香港城市大學
City University of Hong Kong

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:	Advanced Statistics
Course Code:	SDSC8004
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

This course aims to provide students with a solid foundation of statistical concepts, theory, and methods including probability theory, statistical estimation and inference methods, and multivariate statistics. It also aims to provide students with a rigorous introduction to the theory and implementation of linear regression models. Emphasis will be placed on rigorous mathematical derivations of the fundamentals of statistics but implementation of the statistical methods via computer programming in MATLAB or R will be an important part of the course as well.

2. Course Intended Learning Outcomes (CILOs)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes		
			A1	*A2*	*A3*
1.	Prove and apply various fundamental results in probability theory.	20%	✓	✓	
2.	Implement the techniques of parametric inference such as maximum likelihood estimation and Bayesian inference.	35%	✓	✓	
3.	Derive key results in the theory of linear models and linear model selection.	25%	✓	✓	
4.	Derive key results in the theory of nonparametric statistical models and methods such as the bootstrap method and Gaussian process regression.	10%	✓	✓	
5.	Implement statistical inference methods and modelling methodologies with computer codes.	10%	✓	✓	
		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)

LTA	Brief Description	CILO No.					Hours/week (if applicable)
		1	2	3	4	5	
Lecture	Students will engage in formal lectures to gain knowledge about the theory and methods of advanced statistics.	✓	✓	✓	✓	✓	26 hours/semester
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.	✓	✓	✓	✓	✓	12 hours/semester

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.					Weighting	Remarks
	1	2	3	4	5		
Continuous Assessment: 75 %							
Midterm Students will be assessed via the midterm their understanding of concepts, theory, and methods learned in class, textbooks, and reading materials.	✓	✓	✓	✓		25%	
Two assignments Students will work individually to derive or prove results in probability and statistical theory, and apply statistical methods to analyse data with the help of software.	✓	✓	✓	✓	✓	50%	
Examination: 25 % (duration: 3 hours, if applicable)							
Examination Students will be assessed via the examination their understanding of concepts, theory, and methods learned in class, textbooks, and reading materials.	✓	✓	✓	✓		25%	
						100%	

5. Assessment Rubrics

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 1-4 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.	High	Moderate	Basic	Not even reaching marginal levels
3. Examination	Examination questions are designed to assess student's level of achievement of CILOs 1-4 on all material covered. Students will need to demonstrate understanding of various elements of statistical theory and methods taught in the course through precise mathematical exposition.	High	Moderate	Basic	Not even reaching marginal levels

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 1-4 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.	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Examination	Examination questions are designed to assess student's level of achievement of CILOs 1-4 on	High	Significant	Moderate	Basic	Not even reaching marginal levels

	all material covered. Students will need to demonstrate understanding of various elements of statistical theory and methods taught in the course through precise mathematical exposition.					

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

1. Keyword Syllabus

- Probability theory and distributions (probability space, random variables, expectation, inequalities, and convergence of random variables)
- Parametric statistical inference theory and methods (maximum likelihood estimation, Fisher's scoring, Fisher information, consistency and limiting distribution of maximum likelihood estimators, statistical decision theory, Rao-Blackwell theorem, minimum variance unbiased estimation, Bayesian inference)
- Multivariate statistics (covariance matrix estimation, James-Stein estimator, principle components analysis), linear model theory (least squares, Gauss Markov theorem, ridge regression, leave-one-out cross validation, optimal design of experiments), variable selection methods (Bayesian information criterion, LASSO, LARS).
- Nonparametric statistical models and methods (bootstrap, Gaussian process models, local polynomial regression, kernel methods)

2. Reading List

2.1 Compulsory Readings

1.	Wasserman, L. (2013). *All of statistics: a concise course in statistical inference*. Springer Science & Business Media.
2.	Keener, R. W. (2011). *Theoretical statistics: Topics for a core course*. Springer.
3.	Resnick, S. I. (2013). *A probability path*. Springer Science & Business Media.
4.	Casella, G., & Berger, R. L. (2002). *Statistical inference* (Vol. 2). Pacific Grove, CA: Duxbury.
5.	Rasmussen, C. E., & Williams, C. K. (2006). Gaussian Process Regression for Machine Learning. The MIT Press

2.2 Additional Readings

NIL