Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2018

Course Code: CS301

Course Name: THEORY OF COMPUTATION (CS)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks Marks

1		Construct regular expression for the language that consists of all strings ending with 00. Assume Σ= {0, 1}.	(3)
2		Design non deterministic automata (without ε moves) for the regular language that consist of all strings with at least two consecutive 0's. Assume Σ = {0, 1}.	(3)
3		Define regular grammar with suitable example.	(3)
4		List some of the applications of automata theory.	(3)

PART B

Answer any two full questions, each carries 9 marks

5		Prove the equivalence of non deterministic finite automata and deterministic finite automata.	(9)
6		Prove the equivalence of non deterministic finite automata with ε moves and regular expressions.	(9)
7	a)	Construct non deterministic finite automata (with ε moves) for regular expression $(0+1)^*1$.	(4)
	b)	Compare and contrast Moore and Mealy machines. (Justify with diagrams).	(5)

PART C

Answer all questions, each carries 3 marks

8		Construct context free grammar for L= {wcw^R | w in (a+b)*}, Reverse of w is denoted as w^R.	(3)
9		List conditions for symbols to become *useful* symbols in context free grammar.	(3)
10		List conditions required for push down automata to qualify as deterministic push down automata.	(3)
11		List closure properties of context free language.	(3)

PART D

Answer any two full questions, each carries 9 marks

12		Do the following:	(9)
	i)	Construct push down automata with empty stack as final condition for Context free language, L= { wcw^R| w in (a+b)*} .Reverse of w is denoted as w^R.	
	ii)	Describe all instantaneous descriptions from initial ID (start state, **abcba,** initial stack symbol) **|--*** to final ID (state, ε, ε) with respect to constructed push down automata.	

13 Do the following: (9)

i) Derive any two representative strings with minimum length 4 from following context free grammar. G= ({S,A,B},{a,b},P,S)

S→ bA | aB

A→ bAA | aS | a

B→ aBB | bS | b

ii) Draw derivation tree corresponding to string **aabbab** with respect to aforementioned grammar.

14 Prove the equivalence of push down automata and context free grammar. (9)

PART E

Answer any four full questions, each carries 10 marks

15 a) State pumping Lemma for context free language (5)

b) Define formally Turing machine Model. (5)

16 a) Design Turing machine to accept language L={0^n1^n | n >=1} (6)

b) Describe all instantaneous descriptions (ID) from initial ID $q_0$01 to Final ID with respect to constructed TM. Assume q_0 as start state. (4)

17 a) Design Turing machine to compute addition of two numbers. Assume unary notation for number representation. (6)

b) Describe all instantaneous descriptions (ID) from initial ID: $q_0$010 to Final ID: 00 with respect to constructed Turing Machine.(assume q_0 as initial state.) (4)

18 a) Explain the significance of universal Turing machine. (5)

b) Compare and contrast recursive and recursively enumerable languages. (5)

19 a) Prove that union of two recursive languages is recursive. (5)

b) Explain the significance of halting problem. (5)

20 a) Explain general notations for productions of each formal language from Chomsky hierarchy. (5)

b) Prove that complement of a recursive language is recursive. (5)

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Total Pages: 2

Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2017

Course Code: CS301

Course Name: THEORY OF COMPUTATION (CS)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1 Define Non Deterministic Finite Automata? Compare its ability with Deterministic Finite Automata in accepting languages. (3)

2 Write the notations for the language accepted by DFA, NFA, ϵ-NFA (3)

3 Can we use finite state automata to evaluate 1's complement of a binary number? Design a machine to perform the same. (3)

4 Define Two-way finite automata (3)

PART B

Answer any two full questions, each carries 9 marks.

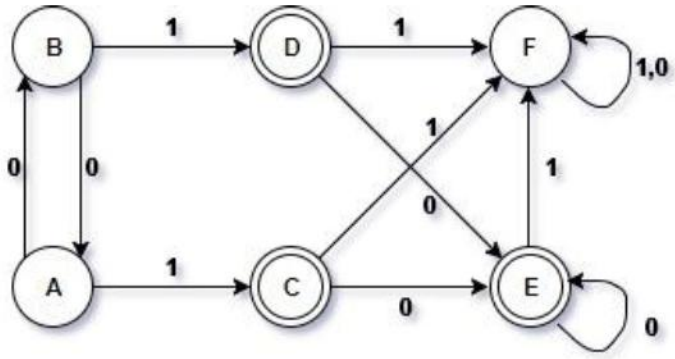
5 a) Design a Finite state automata which accepts all strings over {0,1} with odd number of 1's and even number of 0's. (5)

b) Show the changes needed to convert the above designed automata to accept even number of 1's and odd number of 0's (4)

6 a) Construct Regular grammar for the regular expression : (5)
L = (a + b)*(aa + bb)(a + b)*

b) List the closure properties of Regular sets. (4)

7 State Myhill-Nerode theorem. Minimize the following DFA by table filling method using Myhill-Nerode theorem describing the steps in detail. (9)



PART C

Answer all questions, each carries 3 marks.

8 Which Normal Form representation of CFG will you prefer in converting CFG to NPDA? Why? (3)

9 What do you mean by useless symbol in a grammar? Show the elimination of useless symbols with an example. (3)

10 Explain the different methods by which a PDA accepts a language. (3)

11 Can we construct a Deterministic PDA for the language ww^R?Justify your answer. Otherwise how can we modify this language to make it accepted by DPDA. (3)

PART D

Answer any two full questions, each carries 9 marks.

12 Define CFG for the following languages over the alphabets {a,b} (9)

i. $L = \{ a^{m+n}b^mc^n n,m>0 \}$

ii. L contains all odd length strings only

iii. $L = \{ 0^n 1^n 2^n \ n>0 \}$

13 Design a Push Down Automata for the language $L= \{a^nb^{2n} \mid n>0\}$ (9)
Trace your PDA with n=3.

14 Prove that the following languages are not regular (9)

i. $L = \{0^{i^2} such\ that\ i \geq 1\}$ is not regular

ii. $L = \{a^p\ such\ that\ p\ is\ a\ prime\ n\ umber$

PART E

Answer any four full questions, each carries 10 marks.

