Semester: V						
FINITE AUTOMATA AND FORMAL LANGUAGES (Theory)						
Course Code	**:**	18CS52		**CIE Marks**	**:**	100
Credits: L:T:P	:	3:0:0		**SEE Marks**	**:**	100
Total Hours	:	39L		**SEE Duration**	**:**	3 Hrs

1. Find a grammar that generates $L=\{ a^n b^{n+1} : n>=0\}$
2. Find a grammar that generates the language $L = \{w: n_a (w) = n_b (w)\}$
3. Consider the grammar $G= (\{A,S\},\{a,b\},S,P_1)$ with P_1 consisting of the production $S\rightarrow aAb \mid \lambda$, $A\rightarrow aAb \mid$. Find the language generated by this grammar.
4. Find grammars for $\Sigma = \{a,b\}$ that generate the sets of (a) all strings with exactly one a, (b) all strings with atleast one a.
5. Find grammars for the following languages on $\Sigma = \{0\}$. (a) $L= \{w:|w| mod3 =0\}$,(b) $L = \{ w: |w| mod3>0\}$.
6. Convert the following NFA to a DFA

δ	0	1
→p	{p,q}	{p}
q	{r}	{r}
r	{s}	Φ
*s	{s}	{s}

7. Convert to a DFA the following NFA

δ	0	1
→p	{q,s}	{q}
*q	{r}	{q,r}
r	{s}	{p}
*s	Φ	{p}.

8. Consider the following ε-NFA.(a) Compute the ε-closure of each state. (b) Convert the automaton to a DFA.

δ	ε	a	b	c
→p	Φ	{p}	{q}	{r}
q	{p}	{q}	{r}	Φ
*r	{q}	{r}	Φ	{p}

9. Do same as (8) for

δ	ε	a	b	c
→p	{q,r}	Φ	{q}	{r}
q	Φ	{p}	{r}	{p,q}
*r	Φ	Φ	Φ	Φ

10. Let L be the language accepted by a NFA M_N. Show that there exists a DFA M_D such that $L(M_N) = L(M_D)$.
11. Define a regular expression(RE). Write RE for the language consisting of the set of strings over alphabet {a,b,c} containing at least one a & at least one b.

12. Write REs for the following languages over{0,1} (a) the set of all strings of 0's & 1's such that every pair of adjacent 0's appears before any pair of adjacent 1's. (b) All strings ending in 01.
13. Find the language generated by the following REs (a) $r = (a+b)^*(a+bb)$ (b) $r = (aa)^*(bb)^*b$
14. Show that if r is a RE then there exists a finite automata which accepts L(r).
15. Define regular language. If L is a regular language then prove that there exists a RE r such that L = L(r).
16. Transition table for a DFA is give below

δ	0	1
→p	q	p
q	r	p
*r	r	q

(a) give all the REs $R_{ij}^{(0)}$. (b) Give all the REs $R_{ij}^{(1)}$. Simplify the expressions as much as possible. (c) Construct the transition diagram for the DFA & give a RE for its language by eliminating state q.

28. Convert the following DFA to a RE, using the state elimination technique

δ	0	1
→*p	s	p
q	p	s
r	r	q
s	q	r

29. Convert the following REs to NFA's with ε-transitions. (a) 01* , (b) 00(0+1)*.
30. Write a note on applications of REs.
31. State and prove Pumping Lemma(PL) for regular languages.
32. Prove that following languages are not regular using PL. (a) $\{0^n1^n : n \geq 1\}$ (b) $\{0^n10^n : n \geq 1\}$.
33. Using PL show that the following languages are not regular. (a) $\{0^n$: n is a perfect square$\}$ (b) $\{0^n1^m : m \geq n\}$.
34. If L & M are regular languages then show that LUM is also regular language.
35. If L is a regular language over alphabet Σ then prove that Σ^* - L is also a regular language.
36. If L & M are regular languages then prove that $L \cap M$ is also regular.
37. Show that L-M is regular language if L & M are regular.
38. If L is a regular language prove that L^R is also regular.
39. If L is a regular language over alphabet Σ & h is a homomorphism on Σ then prove that h(L) is also regular.
40. Let h be the homomorphism from the alphabet {0,1,2} to the alphabet {a,b} defined by h(0) = a, h(1) = ab, & h(2) = ba. (a) What is h(0120), h(21120)? (b) If L is the language $L(01^*2)$, what is h(L)? (c) If L is the language $L(a(ba)^*$ what is $h^{-1}(L)$?
41. Define equivalence of states. What are distinguishable & indistinguishable states.
42. Minimize the states of the following DFA using table-filling algorithm.

