Birla Institute of Technology and Science, Pilani
First Semester 2021-2022
Course Handout Part II

Date: 5/08/2021

In addition to the Part-I (General Handout) for all courses appended to the timetable, this portion gives further specific details regarding the course.

Course No. **: CS G526**
Course Title **: Advanced Algorithms & Complexity**
Instructor-in-Charge: Prof. Tathagata Ray
Instructor:
TA: Anand Agrawal

Description : Advanced Algorithm Design Strategies such as Randomization, Approximation and Game-Theoretic Techniques. Design of Parallel and Distributed Algorithms. Design of algorithms for application domains such as Internet / Web, and Computational Biology.

1. Scope and Objective:

The objective of this course is to enable each individual student to pursue some of these activities:

- explore advanced topics in algorithmic and complexity theory;
- engage in analysis and design of complex algorithms for real-world problems in current application domains;
- learn and evaluate advanced / novel algorithm design strategies and techniques
- understand sturdy / open problems in algorithmic or complexity theory by analyzing known approaches and their limitations.

The scope of this course includes

(i) algorithm design strategies such as Randomization and Approximation as well as specific techniques therein.

(ii) NP-hard problems and approaches to handle them using approximation algorithms

(iii) Problem/application domains such as online social networks, Internet and the Web, number theory and cryptography, and distributed computing.

2. Text Book:

T1. “Randomized Algorithms”, by “Motwani, Rajiv & P. Raghavan”, CUP, 1995.
T2. “Combinatorial Optimization: Algorithm & Complexity”, by “Papadimitnou, C.H. & Kenneth Steiglitz”, PHI, 1982

3. Reference Books:

R1. The Design of Approximation of Algorithms. Williamson and Shmoys, Cambridge Press.
R2. Design and Analysis of Randomized Algorithms. Hromkovic, Springer.
R3. Approximation Algorithms. Vijay Vazirani. Springer.
R4. Complexity and Approximation, G. Auseiello, et.al. Springer.
R5. Algorithm Design. Kleinberg and Tardos. Pearson Education.
AR. Additional reading assigned by the Instructor

4. Course Plan

No. of Lectures	Learning Objectives	Topic	Reference
1 Lec	Importance of randomized algorithms and complexity classes	Introduction & Motivation – Advanced Algorithms & Complexity	-
3 Lecs	Review of probability theory	Review of Design Techniques, Complexity Classes and necessary basics in Probability	
4 Lecs	Understanding the classification of randomized algorithms	Randomized Algorithms : Las Vegas & Monte Carlo Techniques,	T1 – Ch 1
4 Lecs	Understanding the success rate of the randomized algorithm	Chebyshev Inequality, Tail Inequalities	T1-Ch3, Ch4
4 Lecs	Understanding how randomization helps in creating some advanced data structures	Data Structures for randomized algorithms - Skip Lists and Hash Tables	T1-Ch8
2 Lecs	Understanding how randomization has helped to obtain algorithms better than deterministic counter parts.	Randomized graph algorithms	T1 – Ch 10
2 Lecs	Understanding the Minimax theorem and its implication in game theory.	Game Theoretic Techniques	T1 – Ch 4
2 Lecs	Understanding role of randomization in parallel algorithms.	Parallel and Distributed Algorithms; PRAM model, Maximal independent sets, Byzantine Agreement	T1-Ch12
4 Lecs	Understanding of complexity classes and their definitions. How to prove a problem is NP-Complete?	Polynomial time reductions, vertex cover, independent set, set cover, 3-satisfiability, Hamiltonian cycle, 3-dimensional cycle, graphs 3-colorability, subset-sum, P vs. NP, NP-completeness, Co-NP, PSPACE, PSPACE-complete, Reducibility, NP-complete problems .	R5
7 Lecs	Design techniques for approximation algorithms	The greedy method, sequential algorithms, local search, linear programming, dynamic programming,	R1 and R4
3 Lecs	Hardness of approximation	Absolute & relative approximation (additive & mutiplicative), approximation classes, APX, PTAS, FPTAS, limits to approximability: the gap technique	R4
4 Lecs	Techniques in	NP, PCP, Non approximability results,	R1 & R4

	proving the hardness of approximation	reduction from NP-complete problems, reductions that preserve approximation, reductions from probabilistically checkable proofs, reduction from unique games	

5. Evaluation Scheme:

Sr. No.	Component	Duration	Weightage (%)	Date & Time	Remarks
1.	Midterm	90 min	25%	TBA	Open Book
3.	Lab Evaluation	During Lab Hours	20% (best 4 out of 5, each of 5%)	Will be announced in Class	Open Book
3.	Term Project - Literature survey & Problem statement - Problem Scoping and Analysis, Mid-Term Progress & Report - Seminar - Conclusion, Viva and Report	Throughout the semester	20 % (10% will be covered before midsem)	Will be announced in Class	Open Book
4.	Compre Exam	2 hrs.	35 %	TBA	Open Book

Note: 40% of the evaluation to be completed by midsem grading.

5. Consultation hours: Prof. Tathagata Ray Saturday 12:00 Noon.

6. Make-up Policy:
Prior Permission of the Instructor-in-Charge is usually required to take a make-up for a test. The regulations set by AGSRD office for make-ups must be followed. A make-up test shall be granted only in genuine cases on justifiable grounds.

7. Notices: Notice regarding the course will be displayed on the CMS or conveyed using BITS official email id only.

8. **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable. **Any kind of unfair means in exams and assignments will be strictly dealt.**

Instructor-in-charge
CS G526.