Hall Ticket Number:

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Code No. : 31525 S

VASAVI COLLEGE OF ENGINEERING *(Autonomous)*, HYDERABAD

B.E. (IT) III Year I-Semester Supplementary Examinations, May/June-2018

Theory of Automata

Time: 3 hours Max. Marks: 70

*Note: Answer **ALL** questions in **Part-A** and any **FIVE** from **Part-B***

Part-A (10 × 2 = 20 Marks)

1. Write the basic differences between a DFA and an NFA?
2. Define regular expression and give two examples.
3. State the pumping lemma for regular languages.
4. What is a parse tree? Give one example.
5. Construct a PDA equivalent to the following grammar.
   S → aAA
   A→ aS | bS | a
6. List the closure properties of context free languages.
7. Describe Multi Stack Turing Machine?
8. Write the formal definition of Turing Machine
9. Define Modified Post's Correspondence Problem (MPCP).
10. What is an NP Complete Problem?

Part-B (5 × 10 = 50 Marks)

11. a) Construct an Є- NFA for the regular expression (00 + 11) 0* [4]

    b) Convert the following Є - NFA to NFA (without ε transitions) [6]

	Є	a	b	c
→p	{q, r}	ϕ	{q}	{r}
q	ϕ	{p}	{r}	{p, q}
*r	ϕ	ϕ	ϕ	ϕ

12. a) Minimization the following DFA. [6]

δ	0	1
→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

    b) Check whether the following grammar is ambiguous or not. [4]
    S -> aB / bA
    A -> aS / bAA / a
    B -> bS / aBB / b

Contd... 2

Code No. : 31525 S

13. a) Design a PDA that accepts **{wcw^r\| w in (0+1)* }** [5]

    b) State pumping Lemma for Context-Free Languages and prove that the following Language is not Context free Language. [5]

    {$0^n 1^n 2^n$ \| n>=1}

14. a) Design a Turing Machine to compute the proper subtraction function which is defined as below [7]

    m – n = m-n if m > = n
    = 0 if m < n

    b) Explain the halting problem of Turing machines. [3]

15. a) What is PCP and test whether the following PCP instance has a solution or not. [5]
    A = (ab, a, bc, c) B = (bc, ab, ca, a).

    b) Define universal language and write the binary code corresponding to the turing machine M whose moves are given as: [5]

    $\delta(q_1,1)=(q_3,0,R)$
    $\delta(q_3,0)=(q_1,1,R)$
    $\delta(q_3,1)=(q_2,0,R)$
    $\delta(q_3,B)=(q_3,1,L)$

16. a) Convert the following DFA to a regular expression using Arden's Theorem. [5]

δ	a	b
–> *P	S	P
Q	P	S
R	R	Q
S	Q	R

    b) Show that **{$0^i 1^j$ \| gcd (i, j) = 1}** is not regular. [5]

17. Answer any *two* of the following:

    a) Obtain a CFG that generates the language accepted by following PDA [5]
    M = ($\{q_0, q_1\}$, {a,b} , {A,Z} , δ , q_0 , Z , $\{ q_1 \}$)
    with the transitions $\delta(q_0 , a , Z) = (q_0 , A Z)$
    $\delta(q0 , b , A) = (q0 , AA)$
    $\delta(q_0 , a , A) = (q_1 , \epsilon)$

    b) Discuss about various modifications of Turing Machines. [5]

    c) Explain the SAT problem. [5]

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Hall Ticket Number:

Code No. : 15605 O2

VASAVI COLLEGE OF ENGINEERING *(Autonomous)*, HYDERABAD

B.E. (IT) III Year I-Semester Backlog (Old) Examinations, December-2018

Theory of Automata

Time: 3 hours Max. Marks: 70

*Note: Answer **ALL** questions in **Part-A** and any **FIVE** from **Part-B***

Part-A (10 × 2 = 20 Marks)

1. Write about String acceptance and Finite Automaton.
2. Derive regular expression for the below finite Automaton.

3. Define context-free grammar.
4. List the closure properties of regular languages.
5. What is Chomsky normal form?
6. Write mathematical definition of a PDA.
7. List the programming techniques for TM's.
8. Write the mathematical notation of a TM.
9. State Church-Turing thesis.
10. Define recursively enumerable language.

