HABIB UNIVERSITY

CS 412: Algorithms: Design and Analysis

Credits: 3+0

"An algorithm must be seen to be believed." – ***Donald E. Knuth***

Spring 2022

Course Prerequisites:	CS 201: Data Structures II
Content Area:	This course is part of CS Kernel. It fulfills the "SSE Elective" and "Free Elective" categories for all other students. It also fulfills the requirement for a CS minor.

I. Logistics

Sections:	Three (03)
Instructors:	Shah Jamal Alam (SJA) and Waqar Saleem (WS)
Course RA:	Asma Idris
Canvas site:	(https://hulms.instructure.com/courses/1921),
Faculty office hours:	WS: Mon 12-14h; Wed 14-16h
	SJA: Tue 16-17h; Fri 09-11h
Course TA's:	TBD
Office hours:	TBD

II. Course Objectives

This is a fundamental course on Algorithms in Computer Science. The main goal of the course is to develop tools and techniques that aid in designing correct and efficient algorithms for computational problems and analyzing their correctness and running time. We will study powerful design techniques, such as dynamic programming and randomization, and useful analytical tools, such as recurrence relations and average case analysis. The algorithms under study are either quite useful, instructive, beautiful or any combination thereof. After taking this course, the student will be conversant in the language of algorithms, which is a chief component of technical interviews and software-related jobs.

III. Program Educational Objectives

The Computer Science program at Habib University aims to produce competent computer scientists who

1. have strong foundations in mathematics and computer science, and the accompanying skills both in breadth and in depth, to position themselves equally well in the Information Technology industry, as technology entrepreneurs and/or in graduate programs in Computer Science or other technical and scientific fields.

2. have a hands-on approach to self-learning and research, and will continually update their knowledge, skills and technical know-how.

3. will be able to assess the societal, cultural, social, religious, legal, environmental, local, and global impact of their actions and will choose an ethical course of action in their professional, personal, and daily lives.

4. will be able to effectively communicate and collaborate with people from diverse backgrounds and in a variety of settings.

IV. Program Learning Outcomes

Upon graduation, students will have the following abilities:

1. **Analysis:** analyze a given situation and reduce it to one or more problems that can be solved via computer intervention.

2. **Design:** design one or more computer-based solutions of a given problem and select the solution that is best under the circumstances.

3. **Programming:** program a given solution in a variety of programming languages belonging to different paradigm.

4. **Implementation:** design and implement software systems of varying complexity.

5. **Tools:** work with the latest tools that support development, e.g., IDE's, version control systems, debuggers, profilers, and continuous build systems.

6. **Self-learning:** research, learn, and apply requirements needed to implement a solution for a given high level problem description.

7. **Ethics and Awareness:** foresee both impact and possible ramifications of computing practices

8. **Communication and Teamwork:** work effectively in inter-disciplinary teams.

V. Student Learning Outcomes / Course Learning Outcomes

The cognition levels are based on Bloom's revised taxonomy.[1]

Course Learning Outcome		
CLO	**Description**	**Cognition**
CLO-1	Identify commonly used algorithmic techniques	Cog-2
CLO-2	Apply common algorithmic techniques to standard computational problems	Cog-3
CLO-3	Analyze computational complexity of common/standard algorithms	Cog-4
CLO-4	Design new algorithms for different computational problems	Cog-5
CLO-5	Construct proofs of correctness and time complexity of various algorithms	Cog-6

[1] Anderson, Lorin W.; Krathwohl, David R., eds. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Allyn and Bacon

VI. Format and Procedures:

There are several websites associated with the course. The LMS (Canvas) site will be used to share the syllabus, give out assignments, and to share other course resources. We will also heavily and frequently use Workplace for course-related announcements, polls, and quick Q&A.

In case of online classes, we will have synchronous classes. In most cases, the lecture slides/lecture notes will be uploaded on Canvas and students are supposed to have read the corresponding material before coming to class. In some cases, instructor(s) may upload pre-recorded videos as well for students to watch before the class meeting.

All lectures/meetings of this course (either synchronous or asynchronous) will be recorded and uploaded on the Video Management System (VMS), in our case, it is called Panopto `vms.habib.edu.pk`, links to the appropriate folder will be provided soon.

You are expected to maintain a behavior befitting *Yohsin* and acknowledging the classroom as a place of learning, exploration, and experimentation.

