City University of Hong Kong
Course Syllabus

offered by School of Data Science
with effect from Semester A 2022/23

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 understanding of 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 R or Matlab 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 self-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)

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

TLA	Brief Description	CILO No.					Hours/week (if applicable)
		1	2	3	4	5	
Lectures	Learning through teaching is primarily based on lectures. Mini-lectures and small-group exercises will be used to facilitate conceptual understanding and industrial applications of various statistical tools and techniques.	✓	✓	✓	✓		26 hours/sem
Tutorial Exercises	In-class exercises provide students with the opportunities to familiarize and apply the statistical tools learnt during the lectures through practical problem solving.		✓	✓	✓	✓	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 %							
Test	✓	✓	✓	✓	✓	25%	
Assignments		✓	✓	✓	✓	30%	
Examination: 45 % (duration: 3 hours, if applicable)							
Examination	✓	✓	✓	✓	✓	45%	
						100%	

For a student to pass the course, at least 30% of the maximum mark for the examination should be obtained.

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following 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. Test	Midterm test to assess students' understanding of Bayesian statistics concepts, ability to apply Bayes theorem correctly, and ability to derive Bayesian estimators.	High	Moderate	Basic	Not even reaching marginal levels
2. Assignments	Students' ability to propose a Bayesian model for a problem and apply relevant Bayesian statistical tools to draw informed conclusions about a data set.	High	Moderate	Basic	Not even reaching marginal levels
3. Examination	Examination questions are designed to assess student's level of achievement of the intended learning outcomes, with emphasis placed on understanding and correct application, mostly through precise mathematical exposition, clear explanation, and 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.

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. Test	Midterm test to assess students' understanding of Bayesian statistics concepts, apply Bayes theorem correctly, and ability to derive Bayesian estimators.	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Assignments	Students' ability to propose a Bayesian model for a problem and apply relevant Bayesian statistical tools to draw informed conclusions about a data set.	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Examination	Examination questions are designed to assess student's level of achievement of the intended learning outcomes, with emphasis placed on understanding and correct application, mostly through precise mathematical exposition, clear explanation, and 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.

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.