Part-B (5 × 10 = 50 Marks)
(All sub-questions carry equal marks)

11. a) Construct a finite automata for the regular expression (0+1)*00

    b) Construct DFA for the given NFA where q_0 is the initial state and q_2 is a final state

	a	b
q_0	$\{q_0, q_1\}$	Φ
q_1	Φ	$\{q_1, q_2\}$
q_2	Φ	Φ

12. a) Determine the language generated by the grammar G = (N, T, P, S) where P = {S→aSb, S→ab}.

    b) What is an ambiguous grammar? Explain with an example.

13. a) Construct an equivalent PDA for the following CFG: S→AA | a, A→SA | b

    b) Convert the following grammar to CNF: S→AB | aB, A→ aab |Є, B→ bbA

14. a) Design a TM to perform addition of two unary numbers.

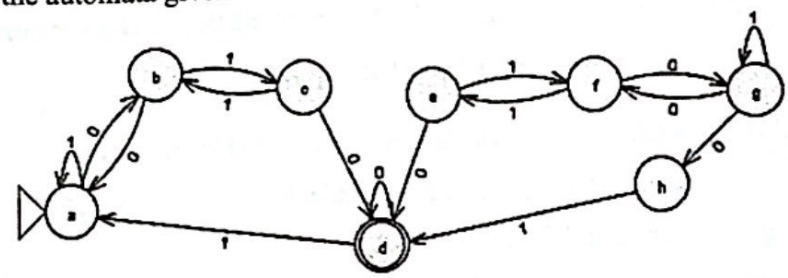
    b) Design a TM over Σ = {0,1} to accept the language L = $\{a^n b^n | n>1\}$

15. a) Prove that the recursive languages are closed under union and complement.

    b) Discuss about Post Correspondence Problem.

Contd...2

16. a) Minimize the automata given below



b) Write the applications of context free grammars.

17. Write short notes on any *two* of the following:

a) Greibach Norma Form (GNF).

b) Restricted Turing Machines.

c) Diagonalization language.

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Hall Ticket Number:

Code No. : 15605

VASAVI COLLEGE OF ENGINEERING *(Autonomous)*, HYDERABAD

B.E. (IT: CBCS) V-Semester Main Examinations, December-2018

Theory of Automata

Time: 3 hours Max. Marks: 70

*Note: Answer **ALL** questions in **Part-A** and any **FIVE** from **Part-B***

Q. No	Stem of the Question	M	L	CO	PO
	Part-A (10 × 2 = 20 Marks)				
1.	Write the properties and limitations of FSM?	2	3	1	1
2.	Explain whether a language of palindromes is accepted by an FSM. Justify.	2	2	1	2
3.	State the pumping lemma for regular languages with conditions?	2	1	2	1
4.	Design the grammar for even palindromes on L= {(a,b) *}	2	3	2	2
5.	What are the components of PDA?	2	1	3	1
6.	What is Greibach normal form (GNF)?	2	2	3	1
7.	Describe Multiple Tape Turing Machine? Is it true that multiple tapes Turing machine is superior to single tape Turing machine in the language acceptance?	2	2	4	1
8.	Contrast between normal Turing machine and restricted Turing machine?	2	3	4	1
9.	Show that if L is a recursive language, then complement of L is also a recursive language.	2	2	5	1
10.	What is the significance of church-Turing thesis?	2	1	5	1
	Part-B (5 × 10 = 50 Marks)				
11. a)	Write the applications of FSM and RE and design a FSM for R={a* | b*}	5	2	1	3
b)	The ε-NFA N = (Q, ∑, δ, q_0, F) is defined as follows: Q ={1,2,3,4,}, ∑= {a,b}, q_0={1}, F={3} with the transition function δ, given by	5	3	1	2

