Lingnan University

Department of Computing and Decision Sciences

Course Syllabus

Course Title	:	Operations Simulation with Decision Analysis
Course Code	:	CDS3002
Recommended Study Year	:	3
No. of Credits/Term	:	3
Mode of Tuition	:	Sectional Approach 3 hours per week Required
Class Contact Hours	:	
Category in Major Prog.	:	
Prerequisite(s)	:	(a) CDS1003 Probability and Statistics 1, or (b) BUS1102 Statistics for Business, or (c) CLD9003 Statistics in Modern Society
Co-requisite	:	Nil
Exclusion	:	Nil
Exemption Requirement	:	Nil

Brief Course Description:

This course is designed for Data Science students. They are required to have previous knowledge of probability and statistics. Simulation is a commonly used and practical technique for modelling and analysing real operating systems to make more effective decisions. Examples of such systems include transportation, supply chain networks, job flow, airports, banks, ocean terminals, information systems, emergency response systems and human behaviour in a social network. Due to the considerable complexity of real systems, many people and organisations find it difficult to investigate human activities, manufacturing and service designs and processes without a computer simulation model. More than 89% of Fortune 500 firms have used simulation for system improvement and have experienced the benefits for a long time. This course is designed to introduce basic concepts of system modelling and computer simulation. The process and methodology of using simulation for problem solving and decision making are emphasised.

Moreover, the course assignments involve the use of the simulation language "Arena". Some of the assignments may require the ability to write computer programs in a language of the student's choice or the use of a spreadsheet.

Aims:

This course deals with the data collection, simulation, analysis, and decisions related to human activities, operations, and optimization of system performance. Students are expected to gain a comprehensive understanding of

1. identification, collection, and probability fitting and estimates of data;
2. realistic and feasible construction of simulation systems using the Arena software;
3. understanding and applications of the simulation results.

Learning Outcomes (LOs):

On completion of this course, students are expected to be able to:

1. apply critical thinking skills to analyze problems and support decision making.
2. collect, manage, store, process, analyze, and visualize data from different data sources with various characteristics.
3. deploy the results in different kinds of information systems and/or intelligent systems.
4. use the Arena software to simulate systems of any size.
5. understand the implications of simulation results and apply them to solve real problems.

Indicative Contents:

Chapter 1: What is simulation?
Preliminary review on the Arena simulation software. Show the simulation models and distribute the Arena---Forward Visibility for Your Business and a successful SCM/Logistics example---An Application of Arena in the Simulations at Bayer Corporation.

Chapter 2: Fundamental Simulation Concepts
Quick review of statistics. Emphasize *Pieces of a simulation model* and *Event- and process-oriented simulation*.

Chapter 3: A Guided Tour Through Arena
Show the process of building an Arena model. Explore Arena functions: menus, toolbars, drawings and printings.

Chapter 4: Modeling Basic Operations and Inputs
Build four Arena models. Learn *Input Analysis* by specifying model parameters and distributions.

Chapter 5: Modeling Detailed Operations
Build two Arena models, which use the *Blocks* and *Elements panels* to construct a **(s,S)** inventory model.

Chapter 6: Statistical Analysis of Output from Terminating Simulations
Emphasize the simulation analysis with Process Analyzer (PAN) and the optimization with Optquest.

Chapter 7: Intermediate Modeling: A Small Manufacturing System
Build an Arena model. Groups for simulation projects are formed based on the students' choices.

Chapter 8: Entity Transfer
Build one Arena model which is concerned with resource-constrained transfers, two Arena models with transporters, and two Arena models with conveyors.

Final Examination

Teaching Method:

The course will adopt a lecture-based sectional format with a focus on the software applications in simulation. All classes will take place in a computer lab, where we lecture practical concepts, skills, and techniques, and then apply the Arena software to the management of real systems and processes. In order to improve the students' skills of solving real problems, we will provide the students with an opportunity to work on real projects.

We encourage the students to actively participate in all classes. We will deliver to students our teaching materials and other materials (e.g., complementary notes, assignments, solutions and cases) through email or other feasible ways. The students are responsible to organize and read the materials.

In classes, we use the teaching notes in .pdf or .ppt format. In addition, we also use the whiteboard to solve some numerical examples. We will post all of our announcements by email, and also show these announcements in class. All students can feel free to meet with the instructor for any question. However, if a student hopes to see the instructor, the student should make an appointment by e-mail and/or phone.

Assessment:

In-class performance	20%
Group based project analysis and presentation	20%*
Individual assignments	20%
End-of-term Examination	40%
Total	100%

* For group-based case study, the whole group will be given a common grade depending on the group's performance.

