

**BUSI 3308B  
SIMULATION METHODS IN BUSINESS  
WINTER 2017**

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**A. PERSONAL INFORMATION**

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Instructor: Iman Niroomand, PhD,  
Office: 919-1 Ext 3248  
Email: iman.niroomand@carleton.ca  
Office hours: TBD

Timetable: Monday: 17:35 pm – 20:25 pm (LECTURE)  
TBD (TUTORIAL 1)

Locations: Southam Hall 501

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**B. UNDERGRADUATE CALENDAR DESCRIPTION & PREREQUISITE STATEMENT**

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Concepts of computer simulation through case studies, worked examples and hands-on project experience. Generation of random variables, input modeling, model design, analysis of output, and experimental design. Emphasizes static simulations with spreadsheets and discrete-event simulations with specialized software. Third-year standing; BUSI 2301 with a grade of C or higher and one of ECON 2202 or STAT 2607 with a grade of C- or higher.

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**C. COURSE MATERIAL**

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1. W. David Kelton, Randall P. Sadowski and Nancy B. Zupick, Simulation with Arena, McGraw-Hill, 2015, sixth edition (hereafter KS). The library reserve keeps a copy of this book. The book comes with a free installation of the Arena software for academic purposes on student computers running on Windows 95 or higher: Go to the following website to download and install the academic software: <https://www.arenasimulation.com/simulation-software-download>. Computer labs located in the Dunton Tower, rooms DT328 has ARENA installed on the appropriate machines.
2. Manuel D. Rossetti, Simulation Modeling and Arena. John Wiley & Sons, 2010 (hereafter MR). The book comes with a free installation of the Arena software for academic purposes on student computers running on Windows 95 or higher (main reference).
3. Averill M. Law, W. David Kenton, Simulation Modeling Analysis, McGraw-Hill, 2007, fourth edition (hereafter LK).
4. Tayfur Altiok, Benjamin Melamed, Simulation modeling and analysis with Arena, Elsevier Inc, 2007, first edition (hereafter AM).
5. Class Notes: Copies of lecture notes will be available on the course website.

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**D. COURSE OBJECTIVES**

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This course is designed to introduce basic concepts of system modeling and computer simulation through case studies, worked examples and hands-on project experience. The process and methodology of using simulation for problem solving and decision-making are emphasized through static simulations with spreadsheets and discrete-event simulations with specialized software. Simulation language Arena will be used as a tool for model building. Students will be learned generation of random variables, input modeling, model design, analysis of output, and experimental design through the entire course. Also, they will be required to apply the modeling techniques to a real world (or fictitious) problem through a term project. They will come out of the class being able to:

- identify situations where simulation can be applied;
- conduct successfully a simulation study;
- Communicate with specialists or managers who use simulation to perform what-if analysis.

The following topics will be covered:

- Fundamental of simulation concepts
- Statistic and Probability in simulation
- Selecting input distributions
- Random-number generation
- Generating random variates
- Simulation output analysis
- Building valid, credible, and appropriately detailed simulation model
- Model building with Arena
- Model building with Spreadsheet

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#### **E. COURSE EVALUATION**

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Class participation	5%
Assignments (5):	10%
Two quizzes	10%
Simulation project:	20%
Computer lab simulation mid-term examination:	15%
Final examination	40%
<b>TOTAL</b>	<b>100%</b>

##### **1. Examination:**

There are two exams (including the final) and two quizzes. The mid-term exam will consist of a computer lab question on simulation with Arena. This exam, scheduled on the week of **February 22, 2017**. The exam date will be announced soon. It is opened book and opened-notes. The final exam will be closed book, closed-notes. The test questions will come from the text, homework assignments, lecture notes and class discussions and may consist of multiple-choice and/or essay questions or problems. The instructor will make available a formula sheet, which should not contain any other material except formulas. The final exam is scheduled on examination period between **April 10 and April 25, 2017**. This exam will be cumulative. No makeup will be given for exams except for documented and acceptable emergencies (as defined by university standard). Students are advised that exam papers (mid-term or final) will not be returned back to them after being marked. They will only be available for consultation at the instructor's office.

