Revised 12/3/21

CBCS SCHEME

USN | | | | | | | | | | |

18CS54

Fifth Semester B.E. Degree Examination, Jan./Feb. 2021
Automata Theory and Computability

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Define the following with example:
i) String ii) Language iii) Alphabet iv) Symbol **(04 Marks)**

b. Design a DFSM to accept each of the following language:
i) $L = \{w \in \{a, b\}^* ; w$ has all strings that ends with sub string abb $\}$
ii) $L = \{w;$ where $|w| \bmod 3 = 0$ where $\Sigma = \{a\}\}$
iii) $L = \{w \in \{a, b\}^*$ every a region in w is of even length.$\}$ **(09 Marks)**

c. Construct an equivalent DFA from the following given NFA using subset construction method. (Refer Fig.Q.1(c)) **(07 Marks)**

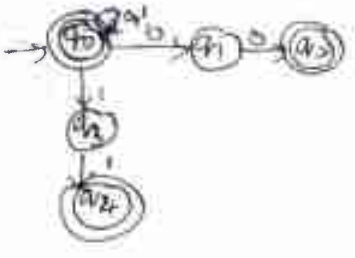

Fig.Q.1(c)

OR

2 a. Construct a minimum state automation equivalent to the FA given table

States	0	1
$\rightarrow q_0$	q_1	q_5
q_1	q_6	q_2
q_2	q_0	q_2
q_3	q_2	q_6
q_4	q_7	q_5
q_5	q_2	q_6
q_6	q_6	q_4
q_7	q_6	q_2

(10 Marks)

b. Consider the following NFA with ϵ-moves construct on equivalent DFA. **(10 Marks)**

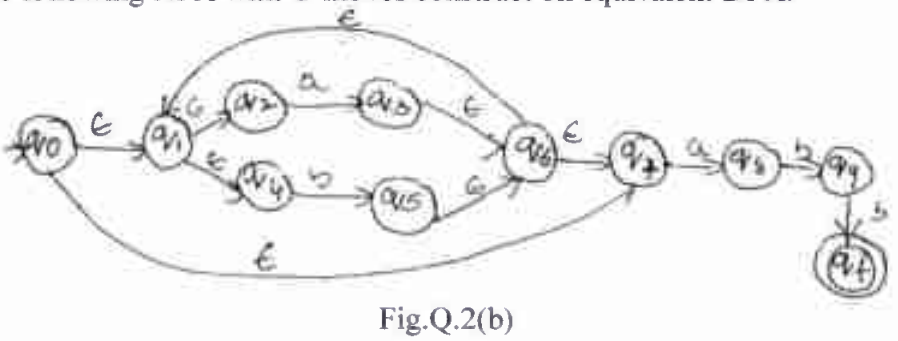

Fig.Q.2(b)

Module-2

3 a. Define Regular expression. Write RE for the following languages:

i) $L = \{a^n b^m \mid m+n \text{ is even}\}$

ii) $L = \{a^n b^m \mid m \geq 1 \;\; n \geq 1 \;\; nm \geq 3\}$

iii) $L = \{a^{2n} b^{2m} \mid n \geq 0, m \geq 0\}$ **(10 Marks)**

b. Construct an $\in$ - NFA for the regular expression $0 + 01^*$ **(05 Marks)**

c. Construct on FA for the regular expression $10 + (0 + 11)0^*1$ **(05 Marks)**

OR

4 a. State and prove pumping lemma theorem for regular languages. **(08 Marks)**

b. Prove that $L = \{a^p \mid p \text{ is a prime}\}$ is not a regular. **(08 Marks)**

c. List out closure properties of regular sets. **(04 Marks)**

Module-3

5 a. Define CFG. Write a CFG to specify

i) all string over {a, b} that are even and odd palindromes.

ii) $L = \{a^n b^{2n} \text{ over } \Sigma = \{a, b\} \; n \geq 1\}$ **(10 Marks)**

b. Write the procedure for removal of $\in$-productions. Simplify the following grammar.

