Birla Institute of Technology and Science, Pilani
Instruction Division
First Semester 2016-2017
Course Handout Part II

Date: 02/08/2016

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: Dr. Anand Narasimhamurthy (anand@hyderabad.bits-pilani.ac.in)

Co-Instructor: Dr. Abhishek Mishra (abhishek.mishra@pilani.bits-pilani.ac.in)

1. Scope and Objective:

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 and (iii) problem/application domains such as number theory and cryptography and distributed computing.

The objective of this course is to enable each individual student to pursue one or more of the following 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; and
- understand study / open problems in algorithmic or complexity theory by analyzing known approaches and their limitations.

While algorithm analysis is included in the scope wherever applicable the emphasis of the course is on algorithm design as such and specific analysis techniques are not emphasized. While the student is exposed to various problem/application domains from an algorithmic perspective the focus is not on the domains but on specific problems and approaches to solving those problems. Of course, the student is encouraged – if interested – to pursue a specific domain for a project during the course and – occasionally, if the student is tenacious enough – beyond the course.

2. Text Book:

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

3. **Reference Books:**

R1. Approximation Algorithms. Vijay Vazirani. Springer.
R2. Complexity and Approximation, G. Auseiello, et.al. Springer.
R3. Algorithm Design. Kleinberg and Tardos. Pearson Education.
AR. Additional reading assigned by the Instructor

4. **Course Plan**

Lectures	Objectives	Topic	Reference
1	Importance of randomized algorithms and complexity classes	Introduction & Motivation – Advanced Algorithms & Complexity	-
2 – 4	Review of probability theory	Review of Design Techniques, Complexity Classes and necessary basics in Probability	-
5 – 7	Introduction to approximation algorithm and their complexity classes.	Introduction to Approximation Algorithms – Examples. Design Techniques and Complexity Classes Basic understanding of NP-completeness	R2- Ch1, Ch2, Ch3
8 – 11	Strategies to deal with NP-complete problems	Approximation algorithms, parameterized complexity	Additional reading
12-14	Understanding the classification of randomized algorithms	Randomized Algorithms : Las Vegas & Monte Carlo Techniques,	T1 – Ch 1
15-17	Understanding the success rate of the randomized algorithm	Chebyshev Inequality, Tail Inequalities	T1-Ch3, Ch4
18-21	Understanding how randomization helps in creating some advanced data structures	Data Structures for randomized algorithms - Skip Lists and Hash Tables	T1-Ch8
22-24	Understanding how randomization has helped to obtain algorithms better than deterministic counter parts.	Randomized graph algorithms	T1 – Ch 10
25-28	Understanding the Minimax theorem and its implication in game theory.	QBF Games, Deterministic Game Tree Evaluation Algorithms. Randomized Game Tree Evaluation Algorithms, Game Theory. Minimax Theorems. Application of Minimax Theorems for Proving Lower Bounds for Game Tree Evaluation.	T1 – Ch 4
29-31	Understanding role of randomization in parallel algorithms.	PRAM Models of Computation, Efficiency of PRAM Algorithms, EREW PRAM Algorithm for Addition. EREW PRAM Algorithm for Maximal Independent Sets. Distributed Algorithm for Byzantine Agreement.	T1-Ch12
32-38	Basic Number theoretic	Divisibility, GCD. Extended	T1 - Ch 14

	algorithms.	Euclid's Algorithm for GCD and its Complexity. Congruences, Fermat's Little Theorem, Euler's Theorem. Modular Exponentiation using Repeated Squaring, Wilson's Theorem. Legendre's Symbol, Randomized Algorithm for finding Square Roots Modulo a Prime. Miller-Rabin Randomized Primality Testing Algorithm. Pollard's Rho Randomized Algorithm for Factorization.	
39-42	Complexity classes and NP-completeness in detail How to prove a problem is NP-Complete?	NP-Completeness of Satisfiability, Independent Sets, Vertex Cover, Clique, 0/1 Integer Programming, etc.	T2 – Ch1, Ch2 & Ch 3, R2 - Ch3

5. Evaluation Scheme:

Sr. No.	Component	Duration	Weightage (%)	Date & Time	Remarks
1.	Test 1	60 min.	15 %		OB
2.	Test 2	60 min.	15%		OB
3.	Term Project - Literature survey & Problem statement - Problem Scoping and Analysis, Mid-Term Progress & Report - Seminar - Conclusion, Viva and Report		40 %		
4.	Comprehensive Exam	3 hrs.	30 %	8/12 FN	CB + OB

Note : This is a Telepresence course in coordination with Pilani campus, also this is an advanced course. The contents and the evaluation scheme are subject to small changes if necessary.

6. Chamber Consultation hours: **Saturdays 12:00 to 13:00**.

7. Make-up Policy:
Prior Permission of the Instructor-in-Charge is usually required to take a make-up for a test.
A make-up test shall be granted only in genuine cases on justifiable grounds.

8. Notices: Notice regarding the course will be displayed on the CMS and CS & IS group notice board.

Instructor-in-charge