITE: IE 425: Stochastic models in operations research. Students enrolling in this course should have already taken IE425 or equivalent courses, and should have a fundamental understanding of queueing models, stochastic systems, statistical inference, and hypothesis testing.

SOFTWARE: This course requires a solid foundation in programming, because many assignments and projects will involve coding to implement and analyze simulation models. This is not a programming course. Students are expected to know programming languages such as MATLAB, Python, or R. *If you do not possess any programming knowledge, this is not a right course to take*.

REFERENCE BOOKS

Nelson, B. & Pei, L (2021). *Foundations and methods of stochastic simulation* (2nd edition). Springer.
Cassandras, C. & Lafortune, S. (2021). *Introduction to discrete event systems* (3rd edition). Springer.
Law, A. (2024). *Simulation modeling and analysis* (6th edition). Mcgraw-hill.

OBJECTIVES

This is a graduate-level course on the theory of discrete-event systems simulation. The objective is to equip students with the skills and knowledge necessary to model, analyze, and optimize complex systems through discrete-event systems simulation. This course focuses on:

– Understanding the principles and techniques of discrete-event simulation as a powerful tool to analyze stochastic and dynamic systems.

– Learning to design, implement, and validate simulation models for a variety of real-world applications in areas such as manufacturing, healthcare, and service systems.

– Applying statistical methods to define and characterize the probabilistic behavior of inputs to the simulation model.

– Applying statistical methods to analyze simulation outputs and make data-driven decisions.

– Gaining knowledge and practical experience in simulation-based experimentation and optimization for system improvements.

TOPICS

1. Introduction to Discrete Event Systems Simulation
   System classification
   Input-output modeling
   Discrete event systems
   Simulation vs. analytical modeling
   Model verification and validation
   Stochastic simulation example

2. Simulating Markov Chains
   Discrete-time Markov Process simulation
   Continuous-time Markov Process simulation
   Renewal Process simulation
   Generalized Markov Modeling

3. Queueing Simulation
   Queueing systems design
   M/M/1, M/G/1, M/D/1, M/M/s, M/M/∞, M/M/1/K, M/M/s/K Queue
   Little's law
   Network of queues
   Case study and applications

4. Random Number/Variate Generation
   Inversion method
   Transformation method
   Acceptance-rejection sampling
   Monte carlo simulation
   Markov Chain monte carlo (MCMC)

5. Input Modeling
   Maximum likelihood estimation (MLE)
   Expectation maximization
   Goodness-of-fit tests
   Moment matching
   Probability plotting
   Multi-variate input generation
   Non-homogeneous Poisson process

6. Output Analysis
   Transient vs. steady-state simulation
   Parameter estimation
   Replications with deletions
   Batch means
   Input uncertainty
   Random-effects modeling

7. Simulation Experimentation and Optimization
   Comparing alternative system configurations
   Ranking and selection
   Simulation experiments
   Statistical metamodeling and Bayesian optimization
   Simulation-based optimization
   Using simulation in research

GRADING POLICY
   Quiz/Homework – 35%
   Midterm Exam – 30%
   Final Project – 35%

Exam dates will be announced as the course progresses. Final grade will be determined based on the student performance in different evaluation elements – as shown above. No make-up exams unless previous arrangements have been made. Students will be expected to attend class and prepare assignments. Habitual failure to do so will result in a reduced grade. An incomplete grade will only be given when a student misses a portion of the semester because of illness or accident. Cheating on examinations, plagiarism and other forms of academic dishonesty are serious offenses and may subject the student to penalties ranging from failing grades to dismissal.

Grading scale will be used: A: 90+; B: 80+; C: 70+; D: 60+, F: <60

CLASS POLICY
   – Homework problem sets will be assigned during the semester. Please use the assignment page as the cover page of your homework submission. Homework solutions should be written neatly, papers **stapled, clearly scanned,** and all steps **must** be shown clearly for full credit. Assignments not meeting these specifications will not be accepted and graded.

   – Homework is due one week after it is assigned. No late homework will be accepted. **Please submit and upload your solutions as a single PDF file to the CANVAS website. Please DO NOT submit through**

emails or hardcopies. Email and hardcopy submission will not be accepted and graded. <u>If you do not submit your homework</u> **on the assigned due date,** <u>it will be considered late</u>.

– During class time, please **turn** your cell phones to **SILENT/VIBRATION** mode.

– Always bring your textbooks to class. Also bring your calculator, notebook, pencils/pens, and eraser.