$S \rightarrow aA \mid aBB$

$A \rightarrow aAA \mid \in$

$B \rightarrow bB \mid bbC$

$C \rightarrow B$ **(10 Marks)**

OR

6 a. Define PDA. Design a PDA for the language that accepts the string with $n_a(w) < n_b(w)$ where $w \in (a + b)^*$ and show the instantaneous description of the PDA on input abbab. **(10 Marks)**

b. What is CNF and GNF? Convert the following grammar into GNF.

$S \rightarrow AA \mid a$

$A \rightarrow SS \mid b$ **(10 Marks)**

Module-4

7 a. With a neat diagram, explain variant of turning machine. **(10 Marks)**

b. Construct a Turning machine that accept the language 0^n, 1^n where $n > 1$ and draw transition graph for Turning Machine. **(10 Marks)**

OR

8 a. Define Turning Machine with its tuples. **(04 Marks)**

b. Explain the working principle of Turning Machine with diagram. Design a Turing Machine to accept strings formed on {0, 1} and ending with 000. Write transition diagram and ID for w = 101000. **(16 Marks)**

Module-5

9 a. Explain restricted turing machines. **(08 Marks)**

b. Explain the following with example:

i) Decidability ii) Decidable languages iii) Undecidable languages. **(12 Marks)**

OR

10 Write a short note on:

a. Post correspondence problem

b. Halting problems in Turning Machine

c. Linear Bound Automation (LBA)

d. Classes of P and NP **(20 Marks)**

* * * * *

Regarding 18CS54 Scheme

"Dr. K. C. Ravishankar" <kcrshankar@gmail.com> March 12, 2021 4:50 PM

To: boe@vtu.ac.in

Dear Sir,

Regarding 18CS54 scheme the following clarifications have been given:
Question
1c. Any method can be accepted as per old or new syllabus.

2a. Any method for NFSM(NFA) to DFSM(DFA) conversion can be accepted.

6b. GNF definition and CNF definitions 2 Marks each. If the student has tried for GNF conversion 6 Marks can be awarded.

Thanking you
With Best Regards

Dr K C Ravishankar
BOE CS/IS Board

On Fri, 12 Mar 2021 at 15:50, <boe@vtu.ac.in> wrote:

> ------ Forwarded message ------
> From: "Shivu Patil" <shivupatil.2009@gmail.com>
> To: boe@vtu.ac.in
> Sent: March 12, 2021 3:49 PM
> Subject: Photo from Shivu

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Dr. K C Ravishankar B.E. M.Tech., Ph.D. FIETE,MIE,LMISTE
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Government Engineering College, Hassan-573201
Karnataka, India
Phone : +91-8172-240444(O)
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"APPROVED"
CBE
Registrar (Evaluation)
Visvesvaraya Technological University
BELAGAVI - 590018
12/03/2021

Re: Sir, regarding Modifications of scheme and solutions

"Ravishankar K C" <kcrshankar@gmail.com>

To: boe@vtu.ac.in

March 4, 2021 6:38 AM

Sir
Schemes of 17CS71 and 18CS54 have been approved.
This is for your kind reference and needful action
Regards

Dr K C Ravishankar
Principal GEC Hassan
Sent from my iPhone

> On 02-Mar-2021, at 3:05 PM, boe@vtu.ac.in wrote:
>
> <17CS71.pdf>
> <18CS54.pdf>

"APPROVED"
Registrar (Evaluation)
Visvesvaraya Technological University
BELAGAVI - 590018

