FORMAL LANGUAGES AND AUTOMATA THEORY

COURSE OBJECTIVE

The purpose of this course is to acquaint the student with an overview of the theoretical foundation of computer science from the perspective of formal languages

- To classify machines by their power to recognize languages
- Employ finite state machines to solve problems in computing.
- Explain deterministic and non-deterministic machines
- Comprehend the hierarchy of problems arising in the computer sciences.

JNTU SYLLABUS

UNIT-I

Fundamentals: Strings, Alphabet, Language, Operations, Finite state machine, definitions, finite automaton model, acceptance of strings, and languages, deterministic finite automaton and non deterministic finite automaton, transition diagrams and language recognizers.

UNIT-II

Finite Automata: NFA with ε transitions - Significance, acceptance of languages. Conversions and Equivalence: Equivalence between NFA with and without ε transitions, NFA to DFA conversion, minimization of FSM, equivalence between two FSM's, Finite Automata with output-Moore and Melay machines.

UNIT-III

Regular Languages: Regular sets, regular expressions, identity rules, Constructing finite Automata for a given regular expressions, Conversion of Finite Automata to Regular Expressions, Pumping lemma of regular sets, closure properties of regular sets (proofs not required)

UNIT-IV

Grammar Formalism: Regular grammars - right linear and left linear grammars, equivalence between regular linear grammar and FA, inter conversion, Context free grammer, derivation trees, sentential forms Rightmost and leftmost derivation of strings.

UNIT-V

Context Free Grammars: Ambiguity in context free grammars, Minimization of Context Free Grammars, Chomsky normal form, Greiback normal form, Pumping Lemma for Context Free Languages. Enumeration of Properties of CFL (proofs omitted).

UNIT - VI

Push down automata: Push down automata, definition, model, acceptance of CFL, Acceptance by final state and acceptance by empty state and its eqivalence. Equivalence of CFL and PDA, interconversion. (Proofs not required), introduction to DCFL and DPDA.

UNIT - VII

Turing Machine: Turing Machine, definition, model, design of TM, Computable functions, recursively enumerable languages. Chruch's hypothesis, counter machine, types of Turing machines (Proofs not required).

UNIT - VIII

Computability Theory: Chomsky hierarchy of languages, linear bounded automata and context sensitive language,LR(0) grammar, decidability of problems, Universal Turing Machine, undecidability of posts Correspondence problem, Turing reducibility, Definition of P and NP problems, NP complete and NP hard problems.

SUGGESTED BOOKS

TEXT BOOKS :

T1 : Hopcroft H.E. & Ullman J.D., '***Introduction to Automata Theory Languages and Computation'*** - Pearson Education

T2 : Thomson, ***'Introduction to theory of computation'***,-Sipser 2nd edition

REFERENCE BOOKS :

R1 : Daniel I.A. Cohen, John Wiley, ***'Introduction to languages and the Theory of Computation'***.

R2 : John C Martin, ***'Introduction to languages and the Theory of Computation'*** - McGraw Hill.

R3 : Lewis H.P. & Papadimition ***'Elements of Theory of Computation'*** - C.H. Pearson/PHI.

R4 : Mishra and Chandrashekaran, ***'Theory of computer science - Automata, Languages, and Computation'***, 2nd edition, PHI

SESSION PLAN :

Topics in each unit as per JNTU syllabus	Lecture No.	Modules / Sub-modules for each topic	Text Books / References Books
UNIT – I			
Fundamentals	1	Introduction to the Subject - FLAT	
	2	Strings, Alphabet, Language, Null String, Operations	T1: 1.5, R4: 1.3

Finite State Machine	3	Finite State Machine, definitions with examples	T1: 2.1, R4: 2.1
Finite Automata	4	Finite Automaton Model, Acceptance of Strings and Languages	T1: 2.2, R4: 2.5
Types of Finite Automata	5	Deterministic Finite Automaton and Non Deterministic Finite Automaton	T1: 2.2, R4: 2.6
Applications of Finite Automata	6	Transition Diagrams, Language Recognizers	T1: 2.2, R4: 2.6
	7	Tutorial	
	8	Revision – UNIT I	
UNIT – II			
NFA with ε-transitions	9	NFA with ε-transitions - Definition with examples, Significance Acceptance of languages	T1:2.5.1
Equivalence and Conversions	10-11	Equivalence and Conversions of NFA with ε-transitions and NFA without ε-transitions	T1:2.5.5
	12-13	Equivalence and Conversions of NFA and DFA	T1:2.3.5, R4: 2.7
Minimization of Finite State Machine	14	Minimization of FSM	T1:4.4,R4:2.9
Equivalence of Finite State Machines	15	Equivalence between two FSMs	T1:4.4,R4:2.9
Finite Automata with output	16-17	Finite Automata with output - Moore and Mealy Machines – definitions with examples	R4: 2.8
Conversions	18	Conversion of Moore Machine to Mealy Machine	R4: 2.8
	19	Conversion of Mealy Machine to Moore Machine	T1:4.4, R4: 2.8
Designing Machines	20	Designing Machines	T1:4.4, R4: 2.9
	21	Tutorial	
	22	Revision – UNIT II	

UNIT – III			
Regular Languages	23	Regular Sets, Regular Expressions Identity Rules	T1:3.1, R4: 4.1
Conversions	24	Constructing Finite Automata for a given Regular Expression	T1:3.2, R4: 4.2
	25	Conversion of Finite Automata to a Regular Expression	T1:3.2, R4: 4.2
Importance of Regular Sets	26	Pumping lemma of Regular Sets	T1:4.1, R4: 4.3
	27	Closure properties of Regular Sets	T1:4.2, R4: 4.5
	28	Tutorial	
	29	Revision – UNIT III	
UNIT – IV			
Grammar Formalism	30	Regular Grammars - Right Linear and Left Linear Grammars - Definitions with examples	R4: 4.6
Equivalence and Conversions	31	Equivalence between regular linear grammar and FA	R4: 4.6
	32	Converting a Regular Grammar to a FA	R4 :4.6
	33	Converting a FA into a regular grammar	R4: 4.6
Context Free Grammar	34	Context Free Grammar – Definition with examples	T1:4.9 R4: 4.7
Derivation Trees	35	Derivation Trees, Sentential Forms	T1:5.1 R4: 5.1
		Right most and left most derivation of strings	T1:5.1 R4: 5.1
	36	Tutorial	
	37	Revision – UNIT IV	
UNIT – V			
Ambiguity and Minimization of Context Free Grammars	38	Ambiguity in Context Free Grammars	T1:5.4 R4: 5.2

