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.

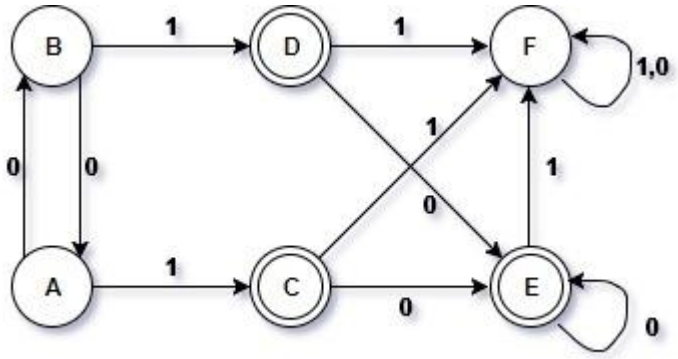
5 a) Design a Finite state automata which accepts all strings over {0,1} with odd number of 1's and even number of 0's. (5)

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

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 $L= \{a^n b^{2n} \mid n>0\}$ (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 $L = \{ a^n b^n c^n \mid n>0 \}$ (10)

17 a) What is a Context sensitive grammar(CSG). Design a CSG to accept the language $L = \{ 0^n 1^n 2^n \mid n>0 \}$ (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, 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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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

Course Code: CS301

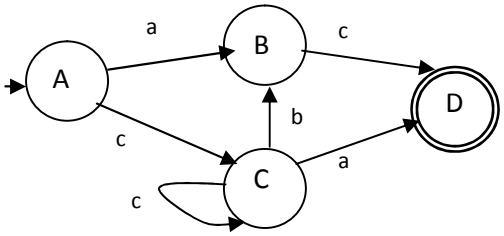
Course Name: THEORY OF COMPUTATION (CS)

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)

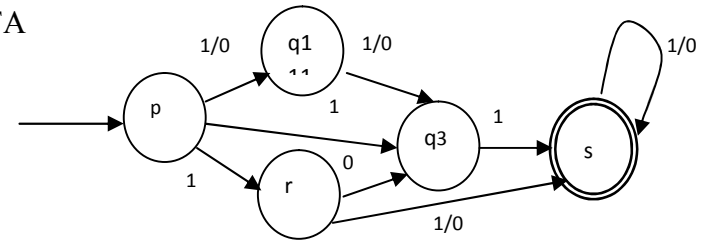
3 Explain in English language the language accepted by the DFA in Question 1. (3)

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 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)

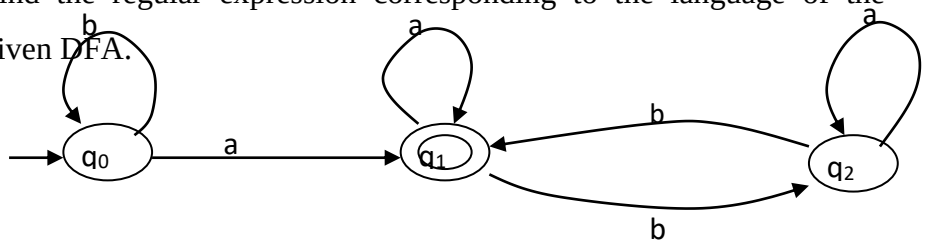
3 Give the regular expression for the language: strings of 'a' and 'b' containing at least two 'b'. (3)

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

PART B

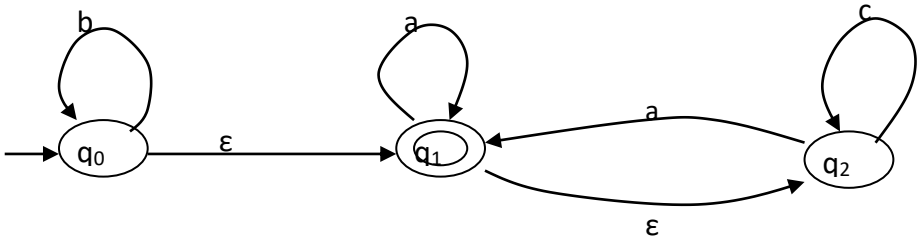
Answer any two full questions, each carries 9 marks.

