Academia International College

Bachelor of Science in Computer Science and Information Technology
Teachers Orientation Program
Paush 1-2, 2066

Course Title: Theory of Computation

Course no: CSC-251 Full Marks: 90+10

Credit hours: 3 Pass Marks: 36+4

Nature of course: Theory (3 Hrs.)+ Tutorials (3 Hrs.)

Course Synopsis: Deterministic and non-deterministic finite state machines, regular expressions, languages and their properties. Context free grammars, push down automata, Turing machines and computability, undecidable and intractable problems, and Computational complexity.

Goal: To gain understanding of the abstract models of computation and formal language approach to computation.

Course contents:

Unit 1: **14 Hrs.**

1.1 **Review of Mathematical Preliminaries:** 1 Hrs.

- Quick review of Sets, Logic, Functions, Relations, Languages, Proofs.

1.2 **Finite Automata:** **7 Hrs.**

- Introduction of Finite State Machine
- Deterministic Finite Automata(DFA): Formal Definition, Notation of DFA, Extending the transition function of DFA,Language accepted by DFA
- Non-deterministic Finite Automata(NFA): Formal Definition, Notation, Extended transition function of NFA, language of NFA, Equivalence of Deterministic and Non-deterministic Finite Automata- The Subset construction method, Theorems related to equivalence of DFA and NFA
- Finite Automata with Epsilon- Transition: Formal Definition, Notation, Extended Transition function of epsilon transition, Removing epsilon transition from epsilon NFA. Construction of DFA from epsilon NFA.
- Finite State Machine with output – Moore Machine and Mealy machine – general concepts.

1.3 **Regular Expressions and Languages**:

- Introduction to regular operators, regular languages, Precedence of regular operators
- Regular expressions, Formal definition of regular expressions,
- Equivalence of Regular Expressions and Finite Automata. Theorem for conversion from regular expression to epsilon FA.
- Application of regular expressions
- Algebraic Laws for Regular Expressions.
- Properties of Regular languages
  - Pumping Lemma and its application
  - Closure properties of regular languages with proofs.
  - Decision properties of regular languages- general concepts of decision properties, Minimization of Finite State Machine.

Unit 2: **11 Hrs.**

2.1 **Context-Free Grammar** 6 Hrs

- Introduction to CFG, using grammer rules to describe a language, formal definition to CFG.
- Derivation using grammer- Bottom up and Top down approach, Left -most and Right -most derivation.
- The language of a Grammer, sentential form, derivation-tree, construction of parse-tree for a string from a grammer.
- Ambiguous grammer, inherent ambiguity, regular grammer.
- Equivalence of regular grammer and finite automata.
- Simplification of CFG.
- Normal Forms: Chomsky and Greibach Normal forms.
- Closure properties of Context Free Language
- Pumping Lemma for Context Free Language- proving a language to be non-context free.

2.2 **Push Down Automata (PDA)** 5 Hrs

- Introduction, deterministic and non-deterministic PDA. Formal Definitions.
- Moves of PDA, Graphical representation of PDA, Instantaneous Description.
- Computation tree for PDA processing the input string.
- Language of PDA- Acceptance by final state and by empty stack
- Conversion of PDA accepting by final state to accpting by empty stack and vice-versa.(theorems)
- Equivalence of PDA and CFG – conversion from CFG to PDA and vice-versa.

Unit 3: **10 Hrs.**

Turing Machines

- Introduction to Turing Machines, Formal Definitions, Transition Diagram and transition table, Language of TM
- Roles of TM- language recognizer, concept of TM as computing a function and enumerator of strings of languages.

- Computation by Turing Machines- Programming techniques viz. storage in a state, TM with multiple tracks, subroutines.
- Variants of Turing Machines – Multi-tape Turing Machine, Non-deterministic Turing Machines, Equivalence of one tape and multi-tape TM(related theorems), Concept of Turing Enumerable Language.
- Church's Thesis and Algorithm
- Universal Turing Machines
- Concept of Halting Problems
- Turing Machines and Computers- Simulating a TM by computer, simulating a real computer by a Turing Machine.

Unit 4: **10 Hrs.**

4.1 Undecidability 6 Hrs

- Concepts of Recursive and Recursively Enumerable Languages.
- Encoding of Turing Machine, the diagonalization language, complements of RE language
- Proof of Universal Language Theorem.
- Concepts of Unrestricted Grammars and Chomsky Hierarchy.
- Unsolvable Problems by Turing Machines.
- Undecidable Problems, Post's Correspondence Problems.