15 State and prove pumping lemma for Context Free Languages. (10)

16 Construct a Turing machine that recognizes the language $L = \{ a^nb^nc^n| \ n>0 \}$ (10)

17 a) What is a Context sensitive grammar(CSG). Design a CSG to accept the language $L = \{ 0^n1^n 2^n| \ n>0 \}$ (6)

b) Define Linear Bound Automata (4)

18 a) Write a note on Recursive Enumerable Languages (5)

b) Discuss about Universal Turing Machines (5)

19 a) Explain Chomsky's Hierarchy of Languages (6)

b) Let$L = \{x/ \ x \in (a + b + c)^*$ and $|x|_a = |x|_b = |x|_c \}$. What class of language does Lbelong? Why? What modification will you suggest in the grammar to accept this language? (4)

20 Discuss the Undecidable Problems About Turing Machines (10)

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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION(R&S), DECEMBER 2019

Course Code: CS301

Course Name: THEORY OF COMPUTATION

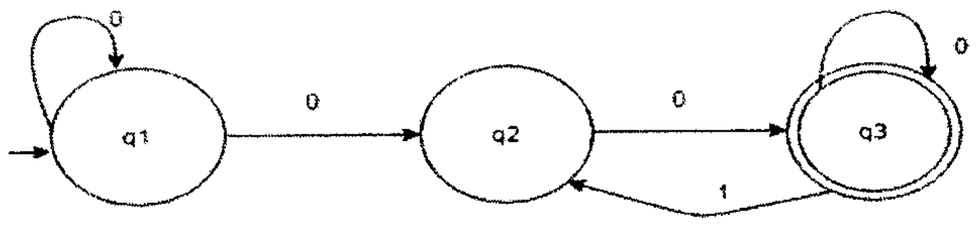
Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1 Define nondeterministic finite automata(NFA). Draw the NFA for the language $L=\{a^n b^m \mid n, m>=1\}$ 3

2 Convert the following NFA to DFA. 3



3 Write regular expression for the language $L=\{1^n 0^m \mid n>=1, m>=0\}$ 3

4 Differentiate Moore machine from Mealy machine. Write the tuple representation for both machines. 3

PART B

Answer any two full questions, each carries 9 marks.

5 a) Write the notation for the language defined by a DFA. Write a string belong to the language L^3 if $L=\{0,1\}$ 3

b) Construct NFA without ϵ – transitions from the following NFA. $M=(\{q_0, q_1, q_2\}, \{a, b, c\}, \delta, q_0, \{q_2\})$ and $\delta(q_0, a) = \{q_0\}$, $\delta(q_0, b) = \{q_1\}$, $\delta(q_0, c) = \{q_2\}$ $\delta(q_1, \epsilon) = \{q_0\}$, $\delta(q_1, a) = \{q_1\}$, $\delta(q_1, b) = \{q_2\}$, $\delta(q2, \epsilon) = \{q_1\}$, $\delta(q_2, a) = \{q_2\}$, $\delta(q2, c) = \{q_0\}$. 6

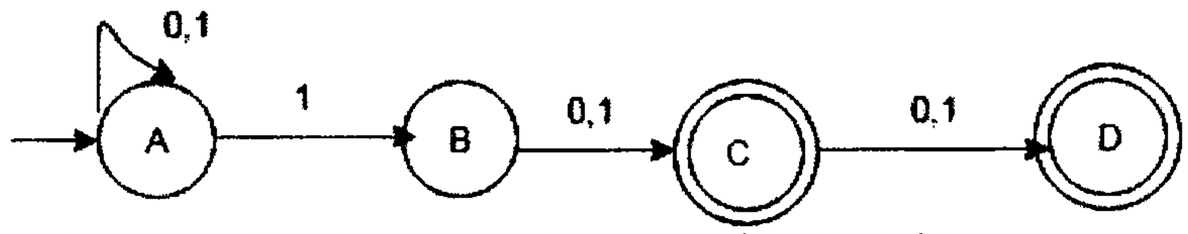
6 a) State Myhill-Nerode Theorem. 3

b) Minimize the following DFA. 6

δ	a	b
→ **P0**	P0	P1
P1	P2	P1
P2	P3	P1
***P3**	P3	P4
***P4**	P5	P4

*P5	P3	P4

7 a) Construct regular expression corresponding to the following state diagram: 4.5



b) Design an ϵ-NFA for the regular expression (0+1)*01 4.5

PART C

Answer all questions, each carries 3 marks.

8 Write the conditions for a pushdown automaton to be considered as deterministic. 3

9 Which are the methods to accept a string in a PDA? Whether both type of PDAs can define the same language. Justify your answer. 3

10 Convert the following grammar to Chomsky Normal Form. 3
S-> 0S0|1S1| ϵ

11 Whether the following grammar is ambiguous? 3
E-> E+E| E*E|I
I-> 0|1|a|b

PART D

Answer any two full questions, each carries 9 marks.

12 a) Verify that the following languages is not regular: 4.5
$\{a^n b^{2n} \mid n>0\}$

b) Which of the following operations are closed under regular sets. Justify your answer. 4.5
i) Complementation ii) Set difference iii) string reversal iv) Intersection

13 a) Give a CFG for the language N(M) where M = ({p,q,r}, {0, 1}, {Z, X_0}, δ, q_0, Z, r) and δ is given by $\delta(p, \epsilon, X_0) = \{(q, ZX_0)\}$, $\delta(q, \epsilon, X_0) = \{(r, \epsilon)\}$, $\delta(q, 1, Z) = \{(q, ZZ)\}$, $\delta(q, 0, Z) = \{(q, \epsilon)\}$. 4.5

b) Find the Greibach normal form grammar equivalent to the following CFG: 4.5
$S \rightarrow AB$
$A \rightarrow BS| 1$
$B \rightarrow SA|0$

14 a) Design a PDA to accept the language $\{0^{2n}1^n \mid n \geq 1\}$. 4.5

b) Find a CFG without ϵ-productions equivalent to the grammar defined by 4.5
$S \rightarrow ABaC$, $A \rightarrow BC$, $B \rightarrow b/\epsilon$, $C \rightarrow D/\epsilon$, $D \rightarrow d$

PART E

Answer any four full questions, each carries 10 marks.