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)

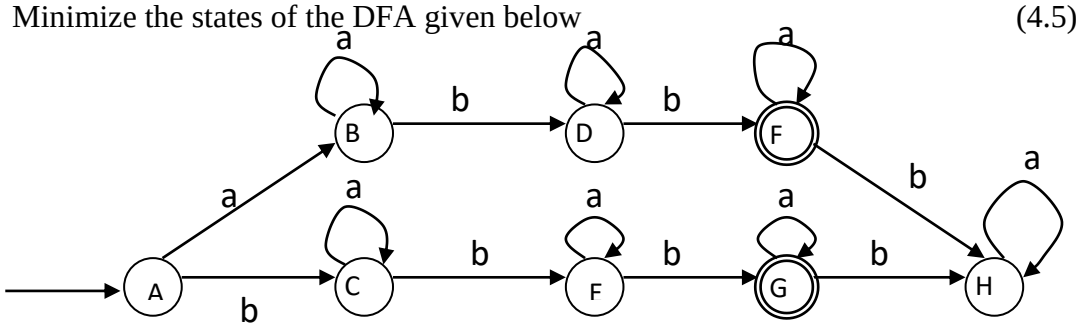
6 a) Convert the ε-NFA to NFA. (4.5)



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)

n>0.

b) What is Multi-tape Turing Machine? (5)

19 a) Design a Turing machine that accepts the language 1^n0^n where n>0. (5)

b) What is a non-deterministic Turing Machine? Give an example. (5)

20 a) What is a Turing machine? Give the specification of a Turing machine and explain. (5)

b) What is recursive and recursively enumerable languages (5)

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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

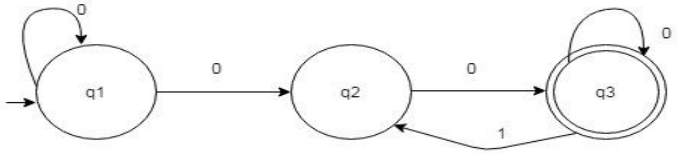
Max. Marks: 100 Duration: 3 Hours

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

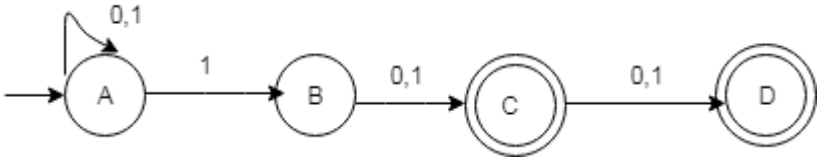
6 a) State Myhill-Nerode Theorem. 3

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 δ(p , ϵ , X_0) = {(q, ZX_0)}, δ(q , ϵ , X_0) = {(r, ϵ)}, δ(q , 1, Z) = {(q, ZZ)}, δ(q , 0, Z) = {(q, ϵ)}. 4.5

b) Find the Greibach normal form grammar equivalent to the following CFG: 4.5
S → AB
A → BS| 1
B → 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 S → ABaC, A→BC, B→b/ ϵ, C→D/ ϵ , D→d 4.5

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

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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

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

Course Code: CS301

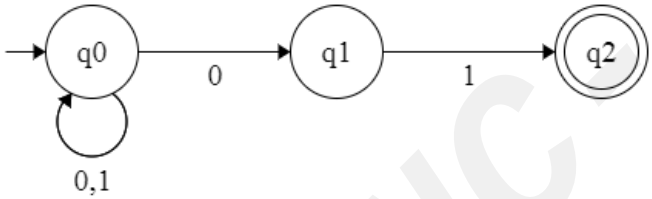
Course Name: THEORY OF COMPUTATION

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

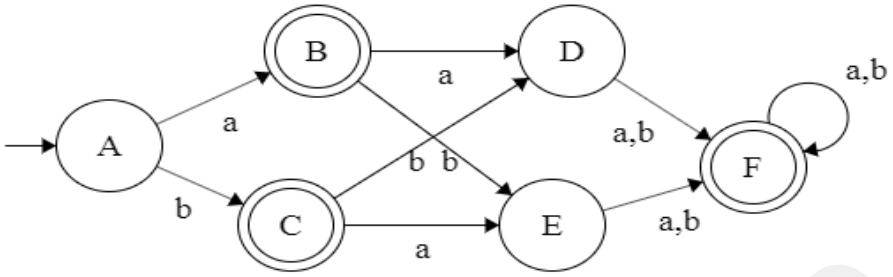
Answer any two full questions, each carries 9 marks.