## 2. Quizzes:

Regarding the quizzes, the first quiz is about the data collection and input data analyzer. The second quiz is about the output data analyzer and system comparisons.

## 3. Homework:

Homework assignments will be posted on the course web site at the dates to be announced on the course news page. They are due at the beginning of the class (one week for each homework). No late homework is accepted. Assignments that are not professionally presented, i.e., **cannot be read without undue effort, will lose marks**. The instructor will not be responsible for a homework submitted through email. Students should make arrangements to have a hard copy of their homework submitted in time if they are not able to make it to class on the day the homework is due. Homework must be submitted individually. Unless otherwise stated, no collaboration is allowed for homework, although discussions are encouraged.

## 4. Simulation Project using ARENA

The purpose of the group project is to integrate the material learned in the course. In conducting the project, students should obtain practical knowledge about the steps in performing a simulation study, from data collection and input analysis, experimental design, model development and debugging, model validation and verification, output analysis and written presentation.

### 4.1 Guidelines

- Students will form a team of up to 5 people. Instructor will assign the member to each team randomly before **January 16, 2017**.
- Each group could work on a project **suggested by the instructor** or could find a problem suitable for system modeling and simulation (real word or fictitious problem). In latter case, you need to have sufficient information about the problem in order to develop the simulation model and **must be approved by instructor**. The final project will be presented in class as scheduled.

### 4.2 Project Proposal

- Each group must submit their project acceptance or project proposal by e-mail to the instructor before **January 23, 2017**. Each group must read the project description and send their acceptance through an email to instructor. Each group should provide a milestone for each phase of the project include model development, animation development (if required), data structure, and data analysis. The proposal should be typed with no more than three pages. Handwriting is not acceptable. If the group decides to work on their own project then the proposal report should include the project title, names of team members, the organization involved, and the brief description of the decision problem under study and the objective of the simulation.

### 4.3 Project Report

The project report should include at least the following sections:

- Introduction. Background of the organization involved or description of the problem they want to simulate. Decision problems under study. The justification of using simulation for solving the problem.
- Problem formulation. Variables and constraints. System performance measures and objective functions.
- The interrelationship between variables.
- Data collection and analysis (if required). Methods of data collection. Data analysis.
- Model construction and validation. Simulation model written using Arena. Model verification and validation.
- Model experimentation and output analysis.
- Conclusion and recommendation. The interpretation of simulation results. Recommendations to solve the problem.
- Limitations and further improvement. The limitation of current study. Suggested improvement in the future.

The final report should be typed with no more than 20 pages (1.5 line spacing), including the appendices. A listing/printout of your program and a soft copy of the Arena model (ready to run!) must be submitted with your report. Students must make sure that simulation will run on Lab or instructor computer and must provide the correct path to any collected statistics. Flow charts/networks diagrams are optional but highly recommended, especially for other than extremely simple models.

#### *4.4 Project peer evaluation*

In an effort to promote fairness, a peer evaluation form will be required at the time of project final report submission on which the contributions made by each of the group members are evaluated. Group members who receive unsatisfactory peer evaluations from the rest of their group will have their project grade lowered accordingly.

### *5. Satisfactory In-term Performance*

Unsatisfactory In-term Performance in this course will lead to failure in this course (regardless of the performance at the Final exam)

#### *5.1 Passing Mark*

The requirement for Satisfactory In-term Performance is set at 50% of all, not each, pre-final term work include assignments, quizzes, and mid-term.

#### *5.2 Critical Criteria*

In addition to item 5.1, extra criteria for Satisfactory In-term Performance are a) Class and tutorial attendance ( More than three sessions absence in class and tutorial will cause failure in this course) b) All the students must participate in term project presentation and project hand over to receive the term project mark. Otherwise, term project mark will be zero no matter of peer evaluation.

