

Lawrence Technological University

EME 7203: Manufacturing Systems Simulation

Spring 2012

Course Information:

Course No.: EME 7203
Course Title: Manufacturing Systems Simulation
Lecture: Thursday, 5:45 – 8:25 pm
Classroom: E30
Office hours: Tuesday, and Friday, 3:30 – 5:30pm or by appointment
Blackboard: my.ltu.edu

Text:

W. Kelton, Randall Sadowski, Nancy Swets, Simulation with Arena, 5th Edition, McGraw-Hill, 2009, ISBN 978-0073376288.

Software Site: <http://highered.mcgraw-hill.com/sites/0073376280/>

Faculty:

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Catalog Description:

This course introduces Discrete-Event Simulation as a design and analysis tool for manufacturing systems. Students will learn how to conduct a simulation project using manufacturing oriented software such as Arena. Topics in simulation methodology include: building valid models, selecting input probability distribution, statistical analysis of output, design of simulation experiments, and variance reduction techniques in simulation. Competence is demonstrated by each student conducting a simulation project of a manufacturing system.

Educational Objectives:

- Expose the students to Discrete-Event Simulation as a design and analysis tool, problem solving tool, risk analysis tool, and decision-making tool in manufacturing environment.
- Know how to conduct a successful project using manufacturing-oriented software such as Arena.

Objectives:

After completing the course you should be able to:

- Understand the nature of discrete-event simulation and the types of simulation models
- Understand the broad applicability of discrete-event simulation to solve complex manufacturing systems problems
- Learn the essential steps of the simulation methodology
- Learn analytical techniques for interpreting input data and output results pertinent to simulation models
- Learn to use the Arena Simulation Software Tool to build credible valid simulation models, design and run simulation experiments, and critically evaluate decision-support simulation results
- Gain insight into system behavior by measuring the performance characteristics of proposed new manufacturing system or the impact of proposed changes for existing manufacturing system

Grading Policy:

Homework/Quiz/ Paper Review – 30%, Midterm – 30%, Simulation Project – 40%

A: 91–100; A-: 87–90; B+: 83–86, B: 80–82; B-: 74–79, C+: 67–73, C: 60–66; F < 60

Test:

All tests will be open books and open notes. There will be no make-up tests except in case of exceptional circumstances. The course instructor must be notified as soon as possible and normally prior to the exam.

Homework and Class Assignments:

Homework is due at the beginning of class. **Late Homework will not be graded and will receive NO CREDIT.** Extensions to turn in homework due to exceptional circumstances will require appropriate documentation or prior permission. There will be no makeup class assignments.

Research Paper Review:

Students will have to review research papers and present in the class for the specific topics assigned in the class. Technical paper review guidelines will be provided.

Course Outlines:

Week	Topics
1	Syllabus, Introduction of Manufacturing Systems Simulation
2	Discrete-Event Modeling and Simulation of Detailed Manufacturing Operations
3	Input Data Analysis for Modeling and Simulation
4	Product Mix Modeling
6	Transporter, and Conveyor Modeling
7	Statistical Analysis of Simulation Output <i>Simulation Project Proposal Presentation</i>
8	Design of Simulation Experiments and ANOVA Verification and Validation
	<i>Mid-semester break</i>
9	<i>Simulation Research Paper Review and Presentation</i>
10	Response Surface Methodology
11	Meta Modeling
12	Simulation Optimization
13	Agent based Simulation
14	Distributed Manufacturing Enterprise Simulation
15	Simulation Project Presentation and Report Submission

Course Project:

A project is required from all students and should be related on real life applications where the course materials could be used for the project. However, the project should be beyond class material. The main purpose of the project is to use simulation for real-life applications. The project will be based on *Systems Modeling and Simulation* for actual or planned in the applications of manufacturing systems. These projects have to be more in-depth than regular class project. It must have experimental design, ANOVA analysis and response surface methodology.

There will be an oral presentation of the project and the written documentation of the study in a clearly, concisely written report form. This report should follow “normal business practice” e.g. it should

have: abstract, introduction, literature review, problem description, input data analysis, modeling and simulation, design of experiments, results and discussions, conclusions, references and appendix (in any). The report must follow the winter simulation conference paper guidelines without page limit.