– *Exams must be taken on the scheduled exam dates.* Students are required to arrange with the instructor in advance for a make-up exam in the event of extenuating circumstances that prevent them from taking the exam as scheduled. In the event of an unforeseen emergency that prevents the student from taking the exam as scheduled, the student must provide documentation to the instructor before a make-up exam can be arranged. *Anyone missing exams without notifying me ahead of time (and/or for a reason not deemed justifiable) will not be able to make it up.*

– In the event of extenuating circumstances, please submit documentation (printed, signed, and dated by students and relevant authorities) to the instructor at least two days ahead of the class for approval. If it is not a university excuse, it will not be accepted. Dropping an email to me without any documentation will not be accepted.

– Exams will be closed book, closed notes. Please be sure to bring your calculator to the exam. There will be absolutely no sharing among students of calculators. Computer or laptop is not allowed in the exam

– If you believe there was an error in the grading of an exam, you may submit the entire exam for a regrade. This must be done *within one week* from the date the exam was returned. The entire exam will be regraded, so that you may gain, or lose, points by resubmitting.

COMMUNICATION AND INSTRUCTION VIA CANVAS

Communication in the course will be through official electronic means: PSU assigned e-mail address and the course website in CANVAS (https://psu.instructure.com/). Students are responsible for all information conveyed during class and on CANVAS. It is the student's responsibility to make sure they are receiving their official PSU email and checking course updates in the CANVAS website.

To access CANVAS, go to: https://psu.instructure.com/

Go to Dashboad and then click on IE 522 Discrete Event Systems Simulation. Check this website frequently for: Course syllabus, important announcements, homework sets, lecture notes, emails, grades, and additional resources.

INSTRUCTOR'S COMMITMENT

You can expect your instructor to be courteous, punctual, well-organized, and prepared for the lecture and other class activities; to answer questions clearly; to be available during the scheduled appointments or to notify you beforehand if he is unable to keep them; and to grade uniformly and consistently according to the posted guidelines.

STUDENTS WITH DISABILITIES SERVICES

Penn State welcomes students with disabilities into the University's educational programs. If you have a disability-related need for reasonable academic adjustments in this course, contact the Office for Disability Services (ODS) at 814-863-1807 (V/TTY). For further information regarding ODS, please visit the Office for Disability Services Web site at http://equity.psu.edu/ods/.

In order to receive consideration for course accommodations, you must contact ODS and provide documentation (see the documentation guidelines at http://equity.psu.edu/ods/guidelines/documentation-guidelines). If the documentation supports the need for academic adjustments, ODS will provide a letter identifying appropriate academic adjustments. Please share this letter and discuss the adjustments with your instructor as early in the course as possible. You must contact ODS and request academic adjustment letters at the beginning of each semester.

ACADEMIC INTEGRITY

Violations of academic honesty will be dispatched in accordance with the university policy. *This course expects the highest standard of academic integrity from students.* The University defines academic integrity as the pursuit of scholarly activity in an open, honest and responsible manner. All students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts (refer to Senate Policy 49-20. Dishonesty of any kind will not be tolerated in this course. Dishonesty includes, but is not limited to, cheating,

plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will receive academic sanctions and will be reported to the University's Office of Student Conduct for possible further disciplinary sanctions (refer to Senate Policy G-9).

EDUCATIONAL EQUITY

Penn State takes great pride to foster a diverse and inclusive environment for students, faculty, and staff. Acts of intolerance, discrimination, or harassment due to age, ancestry, color, disability, gender, gender identity, national origin, race, religious belief, sexual orientation, or veteran status are not tolerated and can be reported through Educational Equity via the Report Bias webpage (http://equity.psu.edu/reportbias/).

PSYCHOLOGICAL COUNSELING AND SUPPORT

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

Counseling and Psychological Services at University Park (CAPS) (http://studentaffairs.psu.edu/counseling/): 814-863-0395

Counseling and Psychological Services at Commonwealth Campuses (http://senate.psu.edu/faculty/counseling-services-at-commonwealth-campuses/)

Penn State Crisis Line (24 hours/7 days/week): 877-229-6400
Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741

IMPORTANT DATES

- Classes Begin
    Monday, January 13
- Regular Drop - **Deadline** [1]
    Saturday, January 18 at 11:59 p.m. (ET)
- Martin Luther King Jr. Day Holiday - **No Classes**
    Monday, January 20
- Final Exam Conflict - **Filing Period**
    Monday, February 17 - Sunday, March 9
- Spring Break - **No Classes**
    Sunday, March 9 - Saturday, March 15
- Withdrawal - **Deadline**
    Friday, May 2 at 5:00 p.m. (ET)
- Classes End
    Friday, May 2
- Final Exams
    Monday, May 5 - Friday, May 9

Good luck and have a great semester!