The University's standard policies on attendance, inclusivity, office hours, and academic integrity apply in this course. These are described in later sections below.

In case of online classes, we will be conducting our classes on Zoom some etiquette for online engagement are listed below.

- We will usually begin with some ice breaking/energizing activities.
- We expect that students will keep their video cameras turned on during the lecture whenever it is possible, and keep their microphones on mute.
- Students should use chat features or raise their hands to indicate if they want to ask questions.

VII. Course Requirements:

- Class participation policy: Background reading for next session and active participation in class discussions.
- Late submission policy: You must submit all assessments no later than the announced deadline. However, with special approval from instructor you may submit late within the faculty's assigned deadline with a 20% deduction in marks.
- Course readings and lecture notes will be made available online through the course website and Canvas (LMS) as classes progress. The following are good references for the material that will be covered.
  - *Algorithms*, by Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani.
  - *Data Structures and Algorithms in Python*, by Michael Goodrich, Roberto Tamassia, and Michael Goldwasser.
- Supplemental reading:
  - *Introduction to Algorithms* (3rd Ed.), by Thomas Cormen, Charles Leiserson, Ronald Rivest and Clifford Stein.
  - *Introduction to Analysis of Algorithms*, by Robert Sedgewick and Philippe Flajolet.

- Additional Resource Reading:
  - *The Art of Computer Programming.* by Donald Knuth.
  - *Discrete mathematics and its applications* (7th Ed.), by Kenneth Rosen.

VIII. Grading Procedures

Grades will be computed as follows.

~~Tentative~~	
Homework × 2	15%
Quizzes × (1 + 4)	20%
Class participation	05%
Weekly challenge	10%
Project	
Proposal	02%
Poster + Demo	08%
Report	05%
Midterm	15%
Final	20%

Grading Scale		
Letter Grade	**GPA Points**	**Percentage**
A+	4.00	[95, 100]
A	4.00	[90, 95)
A-	3.67	[85, 90)
B+	3.33	[80, 85)
B	3.00	[75, 80)
B-	2.67	[70, 75)
C+	2.33	[67, 70)
C	2.00	[63, 67)
C-	1.67	[60, 63)
F	~~0.00~~	[0, 60)

Project and homework are group activities. Students will form a group of ~~3~~ to 4 students (project groups can be different from homework groups).

Homework ~~has to~~ be done in a group setting. Each homework group will appear for viva for their homework and each member will receive the same grade. We expect participation and engagement ~~from~~ all students and therefore will be flexible for deadlines but we will expect that students will generally follow the deadlines.

All quizzes will be in-class and a policy will be shared separately. Final exam and midterm will follow the University's policy on exams developed independently and separately.

Weekly challenge is a an assessment, where students will attempt one or two questions (either coding or theoretical) to test their knowledge of weekly content covered in the class.

IX. Attendance/Engagement Policy

Students are expected to watch any pre-recorded session(s) and attend all classes/synchronous sessions. Student attendance will be recorded based on your on campus/on Zoom presence. Engagement and participation with the course will be based on, in addition to attendance, the Weekly Challenge, submitting homework, and quizzes. Students failing to join any live session must inform their instructor within 24 hours along with the reason.

Every student is expected to attend at least 75% of the synchronous/live sessions, failing to achieve this may result in reporting to the Office of Academic Performance and dropping from the course.

X. Accommodations for students with disabilities

In compliance with the Habib University's policy and equal access laws, we (the instructors) are available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first two weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with the Office of Academic Performance to verify their eligibility for appropriate accommodations.

XI. Inclusivity Statement

We understand that our members represent a rich variety of backgrounds and perspectives. Habib University is committed to providing an atmosphere for learning that respects diversity. While working together to build this community we ask all members to:

- share their unique experiences, values and beliefs
- be open to the views of others
- honor the uniqueness of their colleagues
- appreciate the opportunity that we have to learn from each other in this community
- value each other's opinions and communicate in a respectful manner
- keep confidential discussions that the community has of a personal (or professional) nature
- use this opportunity together to discuss ways in which we can create an inclusive environment in this course and across the Habib community

XII. Office hours

Office hours have been scheduled, circulated, and posted. During these hours the course instructor will be available to answer questions or provide additional help. Every student enrolled in this course must meet individually with the course instructor during course office hours at least once during the semester. The first meeting should happen within the first five weeks of the semester but must occur before midterms. Any student who does not meet with the instructor may face a grade reduction or other penalties at the discretion of the instructor and will have an academic hold placed by the Registrar's Office.