4.2 Computational Complexity and Intractable Problems 4 Hrs

- Measuring Complexity, Class P and Class NP
- Problems solvable in Polynomial time- Kruskal's algorithm for minimum weight spanning tree.
- Non- deterministic Polynomial time-Problem TSP
- NP- Completeness and Problem Reduction
- NP-Complete Problems
- Introduction to Satisfiability Problem
- Normal Forms for Boolean Expressions

Text Book:

John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, **Introduction to Automata Theory, Languages, and Computation,** Second Edition, Addison-Wesley, 2001. ISBN: 81-7808-347-7

References:

1. Efim Kinber, Carl Smith, **Theory of Computing: A Gentle introduction,** Prentice- Hall, 2001. ISBN: 0-13-027961-7.

2. John Martin, **Introduction to Languages and the theory of computation,** 3rd Edition, Tata McGraw Hill, 2003, ISBN:0-07-049939-X

3. Harry R. Lewis and Christos H. Papadimitriou, **Elements of the Theory of Computation**, 2nd Edition, Prentice Hall, 1998.

Homework Assignments:

Homework assignments will be given through out the semester covering the lecture materials in each unit. The homework assignment will cover the 30% of the internal evaluation.

Pre-requisite: Discrete Mathematics, Fundamentals of Computer Programming and Data structure & algorithms.

Evaluation and Grading:

The evaluation and grading includes the 20% weitage for homework assignments and 2 mid term exam and 80 % weitage for final semester exam. The grading of the 20% internal evaluation will be as:

Homework assignment:	30%	(6 marks)
First Mid-term exam:	30%	(6 marks)
Second Mid-term exam:	40%	(8 marks)

Homework assignment will be given in at last each weekend.

Academia International College

Bachelor of Science in Computer Science and Information Technology

Model Question 2009

Course title: Theory of Computation F.M: 80

Course No: CSC-251 P.M: 32

Credit Hours: 3

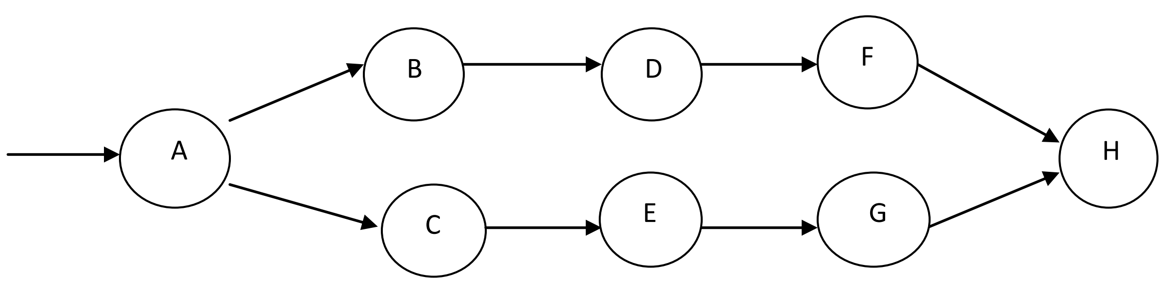
Attempt all Questions

Group A [8x4=32]

1. Differentiate the DEA and NFA with suitable examples.
2. Draw DFA for the following languages over {0,1}
   a) All strings with even no of o's and even no of 1's
   b) All strings of length at most 4.
3. Prove that NDFA = DFA
4. Convert the following grammar into Chomsky Normal form.
   $S \rightarrow AAC, A \rightarrow aAb| \in, C \rightarrow aC|a$
5. How a CFG can be converted into PDA? Convert the following CFG into PDA.
   $$S \rightarrow aAB, A \rightarrow aS|bS|a, B| \rightarrow Sa|Sb|b$$
6. Describe about the Universal Turing Machine.
7. Construct a Turing Machine accepting a language of palindrome over {a,b}* with each string of even length.
8. Explain about recursive and recursively enumerable language

Group B: [6x8=48]

9. Define a NFA with epsilon transition. Explain how a ∈-NFA is converted into DFA? Convert the following ∈-NFA into equivalent DFA.



10. State and prove the pumping lemma for regular language. Show that the language $L=\{a^m b^m \mid m \geq 1\}$ is not a regular language.
11. Define Context Free Grammar. Given the following grammar

$S \rightarrow aB|bA$

$A \rightarrow a|aS|bAA$

$B \rightarrow b|bS|aBB| \in$

For the string **aabbbaabaaab**, find the left-most, right-most derivation and construct a parse tree.

12. Define the PDA and its language with suitable example. Explain how a PDA accepting by empty stack can be converted into PDA accepting by Final stack?
13. Explain multi-tape Turing Machine. Show that every language accepted by a multi-tape Turing Machine is recursively enumerable.
14. Explain the Chomsky hierarchy of the languages.

End

Marks Distribution:

1. Unit 1: 24-28 Marks(2 to 3 questions in Group A and 2 questions in Group B)
2. Unit 2: 20-24 Marks(1 to 2 questions in Group A and 2 questions in Group B)
3. Unit 3: 16 Marks(2 questions in Group A and 1 questions in Group B)
4. Unit 4: 12-16 Marks(1 to 2 questions in Group A and 1 questions in Group B)

Note: Each questions may be asked by breaking down into more than one questions.