	39	Minimization of Context Free Grammars	T1: 7.1.1-7.1.4 R4: 5.3
Normal Forms	40	Chomsky Normal Form	T1: 7.1.5 R4: 5.4
	41	Greiback Normal Form	T1: 7.1.5 R4: 5.4
Context Free Languages	42	Pumping Lemma for Context Free Languages	T1:7.2
	43	Enumeration of properties of CFL	T1:7.3,7.4
	44	Tutorial	
	45	Revision – UNIT V	

UNIT – VI			
Push Down Automata	46	Push Down Automata Definition, Model, Acceptance of CFL	T1: 6.1, 6.2 R4: 6.1,6.2
Acceptance and Equivalence	47	Acceptance by final state, Acceptance by empty state and its equivalence	T1: 6.1, 6.2 R4: 6.1,6.2
Equivalence and Conversions	48	Equivalence of CFL and PDA Converting CFL to PDA	T1: 6.3, R4: 6.3
	49	Converting PDA to CFL	T1: 6.3, R4: 6.3
Introduction to DCFL and DPDA	50	Deterministic CFL (DCFL) Deterministic PDA(DPDA)	T1: 6.4
	51	Tutorial	
	52	Revision – UNIT VI	
UNIT – VII			
Turing Machine	53	Turing machine - Definition, Model	T1: 8.2, 8.3 R4: 7.1-7.5
Design of Turing Machines	54	Design of TM - complement	T1: 8.2, 8.3 R4: 7.1-7.5
	55	Design of TM – add, substract	T1: 8.2, 8.3 R4: 7.1-7.5
	56	Design of TM – multiply, divide	T1: 8.2, 8.3 R4: 7.1-7.5
Applications of Turing Machine	57	Computable Functions, Recursively Enumerable Languages	T1: 8.6, T1: 9.3

	58	Church's Hypothesis	T1: 8.2.2
		Counter Machine	T1:8.4
Types of Turing Machines		Types of Turing machine	T1:8.5.3
	59	Tutorial	
	60	Revision – UNIT VII	
UNIT – VIII			
Computability Theory	61	Chomsky Hierarchy of Languages, Linear Bounded Automata Context SensitiveLanguage	R4:7.6,8.1
LR Grammars	62	LR(k) grammar, properties	R4:7.7
		LR(0) grammar, decidability of problems	R4:7.7
Extensibility of Turing Machine	63	Universal Turing Machine, Turing Reducibility	T1:9.1,9.2
Posts Correspondence Problem		Undecidability of posts Correspondence problem	T1:9.3,9.4
P and NP Problems		P and NP problems NP complete and NP hard problems	T1:10.1,10.2
	64	Tutorial	
	65	Revision – UNIT VIII	

BOOKS REFERED BY FACULTY :

T1 : Hopcroft H.E. & Ullman J.D., '***Introduction to Automata Theory Languages and Computation'*** - Pearson Education

R4 : Mishra and Chandrashekaran, ***'Theory of computer science - Automata, Languages, and Computation'***, 2nd edition, PHI

WEBSITES :

1. www.ieee.org
2. www.acm.org/dl
3. www.cs.vu.nl
4. www.cs.unm.edu
5. www.people.westminstercolleg.edu

JOURNALS :

1. IEEE transactions on Computer Science
2. IEEE transactions on Fuzzy Systems
3. IEEE transactions on Neural Networks
4. IEEE Computer magazine
5. IEEE transaction in software engineering

STUDENTS SEMINAR TOPICS

1. Languages of context free grammars, RAIRO infrimatique theoeique applications, Jurgen Dassow, Victor Mitrana, Page No. 257 – 267
2. Finite automata over free groups International Journal of Algebra and computation Jurgen Dassow, Victor Mitrana,Page No. 725 - 737
3. On the Regularity of languages generated by context free evolutionary grammars, Discrete applied mathematics Jurgen Dassow, Gheorghe paun Page No. 205 - 209
4. Computer studies of Turing machine problems, Journal of the Association for computing machinery, Lin s and Rado.T. Page No. 196 - 212

GUEST LECTURE TOPICS :

1. Church's Hypothesis
2. P and NP problems
3. NP complete and NP hard problems
4. Universal Turing machine
5. Counter machines

ASSIGNMENT QUESTIONS :

UNIT- I

1. Explain Finite State Machine?
2. Draw the block diagram of Finite State Machine?
3. Explain the different operations performed on sets?
4. Explain The terms String, Alphabet?
5. Explain the term Language?
6. Explain the Acceptance of strings And Languages?
7. Describe the Non deterministic finite automata?
8. Describe the Deterministic finite automata?

9. Write the procedure to convert NFA to DFA?

10. Explain Transition diagrams?

11 Describe language recognizers?

12. Construct an NFA that accepts all strings such that the fifth symbol from the left end is zero. Over the alphabet { 0,1}

13 Give a Deterministic Finite automata (DFA) accepting the set of all strings over the alphabet {a,b} having three consecutive a's

14. i. Differentiate NFA and DFA with respected to transition and acceptance.
    ii. Draw DFA which accepts even no a's over the alphabet {a, b}
    iii. Construct DFA equivalent to the following Finite state machine.
15. What is the generating function G (z) for the sequence of fibonacci numbers?