15 a) State Pumping lemma for CFLs. Write the applications of pumping lemma for CFL s. 4

b) Check whether $L=\{a^i b^i c^i \mid i > 0\}$ belong to CFL or not. 6

16 a) Discuss about Multitape Turing Machines. Explain informally how they can 5

		simulate the moves of a Turing Machine	
	b)	Write a note on Universal Turing machines.	5
17	a)	How to identify deterministic Turing machine from nondeterministic TM	3
	b)	Write notes on the following: i) decidable and undecidable problems ii) Halting Problem of Turing machine.	7
18	a)	Write the properties of recursive languages and recursively enumerable languages.	3
	b)	Write the Chomsky hierarchy of languages. Prepare a table indicating the automata and grammars for the languages in the Chomsky Hierarchy.	7
19	a)	Define Turing machine [Write the tuple representation for TM].	5
	b)	Design a Turing machine to identify the strings belong to the language $L=\{0^n1^n \mid n>0\}$.	5
20		Design the Turing machine to recognize the language: $\{0^n1^n0^n \mid n >=1\}$.	10

Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

Course Code: CS301

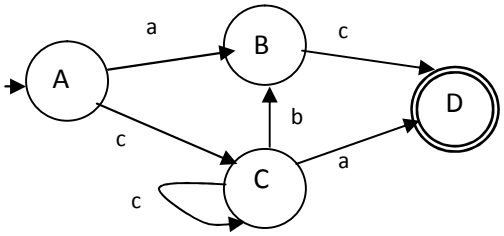
Course Name: THEORY OF COMPUTATION (CS)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1 What is the regular expression for the DFA (3)



2 Compare the transition functions of NFA and DFA. (3)

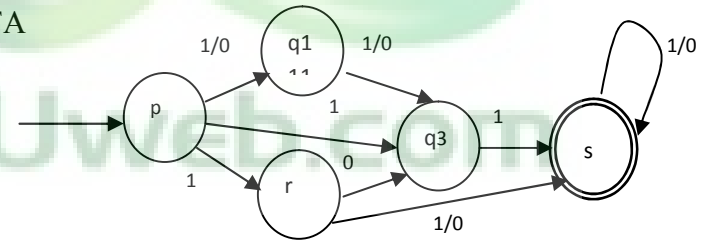
3 Explain in English language the language accepted by the DFA in Question 1. (3)

4 What is a Moore machine? How is it different from mealy machine? (3)

PART B

Answer any two full questions, each carries 9 marks.

5 a) Convert the NFA to DFA (4.5)



b) Prove the equivalence of regular expression and Finite state automata. (4.5)

6 a) Prove the equivalence of NFA and ε-NFA. (4.5)

b) Draw a six state DFA which can be minimized to a three state DFA where set of input symbols is {a, b, c}. Draw both the DFAs. Assume whatever is required. (4.5)

7 a) Prove the equivalence of NFA and DFA. (4.5)

b) What is Myhill Nerode Theorem? (4.5)

PART C

Answer all questions, each carries 3 marks.

8 What is a derivation tree? (3)

9		Is the grammar {E→E+E|E-E|**id**}ambiguous? Why?	(3)
10		What is the difference between NPDA and DPDA?	(3)
11		Is the language $\mathbf{ww^R}$ where w is string of zeroes and ones, accepted by DPDA? Why?	(3)

PART D

Answer any two full questions, each carries 9 marks.

12	a)	Show that L={0^p/ p is a prime number} is not regular.	(4.5)
	b)	Construct the CFG for the union of the languages 0^n1^n and a^nb^n for n>0.	(4.5)
13	a)	Convert the grammar {S→AaCb|ABa, A→bAa|a, B→BaB|b, C→c} to Chomsky normal form.	(4.5)
	b)	Construct the PDA for the language $\{0^n1^n\}^*$.	(4.5)
14	a)	Give the formal definition of an NPDA.	(3)
	b)	Show that NPDA and CFG are equivalent.	(6)

PART E

Answer any four full questions, each carries 10 marks.

15	a)	Consider L = {ww | w ∈ {0, 1}*}. Prove L is not a CFL.	(5)
	b)	Explain Chomsky hierarchy and corresponding type0, type1, type2 and type 3 formalism.	(5)
16	a)	Design a Turing machine that determines whether the binary input string is of odd parity or not	(5)
	b)	How does the Universal Turing machine simulate other Turing machines?	(5)
17	a)	Design a Turing machine that accepts a^nb^m where n>0 and m>n.	(5)
	b)	Explain why Halting problem is unsolvable problem.	(5)
18	a)	What is the instantaneous description for a Turing machine? Explain with an example.	(5)
	b)	Show that normal single tape Turing machine can perform computations performed by multi-tape Turing machine (informal explanation is sufficient).	(5)
19	a)	What is a recursive language? Give an example.	(5)
	b)	How does a Turing machine differ from PDA and FSA?	(5)
20	a)	State pumping lemma for CFL. Mention one application of Pumping lemma	(5)
	b)	What is a non-deterministic Turing machine?	(5)

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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth semester B.Tech degree examinations (S) September 2020