δ	0	1
→A	B	A
B	A	C

C	D	B
*D	D	A
E	D	F
F	G	E
G	F	G
H	G	D

43. Do same as (42) for the following DFA

δ	0	1
$\rightarrow$A	B	E
B	C	F
*C	D	H
D	E	H
E	F	I
*F	G	B
G	H	B
H	I	C
*I	A	E

44. Define CFG, leftmost derivation, rightmost derivation, language of a grammar, sentential form, derivation tree, parse tree.

45. Design CFG for the following languages (a) $\{0^n1^n : n\geq1\}$ (b) $\{a^ib^jc^k : i\neq j \text{ or } j\neq k\}$.

46. Consider the grammar G with productions $S\rightarrow A \mid B$, $A\rightarrow 0A \mid \varepsilon$, $B\rightarrow 0B \mid 1B \mid \varepsilon$. Give leftmost & rightmost derivations of the following strings (a) 00101 (b) 1001.

47. Given the following CFG $E\rightarrow E+T \mid T$, $T\rightarrow T*F \mid F$, $F\rightarrow (E) \mid a \mid b \mid c$ draw parse tree for the following sentences (a) (a+b)*c (b) (a)+b*c.

48. Define ambiguous grammar & inherent ambiguity in a grammar with an example.
49. Show that the following grammar ambiguous $S\rightarrow AB \mid aaB$, $A\rightarrow a \mid Aa$, $B\rightarrow b$. Construct an unambiguous grammar equivalent to above grammar.
50. Show that the following grammar is ambiguous. Also obtain unambiguous grammar for the following grammar $E\rightarrow E+E \mid E*E \mid E/E \mid E-E \mid (E) \mid a \mid b$.
51. Let G be the grammar $S\rightarrow aA \mid a \mid SS$, $A\rightarrow SbA \mid ba$. For the string aabaa find (a) leftmost derivation (b) rightmost derivation (c) derivation tree.
52. Define CNF & GNF, Useless productions, Unit productions, λ-productions.
53. Eliminate all useless productions from the grammar $S\rightarrow aS \mid AB$, $A\rightarrow bA$, $B\rightarrow AA$.
54. Eliminate all useless productions from the grammar $S\rightarrow AB \mid CA$, $A\rightarrow a$, $B\rightarrow BC \mid AB$, $C\rightarrow aB \mid b$.
55. Eliminate useless productions from $S\rightarrow a \mid aA \mid B \mid C$, $A\rightarrow aB \mid \lambda$, $B\rightarrow Aa$, $C\rightarrow cCD$, $D\rightarrow ddd$.
56. Eliminate all λ-productions from $S\rightarrow AaB \mid aaB$, $A\rightarrow\lambda$, $B\rightarrow bbA \mid \lambda$.
57. Find a CFG without λ-productions equivalent to the grammar defined by $S\rightarrow ABaC$, $A\rightarrow BC$, $B\rightarrow b \mid \lambda$, $C\rightarrow D \mid \lambda$, $D\rightarrow d$.
58. Eliminate all unit productions from the grammar $S\rightarrow Aa \mid B$, $B\rightarrow A \mid bb$, $A\rightarrow a \mid bc \mid B$.
59. Eliminate all unit productions from the grammar $E\rightarrow T \mid E+T$, $T\rightarrow F \mid T*F$, $F\rightarrow I \mid (E)$, $I\rightarrow a \mid b \mid Ia \mid Ib \mid I0 \mid I1$.