Academic Honor Code:

Academic integrity and honesty are basic core values of Lawrence Technological University. Lawrence Technological University is committed to creating an academic community that values both individual and collaborative efforts that promote learning and discovery. Such a community expects honesty and integrity in the work of all its members.

Cheating will not be tolerated! LTU's Academic Honor Code is in effect. Students caught cheating will receive an F in the course without the chance of recomputation for GPA purposes. A note to this effect will be placed in the student's file. A second offence will result in expulsion from the university. For details about Academic Honor Code see: http://www.ltu.edu/currentstudents/honor_code.asp

Recommended Texts:

Banks, J., J. S. Carson II, B.L. Nelson, and D. M. Nicol. 2001. *Discrete-Event System Simulation*, 3rd Edition, Prentice Hall.

Banks, J. 1998. *Handbook of Simulation*, Editor John Wiley.

Evans, J.R. and D.L. Olson, 2002. *Introduction to Simulation and Risk Analysis*, 2nd Edn., Prentice Hall.

Law, A. M., and W. David Kelton. 1999. *Simulation Modeling and Analysis*, 3rd Edition. McGraw-Hill.

Roberts, N., D. Andersen, R. Deal, M. Garet, and W. Shaffer. 1994. *Introduction to Computer Simulation – A System Dynamics Modeling Approach*, Productivity Press, Portland, OR.

Recommended Articles:

Grand Challenges in Modeling and Simulation of Complex Manufacturing Systems, John W. Fowler and Oliver Rose, *SIMULATION*, vol. 80, no. 9, pp. 469-476, 2004.

Simulation as a Tool in Understanding the Concepts of Lean Manufacturing, Bernard J. Schroer, *SIMULATION*, vol. 80, no. 3, pp. 171-175, 2004.

Multiple orders per job formation and release strategies in large-scale wafer fabs: a simulation study, L Mönch, J Zimmermann, S. J. Mason and J. W. Fowler, *Journal of Simulation*, vol. 5, pp. 25-43, 2011.

Life-cycle of simulation models: requirements and case studies in the automotive industry, G. Mayer and S. Spieckermann, *Journal of Simulation*, vol. 4, pp. 255-259, 2010.

Impact of ageing workforces on long-term efficiency of manufacturing systems, G. Zülch and M. Becker, *Journal of Simulation*, vol. 4, pp. 260-267, 2010.

Toward a methodological framework for agent-based modelling and simulation of supply chains in a mass customization context, Labarthe, O., Espinasse, B., Ferrarini, A., Montreuil, B., *Simulation Modelling Practice and Theory*, vol. 15, no. 2, pp. 113-136, 2007.

Simulation metamodel development using uniform design and neural networks for automated material handling systems in semiconductor wafer fabrication, Kuo, Y., Yang, T., Peters, B.A., Chang, I., *Simulation Modelling Practice and Theory*, vol. 15, no. 8, pp. 1002-1015, 2007.

General modeling and simulation for enterprise operational decision-making problem: A policy-combination perspective, Wenzhe Tan, Yueting Chai, Wei Wang, and Yi Liu, *Simulation Modelling Practice and Theory*, vol. 21, no. 1, pp. 1–20, 2012.

Testing Line Optimization Based on Mathematical Modeling of the Metamodels Obtained from a Simulation, Roberto Seijo-Vidal and Sonia Bartolomei-Suarez, *Winter Simulation Conference* 2010.

