City University of Hong Kong
Course Syllabus

offered by School of Data Science
with effect from Semester A 2024/25

Part I Course Overview

Course Title:	Bayesian Data Analysis
Course Code:	SDSC6003
Course Duration:	One Semester
Credit Units:	3
Level:	P6
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 aim of this course is to provide students with an introduction to Bayesian statistics and to build students' ability to develop Bayesian models for practical data analysis problems. Students will learn to implement Bayesian models with Markov chain Monte Carlo and other numerical methods in software (MATLAB or R) and interpret the results. In addition, they will learn about the Bayesian perspective and its underlying theory.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	**Define** Bayes theorem and concepts in Bayesian statistics.	10%	✓		
2.	**Apply** Bayes theorem to derive the posterior distribution of statistical model parameters.	30%	✓	✓	
3.	**Apply** Markov chain Monte Carlo and other numerical algorithms in MATLAB or R to compute the posterior distribution of statistical model parameters.	30%	✓	✓	
4.	**Explain** Bayesian decision theory, types of prior distribution, and Bayesian model selection and averaging.	10%	✓	✓	
5.	**Implement** Bayesian methods to analyse a real dataset.	20%		✓	
		100%			

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

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, synthesizing knowledge across disciplines 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. Learning and Teaching Activities (LTAs)

(LTAs designed to facilitate students' achievement of the CILOs.)

LTA	Brief Description	CILO No.					Hours/week (if applicable)
		1	2	3	4	5	
Lectures	Students will engage in formal lectures to gain knowledge about the theory and methods of Bayesian statistics.	✓	✓	✓	✓	✓	26 hours/sem
Demonstration of computer codes	Students will develop an understanding of the computer codes included in the course materials by following an in-class demonstration and explanation of the codes.		✓	✓	✓	✓	13 hours/sem

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.					Weighting	Remarks
	1	2	3	4	5		
Continuous Assessment: 55 %							
Midterm exam	✓	✓	✓	✓	✓	25%	
Assignments	✓	✓	✓	✓	✓	30%	
Examination: 45 % (duration: 2.5 hours (2 hours and 30 minutes), if applicable)							
Examination	✓	✓	✓	✓	✓	45%	
						100%	

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Midterm exam	Midterm exam to assess students' level of achievement of CILOs 1-5 on material covered before the midterm exam.	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Assignments	Assignments are designed to assess student's level of achievement of CILOs 1-5, particularly CILOs 2-5.	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Examination	Examination questions are designed to assess student's level of achievement of CILOs 1-5 on all material covered, with emphasis placed on correct application, mostly through precise mathematical exposition, clear explanation, and accurate numerical calculation, of the various aspects of Bayesian statistics.	High	Significant	Moderate	Basic	Not even reaching marginal levels

The test, assignments, and examination will be numerically-marked, and grades-awarded accordingly.

Applicable to students admitted from Semester A 2022/23 to Summer Term 2024

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Midterm exam	Midterm exam to assess students' level of achievement of CILOs 1-5 on material covered before the midterm exam.	High	Moderate	Basic	Not even reaching marginal levels
2. Assignments	Assignments are designed to assess student's level of achievement of CILOs 1-5, particularly CILOs 2-5.	High	Moderate	Basic	Not even reaching marginal levels
3. Examination	Examination questions are designed to assess student's level of achievement of CILOs 1-5 on all material covered, with emphasis placed on correct application, mostly through precise mathematical exposition, clear explanation, and accurate numerical calculation, of the various aspects of Bayesian statistics.	High	Moderate	Basic	Not even reaching marginal levels

The test, assignments, and examination will be numerically-marked, and grades-awarded accordingly.

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

1. Keyword Syllabus

(An indication of the key topics of the course.)

- Bayes theorem, prior distribution, posterior distribution
- Conjugate priors
- Decision theory, loss functions, Bayes risk, Bayes estimator
- Markov chain Monte Carlo simulation, Gibbs sampling, Metropolis-Hasting algorithm
- Hierarchical models, hierarchical linear models
- Bayesian model selection and model averaging

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

1.	Press, S. J. (2003). *Subjective and objective Bayesian statistics: principles, models, and applications (2nd Edition)* . New Jersey: John Wiley & Sons.
2.	Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2014). *Bayesian data analysis (3rd Edition)*. Boca Raton: CRC press.
3.	Turkman, M. A. A., Paulino, C. D., & Müller, P. (2019). *Computational Bayesian Statistics: An Introduction* (Vol. 11). Cambridge: Cambridge University Press.

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

1.	Kruschke, J. (2014). *Doing Bayesian data analysis: A tutorial with R, JAGS, and Stan*. Academic Press.
2.	Koch, K. R. (2007). *Introduction to Bayesian statistics*. Springer Science & Business Media.