16. Construct a finite state machine with minimum no of states accepting all strings over (a, b), such that the no of a's is divisible by two and the no of b's is divisible by three.
17. Given that L is a language accepted by a finite state machine , show that Lp and LR are also accepted by some finite state machines , where Lp={s?ss'? L some string .s'}
    LR={s?s obtainable by reversing some string in L}

18. Which of the following set can be recognizing by a deterministic finite-state automaton?
    i. The numbers 1, 2, 4, 8,……………2n,………written in binary.
    ii. The numbers1, 2, 4,…………, 2n,……..written in unary.
    iii. The set of binary string in which the number of zeros is the same as the number of ones.
    iv. The set {1, 101, 11011, 1110111, ……}

19. The string 1101 dose not belong to the set represented by
    i. 110*(0+1) ii. 1(0+1)*101
    iii. (10)*(01)*(00+11)* iv. (00+(11)*0)*

20. What is the difference between kleen closure and positive closure??

UNIT-II

1. Construct an NFA for 110(0+1)*(10+01)*

2. (a) Constance state Transition Table for the Moore machine given in Figure below.

3. Construct a minimum automation equivalent to a given automation.
   A b Output
   q0 q1 q2 0
   q1 q2 q3 0
   q2 q3 q4 1

q3 q4 q4 0
q4 q0 q0 0

4. Give Mealy and Moore machines for input from (0+1+2)* that gives residue modulo 4 of the input treated as binary

5. Give Moore and Melay machines for input from (0+1+2)* that prints the residue modulo 5 of the input treated as ternary(base 3)

6. Prove: Let ‘L’ be a set accepted by a non deterministic finite automata. Then there exists a DFA that accepts “ L “

7. Construct state transition table for the following Moore machine

8. For the following NFA, compute the equivalent DFA.

9. Prove that for every NFA there will be equivalent DFA.
10. Give Mealy and moore machines for input from (0+1)* that gives residue modulo 4 of the input treated as binary

11. Explain the procedure for minimization of an Finite State machine, with the help of an example

12. A finite state machine with the following state table has a single input x and a single out z.

13. Let Nf and Np denote the classes of languages accepted by non-deterministic finite automata and non-deterministic push - down automata, respectively. Let D1 and D2 denote the classes of languges accepted by deterministic finite automata and determininstic push - down automata respectively. which one of the following is TRUE. **(Gate 05)**
    a) Df Nf and Dp Np   b) Df Nf and Dp =Np
    c) Df =Nf and Dp =Np   d) Df =Nf and Dp Np

14. Explain moor e and mealy machines

15. Construct the Moore machine for given Mealy machine.

16. Minimize the Finite automation given below and show both given and reduced are equivalent.

17. Define NFA mathematically. Explain its significance and the functioning. Convert the given Finite automation into Deterministic equivalent. Explain a method used. Taking suitable example prove both accept the same strings.
18 Construct the Moose machine for given Melay machine.

19. Given below are the transactions diagrams from two finite state machines M1and M2 recognizing Languages L1and L2 respectively.
    i. Display the transition diagram for a machine to recognizes L1, L2, obtained from transition diagram for M1 and M2by adding only & transitions and no new states.

ii. Modify the transition diagram obtained in part (a) obtain a transition diagram for a machine that recognizes (L1 L2) by adding only ? transitions and no new states.

20. The language recognized by M is.
    a) {W ? {a,b} * | every a in w is followed by exactly two b's}
    b) {W ? {a,b} * | every a in w is followed by at least two b's}
    c) {W ? {a,b} * | W contains the substring "abb"}
    d) {W ? {a,b} * | W does not contain "aa" as a substring}

UNIT - III

1. List the closure properties of regular sets and explain any two of them. **(**

2. State and explain Arden's theorem with a suitable example.

3. Construct FA for regular expression 0*1 + 10.

4. Construct a FA accepting all strings over {a, b} ending in aba or aaba.

5. Show that L = is not regular. State and explain the theorem used.

6. State and explain pumping Lemma.

7. Prove L = {R/ (a/b)} is not regular.

8. Construct FA which accepts the regular expression 10+(0+11)0*1.

9. (a) Find the regular grammar for the following automata.

10. (a) Construct the NFA for the regular expression r =0*1 + 10.
    (b) Consider the FA and construct regular expressions that is accepted by it.
11. If L1 and L2 are recursive languages then show that L1?L2 and L1? L2 are also recursive.

12. Show that the language
    L = { 0n 1n/ n ? 0}
13. Define and Explain the terms Regular sets, Regular expressions and closure properties

14. Give the recursive definition for regular expression

15. With the help of recursive definition above definition, prove whether the following expression is regular or not. E = (0+1)* 111*

16. Explain Pumping Lemma with example

17. Give the word description for the following regular expression
    i. 111 0* (0+1) ii. 11 (
    iv. 110(0+1)* (10+01)*
18. For the following Regular expressions, give the corresponding FSA. (Eliminate E-Transitions, if any)

i. 11(0+1 (01)*) ii. 11 (

19. Give the pumping Lemma : explain its applications, with an example

20. Prove the following identities
    (AB)*A = A(BA)* where A, B are regular expressions

UNIT - IV

1. (a) Construct an DFA for the following regular grammar

2. Eliminate all unit and 2-productions from

2. (a) Define the ‘Handler’. For the derivation aabb find the viable prefixes of the grammar shown below.

3. When an item is said to be complete, find the sets of LR(0) items.

4. (a) Construct finite automata recognizing the following grammar.
   ,

5. Describe the language generated by the grammar

6. Give the rigorous definition for a derivation tree and give an example.
7. Construct a regular grammar G generating the regular set represented by a*b(a+b)*.

8. Give the CFG to generating the following sets The set of all strings of balanced parenthesis

9. Consider the grammar G = (V, E, R S) where
   V = {a, b, s, A}
   E = {a, b}
   R = { S → a A a,
   S → bAb
   S → A
   A → SS }
   Construct a derivation tree and left most derivation to yield the string baabbb in G

10. Let G be a grammar with productions
    S → aB | bA
    A → a | bs| bAA
    B → b | bs | a | bB
    Check whether aaabba is in L(G).