Course Code: CS301

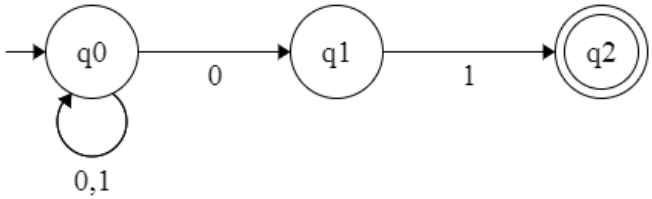
Course Name: THEORY OF COMPUTATION

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries3 marks. Marks

1 Formally define extended delta for an NFA. Show the processing of input $w = 0101$ for the following NFA. (3)



2 Differentiate between the transition function in DFA, NFA and ϵ-NFA (3)

3 Design a Moore machine to determine the residue of mod 2 of the input treated as a binary string. (3)

4 Give a regular expression for the set of all strings not containing 101 as a substring (3)

PART B

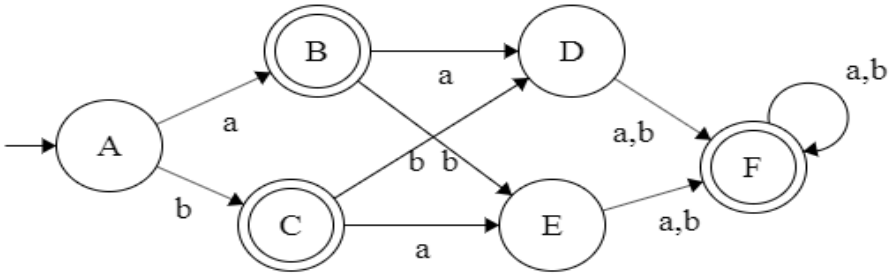
Answer any two full questions, each carries 9 marks.

5 a) Convert the following NFA to DFA and describe the language it accepts. $M = (\{P, Q, R, S, T\}, \{0,1\}, \delta, P, \{S, T\})$ and δ is given as: (5)

	0	1
P	{P,Q}	{P}
Q	{R,S}	{T}
R	{P,R}	{T}
S	-	-
T	-	-

b) Prove that " A language L is accepted by some ϵ-NFA if and only if L is accepted by some NFA" (4)

6 a) State Myhill-Nerode theorem, Minimize the following DFA. (5)



b) Find an equivalent ϵ-NFA for the following regular expression (4)

$(0+1)^*011$

7 a) Convert the following ϵ-NFA to NFA (4)

	ϵ	1	2	3
q0	∅	{ q0}	{ q1}	{ q2}
q1	{ q0}	{ q1}	{ q2}	∅
q2	{ q1}	{ q2}	∅	{ q0}

b) Describe clearly the equivalent classes of the Canonical Myhill-Nerode relation for the language of binary strings with second-last symbol as 0. (5)

PART C

Answer all questions, each carries3 marks.

8 State the closure properties of regular sets. (3)

9 Define context free grammar. Consider the following CFG (3)

$$S \rightarrow aS \mid Sb \mid a \mid b$$

Prove by induction on the string length that no string in L(G) has ba as substring.

10 Design a PDA to accept the set of strings with twice as many 0's as 1's. (3)

11 List the decision problems related with type 3 Formalism. (3)

PART D

Answer any two full questions, each carries9 marks.

12 a) State pumping lemma for regular languages. Prove that the language $L = \{a^{n^2} \mid n > 0\}$ is not regular. (5)

b) Convert the following grammar into Chomsky normal form (4)

$$S \rightarrow ASB|\in, \quad A \rightarrow aAS|a, \quad B \rightarrow SbS|A|bb$$

13 a) Prove the equivalence of acceptance of a PDA by final state and empty stack. (6)

b) Define a deterministic PDA. How a DPDA differs from a non-deterministic PDA? (3)

14 a) Let G be the grammar (4)

$$S \rightarrow aB|bA, \qquad A \rightarrow a|aS|bAA, \qquad B \rightarrow b|bS|aBB$$

For the string $aabbaabbba$ find

i) leftmost derivation, ii) parse tree, and iii) Is the grammar ambiguous?

b) Design a PDA to accept the language $L = \{ww^R | \ w \in \{0,1\}^*\}$. (5)

PART E

Answer any four full questions, each carries10 marks.

15 a) Show that the language $L = \{ww|w \in \{a,b\}^*\}$ is not a CFL. (5)

b) Design a TM to compute the 2's complement of a binary string. (5)

16 a) State and prove pumping lemma for context free languages. Mention the application of pumping lemma. (6)

b) Design a Turing machine to accept , (4)

$L = \{ w \in \{0,1\}^* | \ w \ has \ equal \ number \ of \ 0's \ and \ 1's\}$.

17 a) Compare context sensitive grammar and context free grammar. Can we design a PDA for context sensitive languages? Justify your answer. (5)

b) Design a TM to find the sum of two numbers m and n. Assume that initially the tape contains m number of 0s followed by # followed by n number of 0s (5)

18 a) Are there any languages which are not recursively enumerable, but accepted by a multi-tape Turing machine? Justify your answer. (5)

b) Define formally Type 0, Type 1, Type 2 and Type 3 grammar. Show the corresponding automata for each class (5)

19 a) List the closure properties of Recursive Languages (4)

b) Define a Universal Turing Machine (UTM). With the help of suitable arguments show the simulation of other Turing machines by a UTM. (6)

20 a) Compare recursive and recursively enumerable languages. (3)

b) Show that the class of recursive languages is closed under complementation. (3)

c) Show that the class of recursively enumerable languages are not closed under complementation. (4)

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Scheme for Valuation/Answer Key

