CS6382: ALGORITHM ANALYSIS AND GAME THEORY

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Algorithm Analysis and Game Theory

Subject Code
CS - Computer Science
Course Number
6382

Academic Unit
Computer Science (CS)

College/School
College of Computing (CC)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
CS3334 Data Structures
and
(CS2402 Introduction to Computational Probability Modeling or MA2185 Discrete Mathematics)

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

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.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Identify and explain common game theory concepts.		x		
2	Explain the differences among different ways of designing and analysing algorithms.		x		
3	Apply algorithm design and analysis to solve real-world problems.			x	
4	Design and analyse game theoretic solutions to solve real-world problems.				x

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.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	The students will learn 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 students will learn the algorithms with both toy and real-world examples to get motivated.	1, 2, 4	2 hours/ week

2	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, 2	1 hour/ week
3	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.	3, 4	1 every 3 weeks
4	Mid-term Exam	Midterm examination which covers techniques of analysing algorithms and solution concepts in some basic form of games.	1, 2, 3, 4	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	In-class exercises	1, 2	10	-	Yes
2	Assignments	3, 4	15	-	No
3	Mid-term Exam	3, 4	15	-	No

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Minimum Examination Passing Requirement (%)

30

Additional Information for ATs

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

Assessment Rubrics (AR)

Assessment Task

In-class exercises (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

1.1 CAPACITY for LEARNING about algorithm analysis and game theoretic topics.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Assignments (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
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.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Mid-term Exam (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
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.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
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.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
In-class exercises (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
1.1 CAPACITY for LEARNING about algorithm analysis and game theoretic topics.

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Moderate to Basic

Failure
(F) Not even reaching marginal levels

Assessment Task

Assignments (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

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.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Moderate to Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Mid-term Exam (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

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.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Moderate to Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

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.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Moderate to Basic

Failure

(F) Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

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

a. Overview of algorithm design
   a. greedy algorithms
   b. divide and conquer
   c. dynamic programming
b. Algorithm analysis
   a. approximation algorithms
   b. online algorithms
   c. randomized algorithms
   d. streaming algorithms
   e. amortized analysis
   f. smoothed analysis
c. Overview of game theory
   a. Nash Equilibrium
   b. PoA and PoS
   c. Prisoner’ s Dilemma
d. 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
e. Mechanism design case study
   a. auctions
   b. matching
   c. facility location
   d. scheduling

Reading List

Compulsory Readings

	Title
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

Additional Readings

	Title
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