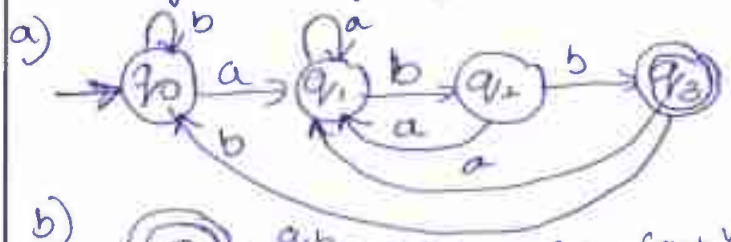
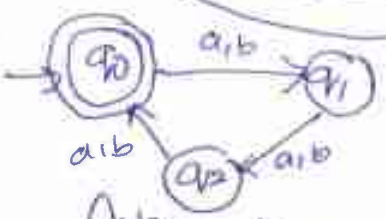
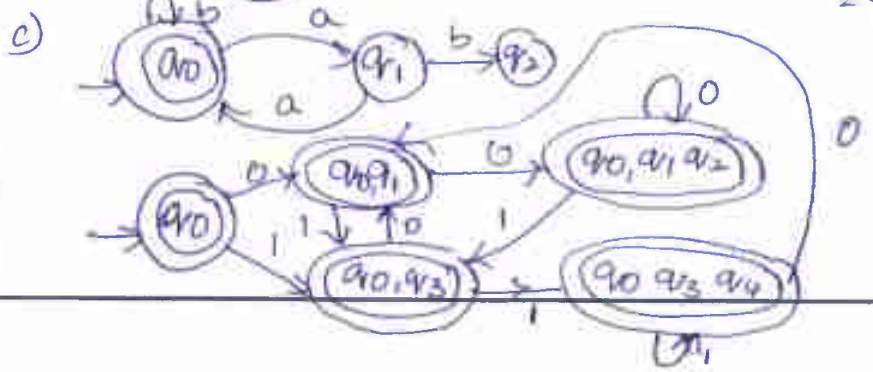
201118CS5424298

Visvesvaraya Technological University
Belagavi, Karnataka – 590 018.

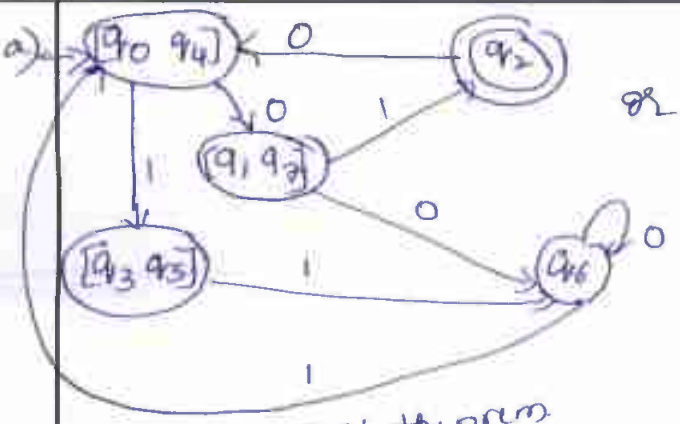
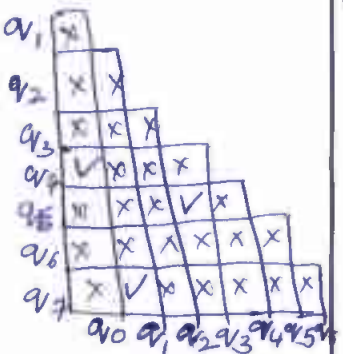
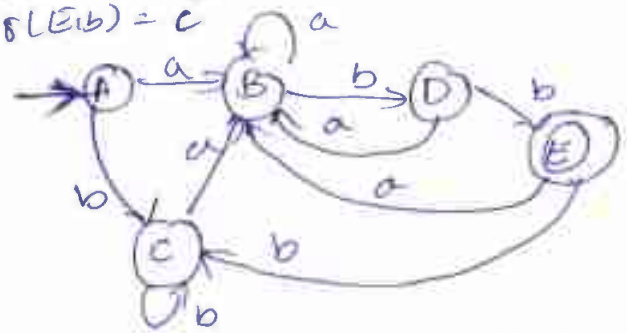
Scheme & Solutions

Signature of Scrutinizer

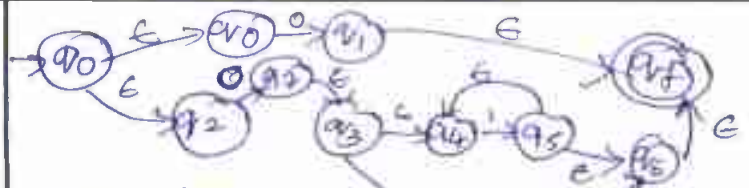
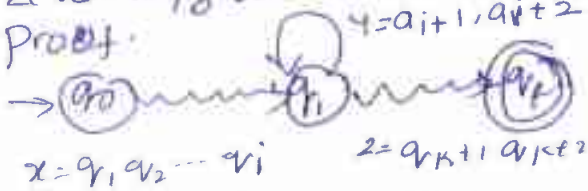
Subject Title : Automata Theory and computability **Subject Code :** 18CS54