11. Construct the CFG that generates the language
L = {WC W R / W Є {a, b}* }

12. Consider the CFG, G = (V, T, P, S) where V = {S, A}, T = {a, b}, P = {S ?AA, A?AAA, A?a, A?bA, A?Ab}. Give leftmost and rightmost derivations for the string babbab. Specify whether the CFG is Ambiguous or Not

13. For the following Finite State Machine Construct an equivalent grammar

14. What are right linear and left linear grammars. Construct left-linear and right-linear grammars for the language 110*(1(0+1))*

15. List the properties of Context Free Languages

16. Prove the following identity
(0*01+10)*0* = (0+01+10)*

17. Construct right-linear and left linear grammars for the following regular expression
11(0+1)* 11 (1+0)*

18. Construct right-linear and left linear grammars for the following regular expression
101(0+1)* (10+01)*

19. Construct left linear and right linear grammars for the language 11(0+1)* 00 (0+1)*

20. Construct the NFA for the regular expression r = 0*1 ((0+1)0*1)* (2+(0+1) (00)*)+0(00)*

UNIT-V

1. Design a PDA to accept the following CFG

2. Explain properties of C.F. languages.

3. Discuss the Chomsky Hierarchy of languages.

4. For the grammar shown below construct the sets of LR(0)items.

5. Construct PDA to accept the strings generated by following CFG
S→ aABC
A→aB/C
B→bA/b
C→a.

6. Let G= ({S}, {a, b} R, S) be ? context free grammar where the rule set R is
S? ?S b? S S ??

7. A grammar G is in Chomsky-normal form (CNF) if all its productions are of the form A→BC or A→a, where A, B and C are non-terminals and a is a terminal. Suppose G is a CFG in CNF and W is a string in L(G) of length, then how long is a derivation of W in G.

8. Give a CFG for the even palindrome over the alphabet (0,1) and design a pushdown automata for the same.

9. Convert the following Grammar to GNF S → AA | a , A → SS | b

10. Construct a PDA equivalent to the following grammar:
    S → aAA, A → aS | bS | a
11. Find a Greibach normal-form grammar equivalent to the following CFG.
    S → AA | 0
    A → SS | 1 | 0.

12. Write short notes on Ambiguous Grammar

13. Consider the following statements about the context free grammar.
    I. G is ambiguous
    II. G produces all strings with equal number of a's and b's
    III. G. can be accepted by a deterministic PDA
    Which combination below expresses all the true statements about G?

14. Find a Greibach normal-form grammar equivalent to the following CFG.
    S → AA| a
    A →SS | b

15. Write short notes on CFL proparties?

16. What is meant by Ambiguous Grammar?

17. Show that the grammar
    S→ a | abSb | aAb
    A→ bS | a Aab
    is ambiguous

18. Reduce the following Grammars to the Chomsky normal form
    S → 1A | 0B
    A → 1AA | 0S | 0
    B → 0BB | 1S |1

19. Show that the grammar is ambiguous.
    S → aB | ab
    A →a AB | a
    B → AB | b

20. Define and Explain the terms, Chomsky' s normal form, Greibach normal-form

UNIT - VI

1. (a) Construct Push Down Automata equivalent to the grammar and verify the result for aabaaa. ,

2. Prove or explain that if L is a Context Free Language then there exists an equivalent Push Down Automata.

3.. (a) Construct PDA for the grammar
S-> aA
A->aABC/bB/a
B-> b
C-> c

4. Convert the following to CNF
S-> 0S0/1S1/A
A-> 2B3
B-> 2B3/

5. Prove that the grammar is ambiguous
S-> aSb/SS/

6. Prove that the grammar is ambiguous
S-> aB/aaB, A-> a/Aa, B-> b

7. (a) Convert the following grammar to CNF
S-> AB
A->a
B->C/b
C->a

8. Design a PDAto accept the language.
L={anbmcman/m,n,1}
9. Explain LBA?

10. Give the CNF of the following grammar.
$S \rightarrow AB \mid CA$
$B \rightarrow BC \mid AB$
$A \rightarrow a$
$C \rightarrow aB \mid b$

11. 'Every context free language is not a context sensitive.' Why? Discuss withthehelp of productions.

12. What do you mean byprefix property of DCFL.

13. Discuss theconcept the conceptofviableprefix witha suitable example.
14. 'Every context free language is not a context sensitive.' Why? Discuss with the help of productions.

15. What do you mean by prefix property of DCFL.

16. Discuss the concept of viable prefix with a suitable example.
17. Write short notes on DCFL and DPDA

18. Obtain a PDA to accept the language {L = an b2n / n ? 1}.
19. Convert the following grammar to GNF
    S → Ba/ab
    A → aAB/a
    B → ABb/b
20. Convert the following grammar to CNF
    S → AB1/0
    A → 00A/0

UNIT-VII

1 Construct Turing machine to accept following language and give its state transition table and diagram. Check the machine by tracing a suitable instance. L={an bm an+m;n 0, m 1}.

2. Explain the Turing reducibility in detail.

3. Construct Turing machine to accept following language and give its state transition table and diagram. Check the machine by tracing a suitable instance. L = { an bn an bn / n 1}.

4. Give formal definition of Turing Machine and explain the concept behind saying "Turing Machine is more powerful than the digital computer".

5. Design Turing Machine To compliment a given binary number.

6. Design Turing Machine To compute f(x,y) = x+y for x and y positive integers represented in Unary.

7. Discuss different languages and their corresponding machines.

8. Explain how a "RAM computer" can be simulated using Turing Machine.

9. Design a Turing machine to multiply two integers.

10. Write short notes on "Modifications of Turing Machines."

11. Design a Turing Machine to recognize the language. L = { an bn cn / n 1}.

12. Write short notes on Halting problem of Turing Machine.

13. What do you mean by "reduction"? Explain the Turing reducability.

14. What is LBA? Explain its model

15. Explain the halting problem of Turing machine; discuss why this problem is undecidable

16. Let M=({q0,q1},{0,1},{z0,X},?,q0,z0,?) be a pushdown automaton where ? is given by
?(q0, 1, z0) = {(q0, x z0)}
?(q0,? z0) = {(q0,?)}
?(q0, 1, X) = {(q0, XX)}
?(q1, 1, X) = {(q1,?)}
?(q0, 0, X) = {(q1, X)}
?(q1, 0, z0) = {(q0, z0)}
i. What is the language accepted by this PDA by empty store?
ii. Describes informally the working of the PDA.

