Re-Modified

CBCS SCHEME

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

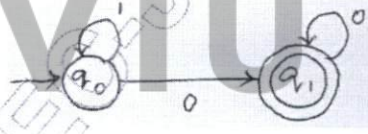
BCS503

Fifth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025
Theory of Computation

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Define the following with example : i) Language ii) String iii) Power of an alphabet.	3	L1	CO1
	b.	Define DFA. Draw a DFA to accepts. i) The set of all strings that contain a substring aba. ii) To accept the stings of a's and b's that contain not more than there b's. iii) L = {w ∈{a, b}* : No 2 consecutive characters are same in w}.	10	L3	CO1
	c.	Convert the following NFA to DFA. → p {p, q} {p} q {r} {r} r {s} ϕ * s {s} {s}	7	L2	CO1
		OR			
Q.2	a.	Define the following with example : i) Alphabet ii) Reversal of string iii) Concatenation of Languages.	3	L1	CO1
	b.	Design a DFA for the Language : L = {w ∈ {0, 1}* : w is a string divisible by 5}.	7	L3	CO1
	c.	Define NFA. Obtain an ε - NFA which accepts strings consisting of 0 or more a's , followed by 0 or more b's followed by 0 or more C's. Also convert it to DFA.	10	L2	CO1
		Module – 2			
Q.3	a.	Define Regular expression. Write the regular expression for the following languages : i) Strings of a's and b's starting with a and ending with b. ii) Set of strings that consists of alternating 0's and 1's. iii) L = {a^n bm , (n + m) is even}. iv) L = {w : / w / mod 3 = 0 , where w ∈{a, b}*}.	10	L2	CO2

	b.	Minimize the following finite automata using Table filling algorithm : $\rightarrow$ A: B, A B: A, C C: D, B * D: D, A E: D, F F: G, E G: F, G H: G, D	**10**	**L2**	**CO2**
		OR			
Q.4	**a.**	Construct ε - NFA for the following Regular expression : i) $(0+1)\,0\,1(1+0)$ ii) $1(0+1)^*\,0$ iii) $(0+1)^*\,0\,1\,1^*$	**6**	**L1**	**CO2**
	b.	Obtain the Regular expression that denotes the language accepted by Fig. Q4(b). Fig. Q4(b)  Using Kleene's theorem.	**6**	**L3**	**CO2**
	c.	State the Pumping Lemma for the Regular Languages. And also prove that the following languages are note regular. i) $L = \{0^n\,1^m \mid n \le m\}$ ii) $L = \{0^n\,1^m\,2^n \mid n, m \ge 1\}$.	**8**	**L1**	**CO2**
		Module – 3			
Q.5	**a.**	Design CFG for the following languages : i) $L = \{a^n\,b^{n+3}, n \ge 0\}$ ii) $L = \{a^i\,b^j\,c^k, j = i + k, i \ge 0, k \ge 0\}$ iii) $L = \{w / /w/ \bmod 3 > 0 \text{ where } w \in \{a\}^*\}$ iv) $L = \{a^m\,b^n / m \ne n\}$ v) Palinderomes over 0 and 1.	**10**	**L3**	**CO3**
	b.	Consider the grammar G with productions. $S \rightarrow A\,b\,B / A / B$; $A \rightarrow aA / \varepsilon$; $B \rightarrow a\,B / b\,B / \varepsilon$. Obtain LMD , RMD and parse tree for the string aaabab. Is the given grammar ambiguous?	**10**	**L2**	**CO3**
		OR			
Q.6	**a.**	Define the following with example : i) Context free grammar ii) Left most Derivation iii) Parse tree iv) Ambiguous grammar.	**4**	**L1**	**CO3**
	b.	Design PDA for the language : $L = \{a^i\,b^j\,c^k / i + k = j, i \ge 0, k \ge 0\}$ and show the moves made by the PDA for the string aabbbc.	**10**	**L3**	**CO3**