Question Number	Solution	Marks Allocated
1 a)	i) A string is a finite sequence of symbols eg:- 1011, abc, 000 ii) A language is defined as a set of a strings of symbols over an alphabet eg:- Let $\Sigma = \{0,1\}$ then $\Sigma^* = \{\epsilon, 0, 1, 00, 01, 10, 11 \ldots\}$ iii) Alphabet: it is a finite set of symbols it is denoted by Σ. eg:- $\Sigma = \{0,1\}$ is binary alphabet $\Sigma = \{a,b,c\}$ is a set of letters iv) Symbol: it is an abstract or user defined entity. eg: letters, digits or any symbol that you want to consider as a part of the language you are going to define.	1×4 = 4 3×3 = 9
b)	a)  b)  $\delta(q_0, \{a,b\}) = q_{(0+1 \bmod 3)} = q_1$ $\delta(q_1, \{a,b\}) = q_{(0+1 \bmod 3)} = q_2$ $\delta(q_2, \{a,b\}) = q_{(2+1 \bmod 3)} = q_0$ c)  	7
c)		

Subject Title : ATC Subject Code : 18CS54

Question Number	Solution	Marks Allocated
Q2 a)	 using equivalent theorem	10 (5+5)
	 tabulation method	
	$\{\{q_0 q_4\}\ \{q_1 q_7\}\ \{q_3 q_5\}\ \{q_2\}\ \{q_6\}\}$	
b)	$A = \{q_0 q_1 q_2 q_4 q_7\}$ $\delta(A,a) = \{q_3 q_6 q_7 q_1 q_2 q_4 q_8\} = B$ $\delta(A,b) = \{q_1 q_2 q_6 q_5 q_6 q_7\} = C$ $\delta(B,a) = \{q_1 q_2 q_3 q_4 q_6 q_7 q_8\} = B$ $\delta(B,b) = \{q_1 q_2 q_4 q_5 q_6 q_7 q_9\} = D$ $\delta(C,a) = \{q_3 q_2 q_3 q_4 q_6 q_7 q_8\} = B$ $\delta(C,b) = \{q_1 q_2 q_4 q_5 q_6 q_7\} = C$ $\delta(D,a) = B$ $\delta(D,b) = \{q_1 q_2 q_4 q_5 q_6 q_7 q_4\} = E$ $\delta(E,a) = B$ $\delta(E,b) = C$ 	10 = (5+5)
Q3 a)	Defn:- RE is a notation to specify a regular set, hence for every RE there exists a FA.	1
	i) $(aa)^*(bb)^* + a(aa)^* b(bb)^*$	3×3=9
	ii) $aaaa^*b + a\,bbbb^* + aaa^* bbb^*$	
	iii) $(aa)^*(bb)^*$	10

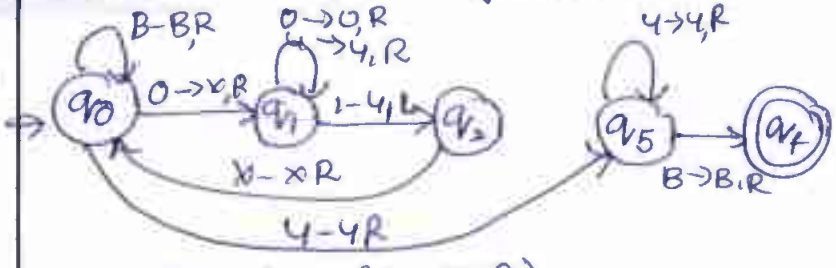
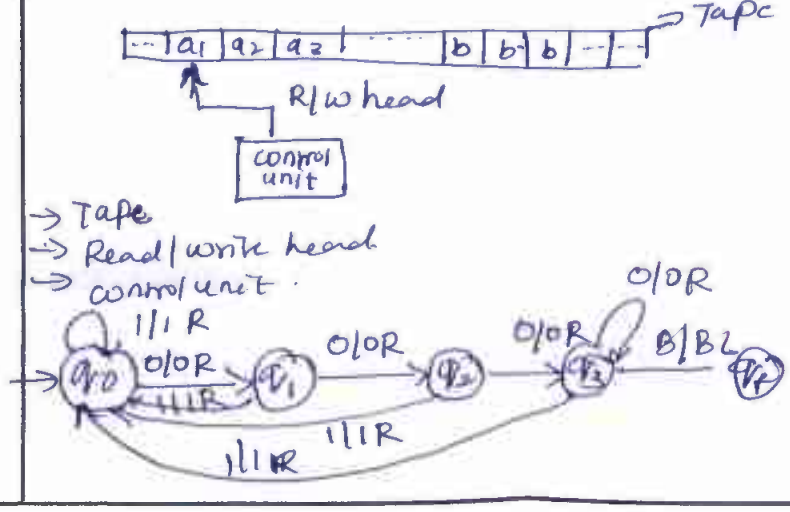
Subject Title : ATC Subject Code : 18CS54