Measurement of Learning Outcomes:

1. Starting from Chapter 3, students will critically think about how to construct Arena models to simulate real systems/operations. All students are required to *independently* identify and collect data, estimate best-fitting probability distributions, simulate real issues with Arena, and learn implications from simulation results. Every student's individual performance will be evaluated in his or her assignments and final exam for **learning outcomes 1, 4, and 5**.
2. At the end of this course, students are required to work on real-life simulation projects and gain experience on applying modern simulation technology for problem solving in a variety of real systems and operations. Specifically, each student will participate in a group which will be formed by the students themselves. It is students' responsibility to find a real world problem for system modeling and simulation. The project should be carefully selected to demonstrate the meaningful use of simulation and to be completed in a reasonable amount of time.

   Each group will identify a real simulation system in Hong Kong, conduct data collection and simulation, and write a project report including at least the following sections: (i) **Introduction**: background of the organization involved, decision problems under study, and justification of using simulation for solving the problem; (**ii**) **Problem formulation**: variables and constraints, system performance measures and objective functions, and interrelationship between variables; (**iii**) **Data collection and analysis**: methods of data

collection, and data analysis; (**iv**) **model construction and validation**: simulation model written using Arena, model verification and validation; (**v**) **model experimentation and output analysis**; (**vi**) **conclusion and recommendation**: the interpretation of simulation results, and recommendations to solve the problem; and (**vii**) **limitations and further improvement**: the limitation of current study, and suggested improvement in the future. Every student's performance in project study will be evaluated for **learning outcomes 1, 2, 3, 4, and 5**.

Required/Essential Readings:

1. W. David Kelton, Randall P. Sadowski and David T. Sturrock, *Simulation with Arena*, *Sixth Edition*. McGraw-Hill Higher Education, 2015.

Recommended/Supplementary Readings:

1. Manuel Laguna and Johan Marklund. *Business Process Modeling, Simulation and Design*. Prentice Hall, 2005.
2. Daniel Maki and Maynard Thompson, *Mathematical Modeling and Computer Simulation*, Thomson Corporation, 2006.
3. Hans P. M. Veeke, *Simulation Integrated Design for Logistics*, DUP Science, 2003.
4. Philip H. Anderson, David A. Beveridge, Timothy W. Scott and David L. Hofmeister, *Threshold Competitor: A Management Simulation*, Version 3.0, Prentice Hall, 2003.
5. **Software**: Arena 14.5 (Academic version) and Microsoft Excel 2016.
   Note: A free version of the Arena software can be downloaded as http://highered.mheducation.com/sites/0073401315/student_view0/arena_software_download.html.

Important Notes:

(1) Students are expected to spend a total of 9 hours (i.e. 3 hours of class contact and 6 hours of personal study) per week to achieve the course learning outcomes.

(2) Students shall be aware of the University regulations about dishonest practice in course work, tests and examinations, and the possible consequences as stipulated in the Regulations Governing University Examinations. In particular, plagiarism, being a kind of dishonest practice, is "the presentation of another person's work without proper acknowledgement of the source, including exact phrases, or summarised ideas, or even footnotes/citations, whether protected by copyright or not, as the student's own work". Students are required to strictly follow university regulations governing academic integrity and honesty.

(3) Students are required to submit writing assignment(s) using Turnitin.

(4) To enhance students' understanding of plagiarism, a mini-course "Online Tutorial on Plagiarism Awareness" is available on https://pla.ln.edu.hk/.

Rubrics for Assessments (CDS3002 – Simulation)

Assessment Task 1: In-Class Performance

- **Program Learning Outcomes**:
  Learning Goal 1: Students can apply critical thinking skills to analyze problems and support decision making.
  Learning Goal 4: Students are able to use the Arena software to simulate systems of any size.
  Learning Goal 5: Students can understand the implications of simulation results and apply them to solve real problems.
- **Process**: Every student will be assessed according to his or her study performance on various class activities, which include questions, comments and recommendations, responses to the instructor's questions, simulation with Arena, and others.
- **QA Criterion**: In terms of the overall performance for all traits, 80% of students will reach the level of satisfactory or above.
- **Maximum Score**: 80.
- **The cutoff score for satisfactory performance**: 60