	c.	Convert the following CFG's to PDA : $S \rightarrow a\,A$; $A \rightarrow a\,ABC / bB / a$; $B \rightarrow b$; $C \rightarrow c$.	6	L2	CO3
		Module – 4			
Q.7	a.	Define CNF. Convert the following CFG to CNF $E \rightarrow E + T / T$ $T \rightarrow T * F / F$ $F \rightarrow (E) / I$ $I \rightarrow Ia / Ib / a / b$.	10	L2	CO4
	b.	Show that $L = \{0^n\,1^n\,2n / n \geq 1\}$ is no context free.	4	L2	CO4
	c.	Prove that the family of context free languages is closed under union and concatenation.	6	L1	CO4
		OR			
Q.8	a.	Define Greibach Normal Form. Convert the following CFG to GNF. $S \rightarrow AB$; $A \rightarrow aA / bB / b$; $B \rightarrow b$.	6	L2	CO4
	b.	Consider the following CFG : $S \rightarrow ABC / BaB$ $A \rightarrow aA / BaC / aaa$ $B \rightarrow bBb / a / D$ $C \rightarrow CA / AC$ $D \rightarrow \varepsilon$ i) What are useless symbols? ii) Eliminate ε - productions , Unit productions and useless symbols from the grammar.	10	L3	CO4
	c.	Prove that the following languages are not context free. i) $L = \{ai / i \text{ is prime}\}$ ii) $L = \{a^{n^2} / n \geq 1\}$.	4	L2	CO3
		Module – 5			
Q.9	a.	Define a turing machine and explain with neat diagram, the working of a basic turing machine.	6	L1	CO4
	b.	Design a Turing machine to accept the language, $L = \{a^n\,b^n\,c^n / n \geq 1\}$. Draw the transition diagram and show the moves for the string aabbcc.	14	L4	CO4
		OR			
Q.10	a.	Design a Turing machine to accept palindrome over {a, b} and draw the transition diagram.	12	L4	CO5
	b.	Write a short notes on : i) Recursively Enumerable Language. ii) Multitape Turing Machine.	8	L1	CO5

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Fwd: BCS503 (Theory of Computation)

"Dr.Sampath S" <23.sampath@gmail.com> January 25, 2025 11:37 AM

To: boe@vtu.ac.in

---------- Forwarded message ---------
From: **Dr.Sampath S** <23.sampath@gmail.com>
Date: Fri, Jan 24, 2025 at 12:17 PM
Subject: BCS503 (Theory of Computation)
To: <boe@vtu.ac.in>

Dear Sir

Ignore my mail of Jan 22nd ,2025 regarding BCS503
In BCS 503 n Question No **4.b** can be awarded 6 marks if students attempted the question. Question No .**8.a** can be awarded 6 marks if students attempt a question. Mentioned two sub Questions slightly varied in the syllabus.
Regards,

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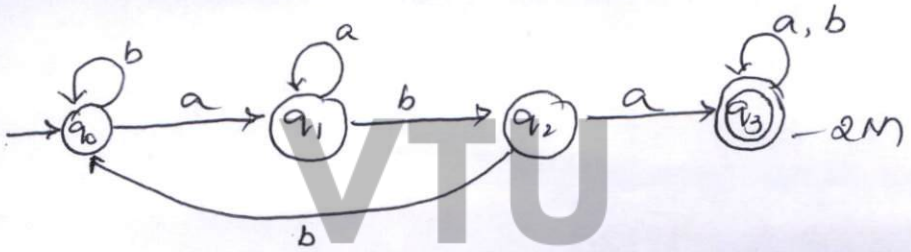
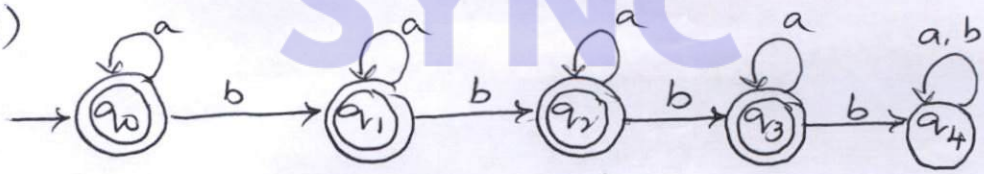
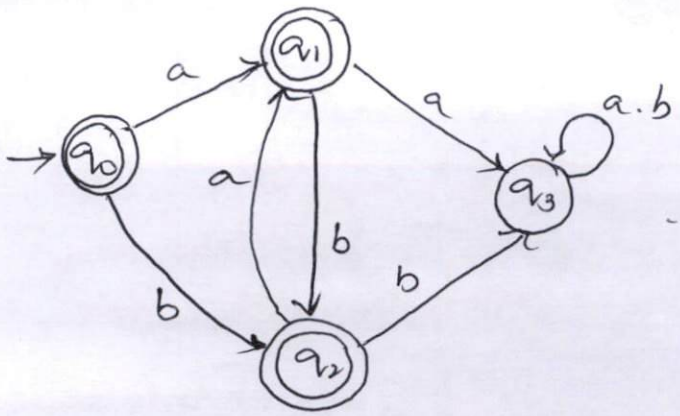
Signature of Scrutinizer