- Manual Assembly Line Operator Scheduling Using Hierarchical Preference Aggregation, Gonca Altuger and Constantin Chassapis, *Winter Simulation Conference*, 2010.
- Kriging Metamodeling in Multi-Objective Simulation Optimization, Mehdi Zakerifar, William E. Biles, and Gerald W. Evans, *Winter Simulation Conference*, 2009.
- Performance Effects of Setup Time Reduction with and Without Decision Variable Re-Optimization: A Simulation-Optimization Study, Chandandeep Singh Grewal, Silvanus Enns, and Paul Rogers, *Winter Simulation Conference*, 2009.
- Methodology for Selecting the Best Suitable Bottleneck Detection Method, Eliseu Lima and Leonardo Chwif and Marcos Ribeiro Pereira Barretto, *Winter Simulation Conference*, 2008.
- Applying a Simulation-Based Tool to Productivity Management in an Automotive-Parts Industry, Adrián Aguirre, Enrique Müller, Sebastián Seffino and Carlos Alberto Méndez, *Winter Simulation Conference*, 2008.
- Using Multicriteria Modeling and Simulation to Achieve Lean Goals, Gerald W. Evans and Suraj M. Alexander, *Winter Simulation Conference*, 2007.
- Simulation Framework for Complex Manufacturing Systems with Automated Material Handling, Rene Driessel and Lars Moench, *Winter Simulation Conference*, 2007.
- A Comprehensive Review of Methods for Simulation Output Analysis, Christos Alexopoulos, *Winter Simulation Conference*, pp. 168-178, 2006.
- Inside Discrete-Event Simulation Software: How It Works and Why It Matters, Thomas J. Schriber, and Daniel T. Brunner, *Proceedings of the Winter Simulation Conference*, pp. 118-128, 2006.
- Simulation Modeling and Analysis of a New Mixed Model Production Line, S. Hasgül, and A.S. Büyüksünetçi. *Proceedings of the 2005 Winter Simulation Conference*, pp. 1408-1412, 2005.
- Analyzing Printed Circuit Board Assembly Lines Using a PCB Assembly Template, P.D. Jadhav, and J.S. Smith, *Proceedings of the Winter Simulation Conference*, pp. 1335-1342, 2005.
- A Template-Based Conceptual Modeling Infrastructure for Simulation of Physical Security Systems, A. Guru, and P. Savory, *Proceedings of the 2004 Winter Simulation Conference*, pp. 866-873, 2004.
- Validation and Verification of Simulation Models, R.G. Sargent, *Winter Simulation Conference*, 17-28, 2004.
- A Methodology for Certification of Modeling and Simulation Applications, Osman Balci, *ACM Transactions on Modeling and Computer Simulation*, vol. 11, no. 4, pp. 352-37, 2001.
- Simulation of Manufacturing Systems*, Averill M. Law, and Michael G. McComas, *Proceedings of the 1998 Winter Simulation Conference*, pp. 49-52, 1998.
- Verification, Validation, and Accreditation, Osman Balci, *Winter Simulation Conference*, pp. 41-48, 1998.
- Intelligent Simulation Environment for Printed Circuit Board Assembly, A. Ali, R. de Souza and A. Kumar, *Journal of Electronics Manufacturing*, vol. 9, no. 4, pp. 299 - 311, 1999.
- Intelligent Simulation of a Final Assembly in Hard Disk Drive Industry, Robert de Souza and Z. Z. Ying, *Proceeding of the World Congress on System Simulation*, Singapore, Sep. 01-03, pp. 131-135, 1997.

Link for full paper access of WSC Papers: <http://informs-sim.org/>

Modeling and Simulation Magazines:

- IIE Solution, Institute of Industrial Engineers (IIE).
- OR/MS Today, Society of Operations Research & Management Science.
- Simulation, Society of Computer Simulation (SCS)

Journals:

- ACM Transactions on Modeling and Computer Simulation
- American Journal of Mathematical Management Sciences
- Annals of Operational Research
- European Journal of Operational Research
- IEEE transactions Parallel and Distributed Systems
- Interface
- International Journal of Engineering Systems Modelling and Simulation (IJESMS)
- International Journal of Experimental Design and Process Optimisation
- International Journal of Human Factors Modelling and Simulation
- International Journal of Industrial and Systems Engineering
- International Journal of Modeling, Simulation, and Scientific Computing
- International Journal of Modelling and Simulation
- International Journal of Modelling in Operations Management
- International Journal of Process Systems Engineering
- International Journal of Simulation Modelling
- International Journal on Computer Simulation
- Journal of Defense Modeling & Simulation
- Journal of Simulation
- Management Science
- Modelling and Simulation in Engineering
- Multiscale Modeling and Simulation: A SIAM Interdisciplinary Journal
- Simulation Modelling Practice and Theory, International Journal of the Federation of European Simulation Societies – EUROSIM
- SIMULATION, Transactions of The Society for Modeling and Simulation International
- World Journal of Modelling and Simulation