Scheme of evaluation (marks in brackets) and answers of problems/key

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2021

Course Code: CST 301

Course Name: FORMAL LANGUAGES AND AUTOMATA THEORY

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) Marks

1	Any valid DFA accepting the given language with a number of states greater than or equal to 6.	3
2	S → 0A, A → 0A | 1B | 1, B → 1B | 1 Any regular grammar which is correct can be considered.	3
3	Construction of ε-NFA from RE using any conversion method.	3
4	Let h(a) = h(b) = a and h(c) = b. When apply homomorphism the language L becomes L' = $\{a^n a^n b^{2n}\}$ which is equal to $\{a^{2n} b^{2n}\}$. Given that $\{a^n b^n : n >= 1\}$ is not regular. By homomorphism L = L' and given that L' = $\{a^{2n} b^{2n}\}$ is not regular. Therefore, L is not regular. Proof by any other method like pumping lemma can also be considered and full marks may be given for correct answer	3
5	State Myhill-Nerode Theorem	3
6	Any correct CSG may be considered. One possible solution is: S → aSa | bSb | c. Full marks may be given if some other variable is used instead of S.	3
7	$\delta(q, a, Z_0) = (q, XZ_0)$ $\delta(q, a, X) = (q, XX)$ $\delta(q, b, X) = (p, \varepsilon)$ $\delta(p, b, X) = (p, \varepsilon)$ $\delta(p, \varepsilon, Z_0) = (r, Z_0)$ Stack symbols and state names may be different.	3
8	Statement of Pumping Lemma for Context Free Grammar	3
9	Formal Definition - (1 marks) Productions for $\{ a^n b^n c^n \mid n>=1 \}$ - (2marks) S → abc | aAbc Ab → bA Ac → Bbcc bB → Bb aB → aa | aaA Any correct CSG may be considered.	
10	Type 0, Type 1, Type 2 and Type 3 classification along with the associated automata/Type of productions	3

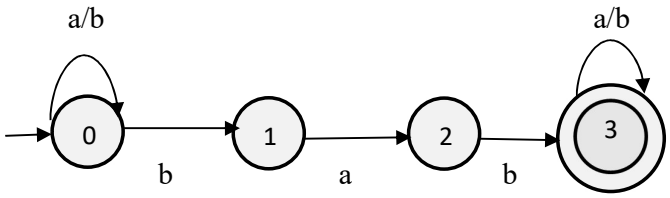
PART B

(Answer one full question from each module, each question carries 14 marks)

Module -1

11 a) Full marks may be given for any correct answer. Marks may also be given for partial correctness. 6

b) NFA - (3 marks) 8



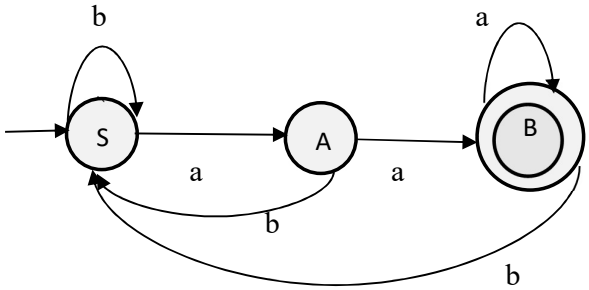
NFA to DFA conversion - (5 marks)

	a	b
→[0]	[0]	[0,1]
[0,1]	[0,2]	[0,1]
[0,2]	[0]	[0,1,3]
[0,1,3]	[0,2,3]	[0,1,3]
[0,2,3]	[0,3]	[0,1,3]
[0,3]	[0,3]	[0,1,3]

12 a) Formal Definition of Regular Grammar (3 marks) 7

Any correct Regular Grammar : (4 marks)

b) Steps for converting each grammar to transition function / General rules for converting Regular Grammar to DFA. (3 marks) 7



(4 Marks)

Module -2

13	a)	State and Explain any three closure properties of Regular Language. (3 * 2 = 6)	6
	b)	Regular expression for the given automata using Kleene construction/State elimination method/Arden's theorem	8
14	a)	State pumping lemma for Regular Laguages (2 marks) Proof (5 marks)	7
	b)	Steps for filling the Table (4 marks)	7

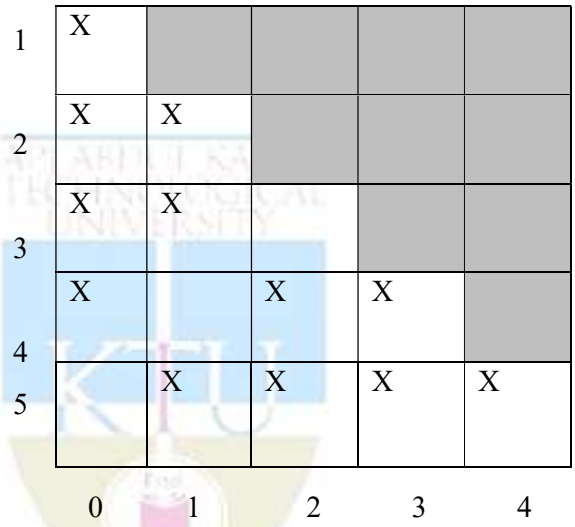


Table (1 mark)

Minimized DFA (2 marks)

Construct DFA with (0,5), (1,4) and (2,3) as equal pair. Minimized DFA contains only 3 states.

Minimization using quotient construction may also be considered and marks may be distributed accordingly.

Module -3

15	a)	DFA-2 Marks. Write the steps to obtain the equivalence classes. -5 Marks There will be four equivalent classes as described below: [C1]: Contains only epsilon [C2] : Contains all the strings which starts and ends with 1 [C3] : Contains all the strings which starts with a 1 and ends with 0	7

[C4] : Contains all the strings begins with a 0

b) Leftmost Derivation (2 marks) 7

Rightmost Derivation (2 marks)

Parse Tree (3 marks)

16 a) CFG which accepts equal number of a's and b's (2 Marks). 7

Any correct CFG should be considered. One possible CFG is S → aSbS | bSaS | ε

Chomsky Normal Form (5 Marks)

Any correct CFG and its CNF may be provided full marks.

b) $S = A_1$, $X = A_2$, $A = A_3$, $B = A_4$ 7

$A_1 \rightarrow bA_3|bA_3A_4A_4|bA_4|bA_3A_4ZA_4|bZA_4$

$A_4 \rightarrow bA_3A_4|b|bA_3A_4Z|bZ$

$Z \rightarrow bA_3A_4A_4|bA_4|bA_3A_4ZA_4|bZA_4|bA_3A_4A_4Z|bA_4Z|bA_3A_4ZA_4Z|bZA_4Z$

