

# THEORY OF COMPUTATION

## 1. Introduction

**Objective:** This course aims to give an understanding of the theoretical foundations of computer science. Study of simple models of computation leading to the model for the modern world digital computer, the Turing machine, is one of the primary goals along with understanding limits of computability.

**Credits: 3-0-0**

## 2. Course Outline

### UNIT - I: Preliminaries on Alphabets and Languages

Finite and infinite sets, fundamental proof techniques.

### UNIT - II: Regular Languages (RL)

Definition and examples; Regular expressions (RE), Non-deterministic Finite automata (NFA),  $\epsilon$ -NFA and Deterministic Finite automata (DFA); Equivalence of RE, NFA and DFA; Conversions from RE to ( $\epsilon$ -) NFA to DFA to RE; Minimal DFA; Moore machine, Mealy machine; Closure properties of RL; Pumping lemma for RL.

### UNIT - III: Context-Free Languages (CFL)

Definition and examples; Grammar formalism for regular languages, Context free grammar (CFG), Derivation trees, Ambiguity, Normal forms; Push down automata (PDA) (deterministic and non-deterministic); Equivalence of CFG and PDA; Closure properties of CFL; Pumping lemma for CFL.

### UNIT - IV: Turing Machine (TM)

Definition of TM; Examples; Variants of TM: Multi-tape and other versions of TM; Nondeterministic TM; Equivalence; Church-Turing Thesis; Universal Turing Machine

### UNIT - V: Decidability and Undecidability

Definition of decidability; decidable problems concerning RL, CFL; Recursive and recursively enumerable (re); Undecidability; The Halting problem; Cantor's diagonalization argument; Examples of undecidable problems: Post's correspondence problem.

## 3. Reading Material

### Text Books

1. Introduction to Automata Theory, Languages and Computation, by John. E. Hopcroft, Rajeev Motwani, J. D. Ullman, published by Pearson Education Asia, 2006.
2. Introduction to Languages and the Theory of Computation, by John C. Martin, published by Tata McGraw Hill, 2003

### Reference Books:

1. Elements of the Theory of Computation, by H.R. Lewis and C.H. Papadimitrou, published by Prentice Hall Inc, 1981.
2. Introduction to Computer Theory by Daniel I.A. Cohen, published by Wiley India, 1991.

### Suggested Assignments:

Construction of DFA, Regular expression, CFG, PDA, TM for a specified language.

### Sample assignments:

1. Write a regular expression and construct DFA for the set of all strings  $\{0,1\}^+$  in which each block of  $_i$ ve consecutive symbols contains at least two 0's. Minimize your DFA.
2. Devise a Context free grammar that recognizes the language  $\{w \in \{a, b, c\}^+ : n_a(w) < n_b(w)\}$  where  $n_x(w)$  denotes the number of occurrences of the symbol  $x$  in  $w$  explaining each rule. Construct a push down automaton that recognizes this language.
3. Construct a Turing machine that recognizes the language  $\{w \in \{a, b, c\}^+ : n_a(w) < n_b(w) < n_c(w)\}$ . First write the idea behind the machine and then show the  $\delta$ -function