	ε	a	b
1	{2}	{3}	{3}
2	Φ	{1,4}	{3}
3	{4}	Φ	Φ
4	Φ	Φ	{2}

Using the standard method to construct an equivalent NFA M

12. a)	Use the following grammar S → AaA | CA | BaB A → aaBa | CDA | aa | DC B → bB | bAB | bb | aS | ε C → Ca | bc | D D → bD | A i) Eliminate ε productions ii) Eliminate Unit productions iii) Convert resulting grammar into Chomsky Normal Form (CNF)	5	5	2	3
b)	Let L denote the non-regular set {a^n b^n | n > 0}. Prove or disprove the following: i) Any infinite subset of L must be non-regular.	5	3	2	2

Contd... 2

13. a)	Design a PDA for the language L= {WcW^R | w Є (a,b)*} and draw a transition diagram ?	5	5	3	3
b)	Convert the following CFG into GNF S → AB | 0 A → BX |1 B → CD | 2 C → AD | 0 D → 1	5	2	3	3
14. a)	What are the elements of Turing machine and list out types of Turing machines?	4	1	4	1
b)	Construct a TM for checking if a set parentheses are well-formed	6	2	4	3
15. a)	Define decidable problems and state its properties	4	1	5	1
b)	Discuss the following: i) P ii) NP iii) NP hard iv) NP complete And give precise examples for each one.	6	2	5	2
16. a)	Design a finite automata which can accept only even number of 1's followed by even number of 0's	6	3	1	2
b)	Explain about Chomsky hierarchy.	4	2	2	1
17.	Answer any *two* of the following:				
a)	Discuss about closure properties of Context-free languages.	5	2	5	2
b)	Discuss about restricted satisfiability problem.	5	2	4	2
c)	Design a TM for finding ones complement.	5	3	3	1

M: Marks; L: Bloom's Taxonomy Level; CO: Course Outcome; PO: Programme Outcome

S. No.	Criteria for questions	Percentage
1	Fundamental knowledge (Level-1 & 2)	61
2	Knowledge on application and analysis (Level-3 & 4)	28.5
3	*Critical thinking and ability to design (Level-5 & 6) (*wherever applicable)	10.5

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Hall Ticket Number:

Code No. : 31506 S

VASAVI COLLEGE OF ENGINEERING *(Autonomous)*, HYDERABAD

B.E. (I.T.) III Year I-Semester Supplementary Examinations, May/June-2017

Theory of Automata

Time: 3 hours Max. Marks: 70

*Note: Answer **ALL** questions in **Part-A** and any **FIVE** from **Part-B***

Part-A (10 × 2 = 20 Marks)

1. Design a DFA for the following Language L={x01y | x and y are any string of 0's and 1's}
2. Construct a R.E for the set of the strings that consists of alternate 0's and 1's.
3. Prove that L= {ww | w in (a+b)*} is not regular.
4. Generate CFG for the following Language L = $\{0^i 1^j 0^k | j > i+k\}$
5. Define Greibach Normal Form.
6. Construct PDA for the following language L = $\{0^n 1^{2n} | n \geq 1\}$
7. What are the special features of a TM?
8. Define Non-deterministic TM.
9. Represent the relation among P, NP, NP- Hard and NP- Complete in Venn diagram.
10. Define satisfiability.