## Tentative Schedule

Week	Date	Topic/Information	Reading(s)
1	01/09	○ Course introduction	
		○ Introduction to modeling and simulation	○ MR and KS, chapter 1 ○ LK chapter 1 (1.1-1.2,1.7,1.9) ○ KS, chapter 2 (2.8) ○ KS, chapter 13
		○ Fundamental of simulation concepts - Static and Dynamic Simulation with Spreadsheet ○ Group and Project Assignment	○ KS, chapter 2 ○ MR, chapter 1
2	01/16	○ Monte Carlo simulation modeling using Excel ○ Estimating Pi value with simulation ○ Basic Statistics and probability in Simulation	○ KS chapter 2(2.7) ○ MR, chapter 3-Appendix 2 ○ KS App B (B.1-B.6) ○ AM chapter 3 -3.1, 3.4, 3.7, 3.8 ○ LK chapter 4 ○ AM chapter 2-2.3
		○ Newsvendor simulation ○ Assignment #1-Mont Carlo simulation	○ MR, chapter 3-Appendix 2
3	01/23	○ Dynamic Simulation - Hand simulation ○ A Guided tour through arena Part I	○ KS chapter 2 (2.2-2.6) ○ LK chapter 1 (1.4) ○ KS chapter 3 ○ AM chapter 5
		○ Airport Checking Model ○ Assignment #2- Hand simulation	○ LK chapter 4 (4.2) ○ AM chapter 6
4	01/30	○ A Guided tour through arena Part II ○ Electronic Assembly System	○ LK chapter 4 (4.2) ○ AM chapter 6
		○ Input data distribution	○ AM chapter 7 (7.1,7.2) ○ KS chapter 4 (4.6.4)
5	02/06	○ Selecting input probability distributions ○ Input modeling with Arena	○ KS chapter 4 (4.6.4) ○ AM chapter 7 (7.5) ○ LK chapter 6 (6.1-6.2,6.4.1-6.4.2,6.5, 6.6.2, 6.11)
		○ A Guided tour through arena Part III ○ Hospital emergency room & Airport Check-in	○ KS Chapter 4 and 5
6	02/13	○ Random number and random variates ○ Assignment #3 Dist. fit and Input Analyzer and Random number generator and generation of random variate	○ KS chapter 12 (12.1-12.2) ○ AM chapter 4 ○ LK chapter 7 (7.1, 7.2)
	TBD	○ Mid-Term (computer lab - TBD) ○ Class feedback	
7		○ Mid-Term (computer lab - TBD)	

Week	Date	Topic/Information	Reading(s)
8	03/06	<ul style="list-style-type: none"> <li>○ Simulation output analysis</li> <li>○ Output Analysis with Arena-terminating system</li> </ul>	<ul style="list-style-type: none"> <li>○ KS chapter 6 (6.1-6.4)</li> <li>○ KS chapter 7 (7.2)</li> <li>○ LK chapter 9 (9.1,9.3, 9.4.1, 9.4.3, 9.5.1-9.5.2)</li> </ul>
9	03/13	<ul style="list-style-type: none"> <li>○ Modeling detailed operations in Arena</li> <li>○ Advanced modeling in arena simulation (Transportation)</li> <li>○ Applications of simulation</li> <li>○ Quiz 1: Modeling , Data collection and input data analyzer</li> </ul>	<ul style="list-style-type: none"> <li>○ KS chapter 5</li> <li>○ KS chapter 7-7.1</li> <li>○ KS chapter 9-9.5-9.6</li> <li>○ AM chapter 12-12.1-12.2</li> </ul>
10	03/20	<ul style="list-style-type: none"> <li>○ Simulation output analysis -non terminating system</li> <li>○ Output Analysis with Arena</li> <li>○ Assignment #4 Confidence Interval &amp; system comparison</li> <li>○ Output Analyzer</li> </ul>	<ul style="list-style-type: none"> <li>○ AM chapter 9</li> <li>○ KS chapter 9</li> <li>○ LK chapter 10 (10.1-10.3)</li> </ul>
11	03/27	<ul style="list-style-type: none"> <li>○ Quiz 2: output data analyzer and system comparisons</li> <li>○ Building valid, credible, and appropriately detailed simulation model</li> <li>○ Assignment #5 System Comparison II</li> </ul>	<ul style="list-style-type: none"> <li>○ LK chapter 5</li> <li>○ AM chapter 8-8.1-8.3</li> </ul>
12	04/03	<ul style="list-style-type: none"> <li>○ <b>Project final presentation and report due</b></li> </ul>	
	TBD	<ul style="list-style-type: none"> <li>○ <b>Final Exam</b></li> </ul>	