17. Design a Turing machine to recognize the language { 1n 2n 3n

18. Design T.M
Design a T. M for the following function:-
F(x,y) = MAX (x, y)

19. Define Turing Machine formally; explain how Turing Machine can be used to compute integer functions. Design the Turing Machine to compute following function, show its transition diagram also f(x, y) = xy where x and y are positive integers represented in unary.

20 . Design a Turing machine to recognize the language {1n 2n 3n | n ? 1 }.

UNIT VIII

1. Construct LR(0) items for the grammar given, find its equivalent DFA. Check the
parsing by taking a suitable derived string. » is null.

2. Explain NP hard problems?

3. Write short notes on Reducability?

4. Explain PCP?

5. Describe UTM.?

6. Is concept of universal gates like Nor and Nand and the universal Turing machine same. Explain the UTM in detail

7. What is modifiedversion PCP? Show or explain that if the PCP is decidable then modified PCP is also decidable.

8. (a) Discuss different languages and their corresponding machines.
(b) Writethe design procedureofshift reduce parserby takingasuitableexample.

9. Explain the terms: NP complete and NP hard problems with exampls.

10. Design a Turing Machine to enumerate:
{0n 1n | n ? 1}

11. What is decidability? Explain any two undecidable problems.

12. Show that the following post correspondence problem has a solution and give the solution.

i	List A wi	List B xi
1	11	111
2	100	001
3	111	11

13. Discuss different languages and their corresponding machines.

14. Write the desing procedure of shift reduce passer by taking a suitable example.

15. Write short notes. LR(0) grammar.

16. Describe Context sensitive Languages.

17. Discuss Church's hypothesis.

18. Chomsky hierarchy of Languages .
19. Construct LR(0) itemsfor the grammar given, find its equivalent DFA. Check the parsing by taking a suitable derived string. is null.

20. Explain Rice's theorem for undecidable problems.

QUESTION BANK:

UNIT - I

1. (a) Find NFA which accepts the set of all strings over f0; 1g in which the number of occurrences of 0 is divisible by 3 and the number of occurrences of 1 is divisible by 2.
   (b) Draw the transition diagram for a NFA which accepts all strings with either two consecutive 0's or two consecutive 1's.
   (c) Differentiate NFA and DFA. **(Nov 09,Reg)**

2. (a) Define String, Alphabet and Language.
   (b) Prove that if $\delta(q,x) = \delta(q,y)$, then $\delta(q,xz) = \delta(q,yz)$ for all strings z in $\sum+$.
   (c) Construct DFA and NFA accepting the set of all strings with three consecutive 0's. **(Nov 09**, **Reg**)

3. (a) Draw the transition diagram of a FA which accepts all strings of 1's and 0's in which both the number of 0's and 1's are even.
   (b) Construct NFA which accepts the set of all strings over f0; 1g in which there are at least two occurrences of 1 between any two occurrences of 0. Construct DFA for the same set. **(Nov 09,Reg)**

4. (a) Construct DFA and NFA accepting the set of all strings not containing 101 as a substring.
   (b) Draw the transition diagram of a FA which accepts all strings of 1's and 0's

in which both the number of 0's and 1's are even.

(c) Define NFA with an example **(Nov 09**, **Reg**)

5. Construct NFAs for the following languages
(a) The set of strings over alphabet {0,1,.........,9} such that the final digit has appeared before.
(b) The set of strings over alphabet {0,1,........,9} such that the final digit has not appeared before.
(c) The set of strings of 0's and 1's such that there are two 0's separated by a number of positions that is a multiple of 4. Note that 0 is an allowable multiple of 4. **(Nov 09**, **sup**)

6. Design DFA for the following languages shown below: ∑ ={a, b }
(a) L={w | w does not contains the sub strings ab}.
(b) L={w|w contains neither the sub strings ab nor ba}
(c) L={w|w is any string that doesn't contain exactly two a's }
(d) L={w|w is any string except a and b} **(Nov 09**, **sup**)

7. Design DFA for the following over {0,1}
(a) All string containing not more than three 0's
(b) All strings that has at least two occurrences of 1 between any two occurrences of 0.
(Nov 09, **sup**)

8. (a) Design a NFA for the language L ={aba^n | n>=1}.
(b) Design a DFA, M that accepts the language. L(M) ={w |w ∑ {a,b}* and w does not contain 2 consecutive b's. **(Nov 09**, **sup**)

9. (a) Design a DFA for the following language. L = {0m1n/m _ 0 and n _ 1} **(Nov 08)**
(b) Represent all five tuples for below transition (diagram 1b) and decide whether it is DFA or NFA

10. (a) Design a DFA that accepts the set {an}U{b/n _ 1} **(Nov 08,Nov 07)**
(b) Draw the transition diagram for below FA.
M= { {A,B,C,D}, {0,1}, ,C, {A,C} }
(A,0) = (A,1) = {A,B,C}
(B,0) = B, (B,1) = { A, C }
(C,0) = {B,C}, (C,1) ={ B, D }
(D,0) = { A, B, C, D }
(D,1) = {A}.

11. Construct DFA for the following: **(Feb 08)**
(a) L={w/w has both an even number of 0’s and even number of 1’s }
(b) L= { w/w is in the form of ‘x01y’ for some strings x and y consisting of 0’sand 1’s}.

12. (a) Explain the differences between NFA and DFA **(Feb 08)**
(b) Design a DFA which accepts all strings which are ending with 101 over an Alphabet {0,1}.

13. Construct NFAs for the following languages **(Nov 07)**

(a) The set of strings over alphabet {0,1,.........,9} such that the final digit has appeared before.

(b) The set of strings over alphabet {0,1,........,9} such that the final digit has not appeared before.

