CSE: Introduction to Complexity Theory

Programme: B.Tech (CSE) Year: 3rd/4th Semester: 6/7/8
Course: Program Elective Credits: 3 Hours: 40

Course Context and Overview (100 words):
The first section of this course talks about what are the functions which are computable and not computable. In other words what is the limit of computation? In the second half of the course we will study different kind of complexity classes which have arisen by different model of computations and computation with resource constraints. The amount of time a computation will take define time complexity of our computation, similarly, the amount of memory used by our computation define space complexity of computation. Since, we have very limited time and memory resources, studying these complexity is an important task of computation. Now, instead of one CPU if we run a finite number of CPU for a computational task then we have parallelized our computation process and it gives a notion of parallel complexity classes, when our moves of Turing machine become probabilistic then it gives a different model of computation, it has named as randomized computation which gives randomized complexity classes. This course is beneficial to those students who want to learn further in the area of theoretical computer cience.

Prerequisite: Discrete Mathematics, Formal Languages and Automata

Course outcomes (COs):

After the completion of this course, the student will have the ability to:
CO1: Understand the functions which are not computable.
CO2: Limits of the mathematical proof system.
CO3: Understanding of the various notions of complexity classes.
CO4: Understanding of the relation between the different complexity classes.

Course Topics:

Contents	**Lecture Hours**	**Unit Hours**
Unit 1: Review of Turing machine and decidability		8
1. Review of Turing machine	4	
2. Non Turing recognizable languages	1	
3. Decidable and undecidable problems	2	
4. Reducability	1	
Unit 2: More topics on computability theory		3
1. Recursion theorem	1	
2. Godel's incompleteness theorem	1	
3. Kolmogorov complexity	1	

Unit 3: Time complexity		15
1. Class P	1	
2. Class NP	1	
3. Cook Levin Theorem	2	
4. NP-Complete	4	
5. Co-NP, EXP, and NEXP	1	
6. Time hierarchy theorems	1	
7. Non deterministic time hierarchy theorem	1	
8. Ladner theorem	2	
9. Oracle and limits of diagonalization	2	
Unit 4: Space complexity		7
1. Definitions and Savitch's theorem	2	
2. PSPACE-Complete	2	
3. L, NL, NL-Complete	2	
4. NL=co-NL	1	
Unit 5: Randomized complexity classes (If time permits)		7
1. Probabilistic Turing machine	1	
2. RP, co-RP, ZPP	2	
3. BPP	2	
4. IP	2	

Text Book:

1. Theory of Computation by Michael Sipser, Cengage Learning, India Edition, For unit 1 and 2.
2. Computational Complexity: A Modern Approach by Sanjeev Arora and Boaz Barak, Cambridge University Press, First Edition, For unit 3, 4 and 5 or any further study in this area.

Evaluation Methods:

Component	Weightage
Quiz	20%
Assignments	10%
Midterm	30%
Endterm	40%

Date: 5/01/2019 **Prepared by:** Mrityunjay Singh