Traits	Very Unsatisfactory (0 point)	Unsatisfactory (5 points)	Fair (10 points)	Satisfactory (15 points)	Very Satisfactory (20 points)
Able to attend all the classes.	Does not attend 20% or above of the classes without providing strong evidence (e.g., medical proofs) to justify the absences.	Attends at least 20% of the classes but does not attend 40% or above of the classes without providing strong evidence to justify the absences.	Attends at least 40% of the classes but does not attend 60% or above of the classes without providing strong evidence to justify the absences.	Attends at least 60% of the classes but does not attend 80% or above of the classes without providing strong evidence to justify the absences.	Attends at least 80% of the classes.
Able to apply critical thinking skills to analyze problems and support decision making.	Does not ask any questions in classes.	Asks some questions that are not well-related to simulation.	Asks 2 or less questions that are related to simulation.	Asks more than 2 but less than 5 questions that are related to simulation.	Asks at least 5 questions related to simulation.
Able to use the Arena software to simulate systems of any size.	Does not construct any correct simulation model with Arena.	Constructs some correct Arena modelsbut other models are wrong.	All Arena models are correct but, cannot understand the implications of any simulation results.	Constructs all correct Arena models but can understand the implications of only some simulation results.	Constructs all correct Arena models, and can understand the implications of all simulation results.
Able to respond to the instructor's questions in classes	Does not respond to any question raised by the instructor.	Responsd to at most 2 questions given by the instructor.	Responds to 2 or more questions given by the instructor, but does not provide any details.	Responds to 2 or more questions and also provides the details, but at least one response is not correct.	Responds to 2 or more questions with the details, and all responses are correct.

Assessment Task 2: Group Case study

- **Program Learning Outcomes**:
  Learning Goal 1: Students can apply critical thinking skills to analyze problems and support decision making.
  Learning Goal 2: Students can collect, manage, store, process, analyze, and visualize data from different data sources with various characteristics.
  Learning Goal 3: Students can deploy the results in different kinds of information systems and/or intelligent systems.
  Learning Goal 4: Students are able to use the Arena software to simulate systems of any size.
  Learning Goal 5: Students can understand the implications of simulation results and apply them to solve real problems.
- **Process**: Every student will be assessed according to his or her performance in case study.
- **QA Criterion**: In terms of the overall performance for all traits, 80% of students will reach the level of satisfactory or above.
- **Maximum Score**: 80
- **The cutoff score for satisfactory performance**: 60

Traits	Very Unsatisfactory (0 point)	Unsatisfactory (5 points)	Fair (10 points)	Satisfactory (15 points)	Very Satisfactory (20 points)
Able to actively participate a case study group.	Do not participate in any case discussion.	Participate some case discussions but do not actively work on the case.	Actively work on all cases, but make some mistakes during the case discussions.	Actively work on the case, but make some minror mistakes in the case study.	Actively work on the case, and do not have any mistakes in the case study.
Able to collect, manage, store, process, analyze, and visualize data from different data sources with various characteristics, and deploy the results in relevant information systems.	Do not properly identify a data source.	Identify a proper data source. but cannot collect any useful data.	Identify a proper data source and also collect some useful data but the data is not sufficient.	Identify a proper data source and also collect sufficient, useful data but cannot use "Input Analyzer" to analyze the data.	Identify a proper data source, collect sufficient, useful data, and also use "Input Analyzer" to analyze the data.
Able to use the Arena software to simulate systems of any size.	Do not understand how to properly use any module in Arena.	Understand the Arena modules but do not understand how to use the software to construct the simulation model.	Understand how to use Arena to construct the simulation model, but the simulation model has some problems.	Construct a correct Arena model, but, the model cannot properly run and generate simulation results.	Construct a correct Arena model that can properly run and generate simulation results.
Able to understand the implications of simulation results and apply them to solve real problems.	Do not include any implications.	Find some implications that cannot help improve the simulation system.	Find a few minor implications that can somewhat help improve the system performance.	Find a few significant implications that can help improve the system performance.	Find considerable implications that can help improve the system performance.

Assessment Task 3: Individual Assignments

- **Program Learning Outcomes**:
  Learning Goal 1: Students can apply critical thinking skills to analyze problems and support decision making.
  Learning Goal 4: Students are able to use the Arena software to simulate systems of any size.
  Learning Goal 5: Students can understand the implications of simulation results and apply them to solve real problems.
- **Process**: Every student will be assessed according to his or her performance in the last assignment (which is selected for assessment because it requires students to understand all functions in Arena).
- **QA Criterion**: In terms of the overall performance for all traits, 80% of students will reach the level of satisfactory or above.
- **Maximum Score**: 80
- **The cutoff score for satisfactory performance**: 60

