Course Syllabus

offered by Department of Mathematics
with effect from Semester A 2022/23

Part I Course Overview

Course Title:	Stochastic and Statistical Computation
Course Code:	MA8023
Course Duration:	One semester
Credit Units:	3
Level:	R8
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: *(Course Code and Title)*	Nil
Precursors: *(Course Code and Title)*	Nil
Equivalent Courses: *(Course Code and Title)*	Nil
Exclusive Courses: *(Course Code and Title)*	Nil

Part II Course Details

1. Abstract

The purpose of this course is to introduce the recent progresses in stochastic computational method for physics and machine learning. It is designed for the postgraduates with background in either classical (PDE, optimization) numerical method or with statistical learning for data analysis. The focus is the efficient and fast numerical methods in solving the stochastic model (as a forward model) and the statistical model (as an inverse problem). The contents include: advanced Monte Carlo method, stochastic simulation of jump and diffusion process, Bayesian computations, stochastic optimization for large scale problem and big data, etc. This course emphasizes the algorithms and the practical applications to standard models. The basic knowledge of stochastic process and numerical analysis is prerequisite. The prior knowledge of statistical physics or machine learning is a plus. The experience of computer programming related to numerical methods or scientific computing is required.

2. Course Intended Learning Outcomes (CILOs)

No.	CILOs[#]	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	explain the mechanisms in various numerical methods for classic stochastic and statistical problems.	10%	✓		
2.	develop a solid and systematic understanding of the fundamental principles behind the classical and model numerical algorithms for stochastic or statistical models; understand the pros and cons of specific algorithms.	30%	✓	✓	
3.	theoretically analyse the convergence, efficiency, stabilities for some algorithms	20%	✓	✓	
4.	write computer codes to implement, tune, benchmark and compare numerical methods.	20%		✓	✓
5.	Solve one entry-level academic research problem by applying the cutting-edge technique from literature.	20%	✓	✓	✓
		100%			

A1: *Attitude*
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity and impendency.

A2: *Ability*
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills to implement existing methods, evaluating the performance of specific methods or applying academic knowledge to real-life problems.

A3: *Accomplishments*
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

3. Teaching and Learning Activities (TLAs)

TLA	Brief Description	CILO No.						Hours/week (if applicable)
		1	2	3	4	5		
Lectures	Learning through teaching is primarily based on lectures	✓	✓	✓	✓	✓		3 hrs/wk
Assignment	Learning through take-home assignments helps students understand basic concepts and theory, and develop the ability of thinking both heuristically and rigorously.		✓		✓	✓		After-class
Programming project	Learning through two computer-programming projects helps students gain the deeper understanding of the algorithms and the application, and helps students develop the skills of solving real problems.	✓	✓	✓	✓	✓		After-class

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.						Weighting*	Remarks
	1	2	3	4	5			
Continuous Assessment: <u>70</u>%								
Hand-in assignments		✓		✓	✓		30%	The assignments are typically derivation/ proof/analysis/ generalization of some classic results or its application to some toy models.
Reports of computer - programming projects	✓	✓	✓	✓	✓		40%	The projects closely monitor the ability of students to handle real problems independently.
Examination: <u>30</u>% (duration: 2 hours, if applicable)	✓	✓	✓	✓	✓		30%	Examination questions are designed to see how much students understand the fundamental methods and theories.
							100%	

5. Assessment Rubrics

Applicable to students admitted in Semester A 2022/23 and thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-,C+,C)	Failure (F)
1. Hand-in Assignments	DEMONSTRATION of the understanding of the basic materials	High	Significant	Basic	Not even reaching marginal levels
2. Project reports	DEMONSTRATION of the ability of handling large-scale computational problems.	High	Significant	Basic	Not even reaching marginal levels
3. Examination	DEMONSTRATION of the knowledge and understanding of the stochastic and statistical computational methods.	High	Significant	Basic	Not even reaching marginal levels

Applicable to students admitted before Semester A 2022/23

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Hand-in Assignments	DEMONSTRATION of the understanding of the basic materials	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Project reports	DEMONSTRATION of the ability of handling large-scale computational problems.	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Examination	DEMONSTRATION of the knowledge and understanding of the stochastic and statistical computational methods.	High	Significant	Moderate	Basic	Not even reaching marginal levels

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

Monte Caro method, Bayesian computation, stochastic simulation, Kalman filter, uncertainty quantification, stochastic gradient method.

2. Reading List

2.1 Compulsory Readings

Stochastic Tools in Mathematics and Science (Texts in Applied Mathematics) by Alexandre J. Chorin, Ole H Hald. 3rd ed. 2013 Edition, Springer.

2.2 Additional Readings

1.	The Elements of Statistical Learning, 2nd edition, by Hastie, Tibshirani, and Friedman, Springer, 2009.
2.	Numerical Methods for Stochastic Computations: A Spectral Method Approach, by Dongbin Xiu, Princeton University Press, 2010.
3.	Deep Learning (Adaptive Computation and Machine Learning series) - November 18, 2016 by Ian Goodfellow , Yoshua Bengio , Aaron Courville. The MIT Press.