$A_2 \rightarrow b$

$A_3 \rightarrow a$

Module -4

17 a) PDA (4 marks) 7

$\delta(q, a, Z_0) = (q, XZ_0)$

$\delta(q, b, Z_0) = (q, YZ_0)$

$\delta(q, a, X) = (q, XX), (p, \varepsilon)$

$\delta(q, b, Y) = (q, YY), (p, \varepsilon)$

$\delta(q, a, Y) = (q, XY)$

$\delta(q, b, X) = (q, YX)$

$\delta(p, a, X) = (p, \varepsilon)$

$\delta(p, b, Y) = (p, \varepsilon)$

$\delta(p, \varepsilon, Z_0) = (p, \varepsilon)$

$\delta(q, \varepsilon, Z_0) = (p, Z_0)$

Full marks can be awarded to any PDA accepting the given language.

Instantaneous Description of PDA on the string 'aabbaa' (3 marks)

b) Use the PDA to CFG conversion method 7

$$
\begin{aligned}
S &\rightarrow [qZ_0p] \\
[qZ_0p] &\rightarrow 0\,[qXp]\,[pZ_0p] \\
[pXp] &\rightarrow 0\,[qXp]\,[pXp]\;|1\,|\epsilon \\
[qXp] &\rightarrow 1 \\
[pZ_0p] &\rightarrow \epsilon
\end{aligned}
$$

The student may rename the variables so that the final CFG seems simple.

Half marks may be given if the production rules are partially right.

18 a) Pumping lemma for Context free languages. (3 marks) 7

Proof (4 marks)

b) Proof/Explanation for Union (2 marks) 7

Proof/Explanation for Concatenation (2 marks)

Proof/Explanation for Homomorphism (3 marks)

Module -5

19 a) Definition and Explanation of LBA- 4 Marks 7

LBA - 3 marks

$\delta(q_0, a) = (q_1, X, R)$

$\delta(q_1, a) = (q_1, a, R)$

$\delta(q_1, b) = (q_2, Y, R)$

$\delta(q_2, b) = (q_2, b, R)$

$\delta(q_2, c) = (q_3, Z, L)$

$\delta(q_3, b) = (q_3, b, L)$

$\delta(q_3, Y) = (q_3, Y, L)$

$\delta(q_3, a) = (q_3, a, L)$

$\delta(q_3, X) = (q_0, X, R)$

$\delta(q_3, b) = (q_3, b, L)$

$\delta(q_0, Y) = (q_4, Y, R)$

$\delta(q_4, Y) = (q_4, Y, R)$

$\delta(q_4, Z) = (q_5, Z, R)$

$\delta(q_5, Z) = (q_5, Z, R)$

$\delta(q_5, \$) = (q_6, S, L)$

$ is the right end marker.

b) TM - (4marks) 7

$\delta(q_0, a) = (q_1, X, R)$

$\delta(q_1, a) = (q_1, a, R)$

$\delta(q_1, b) = (q_2, Y, R)$

$\delta(q_2, b) = (q_3, Y, L)$

$\delta(q_3, Y) = (q_3, Y, L)$

$\delta(q_3, a) = (q_3, a, L)$

$\delta(q_3, X) = (q_0, X, R)$

$\delta(q_1, Y) = (q_1, Y, R)$

$\delta(q_0, Y) = (q_4, Y, R)$

$\delta(q_4, Y) = (q_4, Y, R)$

$\delta(q_4, B) = (q_5, B, L/R)$

Instantaneous Description of 'aaabbbbbb' - (3marks)

20 a) Transitions of TM 7

(Refer Text Book Hopcroft and Ullman)

Any valid solution may be given full marks.

Consideration should be given for partial solution also.

b) Halting Problem (2 marks) 7

Statement : - It is undecidable to check whether an arbitrary Turing Machine halt on an input or not.

OR

The Language $L_H = \{<T, w> \mid T$ is a TM that halts on string $w\}$ is not recursive.

Any valid proof may be given full marks. (5 marks)

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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth Semester B.Tech Degree Examination December 2021 (2019 scheme)

Course Code: CST301

Course Name: FORMAL LANGUAGES AND AUTOMATA THEORY

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) Marks

1	Draw the state transition diagram showing a DFA for recognizing the language L over the alphabet set $\Sigma = \{a, b\}$: $L = \{x \mid x \in \Sigma^*$ and the number of a in x is divisible by 2 or 3$\}$.	3
2	Write a Regular Grammar G for the language: $L = \{0^n 1^m : n, m >= 1\}$	3
3	Construct an ε-NFA for the regular expression (a+b)*ab(a+b)*	3
4	Using homomorphism on Regular Languages, Prove that the language $L=\{a^n b^n c^{2n} \mid n>=0\}$ is not regular. Given that the language $\{a^n b^n : n >= 1\}$ is not regular.	3
5	State Myhill-Nerode Theorem.	3
6	Write a Context-Free Grammar for the language $L = \{wcw^r \mid w \in \{a,b\}^* \}$, w^r represents the reverse of w.	3
7	Write the transition functions of PDA with acceptance by Final State for the language $L = \{a^n b^n : n >= 0\}$.	3
8	State Pumping Lemma for Context Free Languages.	3
9	Write the formal definition of Context Sensitive Grammar and write the CSG for the language $L = \{ a^n b^n c^n \mid n>=1 \}$.	3
10	Explain Chomsky hierarchy of languages.	3

PART B

(Answer one full question from each module, each question carries 14 marks)

Module -1

11	a)	Draw the state-transition diagram showing a DFA for recognizing the language: $L = \{x \in \{a,b\}^* \mid$ every block of five consecutive symbols in x contains two consecutive a's.$\}$	6

b) Draw the state-transition diagram showing an NFA N for the following language L. Obtain the DFA D equivalent to N by applying the subset construction algorithm. L = {x ∈ {a, b} * | x contains 'bab' as a substring} 8

