COMPUTATIONAL COMPLEXITY

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PRE-REQUISITES : Theory of Computation.

INTENDED AUDIENCE : Students of Computer Science discipline. This could be B.Tech students who are interested in Theory or MTech/PhD students.

COURSE OUTLINE :

This course is an introduction to the area of computational complexity theory. We will see different models of computations and computational complexity classes. The computational models measure various different aspects of computation, like time, space, randomness, number of gates, amount of communication etc. The complexity classes classify different computational problems depending on their easiness or hardness as per these different models. We will also see how these complexity classes are related to each other. Many of the results are extremely interesting and use several interesting ideas.

ABOUT INSTRUCTOR :

Prof. Subrahmanyam Kalyanasundaram is an Associate Professor at the Department of Computer Science and Engineering, IIT Hyderabad. He did his Masters from Dept of ECE in IISc. After which, he did his Masters in Mathematics and Phd in Algorithms, Combinatorics and Optimization from Georgia Tech. He has been at the Department of Computer Science and Engineering, IIT Hyderabad since 2011. He is interested in almost all areas of theoretical computer science, and has most recently been working on combinatorics, graph theory and graph algorithms of late.

COURSE PLAN :

Week 1: Introduction to the course, Polynomial time reductions, P and NP classes, Review of NP Completeness, P vs NP

Week 2: NP Complete problems, Cook-Levin Theorem, Polynomial Hierarchy

Week 3: Time Hierarchy Theorem, Space Complexity, Savitch’s Theorem, NL-Completeness, NL = coNL

Week 4: PSPACE Completeness, Space Hierarchy Theorem, Ladner Theorem, Oracles

Week 5: Baker-Gill-Solovay Theorem, Randomized Complexity Classes

Week 6: Randomized Complexity Classes(contd.), BPP is in polynomial hierarchy, Circuit Complexity

Week 7: Circuit Hierarchy Theorem, P/poly complexity class, NC and AC classes, Karp-Lipton Theorem

Week 8: Parity not in AC^0, Adleman’s Theorem, Polynomial Identity Testing, Perfect Matching is in RNC^2

Week 9: Bipartite Perfect Matching is in RNC (contd.), Isolation Lemma, Valiant Vazirani Theorem, #P and #P Completeness.

Week 10: Permanent is #P Complete, Toda’s Theorem

Week 11: Communication Complexity, Lower bound techniques, Monotone depth lower bound for matching.

Week 12: Introduction to Interactive Proofs, #3-SAT is in IP, Private and Public Coin Interactive proofs, Course summary.