Scheme & Solutions

Subject Title : Theory of Computation **Subject Code :** BCS503

Question Number	Solution	Marks Allocated
1.a.	Each definition carries 1 mark 1X3=	3M
1.b	Definition of DFA - 1M	
	i)  - 2M	
	Explanation of 5 tuples - 1M	
	ii)  - 2M	
	Explanation of 5 tuples - 1M	10M
	iii)  - 2M	
	Explanation of 5 tuples - 1M	

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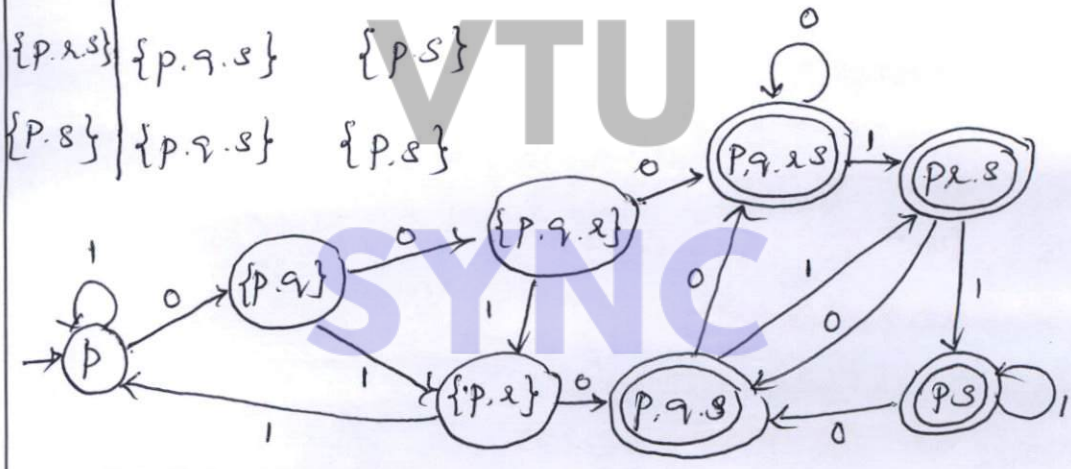
Question Number	Solution	Marks Allocated
1.c.	T.T of DFA	7M

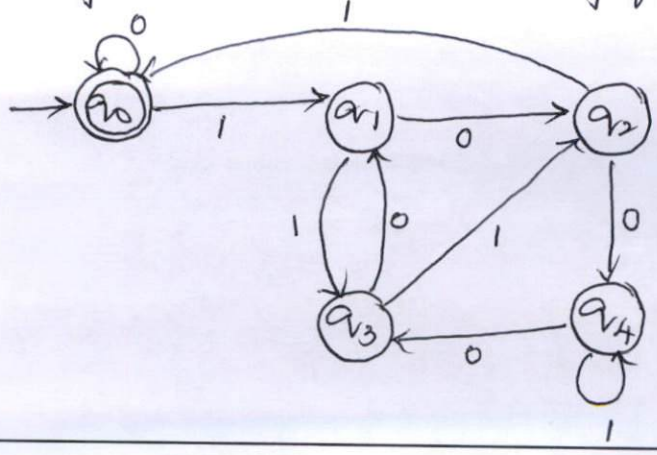
		0	1
→	p	{p,q}	{p}
	{p,q}	{p,q,r}	{p,r}
	{p,q,r}	{p,q,r,s}	{p,r}
	{p,r}	{p,q,s}	{p}
*	{p,q,r,s}	{p,q,r,s}	{p,r,s}
*	{p,q,s}	{p,q,r,s}	{p,r,s}
*	{p,r,s}	{p,q,s}	{p,s}
*	{p,s}	{p,q,s}	{p,s}

– 4M



– 3M

2.a	Each definition carries 1 mark	3M
2.b	Finding out transitions using formula – 3M.	