### Tentative Schedule (Tutorial)

Week	Date	Scheduled topic
2	Week Jan 09	○ Excel spreadsheet review
3	Week Jan 16	○ Simulation with Spreadsheet-Mantel manufacturing system
4	Week Jan 23	○ Serial processing vs. parallel processing
5	Week Jan 30	○ Supermarket cashier management
6	Week Feb 06	○ Input Analyzer and Shop floor simulation
7	Week Feb 13	○ <b>Mid-Term (lab question)</b>
8	Week Feb 20	○ No Class (Winter Break)
9	Week Feb 27	○ Advance process modeling
10	<b>Week Mar 06</b>	○ Advance transfer modeling
11	Week Mar 13	○ System comparison
12	Week Mar 20	○ Transportation system and output analysis
13	Week Mar 27	○ Simulation review and project help

### IMPORTANT ADDITIONAL INFORMATION

#### **Course Sharing Websites**

Student or professor materials created for this course (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s).

#### **Required calculator in BUSI course examinations**

If you are purchasing a calculator, we recommend any one of the following options: Texas Instruments BA II Plus (including Pro Model), Hewlett Packard HP 12C (including Platinum model), Staples Financial Calculator, Sharp EL-738C & Hewlett Packard HP 10bII.

#### **Group work**

The Spratt School of Business encourages group assignments in the school for several reasons. They provide you with opportunities to develop and enhance interpersonal, communication, leadership, follower-ship and other group skills. Group assignments are also good for learning integrative skills for putting together a complex task. Your professor may assign one or more group tasks/assignments/projects in this course. Before embarking on a specific problem as a group, it is your responsibility to ensure that the problem is meant to be a group assignment and not an individual one.

In accordance with the Carleton University Undergraduate Calendar (p 34), the letter grades assigned in this course will have the following percentage equivalents:

A+ = 90-100	B+ = 77-79	C+ = 67-69	D+ = 57-59
A = 85-89	B = 73-76	C = 63-66	D = 53-56
A - = 80-84	B - = 70-72	C - = 60-62	D - = 50-52

F = Below 50      WDN = Withdrawn from the course

ABS = Student absent from final exam

DEF = Deferred (See above)

FND = (Failed, no Deferred) = Student could not pass the course even with 100% on final exam

#### **FND:**

To reduce instances of miscommunication, Carleton introduced a grade FND (Failure with No Deferral) to be assigned to students who fail to meet the minimum in-term performance standards explicitly set out in the outline and applied consistently (i.e., there is no other hidden criteria).

#### **Academic Regulations, Accommodations, Plagiarism, Etc.**

University rules regarding registration, withdrawal, appealing marks, and most anything else you might need to know can be found on the university's website, here: <http://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/>

#### **Academic Accommodations for Students with Disabilities**

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or [pmc@carleton.ca](mailto:pmc@carleton.ca) for a formal evaluation. If you



are already registered with the PMC, contact your PMC coordinator to send me your **Letter of Accommodation** at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). **Requests made within two weeks will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website ([www.carleton.ca/pmc](http://www.carleton.ca/pmc)) for the deadline to request accommodations for the formally-scheduled exam (*if applicable*).

- The deadlines for contacting the Paul Menton Centre regarding accommodation for final exams for the April 2016 exam period is March 10, 2017.

*For Religious Obligations:*

Students requesting academic accommodation on the basis of religious obligation should make a formal, written request to their instructors for alternate dates and/or means of satisfying academic requirements. Such requests should be made during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist, but no later than two weeks before the compulsory event.

Accommodation is to be worked out directly and on an individual basis between the student and the instructor(s) involved. Instructors will make accommodations in a way that avoids academic disadvantage to the student.

Students and instructors can confirm accommodation eligibility of a religious event or practice by referring to the Equity Services website (<http://carleton.ca/equity/accommodation/religious-observances/>) for a list of holy days and Carleton's Academic Accommodation policies. If there are any questions on the part of the student or instructor, they can be directed to an Equity Services Advisor in the Equity Services Department for assistance.

