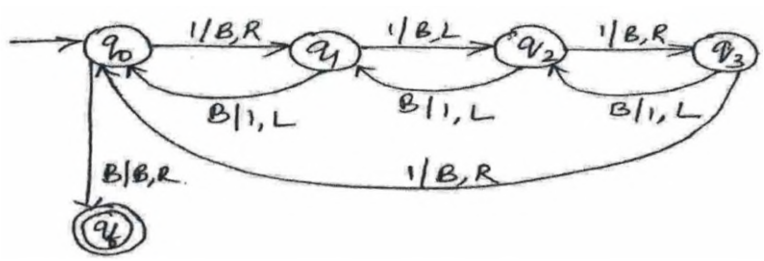
USN | | | | | | | | | | |

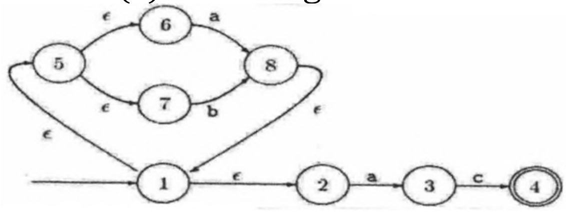
RV COLLEGE OF ENGINEERING®
(An Autonomous Institution Affiliated to VTU)
V Semester B. E. Examinations April/May -2024
Computer Science and Engineering
THEORY OF COMPUTATION

Time: 03 Hours ***Maximum Marks: 100***

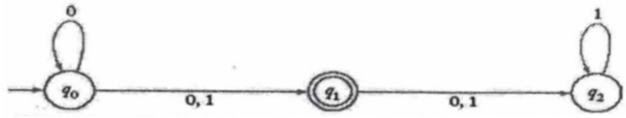
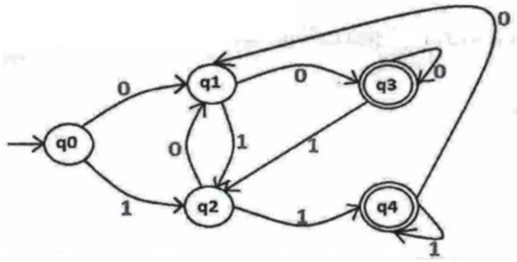
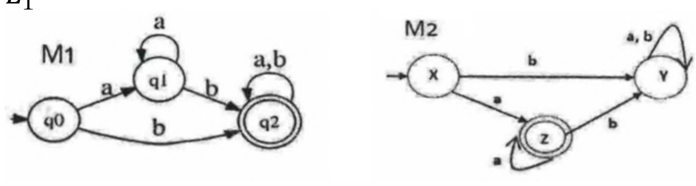
Instructions to candidates:
1. Answer all questions from Part A. Part A questions should be answered in first three pages of the answer book only.
2. Answer FIVE full questions from Part B. In Part B question number 2 is compulsory. Answer any one full question from 3 and 4, 5 and 6, 7 and 8, 9 and 10.

PART-A

			M	BT	CO
1	1.1	If the DFA $A1 = (\{q_0, q_1, q_2\}, \sum, \delta, \{q_0, q_1\}, q_0)$ and DFA $A2 = (\{p_0, p_1, p_2, p_3\}, \sum, \delta, \{p_3\}, p_0)$, then DFA of $\left(L(A1) \cap L(A2)\right)^R$ has ___________ final state(s).	01	1	3
	1.2	Let x be a positive integer represented using unary notation. Identify the function $f(x)$ computed by Turing machine shown in Fig 1.2. Note $x \in 1^*$.  Fig 1.2	01	3	4
	1.3	Consider the machine $M = (Q = \{q_0, q_1, q_2, q_3, q_4\},\ \sum = \{a_1, a_2, a_3\}, \Gamma = \{a_1, a_2, a_3\}, \delta, q_0, B, F = \{q_4\}\}$. A universal Turing machine Mu is an automaton that, given as input the description of any Turing machine M and a string w, can simulate the computation of M on w. For the transition $\delta(q_1, a_1) = (q_2, a_3, R)$, the encoding is ___________.	01	2	4
	1.4	Construct the grammar or the given regular expression $a(a+b)*b$.	02	2	3
	1.5	Consider the Turing machine $M = (Q = \{q_0, q_1\},\ \sum = \{a, b\},\ \Gamma = \{A, B\}, \delta, q_0, B, F = q\}$ with one of the transition (δ) defined by $\delta(q, a, b) = (q, A, B, L)$. Then the Turing machine is a ___________.	01	1	1
	1.6	Identify the nullable variable and eliminate all $\lambda-$productions from $S \to AaB \mid aaB, \quad A \to \lambda, \quad B \to bbA \mid \lambda$.	02	3	3
	1.7	Define GNF. Convert the grammar $S \to abSb \| aa$ into GNF.	02	2	3
	1.8	State any one decidable property of context free language.	01	1	1
	1.9	Consider the regular expression $ab^*(a+b)$. Construct the finite automata for this regular expression.	02	2	2
	1.10	Show that the following grammar is ambiguous: $S \to AB \mid aaB, \quad A \to a \| Aa, \quad B \to b$	02	3	3
	1.11	Distinguish between recursive and recursively enumerable language.	02	2	2