Part-B (5 × 10 = 50 Marks)
(All bits carry equal marks)

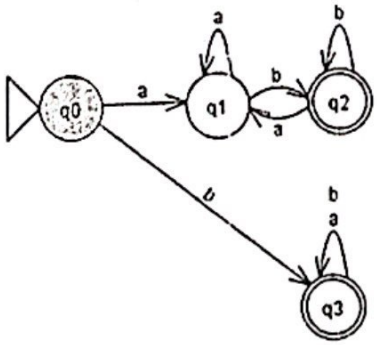
11. a) Differentiate NFA and DFA. Let r = 1(1+0)*, s = 11*0 and t = 1*0 be three regular expressions. Find the relationship between L(r), L(s) and L(t).

    b) Construct NFA without ε for a given NFA with ε where q0 and q2 are the initial and final states respectively.

	a	b	c	ε
q_0	q_0	Φ	Φ	q_1
q_1	Φ	q_1	Φ	q_2
q_2	Φ	Φ	q_2	Φ

12. a) Define CNF. Describe the procedure for converting the given grammar to CNF.

    b) Derive the CFG for the following Finite Automaton.



13. a) Design a PDA that accepts L = $\{wcw^R | w \in (a+b)^*\}$

    b) Find PDA that accept the CFG S→XaaX, X→aX | bX | ε

Contd...2

14. a) Discuss about restricted TM's.

    b) Design a TM for L = { $a^n b^n$ | n >= 1 }

15. a) What is post correspondence problem(pcp). Find whether the lists M = (ab, bab, bbaaa) and N = (a, ba, bab) have a Post Correspondence Solution.

    b) Define P, NP, NP-Hard and NP-complete classification of problem with an example for each.

16. a) Construct a minimum state finite automaton equivalent to the given automaton, whose transition table is given below. Here q_0 is an initial state and q_6 is a final state.

State	a	b
q_0	q_0	q_3
q_1	q_2	q_5
q_2	q_3	q_4
q_3	q_0	q_5
q_4	q_0	q_6

    b) Convert the following CFG in to equivalent grammar without ε – Productions S →aAB | BC, A→bB | b | A, B→C, C→cC | ε

17. Write short notes on any ***two*** of the following:

    a) Pumping lemma for CFL.

    b) Design of TM.

    c) Church-Turing thesis.

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Hall Ticket Number:

Code No. : 31506 S

VASAVI COLLEGE OF ENGINEERING *(Autonomous)*, HYDERABAD

B.E. (I.T.) III Year I-Semester Supplementary Examinations, May/June-2017

Theory of Automata

Time: 3 hours Max. Marks: 70

*Note: Answer **ALL** questions in **Part-A** and any **FIVE** from **Part-B***

Part-A (10 × 2 = 20 Marks)

1. Design a DFA for the following Language L={x01y | x and y are any string of 0's and 1's}
2. Construct a R.E for the set of the strings that consists of alternate 0's and 1's.
3. Prove that L= {ww | w in (a+b)*} is not regular.
4. Generate CFG for the following Language L = $\{0^i 1^j 0^k \mid j > i+k\}$
5. Define Greibach Normal Form.
6. Construct PDA for the following language L = $\{0^n 1^{2n} \mid n \geq 1\}$
7. What are the special features of a TM?
8. Define Non-deterministic TM.
9. Represent the relation among P, NP, NP- Hard and NP- Complete in Venn diagram.
10. Define satisfiability.

Part-B (5 × 10 = 50 Marks)
(All bits carry equal marks)

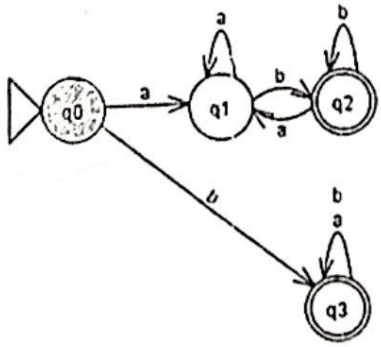
11. a) Differentiate NFA and DFA. Let r = 1(1+0)*, s = 11*0 and t = 1*0 be three regular expressions. Find the relationship between L(r), L(s) and L(t).

    b) Construct NFA without ε for a given NFA with ε where q0 and q2 are the initial and final states respectively.

	a	b	c	ε
q_0	q_0	Φ	Φ	q_1
q_1	Φ	q_1	Φ	q_2
q_2	Φ	Φ	q_2	Φ

12. a) Define CNF. Describe the procedure for converting the given grammar to CNF.

    b) Derive the CFG for the following Finite Automaton.