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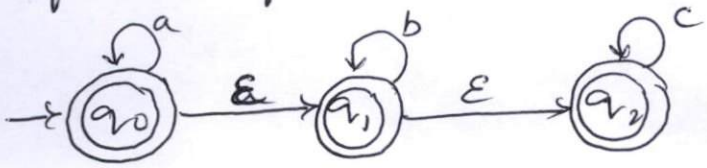
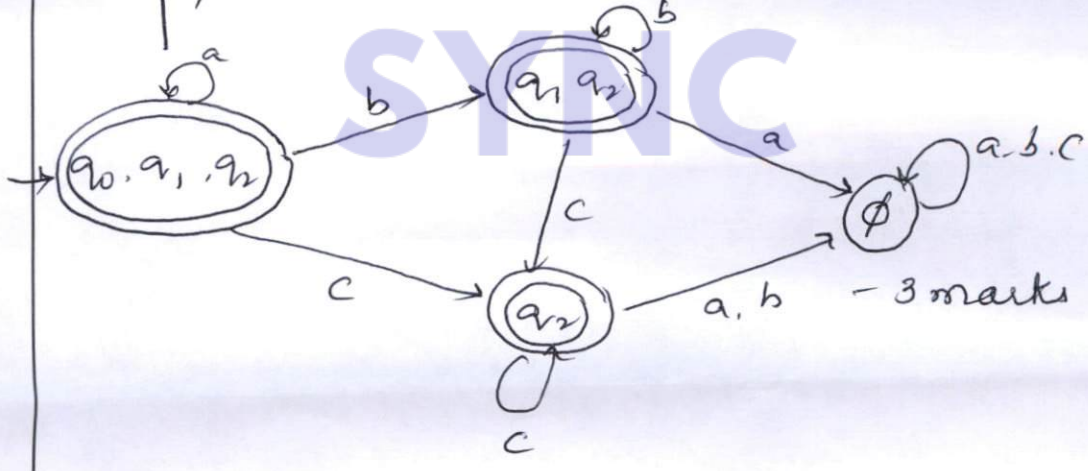
Question Number	Solution	Marks Allocated
2C.	Definition of NFA - 2 mark  $E\text{close}(q_0) = \{q_0, q_1, q_2\}$ $E\text{close}(q_1) = \{q_1, q_2\}$ - 1 Mark $E\text{close}(q_2) = \{q_2\}$ TT of DFA	10M

		a	b	c
	$q_0q_1q_2$	$q_0q_1q_2$	q_1q_2	q_2
*	q_1q_2	ϕ	q_1q_2	q_2
*	q_2	ϕ	ϕ	q_2

- 4 marks



3a.	Definition of RE - 2 marks i) $a(a+b)^*b$ - 2 marks ii) $(01)^* + (10)^* + (01)^*0 + (10)^*1$ - 2 marks iii) $(aa)^*(bb)^* + (aa)^*a(bb)^*b$ - 2 marks iv) $((a+b)(a+b)(a+b))^*$ - 2 marks	10M