12 a) Define Regular Grammar and write Regular Grammar G for the following language : L = {x ∈ {a, b} * | x does not ends with 'bb' } 7

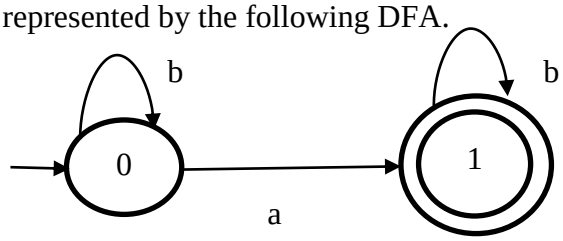
b) Obtain the DFA over the alphabet set Σ = {a, b}, equivalent to the regular grammar G with start symbol S and productions: S → aA | bS , A → aB | bS | a *and*

B → aB | bS | a 7

Module -2

13 a) State and explain any three closure properties of Regular Languages. 6

b) Find the equivalent Regular Expression using Kleene's construction for the language represented by the following DFA. 8



14 a) Using pumping lemma for Regular Languages, prove that the language $L = \{0^n \mid n \text{ is a perfect square}\}$ is not Regular. 7

b) Obtain the minimum state DFA for the following DFA. 7

	a	b
→ 0	1	2
1	4	5
(2)	0	3
(3)	5	2
4	1	0
5	4	3

Module -3

15 a) Show the equivalence classes of Canonical Myhill-Nerode relation for the language of binary string which starts with 1 and ends with 0. 7

b) Consider the following productions: 7

S → aB | bA

A → aS | bAA | a

$B \rightarrow bS \mid aBB \mid b$

For the string 'baaabbba' find

i) The leftmost derivation

ii) The rightmost derivation

iii) The parse tree

16 a) Construct the Grammars in Chomsky Normal Form generating the set of all strings over {a,b} consisting of equal number of a's and b's. 7

b) Find the Greibach Normal Form for the following Context Free Grammar $S \rightarrow XA \mid BB$, $B \rightarrow b \mid SB$, $X \rightarrow b$, $A \rightarrow a$ 7

Module -4

17 a) Design a PDA for the language $L = \{ww^r \mid w \in \{a,b\}^* \}$. Also illustrate the computation of the PDA on the string 'aabbaa'. 7

b) Construct a CFG to generate L(M) where $M = (\{p, q\}, \{0, 1\}, \{X, Z_0\}, \delta , q, Z_0 , Ø \}$ where δ is defined as follows: 7

$\delta (q, 0, Z_0) = (q, XZ_0)$

$\delta (q, 0, X) = (q, XX)$

$\delta (q, 1, X) = (p, \varepsilon)$

$\delta (p, 1, X) = (p, \varepsilon)$

$\delta (p, \varepsilon, X) = (p, \varepsilon)$

$\delta (p, \varepsilon, Z_0) = (p, \varepsilon)$

18 a) Using pumping lemma for Context free languages, prove that the language $L = \{ a^n b^n c^n \mid n>=1 \}$. 7

b) Prove that CFLs are closed under Union, Concatenation and Homomorphism. 7

Module -5

19 a) Design Linear Bounded Automata for the language $L = \{ a^n b^n c^n \mid n>=1 \}$. 7

b) Design a Turing Machine for the language $L = \{ a^n b^{2n} \mid n>=1 \}$. Illustrate the computation of TM on the input 'aaabbbbbb'. 7

20 a) Design a Turing Machine to obtain the product of two natural numbers a and b both represented in unary on the alphabet 0. For example, number 5 is represented as 00000 ie 0^5. Assume that initially the input tape contains 0^a10^b and Turing machine should halt with 0^{a*b} as the tape content. 7

b) Prove that 'Turing Machine halting problem' is undecidable. 7

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A E1107 Pages: 3

Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION(S), MAY 2019

Course Code: CS301

Course Name: THEORY OF COMPUTATION

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1 What is a Finite state automata? (3)

2 Construct DFA for the language 101^* (3)

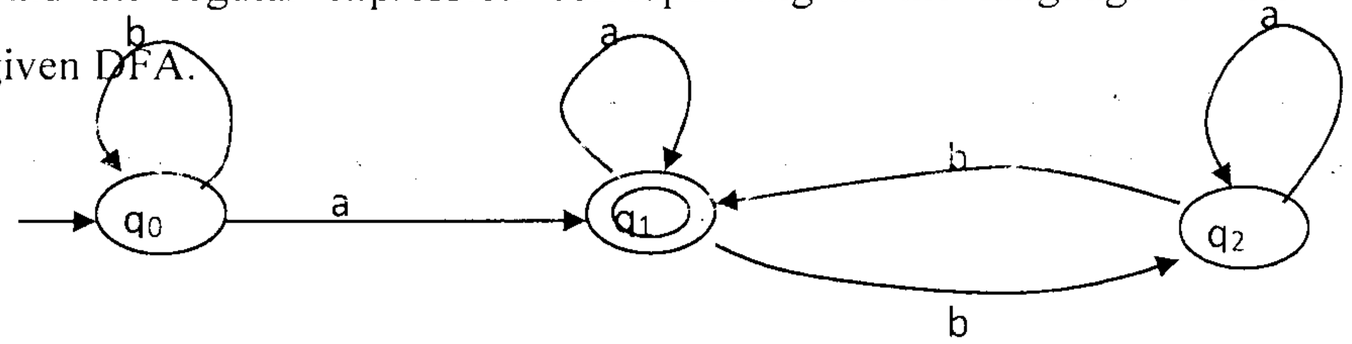
3 Give the regular expression for the language: strings of 'a' and 'b' containing at least two 'b'. (3)