13. a) Design a PDA that accepts L = $\{wcw^R \mid w \in (a+b)^*\}$

    b) Find PDA that accept the CFG S→XaaX, X→aX | bX | ε

Contd...2

14. a) Discuss about restricted TM's.

    b) Design a TM for L = { $a^n b^n$ | n >= 1 }

15. a) What is post correspondence problem(pcp). Find whether the lists M = (ab, bab, bbaaa) and N = (a, ba, bab) have a Post Correspondence Solution.

    b) Define P, NP, NP-Hard and NP-complete classification of problem with an example for each.

16. a) Construct a minimum state finite automaton equivalent to the given automaton, whose transition table is given below. Here q_0 is an initial state and q_6 is a final state.

State	a	b
q_0	q_0	q_3
q_1	q_2	q_5
q_2	q_3	q_4
q_3	q_0	q_5
q_4	q_0	q_6

    b) Convert the following CFG in to equivalent grammar without ε – Productions S →aAB | BC, A→bB | b | A, B→C, C→cC | ε

17. Write short notes on any ***two*** of the following:

    a) Pumping lemma for CFL.

    b) Design of TM.

    c) Church-Turing thesis.

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Hall Ticket Number:

Code No. : 31528

VASAVI COLLEGE OF ENGINEERING *(Autonomous)*, HYDERABAD

B.E. (I.T.) III Year I-Semester Main & Backlog Examinations, December-2017

Theory of Automata

Time: 3 hours Max. Marks: **70**

*Note: Answer **ALL** questions in **Part-A** and any **FIVE** from **Part-B***

Part-A (10 × 2 = 20 Marks)

1. Design a DFA that accepts strings containing Even no. of zeros and Odd no. of ones.
2. Write the applications of finite automata.
3. Write the closure Properties of Regular Languages.
4. Draw the derivation tree for the string **aabbaa** using the following grammar
   S →aAS | a
   A→SbA | SS | ba
5. Define the languages of PDA accepted by final state and by empty stack.
6. Define Griebach Normal Form and give one example for GNF grammar.
7. What is an Instantaneous Description (ID) in Turing Machine and Give the TM formal definition.
8. Distinguish Multi Tape and Multi Track Turing Machines.
9. State Rice Theorem.
10. When a boolean expression is said to be in Conjunctive normal form?

Part-B (5 × 10 = 50 Marks)

11. a) Convert the following NFA to its equivalent DFA. [6]

δ	a	b
->q_0	{ q_0, q_1}	{ q_0, q_3}
q_1	Ø	{ q_2}
*q_2	Ø	Ø
q_3	{ q_4}	Ø
*q_4	Ø	Ø

b) Obtain a regular expression for the following Finite Automata. [4]

δ	0	1
->q_0	q_1	q_0
*q_1	q_1	q_1

12. a) State the pumping Lemma for Regular Languages and prove that the following Language is not regular. [5]
   L = { a^p / p is prime }

   b) Given the grammar **E -> +EE / *EE / -EE / x / y and** the input string **+ * - x y x y** [5]
   i) Find Left most Derivation
   ii) Find Right most Derivation
   iii) Draw parse tree

Contd... 2

Code No. : 31528

13. a) Convert the following Context free grammar to Pushdown Automata [4]

I -> a / b / Ia / Ib / I0 /I1
E -> I / E*E / E+E / (E)

b) Convert the following grammar into Chomsky Normal Form(CNF) by making necessary elimination of ϵ-Productions, unit productions and useless symbols. [6]

S -> aSB / ϵ
A -> aAS / a
B -> SbS /A /bb

14. a) Design a Turing Machine to accept the language [7]