(c) The set of strings of 0’s and 1’s such that there are two 0’s separated by a number of positions that is a multiple of 4. Note that 0 is an allowable multiple of 4.

14. Construct DFA for the following: **(Nov 07)**

(a) L={w/w has both an even number of 0’s and even number of 1’s }

(b) L= { w/w is in the form of ‘x01y’ for some strings x and y consisting of 0’s and 1’s}.

UNIT – II

1. (a) Write the steps in construction of minimum automaton.
   (b) Write the applications of Finite Automata.
   (c) Define NFA with Є-moves. **(Nov 09,Reg)**

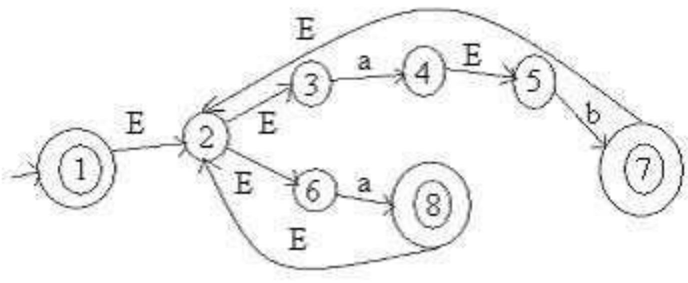
2. (a) Write the steps in minimization of FA.
   (b) Construct a Moore machine to determine the residue mod 3 for each binary string treated as a binary integer. **(Nov 09,Reg)**

3. (a) Define NFA with Є-moves.
   (b) Differentiate Moore and Mealy machines.
   (c) Write the steps in minimization of FA. **(Nov 09,Reg)**

4. (a) Write the steps in construction of minimum automaton.
   (b) Discuss about Finite Automata with outputs in detail. **(Nov 09, Reg)**

5. (a) Design a Moore Machine to determine the residue mod 4 for each binary string treated as integer.
(b) Design a Mealy machine that uses its state to remember the last symbol read
and emits output `y' whenever current input matches to previous one, and emits n otherwise.
(Nov 09, **sup**)

6. For the following NFA with 2 -moves convert it in to an NFA with out 2 -moves
and show that NFA with 2-moves accepts the same language as shown in _gure



(Nov 09, **sup**)

7. Minimize the following DFA.

_	0	1
q0	q1	q3
q1	q2	q4
q2	q1	q4
q3	q4	q2
q4	q4	q4

(Nov 09, **sup)**

8. (a) Design a Moore Machine to determine the residue mod 4 for each binary string treated as integer. **(Feb 08)**
   (b) Des ign a Mealy machine that uses its state to remember the last symbol read and emits output 'y' whenever current input matches to previous one, and emits n otherwise.

9. For the following NFA with 2 -moves convert it in to an NFA with out 2 –moves and show that NFA with 2-moves accepts the same language as shown in figure **(Feb 08)**

10. (a) Design a Moore machine to determine the residue mod 5 for each ternary string (base 3) treated as ternary integer. **(Feb 08)**
    (b) Convert the following Mealy machine into equivalent Moore machine as shown in figure

11. Construct DFA for given (figure 2) NFA with 2-moves. **(Feb 08)**

12. For the following NFA with 2 -moves convert it in to an NFA with out 2 –movesand show that NFA with 2-moves accepts the same language as shown in figure **(Feb 08)**

13. Construct DFA for given (figure 2) NFA with 2-moves. **(Feb 08)**

14. (a) Shown in figure 2a **(Feb 08)** Con
    (b) Describe the language accepted by automata as shown in figure

15. (a) Design a Moore Machine to determine the residue mod 4 for each binary string treated as integer.
    (b) Design a Mealy machine that uses its state to remember the last symbol read and emits output 'y' whenever current input matches to previous one, and emits n otherwise.

16. Define NFA mathematically. Explain its significance and function. Convert thegiven Finite automaton into its Deterministic equivalence. Explain method used.Taking suitable example and prove both accept the same string. **(Feb 07)**

17. (a) Construct the Moore machine for Figure 2 Melay machine. **(Feb 07)**
    Figure 2:
    (b) Minimise the Finite automation given Figure 3 below and show both given and reduced are equivalent. **(Feb 07)**

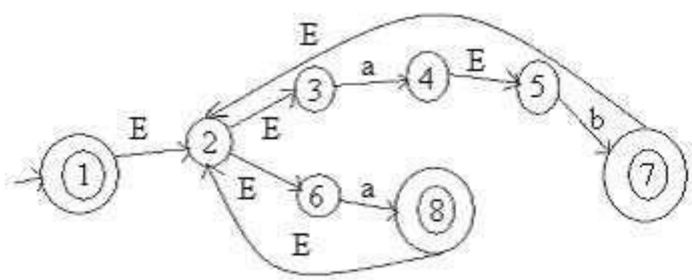
UNIT – III

1. Describe, in the English language, the sets represented by the following regular expressions:
(a) a(a+b)*ab
(b) a*b + b*a **(Nov 09, Reg)**

2. (a) Prove the following identity: (a*ab + ba)* a* = (a + ab + ba)*
(b) Construct transition systems equivalent to the regular expression
(ab + a)* (aa +b) **(Nov 09,Reg)**

3. (a) Show that L = fww j w " fa, bg*g is not regular.
(b) Is L = fa2n j n>= 1g regular? **(Nov 09, Reg)**

4. For the following NFA with 2 -moves convert it in to an NFA with out 2 –moves and show that NFA with 2-moves accepts the same language as shown in figure



(Nov 09, sup)

5. Find a Regular expression corresponding to each of the following subsets over {0,1}*. **(Feb 08)**
   (a) The set of all strings containing no three consecutive 0's.
   (b) The set of all strings where the 10th symbol from right end is a 1.
   (c) The set of all strings over {0,1} having even number of 0's & odd number of 1's.
   (d) The set of all strings over {0,1} in which the number of occurrences of is divisible by 3.