4 What is a two-way finite automata? (3)

PART B

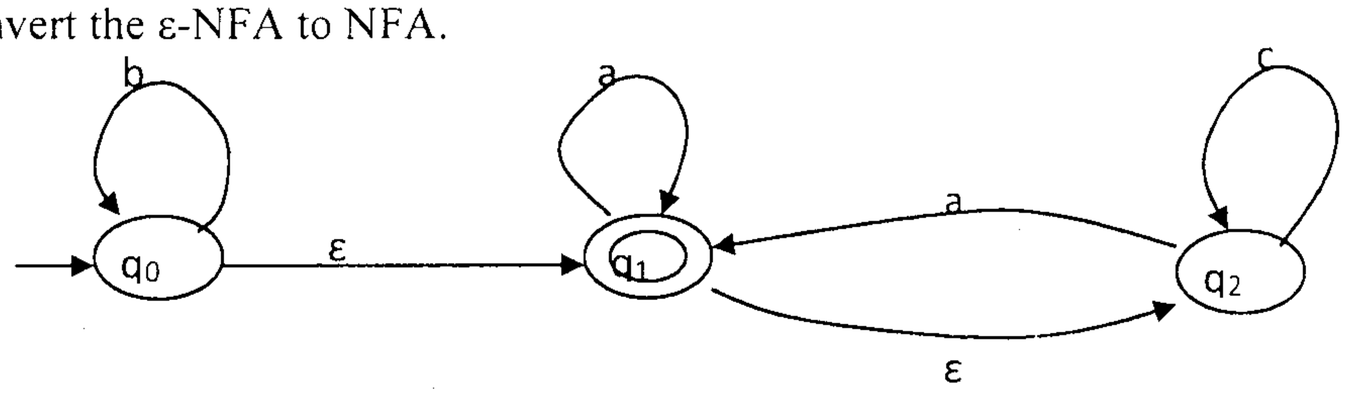
Answer any two full questions, each carries 9 marks.

5 a) Find the regular expression corresponding to the language of the given DFA. (4.5)



b) Prove the equivalence of NFA and ε-NFA. (4.5)

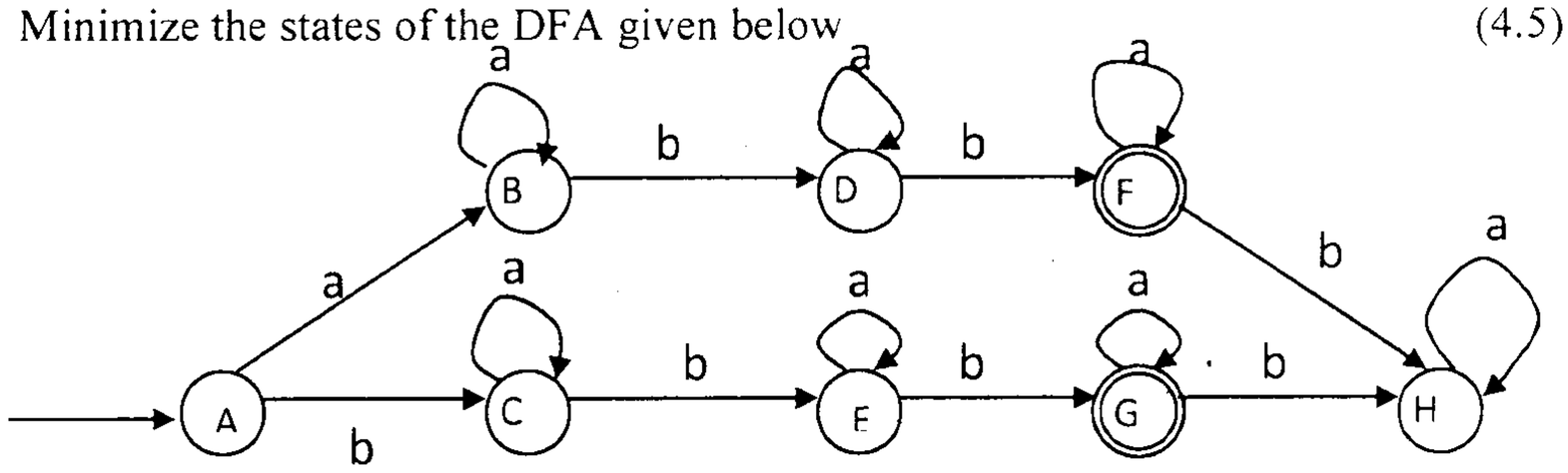
6 a) Convert the ε-NFA to NFA. (4.5)



b) Prove the equivalence of regular expression and finite state automata (4.5)

7 a) Compare the transition functions of DFA, NFA and ε-NFA. (4.5)

b) Minimize the states of the DFA given below (4.5)



PART C

Answer all questions, each carries 3 marks.

8 Give the CFG for the language $\mathbf{ww^R}$ where w is string of zeroes and ones. (3)

9 What is a derivation tree? Give an example. (3)

10 Compare DPDA and NPDA. (3)

11 Explain any two closure properties of CFL. (3)

PART D

Answer any two full questions, each carries 9 marks.

12 a) Prove that the language 1^n0^n is non-regular where n>0. (4.5)

b) Construct PDA for the language $\mathbf{wcw^R}$ where w is string of zeroes and ones. (4.5)

13 a) Prove the equivalence of PDA accepting by empty stack and final states (4.5)

b) Convert the grammar {S→ABaC|ABa, A→Aa|a, B→BaB|b, C→CC} to Chomsky normal form. (4.5)

14 a) Convert to Greibach Normal form. {S→AB, A→SA|AA|a, B→SB|b} (4.5)

b) Prove the equivalence of CFG and PDA. (4.5)

PART E

Answer any four full questions, each carries 10 marks.

15 a) Prove that $a^nb^nc^n$ is non-context free language where n>0. (5)

b) What is a Universal Turing Machine? (5)

16 a) What is Pumping lemma for CFL? (5)

b) What is Halting problem? (5)

17 a) What is Linear Bounded Automata? (5)

b) What is Chomsky hierarchy? Give example for each type. (5)

18 a) Give the context sensitive grammar for the language $a^nb^nc^n$ where (5)