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: 80+20
Credit hours: 3 Pass Marks: 32+8

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 6 Hrs

- 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 grammar rules to describe a language, formal definition of CFG.
- Derivation using grammar – Bottom up and Top down approach, Left-most and Right-most derivation.
- The language of a Grammar, sentential form, derivation-tree, construction of parse-tree for a string from a grammar.
- Ambiguous grammar, inherent ambiguity, regular grammar.
- Equivalence of regular grammar and finite automata.
- Simplification of CFG.
- Normal Forms: Chomsky and Greibach Normal forms.
- Closure properties of Context Free Languages
- 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 strings.
- Language of PDA- Acceptance by final state and by empty stack
- Conversion of PDA accepting by final state to accepting 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), Concepts of Turing Enumerable Languages.
- 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

- Concept 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 least each weekend.

Bachelor of Science in Computer Science and Information Technology
Model Question 2009

Course Title: Theory of Computation

Course No: CSC -251 F.M: 80

Credit Hours: 3 P.M: 32

Attempt all questions

Group A [8 × 4 =32]

1. Differentiate the DFA 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 lf 1's
   b) All strings of length at most 4.

3. Prove that NDFA = DFA

4. Convert the following grammar into Chomsky Normal from.
   S→AAC, A→aAb** | ∈ **, C→ aC | a

5. How a CFG can be converted into PDA? Convert the following CFG into PDA.
   S → aAB, A → aS | bS | a, B → Sa | Sb | b

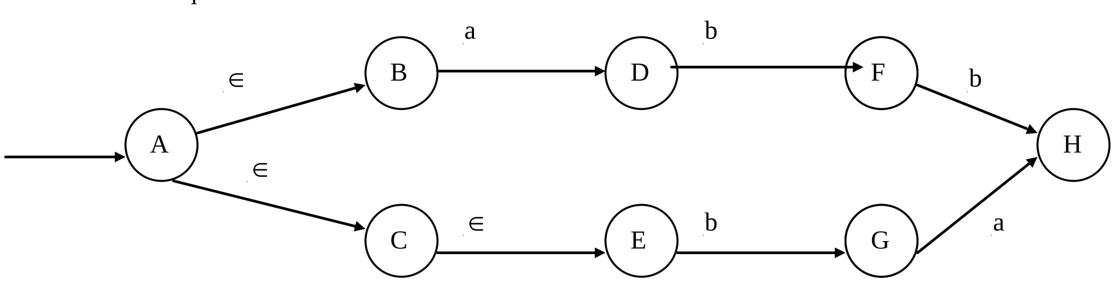
6. Describe about the Universal Turing Machine.

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 languages

Group B:[6 × 8 = 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 → aB | bA
    A → a | aS | bAA
    B → b | bS | aBB | ∈

    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 in to 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 question in Group B)
4. Unit 4: 12 – 16 Marks (1 to 2 questions in Group A and 1 question in Group B)

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

Subject Expert:

1. Hemanta GC Patan Multiple Campus / ASCOL

Participants

1. Dhiraj Kedar Pandey Siddanath Science Campus, Mahaendra nagar

2. Kamal Raj Sharma St. Xavier College, Kathmandu