Conferences:

- ACM SIGMETRICS Conference
- ASME International Computers in Engineering Conference
- European Modelling & Simulation Symposium
- European Simulation Multi-Conference (ESM)
- IASTED International Conference on. Modelling and Simulation
- IIE Annual Conference
- INFORMS Annual Conference
- Michigan Simulation User Group (MSUG) Annual Conference
- Summer Computer Simulation Conference (SCS)

- Winter Simulation Conference (WSC): <http://wintersim.org/>

Modeling and Simulation Internet Resources:

- AnyLogic, XJ Technologies, <http://www.xjtek.com/anylogic/>
- Arena Simulation Software, Rockwell Automation, <http://www.arenasimulation.com/>
- AutoMod, Applied Materials, <http://www.automod.com/>
- Extend Simulation, Imagine That Inc, <http://www.imaginethatinc.com/>
- I-Think/STELA, ISEE Systems Inc. <http://www.iseesystems.com/>
- Powersim Software, <http://www.powersim.com/>
- PromModel Software, ProModel Corporation, <http://www.promodel.com/>
- SIMUL8, SIMUL8 Corporation, <http://www.simul8.com/>
- The Association for Computing Machinery has a special interest group in computer simulation, SIGSIM, which maintains a web site at ACM-SIGSIM <http://www.sigsim.org/>
- The Institute of Industrial Engineers maintains a site at <http://www.iienet.org/>
- The Michigan Simulation User Group (MSUG) maintains a site at <http://www.m-sug.org/>
- The Society for Computer Simulation maintains a site at <http://www.SCS.org/>
- The Winter Simulation Conference <http://www.wintersim.org/pastprog.htm> for WSC Papers.
- Vensim, Ventana Systems, Inc. <http://www.vensim.com/>
- WITNESS Software maintains a site at <http://www.Lanner.com/>

This is a sample. Do not need to address all sections. You can also add new sections / chapters as needed based on your project.

Sample Report Format for Simulation Project EME 7203: Manufacturing Systems Simulation

Abstract

1. Introduction

- 1.1. Motivation
- 1.2. Problem description
- 1.3. Objectives of study
- 1.4. Scope of the study

2. Literature Review and Critical Analysis [Required]

- 2.1. Year-wise / category-wise review (should have minimum 10-15 research papers in the review)
- 2.2. Summary of the literature review
- 2.3. etc.

3. Input Data Analysis [Required]

- 3.1. Source of data
- 3.2. Method of collection
- 3.3. Assumptions
- 3.4. Data Analysis

4. Simulation Model Building [Required]

- 4.1. Introduction of the Modeling and Simulation Design System
- 4.2. Model Design and Description
- 4.3. Design of Experiments / Scenario Analysis / Model Optimization

5. Simulation Results and Discussions [Required]

- 5.1. Analysis on Simulation Results
 - 5.1.1. Comparison of Utilization for Various Resources
 - 5.1.2. Queuing Analysis
 - 5.1.3. Bottleneck Identification
 - 5.1.4. WIP Analysis
 - 5.1.5. Throughput Analysis
 - 5.1.6. Line Balancing
- 5.2. Model Validation and Verification [Required]
- 5.3. Scenario Analysis and Comparisons
- 5.4. Design of Experiments and Analysis /ANOVA [Required]
- 5.5. Response Surface Methodology
- 5.6. Meta Modeling
- 5.7. Simulation based Optimization

6. Conclusion and Recommendations

7. References

8. Appendices

- 8.1. Process Variables
- 8.2. Input Data
- 8.3. Arena Simulation Results
- 8.4. Statistical Analysis

Point Distributions

Abstract & Introduction	10 points
Literature Review	20 points
Input Analysis	20 points
Model Development	20 points
Results and Discussions	20 points
DOE/RSM/Optimization	30 points
Conclusions	10 Points
Presentation (30 min)	30 points
Formatting (WSC 2012)	10 points

**Must Follow WSC
2012 Format
Twelve (12) to Fifteen
(15) page requirement**

Typed and Bound Report