THE UNIVERSITY OF MICHIGAN - DEARBORN
COLLEGE OF BUSINESS

- Course: DS 632, Section 201, CRN 30468
- Title of Course: System Simulation
- Instructor: Edward Williams
- Term: Summer II, 2021
- Office Hours: Mondays, Tuesdays, Wednesdays, and Thursdays 4:30pm 5:45pm online via Zoom (link will be in Canvas Announcements), and by appointment
- Class Places/Times: Online, asynchronous
- Telephone: 131D, my office 313-583-6553 (inapplicable this semester)
- Departmental Office: 313-583-5336 (but essentially unstaffed this semester)
- Fax: 313-271-9836 (but essentially unstaffed this semester)
- E-Mail Address: williame@umich.edu

Questions explicitly pertinent to the course material and hence of likely interest to the entire class (e.g., how to solve a particular exercise in optimization or analysis) should be posted on the Canvas website. More individual questions or issues (e.g., notifying me of a problem such as illness, business travel, or bereavement) should be handled via electronic mail. The preferred method of contact is email to Canvas (or to my campus address (the first of the two addresses above)); I intend to check that address daily except when away or ill.

Course Description:

In the course students will learn how to design, model, verify, validate, and implement discrete-event computer simulation models of real or conceptual systems. Simulation studies will be conducted the contemporary, powerful, interactive, drag-&-drop software Simio® (version 14). Students will learn random number generation, application of distribution sampling, selection of probability distributions based on goodness-of-fit tests, and conducting of output analysis.

Course Objectives:

Specific course objectives are to develop comprehensive understandings of:

1. The meaning of simulation and its importance in business.
2. The common applications of discrete-event system simulation, e.g., in manufacturing, service industries, health care delivery, transportation, and logistics (example).
3. Ability to build, verify, and validate a simulation model using appropriate software (this course will use the Simio® software, with mention of others).
4. Basic results of queuing theory.
5. Basic techniques of input and output analysis.
6. Visualization of a system simulation animation.

Required Text:

W. David Kelton, Jeffrey Smith, and David Sturrock. 2018. *Simio and Simulation: Modeling, Analysis, Applications*, 5th edition. Learning Solutions. ISBN-13: 9781727854961 (pertains to "Economy Edition," which has grayscale illustrations).

Recommended Reference:

Joines, Jeffrey A. and Stephen D. Roberts. 2015. *Simulation Modeling with Simio: A Workbook*, 4th edition. Simio® LLC. ISBN-13: 9781519142207.

For availability of these and other materials at the campus bookstore, see their web site.

Student Evaluation:

Examination One online week of July 19, 2021 (two parts, see below)	30%
Examination Two online week of August 19-20 or 23-25, 2021 (one part; see below)	20%
Term Project (team) due by August 17, 2021	25%
Homework team assignments throughout	20%
Class participation (in online context) throughout	5%

Grading Scale:

94-100 = A	90-93 = A-	
87-89 = B+	84-86 = B	80-83 = B-
77-79 = C+	74-76 = C	70-73 = C-
67-69 = D+	64-66 = D	60-63 = D-

Grades will be computed to a scale of 1000. For example, suppose the first examination contains questions totaling 100 points. Its percentage weight of 1000 is 25, so your score would be multiplied by 2.5. If the first examination contains questions totaling 80 points, your score on it would be multiplied by 3.125.

Deliverables for term project:

1. A Simio® model built to solve a business problem at a company. The model must be statistically valid and have ample internal documentation. These two requirements are *vastly* more important than a lovely, flashy animation.
2. A written report (MS Word® please) documenting your project. Suggested outline:
    A. Brief background of enterprise on whose behalf the modeling was undertaken.
    B. Description of the business problem (e.g., low throughput, inappropriate resource utilizations, long queues (# of entities in queue and/or long waiting times), excessive costs, etc.
    C. Commentaries on how you collected and analyzed input data.
    D. Commentaries on how you built, verified, and validated the Simio® model.

E. Analysis of your output results (e.g., performance metrics of current system and of the system as you would recommend be modified, based on your simulation results); these should include commentaries on # of replications run, length of replications, whether the model is terminating or steady-state (and length of warm-up if steady-state), and confidence levels (usually 90%, 95%, or 99%) for the predicted performance metrics).
F. Suggestions on how your work might be extended in the future.