1.12	Find the $\epsilon - CLOSURE(8)$. Refer Fig 1.12.  Fig 1.12	01	1	2
1.13	Define $DPDA$.	02	2	3

PART-B

2	a	Show that the language $L = \{awa: w \in \{a, b\}^*\}$ is regular using deterministic automata.	03	2	3
	b	Convert the following NFA to DFA and minimize the converted DFA.  Fig 2b	08	3	2
	c	Discuss the algebraic properties of regular expressions.	05	2	1
3	a	Define CFG. Construct CFG for the following languages. i) $L = \{a^i b^j c^k : i! = j\}$ ii) $L = \{a^i b^j c^k : j = i + k\}$	04	2	2
	b	Define left linear grammar. Find all left linear grammar for the language accepted by the finite automata in Fig 3b.  Fig 3b	07	3	3
	c	Transform the grammar with productions into Chomsky normal form: $S \to abAB, \quad A \to bAB \mid \lambda, \quad B \to BAa \mid A \mid \lambda$	05	3	4
		OR			
4	a	Construct a finite automaton that accepts the language generated by the right linear grammar. $S \to cA \mid baS, \;\; A \to bB \mid aC \mid \varepsilon, \;\; B \to aA \mid bbC \mid \varepsilon, \;\; C \to abA \mid baC$	04	2	3
	b	Let $M1$ and $M2$ be the FA's as shown in Fig 4b, accepting languages $L1$ and $L2$ respectively. Draw $FA's$ accepting the following languages. i) $L_1 \cup L_2$ ii) $L_2 - L_1$ iii) L_1^R iv) $\overline{L_1}$  Fig 4b	08	3	2

	c	Eliminate the useless productions form the productions listed below and justify your answer. $S \to c\|aA\|B\|C,\quad A \to aB\|\lambda,\quad B \to Aa,\quad C \to cCD,\quad D \to ddd$	04	3	3
5	a	State and prove pumping lemma for $CFL's$. Show that the language $L = \{a^n b^n c^n : n \geq 0\}$ is not context free.	08	2	2
	b	Construct an $NPDA$ that accepts the language $L = \{a^n b^m : n \geq 0, n \neq m\}$. Give the graphical representation for PDA obtained. Show the moves made by the PDA for the string $aabbb$.	08	3	3
		OR			
6	a	Show that $CFL's$ are closed under union and concatenation.	04	2	1
	b	Give an algorithm to convert PDA to CFG. Convert the following Push Down Automata transitions to CFG. $\delta(q_0, a, z) = \{(q_0, A_z)\}$ $\delta(q_0, a, A) = \{(q_0, A)\}$ $\delta(q_0, b, A) = \{(q_1, \lambda)\}$ $\delta(q_0, \lambda, z) = \{(q_2, \lambda)\}$	08	3	2
	c	Discuss and elaborate on the languages accepted by PDA.	04	3	1
7	a	Define Turing machine. Let x and y are two positive integers represented using unary notation. Design a Turing machine that computes the function. i) $f(x,y) = x + y$ where $W(x), W(y)$ $\varepsilon 1+$ and $q \circ W(x) \circ W(y) \vdash qfW(x+y)0$ ii) $f(x) = x \, mod \, 4,\ x \in 1^+$	07	4	4
	b	Write a note on the following: i) Semi-infinite Tape Turing machine ii) Multi-stack Turing machine iii) Offline Turing machine.	09	2	1
		OR			
8	a	Design Turing machine to compute the function $f(w) = w^R$ where $w \in \{a, b\}^*$. Using instantaneous descriptions, show operation on $w = abb$.	06	3	4
	b	Define multitape TM. Explain how multitape TM can be simulated using single tape TM.	06	2	1
	c	If L_1 and L_2 are recursively enumerable languages over Σ , then prove that $L_1 \cap L_2$ and $L_1 \cup L_2$ are recursively enumerable.	04	1	2
9	a	Define post correspondence problem. Identify whether it is possible to solve the PCP given below. i) $A = \{1, 10111, 10\}$ and $B = \{111, 10, 0\}$ ii) $A = \{100, 101, 110\}$ and $B = \{10, 01, 1010\}$	08	3	4
	b	With the help of a neat diagram, discuss the relationship between the families of languages.	08	1	2
		OR			
10	a	Define context sensitive grammar. Design CSG for the language $L = \{a^n b^n c^n \mid n \geq 1\}$. Derive the string $a^3 b^3 c^3$ from the constructed CSG.	08	3	2
	b	Discuss the following: i) Halting problem of a TM ii) Unrestricted grammar.	08	2	1