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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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth Semester B.Tech Degree Regular and Supplementary Examination December 2020

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		Design a DFA to accept the set of binary strings ending with 0	(3)
2		Show the formal definition of the transition relation in an ε-NFA. Illustrate how a transition is performed by an ε-NFA.	(3)
3		List two differences between Moore and Mealy Machines. Give a Mealy machine with the minimum possible number of states that outputs the one's complement of a given binary string.	(3)
4		Give a regular grammar for the language {$w \in \{a, b\}^* \mid w$ has even number of 'a's and even number of 'b's}	(3)

PART B

Answer any two full questions, each carries 9 marks.

5	a)	Design a DFA for the language {$w \in \{0, 1\}^* \mid w$, when considered as an integer, is a multiple of 3}.	(6)
	b)	Design a DFA for the language {$w \in \{a, b\}^* \mid w$ did not contain 'aab' as a substring}.	(3)
6	a)	Find an ε-NFA for the language L($a(a+b)^*b$) employing the rules for regular expression to ε-NFA conversion.	(3)
	b)	Convert the above ε-NFA into an equivalent DFA, clearly showing the steps of the standard procedure for the same.	(6)
7		Find a DFA and a regular expression for the language {$w \in \{a, b\}^* \mid w$ has odd number of 'a's}.	(9)

PART C

Answer all questions, each carries 3 marks.

8		When a Grammar is said to be ambiguous? Show that the grammar with productions P = {E → E + E | E * E | (E) | a } for simple arithmetic expressions, is ambiguous.	(3)

9		Given that, the language $\{a^n b^n \mid n \geq 0\}$ is not regular. Prove that the language $\{w \in \{a, b\}^* \mid w$ has equal number of 'a's and 'b's$\}$ is not regular, without using Pumping Lemma.	(3)
10		Give a formal definition for NPDA.	(3)
11		Give a PDA which accepts the language $\{a^n b^n \mid n > 0\}$ by empty stack	(3)

PART D

Answer any two full questions, each carries 9 marks.

12		Is the following language regular? Prove it.	(9)
	(i)	$\{w \in \{0, 1\}^* \mid$ the length of w is a prime number$\}$	
	(ii)	L* (i.e., the Kleene closure of L) where L = $\{a^p \mid$ where p is a prime number$\}$	
13		Give a CFG with two productions for the language $\{a^{4n} \mid n > 0\}$and convert it into Chomsky Normal Form.	(9)
14		Prove that there is a PDA which accepts a language L by final state *if and only if* there is a PDA which accepts L by empty stack.	(9)

PART E

Answer any four full questions, each carries 10 marks.

15	a)	State 'Pumping Lemma for Context Free Languages.'	(3)
	b)	Prove that the language $\{0^n 1^n 2^n \mid n > 0\}$ is not a CFL.	(7)
16	a)	Design a Turing Machine which accepts the set of all palindromes over $\{a, b\}$	(8)
	b)	Show the computations done by the above machine when the input is '1001' by means of Instantaneous Descriptions (IDs).	(2)
17		Design a Turing Machine that multiplies two unary numbers, by first giving an outline of the strategy of operation of the machine in English sentences.	(10)
18	a)	Give the structure and explain the working of a Multi-tape Turing Machine	(5)
	b)	Give a formal definition for a Non-deterministic Turing Machine. Show an example NDTM	(5)
19	a)	Prove that if a language L is recursive, so is its complement.	(5)
	b)	Prove that if both a language L and its complement are recursively enumerable, then L is recursive.	(5)
20		Prove that 'Turing Machine Halting Problem' is undecidable.	(10)

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