NANYANG TECHNOLOGICAL UNIVERSITY

Teaching, Learning and Pedagogy Division

Reg. No. 200604393R

COURSE CONTENT FOR MH4702

Academic Year	AY 19/20	**Semester**	1
Course Coordinator	Yan Zhenzhen		
Course Code	MH4702		
Course Title	Probabilistic Methods in Operations Research		
Pre-requisites	{MH2500, MH3512, MH3701}		
No of AUs	4 AU		
Contact Hours	3 hours lecture and 1 hour tutorial per week		
Proposal Date	01/04/2019		

Course Aims

Operations Research (OR) is about assessing the best utilization of resources based on scientific principles, it aims to improve efficiency and productivity in complex decision-making situations. You will acquire knowledge in modelling and finding solutions to practical problems under an uncertain circumstance. Students who wish to acquire some mathematical models to solve industrial problems will benefit from this course.

Intended Learning Outcomes (ILO)

By the end of the course, you should be able to:

1. Recognise a queueing system and determine its expected queue length and average waiting time.
2. Evaluate a stochastic system, e.g. queueing system using the simulation method
3. Model an operational problem under an uncertain circumstance in a mathematical form
4. Solve the optimization problem under uncertainties
5. Formulate a Markov decision model to solve for a sequential decision making under uncertainty
6. Use one of the algorithms discussed in the lecture to determine the optimal policy for a Markov decision process.

Course Content

Queueing Theory

- Revision of Exponential and Poisson Distributions
- Basic Queueing System, Birth-death Process
- Little's Formula
- The M/M/s, M/M/s/K models, Queue Length and Waiting Time

Simulation

- Techniques for Simulating Continuous Random Variable
- Simulating from Discrete Distributions
- Monto Carlo Method
- Variance Reduction Techniques

Optimization under Uncertainty: Prologue

- Sensitivity Analysis in a Linear Program
- Sample Average Approximation Method

- Robust Optimization with Box Uncertainty Set

Markov Decision Process

- Formulating Markov Decision Model
- Linear Programming Approach
- Policy Improvement Algorithm (*)

Assessment (includes both continuous and summative assessment)

Component	Course ILO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment rubrics
1. Final Examination	1 – 6	A1, A2, A3, B1, B2, B3	60%	Individual	Point-based
2.Midterm Test	1 – 2	A1, A2, A3, B1, B2, B3	20%	Individual	Point-based
3.Assignments	1 – 6	A1, A2, A3, A4, B1, B2, B3, B4, C1,C2,E	20%	Team	Appendix 1
Total			100%		

Graduates of MAS programmes should be able to:

Competence	
A1: {Understanding}	*independently process and interpret mathematical theories and methodologies, and apply them to solve problems*
A2: {Rigour}	*formulate mathematical statements precisely using rigorous mathematical language*
A3: {Intuition}	*discover patterns by abstraction from examples*
A4: {Modern Tool Usage}	*use computer technology to solve problems, and to communicate mathematical ideas*
Creativity	
B1: {Critical Thinking}	*critically assess the applicability of mathematical tools in the workplace*
B2: {Analysis}	*critically analyse data from a multitude of sources*
B3: {Interdisciplinarity}	*build on the connection between subfields of mathematics to tackle new problems*
B4: {Creativity}	*develop new applications of existing techniques*
Communication	
C1: {Communication}	*present mathematics ideas logically and coherently at the appropriate level for the intended audience*
C2: {Teamwork}	*work in teams on complicated projects that require applications of mathematics, and communicate the results verbally and in written form*
Civic-Mindedness	
D: {Professionalism}	*develop and communicate mathematical ideas and concepts relevant in everyday life for the benefits of society*
Character	
E: {Ethics}	*act in socially responsible and ethical ways in line with the societal expectations of a mathematics professional, particularly in relation to analysis of data, computer security, numerical computations and algorithms*

Formative feedback

Component 2: Feedback on common mistakes and the level of difficulty of the problems will be given.

Component 3: Students will receive individual written and/or verbal feedback about their assignments, as the lecturer will return each assignment individually.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lecture	Helps you to understand the motivation and definitions of the concepts and notions, approaches to solving problems in pursuant to the learning outcomes
Assignment	Develops your writing and presentation skills, strengthens your understanding of the concepts and notions, and offers you the opportunity to apply the techniques in problem solving
Tutorial	Develops your problem solving skills, reinforces your understanding of the concepts and notions

Reading and References

1. *Introduction to Operations Research. Hillier & Lieberman, 10th Ed, McGraw Hill 978-0073523453*
2. *Introduction to Probability Models, by Sheldon M. Ross. 10th Edition 978-0123756862*
3. *Stochastic Models in Operations Research by D. Heyman and M. Sobel (2 volumes) 978-0486432601*

Course Policies and Student Responsibilities

(1) General

You are expected to complete all assignments and take the midterm test. You are expected to take responsibility to follow up with course notes, assignments and course related announcements if they are absent.

(2) Absenteeism

Absence from test and examination without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.

(3) Absence Due to Medical or Other Reasons

If you are sick and not able to attend the midterm, you have to submit the original Medical Certificate (or another relevant document) to the administration to obtain official leave. In this case, the missed assessment component will not be counted towards the final grade. There are no make-up midterm.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set

of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Use of materials outside the course is strongly discouraged. If you use outside source, you must reference it in your solution.

You must write up your solutions by yourself and understand anything that you hand in.

Course Instructors

Instructor	Office Location	Phone	Email
Yan Zhenzhen	SPMS-MAS-05-19	(65) 6513 7466	yanzz@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	General Introduction to Operations Research: methods and applications, Revision of Basic Probability Theory	1	Lecture notes
2 – 5	Basic Queueing System, Birth-death Process, Little's Formula, The M/M/s, M/M/s/K models, Queue Length and Waiting Time,	1	Lecture notes / Tutorial / Assignment
6– 7	Sampling continuous and discrete distribution, Sampling from MDP, Monto Carlo methods	2	Lecture notes / Tutorial / Assignment
8 – 11	Introduction to optimization under uncertainty. Introduce Stochastic Optimization and Robust optimization and Sample Average Approximation Method	3-4	Lecture notes / Tutorial / Assignment
12 – 13	Formulating Markov Decision Model, Linear Programming Approach, Policy Improvement Algorithm, Successive Approximation approach	5 – 6	Lecture notes / Tutorial / Assignment

Appendix 1: Assessment Criteria for Assignments

Criteria	Standards		
	Fail standard	**Pass standard**	**High standard**
Methods of approach	• Using methods that are irrelevant or do not apply to the given problem. • Invoking theorems whose conditions are not satisfied.	• Using relevant methods that help solve the problem. • Invoking theorems whose conditions are satisfied.	Finding methods and utilizing theorems that are both relevant and effective

Validity of reasoning	Reasoning is logically invalid.	Reasoning is logically valid.	Reasoning is logically valid and effective.
Clarity of argument	Reasoning is poorly explained or not explained at all.	Reasoning is clear but may contain some gaps.	Reasoning is clear, precise with no or insignificant gaps.