Traits	Very Unsatisfactory (0 point)	Unsatisfactory (5 points)	Fair (10 points)	Satisfactory (15 points)	Very Satisfactory (20 points)
Able to set up a correct simulation file with Arena	Does not properly use any required module.	Properly uses Arena modules, but does not properly analyze any required data in "Input Analyzer."	Properly uses Arena modules and also properly analyzes any required data but cannot correctly input distributions and define parameters properly.	Properly uses Arena modules, properly analyzes any required data, and also correctly inpust distributions and defines parameters. But, the Arena model is not entirely consistent with the simulation problem.	Properly uses Arena modules, properly analyzes any required data, and also correctly inputs distributions and define parameters. The Arena model is consistent with the simulation problem.
Able to properly run Arena models	Does not correctly define parameters for running Arena models.	Some parameters are correct; but others are wrong.	All parameters are correc,; but, cannot be properly used to answer questions.	All parameters are correctly defined to answer questions, but the run time is not specified.	All parameters are correctly defined to answer questions and the run time is specified.
Able to analyze the simulation results with "Output Analyzer"	Does not understand which simulation results will be used in "Output Analyzer."	Understands how to use simulation results in "Output Analyzer." but does not understand how to obtain/extract the results.	Understands how to use simulation results in "Output Analyzer" and how to obtain/extract the results but does not obtain proper data.	Understands how to use simulation results in "Output Analyzer" and how to obtain/extract the proper results, but does not properly use "Output Analyzer."	Uses "Output Analyzer" to analyze proper simulation results.

Traits	Very Unsatisfactory (0 point)	Unsatisfactory (5 points)	Fair (10 points)	Satisfactory (15 points)	Very Satisfactory (20 points)
Able to use "OptQuest" to optimize the simulation system	Does not know how to use "OptQuest."	Understands "OptQuest" but does not input correct parameters.	Understands "OptQuest" and also inputs correct but does not correctly define decision variables.	Understands "OptQuest" and also inputs correct parameters and defines correct decision variables, but deso not correctly set up an objective function.	Understands "OptQuest" and also inputs correct parameters, defines correct decision variables, and also correctly sets up an objective function.

Assessment Task 4: End-of-Term (Final) Examination

- **Program Learning Outcomes**:
  Learning Goal 1: Students can apply critical thinking skills to analyze problems and support decision making.
  Learning Goal 4: Students are able to use the Arena software to simulate systems of any size.
  Learning Goal 5: Students can understand the implications of simulation results and apply them to solve real problems.
- **Process**: Every student will be assessed according to his or her performance in the final exam, which is an open-book, computer exam. We will use the exam to test students' ability in using Arena and OptQuest for simulation systems.
- **QA Criterion**: In terms of the overall performance for all traits, 80% of students will reach the level of satisfactory or above.
- **Maximum Score**: 100
- **The cutoff score for satisfactory performance**: 60

Traits	Very Unsatisfactory (0 point)	Unsatisfactory (5 points)	Fair (12 points)	Satisfactory (18 points)	Very Satisfactory (25 points)
Able to set up a correct simulation file with Arena	Does not properly use any required module.	Properly uses Arena modules, but does not properly analyze any required data in "Input Analyzer."	Properly uses Arena modules and also properly analyzse any required data but cannot correctly input distributions and define parameters properly.	Properly uses Arena modules, properly analyzes any required data, and also correctly inputs distributions and define parameters but the Arena model is not entirely consistent with the simulation problem.	Properly uses Arena modules, properly analyzes any required data, and also correctly inputs distributions and defines parameters. The Arena model is consistent with the simulation problem.
Able to properly run Arena models	Does not correctly define parameters for running Arena models.	Some parameters are correct but others are wrong.	All parameters are correct but cannot be properly used to answer questions.	All parameters are correctly defined to answer questions but the run time is not specified.	All parameters are correctly defined to answer questions and the run time is specified.
Able to analyze the simulation results with "Output Analyzer"	Does not understand which simulation results will be used in "Output Analyzer."	Understansd how to use simulation results in "Output Analyzer," but does not understand how to obtain/extract the results.	Understands how to use simulation results in "Output Analyzer" and how to obtain/extract the results but does not obtain proper data.	Understands how to use simulation results in "Output Analyzer" and how to obtain/extract the proper results but does not properly use "Output Analyzer."	Uses "Output Analyzer" to obtain/extract data and to analyze proper simulation results.
Able to use "OptQuest" to optimize the simulation system	Does no knowt how to use "OptQuest."	Understands "OptQuest" but do not input correct parameters.	Understands "OptQuest" and also inputs correct parameters but does not correctly define decision variables.	Understands "OptQuest" and also inputs correct parameters and defines correct decision variables but does not correctly set up an objective function.	Understands "OptQuest" and also inputs correct parameters, defines correct decision variables, and also correctly sets up an objective function.