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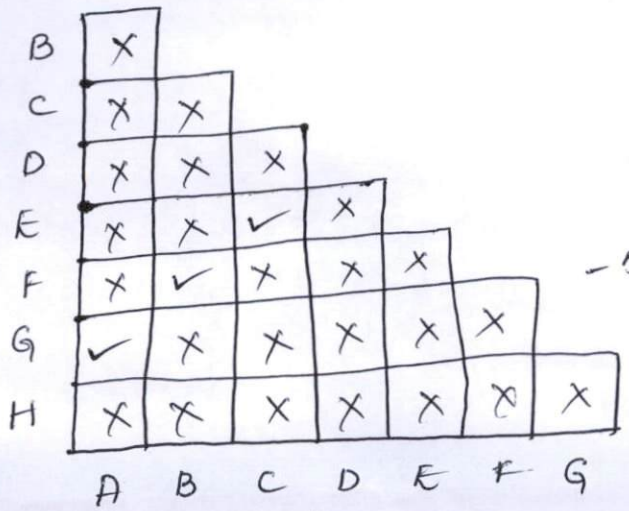
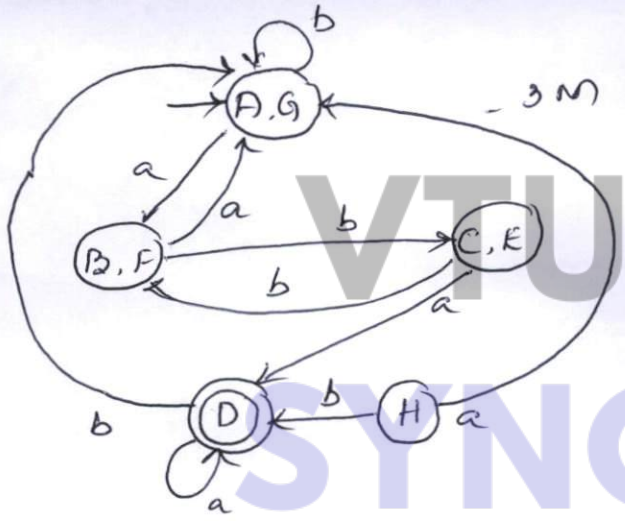
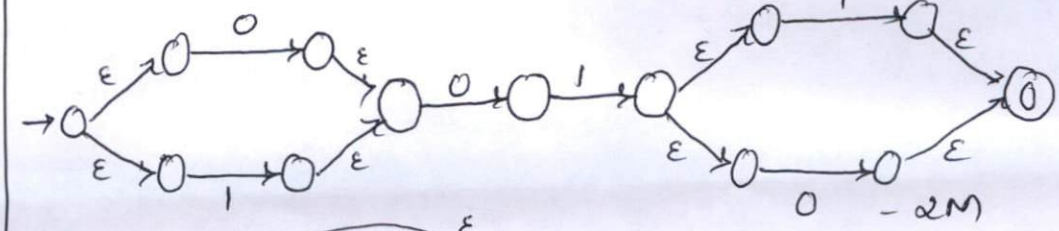
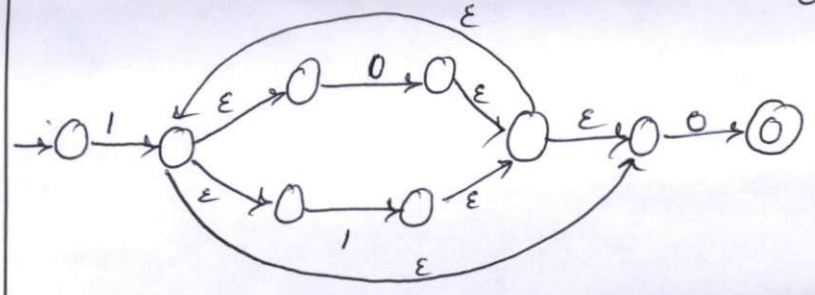
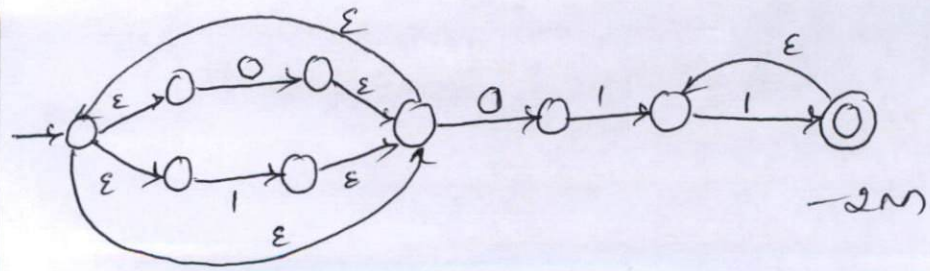
Question Number	Solution	Marks Allocated
3b.	 -5M  -3M transition table - 2M	10M
4a	 -2M  -2M  -2M	6M

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Question Number	Solution	Marks Allocated
4b.		6M
4.C	Statement - 2 M Proving Language is not regular Each carries 3 marks $3 \times 2 = 6$ M	8M
5a.	i) $P: S \to asb \mid bbb$ $G = (\{s\}, \{a,b\}, P, S)$ ii) $P: S \to S_1\$_2 \quad S_1 \to aS_1b \mid \varepsilon \quad S_2 \to aS_2b \mid \varepsilon$ $G = (\{S, S_1, S_2\}, \{a,b,c\}, P, S)$ iii) $P: S \to aaas \mid a \mid aa$ $G = (\{S\}, \{a\}, P, S)$ iv) $P: S \to asb \mid A \mid B \quad A \to aA \mid a \quad B \to bB \mid b$ $G = (\{S, A, B\}, \{a,b\}, P, S)$ v) $P: S \to 0S0 \mid 1S1 \mid 0 \mid 1 \mid \varepsilon$ $G = (\{S\}, \{0,1\}, P, S)$	10 M

