BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

FIRST SEMESTER 2020-2021
Course Handout Part II

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

Course No. : **CS F351**
Course Title : **Theory of Computation**
Instructor-In-Charge : **VISHAL GUPTA (vishalgupta@pilani.bits-pilani.ac.in)**
Instructors : **Dr. Shashank Gupta (shashank.gupta@pilani.bits-pilani.ac.in)**
Dr. Vinti Agarwal (vinti.agarwal@pilani.bits-pilani.ac.in)
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1. Course Description
Finite automata and regular languages, equivalence, closure properties, context free languages and push down automata – equivalence, closures properties, concepts in parsing; Turing machines; computability :decidability and semi-decidability, recursive and mu-recursive functions, Church-Turing hypothesis, undecidable problems – the halting problem, reductions between languages, complexity classes – P, NP, and NP-completeness

2. Objective
To provide a theoretical foundation for the process of computation and to impart an understanding of the notions of automata, formal languages, computability and complexity classes.

3. Scope
This course covers basic concepts of formal models of computation and computability. It introduces a hierarchy of machines and languages to capture classes of computable sets. It concludes with a generic notion of computability, and complexity classes of computable functions.

4. Textbook
1. Elements of Theory of Computation, Harry Lewis and Chistos Papadimitrou, Second Edition, Pearson Education, Asia 1998

5. Reference Books
1. Introduction to Automata Theory, Languages and Computation, John Hopcroft, Rajeev Motwani and Jeffrey Ullman, Second Edition, Pearson, Asia 2001
2. Introduction to Theory of Computation, Michael Sipser.

6. Lecture Modules

	Module	Learning Objective
1	Background and Introduction (1 Lecture)	To understand the basic concepts and notation
2	Finite automata and regular languages (10 lectures)	To understand finite automata as recognizers of languages and regular expressions as specifiers of languages. To understand the expressive power and limitations of finite automata and regular expressions

3	Context free languages and push down automata (15 lectures)	To understand context free grammars as specifiers and push down automata as recognizers of languages. To understand the expressive power and limitations of context free grammars and PDAs
4	Turing machines (7 lectures)	To understand Turing machines as recognizers of languages and theoretical models of general purpose computers
5	Computability and decidability	To understand the models of computable specifications and equivalences. To understand the notion of decidability
6	Complexity of classes (7 lectures)	To understand the classification of computable problems based on the notions of complexity of computation

7. Lecture Schedule

Lecture No.	Modules	Topics
1	Background and Introduction	Computation, Computational Models, Formal Languages, Automata, Basic Terminologies: Symbol, Input Alphabet, Language, Finite Strings
2-6	Regular Languages and Finite Automata	Introduction: Deterministic Finite Automata (DFA), Non-Deterministic Finite Automata (NFA), Equivalence of NFA and DFA, NFA with e (Null) Moves, Conversion of epsilon NFA to DFA, Minimization of DFA
7-11	Regular Expression	Regular language, Designing of Regular Expressions, Identities of Regular Expression, Equivalence of Finite Automata with Regular Expression, Closure Properties of Regular Expression. Non-Regular Languages: Pumping Lemma for Regular Expression
12-15	Context-Free Grammar (CFG)	Introduction: Context-Free Languages (CFL), Designing of CFG. Ambiguity in CFG, Simplification of CFG: Normal Forms. Closure Properties
16-20	Pushdown Automata (PDA)	Pushdown Automata (PDA): Designing of PDA, Acceptance Mechanisms, Equivalence of Context-Free Grammars with PDA, Deterministic Context-Free Languages, Relationship of CFG with Deterministic Pushdown Automata (DPDA)
21 - 26	Parsers	Top down parsers, Bottom up parsers
26-31	Turing Machine	Formal definition of a Turing machine, Designing of Turing Machine, Recursive Languages and Recursive Enumerable languages, Variants of Turing Machines: Multitape Turing machines, Nondeterministic Turing machines. Decidability, Halting Problem
32 – 37	Computability Theory	Notion of Algorithms, Decidability and Un-decidability, Computability theory and Turing Machines, Proving problems to be decidable and un-decidable.
38 – 41	Complexity Theory	Notion of Class-P, Class-NP, Class-NPC. Proving problems to be under these classes.

