City University of Hong Kong
Course Syllabus

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

Part I Course Overview

Course Title:	Algorithm Analysis and Game Theory
Course Code:	CS6382
Course Duration:	One semester
Credit Units:	3 credits
Level:	P6
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: *(Course Code and Title)*	CS3334 Data Structures and (CS2402 Introduction to Computational Probability Modeling or MA2185 Discrete Mathematics**)**
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 goal of this course is to introduce students to the field of algorithm analysis and game theory. Different ways of algorithm analysis are coupled with algorithm design, showing provable bounds either in running time or performance. Game theory is a rich domain which interplays with many subjects including computer science. This course is intended to give a broad overview of game theory together with different ways of analysing algorithms, which could be used to explain interactive nature of real-world problems and provide provable performance for them. Computational aspects of game theory will also be covered. At the end of the course, students will have knowledge on how to apply game theory and algorithm analysis in the problems that may arise around them.

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.	Identify and explain common game theory concepts.		✓		
2.	Explain the differences among different ways of designing and analysing algorithms.		✓		
3.	Apply algorithm design and analysis to solve real-world problems.			✓	
4.	Design and analyse game theoretic solutions to solve real-world problems.				✓
		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	
Lecture	The lectures will present the general framework of algorithm design together with different ways of analysis, and different game theory concepts that may be used to solve real-world problems. The algorithms will be illustrated with both toy and real-world examples to motivate the students' understanding.	✓	✓		✓	2 hours/ week
Tutorial	In each week's tutorial session, students will use algorithms or game theory concepts on small examples to gain better understanding of the lecture material.	✓	✓			1 hour/ week
Assignments	Students will apply algorithm analysis to various problems and students can then observe the effectiveness of the algorithms, and evaluate the differences among various algorithms. Game theory concepts will be used in the assignment to address various issues.			✓	✓	1 every 3 weeks
Mid-term Exam	Midterm examination which covers techniques of analysing algorithms and solution concepts in some basic form of games.	✓	✓	✓	✓	

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		
Continuous Assessment: 40%						
In-class exercises	✓	✓			10%	
Assignments			✓	✓	15%	
Mid-term Exam			✓	✓	15%	
Examination^: 60% (duration: 2 hours)	✓	✓	✓	✓	60%	
					100%	

^For a student to pass the course, at least 30% of the maximum mark for examination must 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. In-class exercises	1.1 CAPACITY for LEARNING about algorithm analysis and game theoretic topics.	High	Significant	Moderate to Basic	Not even reaching marginal levels
2. Assignments	2.1 ABILITY to IMPLEMENT and APPLY algorithm analysis and game theoretic solutions to small problems and INTERPRET the results 2.2 ABILITY to COMPARE different ways of algorithm analysis.	High	Significant	Moderate to Basic	Not even reaching marginal levels
3. Mid-term Exam	3.1 ABILITY to EXPLAIN different algorithms and game theoretic solutions. 3.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different algorithms and game theoretic solutions.	High	Significant	Moderate to Basic	Not even reaching marginal levels
4. Examination	4.1 ABILITY to EXPLAIN different algorithms and game theoretic solutions. 4.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different algorithms and game theoretic solutions.	High	Significant	Moderate to 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. In-class exercises	1.1 CAPACITY for LEARNING about algorithm analysis and game theoretic topics.	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Assignments	2.1 ABILITY to IMPLEMENT and APPLY algorithm analysis and game theoretic solutions to small problems and INTERPRET the results 2.2 ABILITY to COMPARE different ways of algorithm analysis.	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Mid-term Exam	3.1 ABILITY to EXPLAIN different algorithms and game theoretic solutions. 3.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different algorithms and game theoretic solutions.	High	Significant	Moderate	Basic	Not even reaching marginal levels
4. Examination	4.1 ABILITY to EXPLAIN different algorithms and game theoretic solutions. 4.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different algorithms and game theoretic solutions.	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

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

The course will mainly focus on different ways of algorithm analysis and game theoretic concepts. Topics include online algorithms, randomized algorithms, approximation algorithms (including FPTAS), streaming algorithms, amortized analysis, smoothed analysis, Nash Equilibrium, zero-sum games, extensive form games, stochastic games, coalitional games, bayesian games, mechanism design, auctions.

Syllabus

1. Overview of algorithm design
    a. greedy algorithms
    b. divide and conquer
    c. dynamic programming
2. Algorithm analysis
    a. approximation algorithms
    b. online algorithms
    c. randomized algorithms
    d. streaming algorithms
    e. amortized analysis
    f. smoothed analysis
3. Overview of game theory
    a. Nash Equilibrium
    b. PoA and PoS
    c. Prisoner's Dilemma
4. Various games
    a. Zero-sum games
    b. Extensive form games
    c. Repeated games
    d. Stochastic games
    e. Coalitional games
    f. Bayesian games
    g. Hedonic games
5. Mechanism design case study
    a. auctions
    b. matching
    c. facility location
    d. scheduling

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.	Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein (2009) *Introduction to Algorithms.* MIT Press
2.	Noam Nisan, Tim Roughgarden, Eva Tardos and Vijay V. Vazirani (2007) *Algorithmic Game Theory.* Cambridge University Press

2.2 Additional Readings

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

1.	M. Machler, E. Solan, S. Zamir (2013), *Game Theory*, Cambridge U.P.
2.	Anna R. Karlin and Yuval Peres (eds) (2017), *Game Theory*, Alive, AMS