*For Pregnancy:*

Pregnant students requiring academic accommodations are encouraged to contact an Equity Advisor in Equity Services to complete a letter of accommodation. The student must then make an appointment to discuss her needs with the instructor at least two weeks prior to the first academic event in which it is anticipated the accommodation will be required.

### **Academic Integrity**

Violations of academic integrity are a serious academic offence. Violations of academic integrity – presenting another's ideas, arguments, words or images as your own, using unauthorized material, misrepresentation, fabricating or misrepresenting research data, unauthorized co-operation or collaboration or completing work for another student – weaken the quality of the degree and will not be tolerated. Penalties may include; a grade of Failure in the submitted work and/or course; academic probation; a refusal of permission to continue or to register in a specific degree program; suspension from full-time studies; suspension from all studies at Carleton; expulsion from Carleton, amongst others. Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy which is available, along with resources for compliance at: <http://carleton.ca/studentaffairs/academic-integrity>.

### **Sprott Student Services**

The Sprott student services office, located in 710 Dunton Tower, offers academic advising, study skills advising, and overall academic success support. If you're

having a difficult time with this course or others, or just need some guidance on how to successfully complete your Sprott degree, please drop in any weekday between 8:30am and 4:30pm. Our advisors are happy to discuss grades, course selection, tutoring, concentrations, and will ensure that you get connected with the resources you need to succeed! <http://sprott.carleton.ca/students/undergraduate/support-services/>

Be in the know with what's happening at Sprott: Follow @SprottStudents and find us on Facebook SprottStudents Sprott.

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**Assistance for Students:**

Student Academic Success Centre (SASC): [www.carleton.ca/sasc](http://www.carleton.ca/sasc)

Writing Tutorial Services: <http://www1.carleton.ca/sasc/writing-tutorial-service/>

Peer Assisted Study Sessions (PASS): [www.carleton.ca/sasc/peer-assisted-study-sessions](http://www.carleton.ca/sasc/peer-assisted-study-sessions)

**Important Information:**

- Students must always retain a hard copy of all work that is submitted.
  - All final grades are subject to the Dean's approval.
  - Please note that you will be able to link your CONNECT (MyCarleton) account to other non-CONNECT accounts and receive emails from us. However, for us to respond to your emails, we need to see your full name, CU ID, and the email must be written from your valid CONNECT address. Therefore, it would be easier to respond to your inquiries if you would send all email from your connect account. If you do not have or have yet to activate this account, you may wish to do so by visiting <https://portal.carleton.ca/>
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**Winter Term 2017 Dates and Deadlines**

**January 5, 2017**

- Winter-term classes begin.

**January 18, 2017**

- Last day for registration for winter term courses.
- Last day to change courses or sections for winter term courses.

**January 20-22, 27-29, 2017**

- Fall-term deferred examinations will be written.

**January 31, 2017**

- Last day for withdrawal from winter term and winter portion of fall/winter courses with full fee adjustment.
- Last day for receipt of applications for review of final grades in fall-term courses.

**February 17, 2017**

- April examination schedule available online.

**February 20, 2017**

- Statutory holiday. University closed.

**February 20-24, 2017**

- Winter Break, classes suspended.

**March 1, 2017**

- Last day for receipt of applications from potential Spring (June) graduates.

**March 10, 2017**

- Last day to submit, to the Paul Menton Centre for Students with Disabilities, Formal Examination Accommodation Forms for April examinations.

**April 7, 2017**

- Winter term ends
- Last day of fall/winter and winter-term classes.
- Last day for academic withdrawal from fall/winter and winter-term courses.
- Last day for handing in term work and the last day that can be specified by a course instructor as a due date for term work for fall/winter and winter-term courses.

**April 7-9, 2017**

- No classes or examinations take place

**April 10-25, 2017**

- Final examinations in winter term and fall/winter courses may be held. Examinations are normally held all 7 days of the week.

**April 14, 2017**

- Statutory holiday, University closed.