First Semester 2020-21

Course Handout Part II

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

Course No.: **CS G526**

Course Title: **Advanced Algorithms & Complexity**

Instructor in Charge: **Abhishek Mishra**

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Course Objectives:
1) To learn about some **Probability Theory** that is applied in **Algorithm Design and Analysis** and **Computational Complexity**.
2) To learn about some applications of **Probability Theory** in **Algorithm Design and Analysis:**
a) Game Theory
b) Parallel Algorithms
c) Distributed Algorithms
d) Number Theoretic Algorithms
3) To learn about some applications of **Probability Theory** in **Computational Complexity:**
a) Deterministic Complexity Classes: P, NP, PSPACE, #P
b) Randomized Complexity Classes: BPP, RP, co-RP, ZPP
c) Interactive Proofs
d) Probabilistically Checkable Proofs

Text Book:

[T1] R. Motwani, P. Raghavan, Randomized Algorithms, 1995, Cambridge University Press.

Reference Books:

[R1] S. Arora, B. Barak, Computational Complexity: A Modern Approach, 2009, Cambridge University Press. Available online at: **http://theory.cs.princeton.edu/complexity/book.pdf**

Lecture Plan:

Lectures	Topics
1	The Complexity Class P.
2	The Complexity Class NP.
3	Polynomial Time Reductions. The Complexity Classes NP-Complete and NP-Hard. The Satisfiability Problem.
4	Cook-Levin Theorem.
5	NP-Completeness of 3SAT, 0/1 Integer Programming and Independent Set.
6	The Complexity Classes PSPACE and NPSPACE.
7	PSPACE-Completeness of True Quantified Boolean Formulas.
8	Probability, Random Variables and Expectation. Linearity of Expectation.
9	The Randomized Complexity Classes BPP, RP, co-RP and ZPP.
10	Markov's Inequality, Chebyshev's Inequality and Chernoff's Bounds.
11	Atlantic City, Monte Carlo and Las Vegas Algorithms.
12	The Birthday Paradox.
13	QBF Games. Deterministic Game Tree Evaluation Algorithms.
14	Randomized Game Tree Evaluation Algorithms. Game Theory.
15	Minimax Theorems.
16	Application of Minimax Theorems in Proving Lower Bounds for Game Tree Evaluation.
17	PRAM Models of Computation. Efficiency of PRAM Algorithms. EREW PRAM Algorithm for Addition.
18	EREW PRAM Algorithm for Maximal Independent Sets.
19	Distributed Algorithm for Byzantyne Agreement.
20	Divisibility. GCD.
21	Extended Euclid's Algorithm for GCD and its Complexity.
22	Congruences. Fermat's Little Theorem. Euler's Theorem.
23	Modular Exponentiation using Repeated Squaring. Wilson's Theorem.
24	Legendre's Symbol. Randomized Algorithm for finding Square Roots Modulo a Prime.
25	Miller-Rabin Randomized Primality Testing Algorithm.
26	Pollard's Rho Randomized Factorization Algorithm.

27	Counting Problems. The Complexity Class #P.
28	#P-Completeness.
29	Deterministic Interactive Proofs. dIP = NP.
30	Interactive Proofs. Interactive Proof for Graph Non Isomorphism. Interactive Proof for Quadratic Non Residuosity.
31	Arthur-Merlin Proofs and Merlin-Arthur Proofs. Pairwise Independent Hash Functions.
32	Interactive Proof for Set Lower Bound. GNI \in AM[2].
33	Interactive Proof for SAT_D.
34	IP = PSPACE.
35	Approximation Algorithms for NP-Hard Optimization Problems.
36	Probabilistically Checkable Proofs. PCP Theorem and Locally Testable Proofs. PCP Theorem and Hardness of Approximation.
37	Equivalence of the "Proof View" and the "Hardness of Approximation View" of the PCP Theorem.
38	Hardness of Approximation for Vertex Cover and Independent Set.
39	Walsh-Hadamard Code.
40	NP \in PCP(poly(n), 1).

Evaluation:

Component	Mode	Weightage	Duration	Remarks
Test 1	Open Book	11%	30 minutes	17th September, 12:00 – 12:30
Test 2	Open Book	12%	30 minutes	17th October, 12:00 – 12:30
Test 3	Open Book	12%	30 minutes	17th November, 12:00 – 12:30

Comprehensive Exam	Open Book	35%	180 minutes	12th December, 14:00 – 17:00
Project		30%		Evaluation in November

Open Book Policy: Only hard copies are allowed (lecture notes, text book, or reference books).

Make-up Policy: Make-up exam may be arranged only in genuine cases with prior permission.

Malpractise Regulation: A student will get 0 if found cheating.

Chamber Consultation Hour:
Abhishek Mishra: 15:00 to 16:00 on Fridays (with prior appointment by email).

Notices: All notices will be posted on Nalanda.

Google Meet Id: meet.google.com/syf-dmwj-gxs