Given the brevity of the course, I will, if needed, suggest projects.

As an enticement, the five citations below had *exactly* this origin from previously taught sections of this course:

Gruber, Jared W., Renée Smiddy, Jeffrey M. Watson, and Edward J. Williams. 2015. Simulation Helps Local Grocery Store Compete Effectively Against Large Chains. In *Fifth International Conference on Industrial Engineering and Operations Management* (ISBN 978-0-9855497-2-5, pages 2421-2424).

Sivaramakrishnan, Sapthagirishwaran Thennal, Shanmugasundaram Chandrasekaran, Jennifer Dhanapal, Paul Ajaydivyan Jeya Sekar, and Edward J. Williams. 2016. Simulation Improves Operations at a Specialized Takeout Restaurant. In *Proceedings of the 30th European Conference on Modelling and Simulation*, eds. Thorsten Claus, Frank Herrmann, Michael Manitz, and Oliver Rose, 59-65.

Ramesh, Ganapathi Baliada, Brittany Harju, Daniel Scipione, Kristina Vujic, and Edward J. Williams. 2018. Simulation Improves Service and Resource Allocation at a Salon. In *Proceedings of the 17th International Conference on Modeling and Applied Simulation*, eds. Agostino G. Bruzzone, Fabio De Felice, Claudia Frydman, Francesco Longo, Marina Massei and Adriano Solis, 89-94.

Hassan, Mohan Mano, Sai Priyanika Kalamraju, Sandeep Dangeti, Sirisha Pudipeddi, and Edward J. Williams. 2019. Simulation Improves Efficiency and Quality in Shoe Manufacturing. In *Proceedings of the 31st European Modelling and Simulation Symposium*, eds. Michael Affenzeller, Agostino G. Bruzzone, Francesco Longo, and Guilherme Pereira, 231-236.

Deng, Wenqi, Yang Yang, Di Zhao, and Edward J. Williams. 2021. Simulation Improves Service and Resource Allocation at an Automotive Garage. In *Proceedings of the 2nd South American International Conference on Industrial Engineering and Operations Management*.

Students are *strongly* encouraged to form teams (ideal size 3, team of 4 or 5 is fine) to work on *all* course and homework assignments (other than the two examinations). Early in the course, one person on a team (you will self-select the teams) should email me the team roster. I will define those teams in Canvas for convenience of submitting assignments, including the Term Project deliverables.

The two examinations will be individual efforts. The first examination will have two parts: a closed-book, closed-notes portion written in class and comprising conceptual short-answer essay questions, and an open-book, open-notes part, due several days afterward and involving the building of a simulation model. The second examination (in view of the term project) will have only a closed-book, closed-notes portion written online and comprising conceptual short-answer

essay questions. Therefore, the first examination carries more grading weight. Review Guides will be provided on Canvas a week ahead of each examination.
The closed-book questions will *not* require you to formulate problems, undertake computations, or memorize formulas (that's what computers are for!).

Late work will be penalized proportionate to the length of delay (documented extenuating circumstances excepted).

Course Schedule:
Text Topic

Expected course schedule:

Textbook	Topic
Chapter 1	Introduction to Simulation
Chapter 2	System Dynamics, Basics of Queueing Theory, Queueing Models
Chapter 3	Types of Simulation
Chapter 4	Getting Started with Simio®
Chapter 5	Additional Powers of Simio®
Chapter 6	Analysis of Input Data
Chapter 7	Convenient Model Representation of Input Data
Chapter 8	Animation (*very* cursory); Entity Movement
Chapter 9	Advanced Simio® Modeling Techniques
Chapter 10	Advanced Topics (e.g., balking, reneging, searching, task sequences,...)
Chapter 12	Modeling Manufacturing Systems
Chapter 12	Modeling Service Systems

University-wide Policies or Statements Relevant to Courses:

Please see the 'Course Policies' Menu on Canvas for information on the following:

- University Attendance Policy
- Academic Integrity Policy
- Counseling
- Disabilities Services
- Safety Statement
- Harassment, Sexual Violence, Bias, and Discrimination