Question Number	Solution	Marks Allocated
2g b)		5
c)		5
4 a)	Theorem:- Let $M=(Q, \Sigma, \delta, q, F)$ be a DFA having n states M recognizes the language L. A long string $w \in L$ such that $\|w\| \geq n$ & $w = xyz$ where $y \neq \epsilon$ then $xy^i z \in L$ for $i \geq 0$.	2
	Proof:  $y = a_{i+1}, a_{i+2} \cdots q_k$ $x = q_1 q_2 \cdots q_i$ $z = q_{k+1} q_{k+2} \cdots q_m$	6
b)	1) Assume L is regular. 2) Choose a string $w \in L$ such that $\|w\| \geq n$. Let $w = ap$ such that $p \geq n$. $\|w\| = \|ap\| = p\|a\|$. 3) Choose a suitable integer i such that $xy^i z \in L$ $w = xyz$ $xy \leq n$ $y > 0$. $w = xyz = ap = a^r a^m a^k$. $i+ = i-1 = p$ $= \|xyz\| + \|y^{i-1}\|$ $i = p+1$ $= p + (i+1)\|y\|$ $p = (i-1)m$. $p + p(m)$ $p(1+m)$ is not regular.	8
c)	closed under union, " " concatenation. closed under Kleen star. " " complementation, intersection, substitution, homomorphism & inverse homomorphism, quotient with arbitary any set.	4

Subject Title : ATC Subject Code : 18CS54

Question Number	Solution	Marks Allocated
Q5 a)	Definition G = (V, P T S) P → productions (i) S → aSa S → bSb even S → ∈ for odd palindrome. S → asa/bsb/a/b for odd palindrome. (ii) S → aSbb/abb Procedure for elimination	2 4 5 3
b)	Removing ∈-production Eliminate unit production Remove useless symbols. S → aA/a A → aAA/aAa.	4 6
c)	1) L is context free. 2) Not that $\|z\| > n$, R uniquely such that $\|vwx\| \le n$ & $\|vx\| \ge 1$. 3) according to pumping lemma. $uv^iwx^iy \notin L$.	
Q6 a)	$\delta(q_0, a, z_0) = (q_0, az_0)$ $\delta(q_0, b, z_0) = (q_0, bz_0)$ $\delta(q_0, a, a) = (q_0, aa)$ $\delta(q_0, b, a) = (q_0, a)$ $\delta(q_0, b, a) = (q_0, \epsilon)$ $\delta(q_0, \epsilon, z_0) = (q_0, \epsilon)$ q_0, abbab z_0 ⇒ q_0 bbab az_0 ⇒ q_0 bab az_0 ⇒ q_0 ab z_0 ⇒ q_0 b az_0 ⇒ q_0 ϵ z_0 ⇒ q_f, ϵ accepted by empty stack.	10
b)	There are two two normal form 1) Chomsky Normal Form (CNF) 2) Greibach Normal Form (GNF) CNF :- A CFG G is in CNF if any production is of the form A → BC or A → a. GNF : if every production rule of the grammar is of the form A → aα, where A is a non terminal a is terminal and α is a string of non terminal. GNF productions are $A_1 \to aA_1A_2 \mid aA_1B_2A_2 \mid bA_2 \mid bB_2A_2 \mid a$ $A_2 \to aA_1 \mid aA_1B_2 \mid b \mid bB_2$ $B_2 \to aAA_1 \mid aA_1B_2A_1 \mid bA_1 \mid bB_2A_1$ $B_2 \to aAA_1B_2 \mid aA_1B_2A_1B_2 \mid bA_1B_2 \mid bB_2A_1B_2$	10 2 8