6. Construct NFA for the following regular expressions **(Feb 08)**
   (a) 0+10* +01*0 (b) (0+1)*(01+110).

7. Give the English description and NFA for the following regular expressions. **(Feb 08)**
   (a) r=(1+01+001)*(+0+00)
   (b) r=[00+11+(01+10)(00+11)*(01+10)]*

8. Give a regular expression for the set of all strings over {a, b} accepting all strings(Feb 08) which have number of a's divisible by 6 and number of b's divisible by 8.

9. Find a Regular expression corresponding to each of the following subsets over {0,1}*. **(Feb 08)**
   (a) The set of all strings containing no three consecutive 0's.
   (b) The set of all strings where the 10th symbol from right end is a 1.
   (c) The set of all strings over {0,1} having even number of 0's & odd number of 1's.
   (d) The set of all strings over {0,1} in which the number of occurrences of is divisible by 3.

10. Construct a DFA accepting language represented by 0*1*2*. **(Feb 08)**

11. Find a Regular expression corresponding to each of the following subsets over {0,1}* **(Feb 08)**
    (a) The set of all strings containing no three consecutive 0's.
    (b) The set of all strings where the 10th symbol from right end is a 1.
    (c) The set of all strings over {0,1} having even number of 0's & odd number of 1's.
    (d) The set of all strings over {0,1} in which the number of occurrences of is divisible by 3.
    [4×4]

12. Find Regular Expression for the following NFA's.
    (a) Figure 3a

    (b) Figure 3b

13. (a) List the closure properties of regular sets and explain any two of them. **(Feb 07)**
    (b) State and explain Arden's theorem with a suitable example.
    (c) Construct FA for regular expression 0*1 + 10.

UNIT – IV

1. (a) If G=({S}, {0, 1}, {S→0S1, S→Є},S), find L(G).
(b) Construct a G so that L(G) = $\{a^n ba^m \mid m,n >= 1\}$ **(Nov 09, Reg)**

2. (a) Construct a G so that L(G) = $\{a^n ba^m \mid m,n >= 1\}$
(b) If G is S→aS | a, then show that L(G) = $\{a\}^+$ **(Nov 09, Reg)**

3. (a) Construct a grammar G generating {xx | x Є {a, b}*}
(b) Construct a grammar generating L = $\{wcw^r \mid w$ Є {a, b}*} **(Nov 09, Reg)**

4. (a) Obtain a CFG to generate unequal number of a's and b's. **(Feb 08,Nov 07)**
    (b) Obtain a CFG to obtain balanced set of parentheses.(i.e every left parentheses should match with the corresponding right parentheses).

5. (a) Obtain a regular grammar to obtain the set of all strings not containing three consecutive 0' s.
    (b) Obtain a CFG to generate the set of all strings over alphabet {a ,b} with exactly twice as many a's as b's.

6. (a) Obtain a Right Linear Grammar for the language **(Feb 08)**
    L = {anbm |n >= 2,m >= 3 }
    (b) Obtain a Left Linear Grammar for the DFA as shown in figure

7. (a) Obtain regular grammar for the following FA as shown in figure **(Nov 07)**

    (b) What is the language accepted by above FA? **(Nov 07)**

8 . (a) Obtain a regular grammar to obtain the set of all strings not containing three consecutive 0' s.
(b) Obtain a CFG to generate the set of all strings over alphabet {a ,b} with exactly twice as many a's as b's.

9. (a) Construct an DFA for the following regular grammar **(Feb 07)**

(b) Eliminate all unit and 2-productions from

10. (a) Define the 'Handler'. For the derivation aabb find the viable prefixes of the grammar shown below. **(Feb 07)**

(b) When an item is said to be complete, find the sets of LR(0) items.

UNIT –V

1. (a) Eliminate productions from the grammar G given as
A→ aBb | bBa
B → aB | bB | Є **(Nov 09, Reg)**

(b) Convert the following grammar to Greibach Normal Form
S → ABA | AB | BA | AA | B
A → aA | a
B → bB | b **(Nov 09, Reg)**

2. What is Chomsky Normal Form? Convert the following Context Free Grammar to Chomsky Normal Form.
S→AaB | aaB
A→ Є
B→ bbA | Є **(Nov 09, Reg)**

3. (a) What do you mean by ambiguity? Show that the grammar S àS/S, S à a is ambiguous.
(b) Show that the grammar G with production
Sa/aAb/abSb
AaAAb/bS is ambiguous. **(Feb 08)**

4. (a) Show that L = {aibj/j = i2} is not context free language. **(Feb 08)**
(b) List the properties of CFLs.
(c) Find if the given grammar is finite or infinite.
SAB, ABC/a, BCC/b, Ca.

5. (a) Simplify the grammar= { {S,A, B, C, E }, {a,b,c}, P, S } **(Feb 08,Nov 07))**
Where, P is S AB
A a
B b
B C
E c/^
(b) Prove that the following language is not context-free language
L = {www |w 2 {a, b}"} is not context free.

6. (a) Reduce the Grammar G given by SàaAa **(Nov 07)**

ASb/bcc/DaA

Cabb/DD

Eac

DaDA

into an equivalent grammar by removing useless symbols and useless productions from it.

(b) Convert the following grammar into CNF.

SaAD

AaB/bAB

Bb

Dd.

7. (a) What do you mean by Greibach Normal Form (GNF). **(Nov 07)**

(b) When is a CFG said to be in GNF?

(c) Convert the following grammar into GNF :

SAB

ABS/b

BSA/a.

8. (a) Reduce the Grammar G given by **(Nov 07)**

SaAa

ASb/bcc/DaA

Cabb/DD

Eac

DaDA

into an equivalent grammar by removing useless symbols and useless productions from it.

(b) Convert the following grammar into CNF.

SaAD

AaB/bAB

Bb

Dd.

9. (a) Define the context free grammars in the 4 tuple form. (V, T, P, S) for the given languages on _ (a, b). **(Nov 07)**

i. All strings having atleast two 'a's.

ii. All possible strings not containing triple 'b's.

(b) Find the context free grammar with no useless symbols equivalent to

SAB/Ca, BBC/AB, Aa, CaB/b.