$L=\{ a^n b^n c^n \mid n \geq 1 \}$

b) Discuss about the extensions to the Turing Machine. [3]

15. a) What is PCP and whether the following PCP instance has a solution or not. [5]

A=(01,001,10) B=(011,01,00).

b) Put the following Boolean expression into 3-CNF. [5]

$x y + \bar{x} z$

16. a) Explain the procedure to convert a ϵ-NFA to a NFA and covert the following ϵ-NFA to NFA without ϵ transitions. [6]

δ	ϵ	a	b	c
->q_0	Ø	{q_0}	{q_1}	{q_3}
q_1	{q_0}	{q_1}	{q_2}	Ø
*q_2	{q_1}	{q_2}	Ø	{q_0}

b) Discuss Chomsky Hierarchy of languages. [4]

17. Answer any ***two*** of the following:

a) Consider the following CFG and test whether the string **10010** is a member or not in the corresponding language. [5]

$S \rightarrow A_1A_2 / A_2A_3$
$A_1 \rightarrow A_2A_1 / 0$
$A_2 \rightarrow A_3A_3 / 1$
$A_3 \rightarrow A_1A_2 / 0$

b) Write about different Programming Techniques for Turing Machine. [5]

c) Define Recursive and Recursively enumerable languages and write their properties. [5]

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Hall Ticket Number:

Code No. : 31528

VASAVI COLLEGE OF ENGINEERING *(Autonomous)*, HYDERABAD

B.E. (I.T.) III Year I-Semester Main & Backlog Examinations, December-2017

Theory of Automata

Time: 3 hours Max. Marks: 70

*Note: Answer **ALL** questions in **Part-A** and any **FIVE** from **Part-B***

Part-A (10 × 2 = 20 Marks)

1. Design a DFA that accepts strings containing Even no. of zeros and Odd no. of ones.
2. Write the applications of finite automata.
3. Write the closure Properties of Regular Languages.
4. Draw the derivation tree for the string **aabbaa** using the following grammar
   S →aAS | a
   A→SbA | SS | ba
5. Define the languages of PDA accepted by final state and by empty stack.
6. Define Griebach Normal Form and give one example for GNF grammar.
7. What is an Instantaneous Description (ID) in Turing Machine and Give the TM formal definition.
8. Distinguish Multi Tape and Multi Track Turing Machines.
9. State Rice Theorem.
10. When a boolean expression is said to be in Conjunctive normal form?

Part-B (5 × 10 = 50 Marks)

11. a) Convert the following NFA to its equivalent DFA. [6]

δ	a	b
->q_0	{ q_0, q_1}	{ q_0, q_3}
q_1	Ø	{ q_2}
*q_2	Ø	Ø
q_3	{ q_4}	Ø
*q_4	Ø	Ø

b) Obtain a regular expression for the following Finite Automata. [4]

δ	0	1
->q_0	q_1	q_0
*q_1	q_1	q_1

12. a) State the pumping Lemma for Regular Languages and prove that the following Language is not regular. [5]
   L = { a^p / p is prime }

   b) Given the grammar **E -> +EE / *EE / -EE / x / y and** the input string **+ * - x y x y** [5]
   i) Find Left most Derivation
   ii) Find Right most Derivation
   iii) Draw parse tree

Contd... 2

Code No. : 31528

13. a) Convert the following Context free grammar to Pūshdown Automata [4]

I -> a / b / Ia / Ib / I0 /I1
E -> I / E*E / E+E / (E)

b) Convert the following grammar into Chomsky Normal Form(CNF) by making necessary elimination of ϵ-Productions, unit productions and useless symbols. [6]

S -> aSB / ϵ
A -> aAS / a
B -> SbS /A /bb

14. a) Design a Turing Machine to accept the language [7]

$L=\{ a^n b^n c^n \mid n \geq 1 \}$

b) Discuss about the extensions to the Turing Machine. [3]

15. a) What is PCP and whether the following PCP instance has a solution or not. [5]