XIII. Academic Integrity

Each student in this course is expected to abide by the Habib University Student Honor Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work.

For this course, collaboration is allowed in homework provided complete information about the collaborators and their contribution is clearly mentioned in such homework. Furthermore, projects will be done in groups.

Scholastic dishonesty shall be considered a serious violation of these rules & regulations and is subject to strict disciplinary action as prescribed by Habib University regulations and policies. Scholastic dishonesty includes, but is not limited to, cheating on exams, plagiarism on assignments, and collusion.

PLAGIARISM: Plagiarism is the act of taking the work created by another person or entity and presenting it as one's own for the purpose of personal gain or of obtaining academic credit. As per University policy, plagiarism includes the submission of or incorporation of the work of others without acknowledging its provenance or giving due credit according to established academic practices. This includes the submission of material that has been appropriated, bought, received as a gift, downloaded, or obtained by any other means. Students must not, unless they have been granted permission from all faculty members concerned, submit the same assignment or project for academic credit for different courses.

CHEATING: The term cheating shall refer to the use of or obtaining of unauthorized information in order to obtain personal benefit or academic credit.

COLLUSION: Collusion is the act of providing unauthorized assistance to one or more person or of not taking the appropriate precautions against doing so.

All violations of academic integrity will also be immediately reported to the Student Conduct Office.

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e-mail, an e-mail attachment file, a diskette/flash-drive, or a hard copy.

Should copying occur, the student who copied work from another student and the student who gave material to be copied will both be in violation of the Student Code of Conduct.

During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Penalty for violation of this Code can also be extended to include failure of the course and University disciplinary action.

XIV. Week-wise schedule

	Topic(s)	Notes
Week 1: 10/01 – 14/01 First day of classes: 10/01	**Introduction** Course syllabus Basics of algorithm analysis Computational tractability A refresher on asymptotic notations	
Week 2: 17/01 – 21/01 Last day to drop classes: 19/01 Last day to add classes: 20/01	**Searching and Sorting** A lower bound on Sorting Solving linear recurrences	Quiz 1
Week 3: 24/01 – 28/01	**Divide and Conquer algorithms** Analysis of Merge Sort Proof of Master Theorem and solving recurrences Maximum Subarray Problem other problems.	
Week 4: 31/01 – 04/02	**Graph algorithms-I** Directed acyclic graphs Topological ordering Connected and strongly-connected components. Planar graphs [optional]	Quiz 2 Homework 1 out
Week 5: 07/02 – 11/02	**Graph algorithms-II** Maximum Flow Problem Ford-Fulkerson algorithm Max-Flow-Min-Cut algorithm	
Week 6: 14/02 – 18/02	**Dynamic Programming-I** Chain matrix multiplication Longest Common Subsequence and related problems.	Quiz 3
Week 7: 21/02 – 25/02	**Dynamic Programming-II** Finding the shortest path in dags Edit distance and related problems. Knapsack problem	
Week 8: 28/02 – 04/03	**Greedy algorithms-I** Dijkstra's algorithm Finding minimum spanning trees	Project proposals d
Week 9: 07/03 – 11/03	**Greedy algorithms-II** Knapsack problem Huffman Coding [optional]	Midterm
Week 10: 14/03 – 18/03	**Randomized algorithms-I** Basic probability theory (a refresher)	Quiz 4
21/03 – 25/03	**Conference Week**	No class this week

Week 11: 28/03 – 01/04	**Randomized algorithms-II** Analysis of Quickselect Analysis of Quicksort	Homework 2 out
Week 12: 10/01 – 14/01 Last day to withdraw courses(s): 08/04	**Randomized Algorithms-III**	
Week 13: 11/04 – 15/04	**Computational complexity** Class P, NP NP-complete and NP-hard problems	Quiz 5
Week 14: 18/04 – 22/04	**Project presentations**	Posters due
Week 15: 25/04 – 29/04 Last day of classes: 29/04	**Project presentations**	Posters due Reports due
Exam week: 30/04 – 02/05	**Reading days**	
Exam week: 09/05 – 14/05 and 16/05 – 18/05	**Final exams**	