(c) State in English about the language corresponding to below given grammar

SaB/bA, Aa/aS/bAA , Bb/bS/aBB.

10. (a) Design a PDA to accept the following CFG **(Feb 07)**

(b) Explain properties of C.F. languages.

UNIT – VI

1. (a) Explain the procedure to convert Context Free Grammar to Push Down Automata

(b) Convert the following Context Free Grammar to Push Down Automata

$S \rightarrow aAA$
$A \rightarrow aS|bS|a$

(Nov 09, Reg)

2. (a) Convert the following Context Free Grammar to Push Down Automata

$S \rightarrow aA \mid bB$
$A \rightarrow aB \mid a$
$B \rightarrow b$ **(Nov 09, Reg)**

(b) Verify the string aab is accepted by equivalent Push Down Automata

3. Design Push Down Automata for the language L= $\{ww^r \mid w \sum(0+1)^* \}$

(Nov 09, Reg)

4. (a) Explain the terms: Push Down Automata and context free language. **(Feb 08)**
   (b) Let G be a CFG with the following productions.
   S a B c
   A a b c
   B a A b
   C A B
   C c
   Construct a PDA M such that the language generated by M and G are equivalent.

5. (a) Construct the PDA for the following grammar. **(Feb 08)**
   SAA/a ASA/b
   (b) Design a PDA for the following grammar.
   S-0A A0AB/1 B1.

6. Show that the languages **(Feb 08)**
   (a) L1={0n1m/n = m and n_ 1}
   (b) L2={0n1m / n=2m and n_ 1}
   Are deterministic context free languages?

7. (a) Let G be the grammar given by **(Feb 08)**
   SaABB/aAA,
   AaBB/a,
   BbBB/A
   Construct the PDA that accepts the language generated by this grammar G.
   (b) Define Deterministic pushdown automata. Explain with an example.

8. (a) Construct the PDA for the following grammar. **(Nov 07)**
   SAA/a ASA/b
   (b) Design a PDA for the following grammar.
   S0A A0AB/1 B1.

9. (a) Find the PDA with only one state that accepts the language {ambn : n > m } **(Nov 07)**
   (b) Construct the PDA that recognizes the languages L={x=×R: x2{a,b}+}.

10. (a) Let G be the grammar given by **(Nov 07)**
    SaABB/aAA,
    AaBB/a,
    BbBB/A

Construct the PDA that accepts the language generated by this grammar G.

(b) Define Deterministic pushdown automata. Explain with an example.

11. (a) Find the CFG corresponding to PDA whose transition mapping is as follows **(Nov 07)**

ä(S,a,×)=(s,A×)

ä(S,b,A)=(s,AA)

ä(S,a,A)=(s, ^).

(b) Let G be a CFG that generates the set of palindromes given by

SaSa/bSb/a/b

Find the PDA that accepts L(G).

UNIT - VII

1. Design Turing Machine for L = $\{0^n 1^n 0^n \mid n >= 1\}$ **(Nov 09, Reg)**
2. Design Turing Machine which will recognize strings containing equal number of 0's and 1's **(Nov 09, Reg)**
3. Design Turing Machine to find out GCD of two given numbers. **(Nov 09, Reg)**
4. Design Turing Machine for L = $\{a^n b^n c^n \mid n >=1\}$ **(Nov 09, Reg)**

5. Give a Turing machine for the following: **(Feb 08, Nov 07)**
   (a) That computes ones complement of a binary number
   (b) That shifts the input string, over the alphabet (0,1) by one position right by inserting ‘#2 as the first character.

6. (a) Design a Turing Machine that accepts the set of all even palindromes over { 0,1}. **(Feb 08)**
   (b) Given _ = {0,1}, design a Turing machine that accepts the language denoted by the regular expressions 00_.

7. Define Turing machine formally; explain how Turing machine can be used to compute integer functions. Design the Turing machine to compute following function, Show its transition diagram also f(x,y)=xy where x and y are positive integers represented in unary. **(Nov 07)**

8 Design a T.M for copying of information from one place to the other place. Assume all the necessary. Assumptions. Give Example of the working of your T.M. **(Nov 07)**

9. (a) What are the types of T.M’s explain in brief; **(Nov 07)**
   (b) Explain the importance of Turing machine concept.

10. ConstructTuring machine to accept following language and give it state transition table and diagram. Check the machine by tracing a suitable instance. L=$\{a^n b^m a^{n+m}; n\ 0,\ m\ 1\}$. **(Feb 07)**

UNIT - VIII

1. Construct LR(0) items for the grammar given and it’s equivalent DFA.

   S1→ S
   S → AS | a
   A → aA | b **(Nov 09, Reg)**

2. Write about the following

(a) Linear-Bounded Automata
(b) Context-Sensitive Language
(c) Decidability of PCP. **(Nov 09, Reg)**

3. Construct LR(0) items for the following grammar
S→ SA | A
A→ aSb | ab **(Nov 09, Reg)**

4. Construct LR(0) items for the following grammar
E→ E + T | T
T→ T * F | F
F→ (E) | id **(Nov 09, Reg)**

5. (a) What is decidability? Explain any two undecidable problems. **(Feb 08)**
(b) Show that the following post correspondence problem has a solution and give the solution.

I	List A	List B
1	11	11
2	100	001
3	111	11

6. (a) Find whether the post correspondence proble P={(10,101),(011,11),(101,011)} has a match. Give the solution. **(Feb 08,Nov07)**
(b) Explain Turing reducibility machines.
(c) Show that if L and L? are recursively enumerable, and then L is recursive.

7 (a) Explain about Deterministic context free language and D PDA. (Feb 08,Nov07)
(b) Show that L={anbncn : n >= 1} is a CSL.

8. Give LR(0) items for the grammar SàaAB, AàaAb/ab, BàaB/a. Find its equivalent DFA. Check the parsing by taking a suitable string. **(Nov 07)**

9. What are NP-complete and NP-hard problems? Explain them with examples. **(Nov 07)**