A=(01,001,10) B=(011,01̄,00).

b) Put the following Boolean expression into 3-CNF. [5]

$x y + \bar{x} z$

16. a) Explain the procedure to convert a ϵ-NFA to a NFA and covert the following ϵ-NFA to NFA without ϵ transitions. [6]

δ	ϵ	a	b	c
->q_0	Ø	{q_0}	{q_1}	{q_3}
q_1	{q_0}	{q_1}	{q_2}	Ø
*q_2	{q_1}	{q_2}	Ø	{q_0}

b) Discuss Chomsky Hierarchy of languages. [4]

17. Answer any *two* of the following:

a) Consider the following CFG and test whether the string **10010** is a member or not in the corresponding language. [5]

$S \rightarrow A_1A_2 / A_2A_3$
$A_1 \rightarrow A_2A_1 / 0$
$A_2 \rightarrow A_3A_3 / 1$
$A_3 \rightarrow A_1A_2 / 0$

b) Write about different Programming Techniques for Turing Machine. [5]

c) Define Recursive and Recursively enumerable languages and write their properties. [5]

Hall Ticket Number:

Code No. : 15605 S

VASAVI COLLEGE OF ENGINEERING (AUTONOMOUS), HYDERABAD

B.E.(IT: CBCS) V-Semester Supplementary Examinations, May/June-2019

Theory of Automata

Time: 3 hours Max. Marks: 70

Note: Answer ALL questions in Part-A and any FIVE from Part-B

Part –A (10x2=20 Marks)

1. What is the role of Automata in real world?
2. Design the finite automata for (0*|1*).10?)
3. List out closure properties for regular language?
4. Define useless symbols of CFG and Give an example to show the Elimination of Unit Productions?
5. Write about Leftmost derivation and rightmost derivation with example?
6. Define CNF and point out the significance of CNF clearly.
7. Compare FSM and TM?
8. Explain about offline Turing Machine?
9. Define Diagonalization Language.
10. What are the applications of NP-hard and NP complete?

Part-B (5 ×10=50 Marks)

(All sub-questions carry equal marks)

11. a) Define regular expression, build NFA for the given expression (ab+b)*ab

    b) Construct NFA with ε transitions for the regular expression (0 + 1)*(00 + 11)(0 + 1)* and Convert to DFA.

12. a) Using pumping lemma check whether L = {$a^n b^n$ | n >=1 1} is regular or not.

    b) Use the following grammar

    S → ABC | BbB
    A → aA | BaC | aaa
    B → bBb | a| D
    C → CA |AC
    D → ϵ

    I. Eliminate ϵ productions II. Eliminate Unit productions III. Convert resulting grammar into Chomsky Normal Form (CNF)

13. a) Design a PDA for the language L= {WW^R} and draw a transition diagram.

    b) Convert the following grammar to Greibach normal form: G= ({ A_1,A_2,A_3}, {a,b}, P,A_1), Where P consists of the following

    $A_1 \rightarrow A_2A_3$

    $A_2 \rightarrow A_3A_1$ | b

    $A_3 \rightarrow A_1A_2$ |a

Contd...2

14. a) What are the types of Turing machines and contrast between traditional TM and restricted TM's.

    b) Design a Turing machine for the language L={a^n b^n $c^n$$d^n$ n>=1} and draw its transition diagram.

15. a) What are the properties of recursive and recursive Enumerable languages?

    b) State and justify the restricted satifieability problem.

16. a) Check whether or not the following grammar is ambiguous : if it is ambiguous, remove the ambiguity and write an equivalent unambiguous grammar

    S → iCtS | iCtSeS | a

    C → b

    b) Write the CFG for the language L= {$0^m1^n0^{m+n}$, m,n >= 1}

17. Answer any ***two*** of the following:

    a) Write closure properties of context free languages.

    b) Design a TM for finding factorial of given number.

    c) Write short notes on PCP and MPCP.

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