8. Extended Lecture Schedule

	Lec No	Topic	Reference(sections of textbook)
1	1	Introduction and motivation	1.1-1.3

	2	Infinite sets, proofs	1.4-1.5
	3	Closures	1.6
	4	Alphabets, languages, and representations	1.7-1.8
2	5	Deterministic finite automata	2.1
	6	Non-deterministic finite automata	2.2
	7,8	Closure properties and equivalences	2.3
	9	Regularity	2.4
	10	State Minimization	2.5
	11	Context free grammars	3.1
	12,13	Parse trees and ambiguity	3.2
	14	Push down automata	3.3
	15	Equivalence of PDA and CFG	3.4
	16,17	Properties of context free languages	3.5
	18	Determinism and parsing, DCFG	3.7
	19,20	top-down and bottom-up parsing	3.7
	21	Turing machines - introduction	4.1
	22	Turing machines - notation	4.1
	23	Recursive and recursively enumerable languages	4.2
	24,26	Random access Turing machines	4.3
	27	Non-deterministic Turing machines	4.5
	28	Grammars	4.6
	29	Primitive recursive functions	4.7
	30	Mu-recursive functions	4.7
	31	Church-Turing thesis and universal computing machines	5.1,5.2
	32	Halting problem	5.3
	33,34	Undecidable problems	5.7
	35	Properties of recursive languages	5.7
	36,37	The complexity class P	6.1,6.2
	38	Satisfiability	6.3
	39	The complexity class NP	6.4
	40	NP Completeness and Reducibility	7.1
	41	NP Completeness - Problems	7.2

9. Evaluation Scheme

Component	Mode	Duration	Date	Weightage
Test 1	Closed Book	30 Mins	TBA (Sept 10 – Sept – 20)	*15%
Test 2	Closed Book	30 Mins	TBA (Oct 09 – Oct 20)	*15%
Test 3	Closed Book	30 Mins	TBA (Nov 10 – Nov 20)	*15%
Test 4	Closed Book	30 Mins	TBA	*15%
Surprise Quizzes (3 Nos) During Tutorial hour	Open Book	10 Mins each	During Tutorial Hour	# 05%
Comprehensive Exam	Partly Open Book	180 Mins	As per AUGSD	35%

12. Make UP Policy:

- *Test 1, *Test 2, *Test 3, and *Test 4 would have one make up combined. This means, that a student can abstain herself/himself (on valid reasons) in one Test. This make up would be conducted at last and would include complete syllabus. Of course, the student would apply for the make up in advance with documentary proof.
- #Three **surprise quizzes** (for 2.5% weightage each) would be conducted during tutorial hours. There would be no explicit make up for these. Out of three, marks of best two would be taken for final grading.
- *Only on producing documentary proof of possible absence, which proves that student would be physically unable to appear for the test/exam, the decision of granting the make-up will be taken*.

- Prior Permission of AUGSD is required to get make-up for the comprehensive exam.

10. Notices and Announcements

Necessary notices, course announcements, uploading of marks of each component will be done on BITS-Nalanda. You are requested to check its website periodically. E Mail will be used as and when required.

11. Consultation Hour

Instructor	**Hour**
Shashank Gupta	Thursday, 5-6 PM
Vinti Agarwal	Thursday, 11 AM – 12 Noon
Vishal Gupta	Thursday, 11 AM – 12 Noon
Shail Saharan	Tuesday's, 5-6 PM

12. Open Book Policy

The prescribed text book, reference books listed in the handout and hand written (student's own) class notes are the only materials that will be allowed.

Instructor In-Charge
CS F351