60. Put the grammar with productions given below into CNF $S \to ASB \mid \varepsilon$, $A \to aAS \mid a$, $B \to SbS \mid A \mid bb$.
61. Convert the following grammar into CNF $S \to 0A0 \mid 1B1 \mid BB$, $A \to C$, $B \to S \mid A$, $C \to S \mid \varepsilon$.
62. Transform the grammar with productions $S \to abAB$, $A \to bAB \mid \varepsilon$, $B \to Baa \mid A \mid \varepsilon$ into CNF.
63. Convert the following grammar into GNF $S \to AA \mid 0$, $A \to SS \mid 1$.
64. Convert the grammar $S \to ab \mid aS \mid aaS$ into GNF.
65. Convert the grammar $S \to ABb \mid a$, $A \to aaA \mid B$, $B \to bAb$ into GNF.
66. State & prove Pumping Lemma(PL) for Context Free Languages(CFL).
67. Using CFL PL show that $\{ a^i b^j c^k \mid i<j<k \}$ is not CFL.
68. Using CFL PL show that $\{0^i 1^j \mid j = i^2 \}$ is not CFL.
69. Show that CFL's are closed under union & concatenation.
70. Prove that CFL's are closed under closure & homomorphism.
71. Show that CFL's are not closed under intersection.
72. Define PDA. Design a PDA to accept the language $L = \{ ww^R \mid w$ is a string consisting of 0's and 1's$\}$. Draw transition diagram.
73. Define NPDA. Design a PDA to accept the language $L = \{ a^i b^j c^k : i+j = k, i \geq 0, j \geq 0\}$. Draw the transition diagram.
74. Design an NPDA for $L = \{a^n b^{2n} : n \geq 0\}$.
75. Obtain a PDA to accept the language $L = \{ a^n b^n \mid n \geq 0\}$ by a final state. Give the graphical representation for PDA obtained. Show the moves made by the PDA for the string aaabbb.
76. For any CFL L, show that there exists an NPDA M such that L = L(M).
77. Construct a PDA that accepts the language generated by grammar with productions $S \to aSbb \mid a$,
78. Construct an NPDA that accepts the language generated by the grammar $S \to aA$, $A \to aABC \mid bB \mid a$, $B \to b$, $C \to c$.
79. If L = L(M) for some NPDA M then show that L is a CFL.
80. Define Turing Machine(TM). Design a TM that accepts the strings of the form $0^n 1^n$. Write transition diagram.
81. Design a TM that accepts the language $L = \{ a^n b^n c^n : n \geq 1\}$. Give graphical representation of the TM.
82. Do the same as Q(81) for $L = \{ww^R : w$ is any string of 0's & 1's$\}$.
83. Define counter machines. Describe a counter machine that accepts the language $\{0^n 1^m : 1 \leq m \leq n\}$.
84. Prove that every language accepted by a multitape TM is recursively enumerable.
85. Write short notes on (a) Multitape TM, (b) Nondeterministic TM.
86. Explain the general structure of multitape & multidimensional TMs, show that those are equivalent to standard TM.
87. Explain the programming techniques for TMs.
88. Explain the techniques for simulating a TM by computer.
89. Explain the method for simulating computer by a TM.
90. Write short notes on (a) TMs with semi-infinite tapes (b) Multistack machines.
91. What is meant by halting problem of TM? Explain the blank tape halting problem.

92. Define recursively enumerable language, recursive language & universal languages.
93. Show that if L is a recursive language so its complement.
94. Define Post's correspondence Problem(PCP) & the modified PCP
95. Write notes on (a) PCP (b) Halting problem
96. Write notes on (a) Application of Finite Automata (b) Applications of CFG's
97. Write notes on (a) Homomorphism (b) Multitape TMs.
98. Solve the PCP given below

	List A	List B
i	w_i	x_i
1	10	101
2	011	11
3	101	011

99. Solve the PCP given below

	List A	List B
i	w_i	x_i
1	11	111
2	100	001
3	111	11

100. Solve the PCP given below

	List A	List B
i	w_i	x_i
1	1	111
2	10111	10
3	10	0