Subject Title : ATC Subject Code : 18CS54

Question Number	Solution	Marks Allocated
Q7 a)	Turing M/c with a tape is Modified version of the PDA & it is more powerful than PDA (1) Multitape turing M/c (2) Non deterministic Turing m/c (3) Enumerating Turing M/c	1 3×3=9
b)	 δ(q0,B) = (q0,B,R)	10
Q8 a)	Definition & explanation — Application of Pumping lemma for CFLs is used to prove that certain Language are not CFL. Step1: L is cf and is infinite $z = a^n b^n c^n \in L$ Step2: $\|z\| > n$ and we can split z into uvwxy such that $\|vwx\| \le n$ & $\|vx\| \ge 1$. Step3 $w = uv^i wx^i y$ $w = a a^i b b^i c c$ uv wx y if i = 0 $w = a b c c \notin L$ Hence our assumption is wrong. case1 = vwx within a^n case2 = vwx $a^n b^n$ case3 = vwx within c^n.	(4)
b)	 Diagram —— (3) ID —— for 1011000 (3)	10

Subject Title : ATC Subject Code : 18CS54

Question Number	Solution	Marks Allocated
9 (a)	TM by imposing certain restriction on TM. Instead of providing the complete Simulation. → TM with Semi-infinite tape. → Multi Stack M/C → Counter M/C → linear bounded automata. → Off line TM.	4x2
(b)	a) Decidability :- → we investigate the Power of algorithms to solve problems. → certain problems that can be solved algorithmically and others that can not be solved. b) Decidable languages. → knowing a problem is ~~co~~unsolvable useful because i) it must be simplified & altered before we find an algorithmic soln. ii) Gain a better perspective on computation and its limitations. b) Decidable language : A language is called Decidable or Recursive if there is a Turing machine which accepts and halts on every input string w. Every decidable language is turing Acceptable. → A decision problem P is decidable if the language L of all yes instances to P is decidable eg: Find out whether the following problem is decidable or not - Is a number 'm' prime. c) ~~the~~ problems for which c) undecidable languages : There is no TM which accepts the language and makes a decision for every input string w. undecidable languages are not recursive but sometimes they may be recursively ~~e~~ numerable languages.	4 4 4

Subject Title : ~~18CS54~~ ATC Subject Code : 18CS54

Question Number	Solution	Marks Allocated
	eg:- The halting problem of TM ⇒ Post correspondence problem	
Q 10 a)	PCP introduced by Emil Post in 1946 is an undecidable decision problem. The PCP problem over an alphabet Σ is stated as follows: Give the following two lists M and N of non empty string over Σ $M = (x_1 x_2 \dots x_n)$ $N = (y_1 y_2 \dots y_n)$ we can say that there is a PCS dn, if for some $i_1 i_2 \dots i_k$ where $1 \le i_j \le n$, the condition $x_{i_1} \dots x_{i_k} = y_{i_1} \dots y_{i_k}$ satisfies examples Turing MLC Halting problem undecidability of PCP.	5
b)	Halting problem in TM:- The problem:- Given a Turing MLC M and an i/p string x does M halt on i/p x? importance:- if a MLC does not stop then we do not know for sure if it is going to accept or the given i/p or not	5
c)	LBA :- LBA is a multitrack non deterministic TM with a tape of some bounded finite length. length = function (length of the initial input string, constant c) Here Memory information $\le c \times$ i/p information	5
d)	class of P and NP :- P class is a set of problems whose soln running time depend polynomially on the size of the i/p ∴ it is relatively easy to find these soln using programs that are efficiently run.	5

Subject Title : ATC

Subject Code : 18CS54

Question Number	Solution	Marks Allocated
	NPclass:- it a set of problems whose soln is very hard to find perhaps requiring billions of years worth of computation but once found, it is easily checked in polynomial time.  "APPROVED" Registrar (Evaluation) Visvesvaraya Technological University BELAGAVI - 590018	