R-E	K=0	K=1	K=2
$R_{11}^{(k)}$	$\varepsilon+1$	1^*	
$R_{12}^{(k)}$	0	1^*0	$1^*0(0+1)^*$
$R_{21}^{(k)}$	ϕ	ϕ	
$R_{22}^{(k)}$	$\varepsilon+0+1$	$\varepsilon+0+1$	

R-E - $1^*0(0+1)^*$

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Question Number	Solution	Marks Allocated
5b	LMD: $S \Rightarrow AbB$ $S \Rightarrow aAbB$ $S \Rightarrow aaAbB$ $S \Rightarrow aaaAbB$ $S \Rightarrow aaabaB$ $S \Rightarrow aaababB$ $S \Rightarrow aaababab$ – 3M RMD: $S \Rightarrow B$ $\Rightarrow aB$ $\Rightarrow aaB$ $\Rightarrow aaaB$ $\Rightarrow aaabB$ $\Rightarrow aaababB$ $\Rightarrow aaababab$ – 3M Hence the grammar is ambiguous. Parsetrees – 4M.	10M
6a	Each definition carries 1 mark	4M
6b	$\delta(q_0, \varepsilon, z_0) = (q_2, z_0)$ $\delta(q_0, a, z_0) = (q_0, az_0)$ $\delta(q_0, a, a) = (q_0, aa)$ $\delta(q_0, b, a) = (q_1, \varepsilon)$ $\delta(q_1, b, a) = (q_1, \varepsilon)$ $\delta(q_1, b, z_0) = (q_1, bz_0)$ $\delta(q_1, b, b) = (q_1, bb)$ $\delta(q_1, c, b) = (q_2, \varepsilon)$ $\delta(q_2, c, b) = (q_2, \varepsilon)$ $\delta(q_2, \varepsilon, z_0) = (q_3, z_0)$ $\delta(q_0, b, z_0) = (q_1, bz_0)$ $\delta(q_1, \varepsilon, z_0) = (q_2, z_0)$. – 6M moves: $(q_0, aabbbc, z_0)$ $\vdash (q_0, abbbc, az_0)$ $\vdash (q_0, bbbc, aaz_0)$ $\vdash (q_1, bbc, az_0)$ $\vdash (q_1, bc, z_0)$ $\vdash (q_1, c, bz_0)$ $\vdash (q_2, \varepsilon, z_0)$ $\vdash (q_3, \varepsilon, z_0$ – 4M	10M

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Question Number	Solution	Marks Allocated
6.c.	$\delta(q_0, \varepsilon, z_0) = (q_1, S z_0)$ $S \to aA$ – $\delta(q_1, a, S) = (q_1, A)$ $A \to aABC$ – $\delta(q_1, a, A) = (q_1, ABC)$ $A \to bB$ – $\delta(q_1, b, A) = (q_1, B)$ $A \to a$ – $\delta(q_1, a, A) = (q_1, \varepsilon)$ $B \to b$ – $\delta(q_1, b, B) = (q_1, \varepsilon)$ $C \to c$ – $\delta(q_1, c, C) = (q_1, \varepsilon)$ $\delta(q_1, \varepsilon, z_0) = (q_2, z_0)$	6M
7a.	CNF $A \to a$ $A \to BC$ – 2M. Step 1 : No ε Step 2 : $E^+ = \{T, F, I\}$ $T^+ = \{F, I\}$ $F^+ = \{I\}$ $E \to E+T \mid T*F \mid (E) \mid Ia \mid Ib \mid a \mid b$ $T \to T*F \mid (E) \mid Ia \mid Ib \mid a \mid b$ $F \to (E) \mid Ia \mid Ib \mid a \mid b$ $I \to Ia \mid Ib \mid a \mid b$ Step 3 : No useless Step 4 : $E \to EPT \mid TSF \mid OEC \mid IXa \mid IXb \mid a \mid b$ $O \to C$ $C \to)$ $X_a \to a$ $X_b \to b$ $P \to +$ $S \to *$ $T \to TSF \mid OEC \mid IXa \mid IXb \mid a \mid b$ $F \to OEC \mid IXa \mid IXb \mid a \mid b$ $I \to IXa \mid IXb \mid a \mid b$	

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Question Number	Solution	Marks Allocated
	step 5 : $E \to ER / TZ / OW / IX_a / IX_b / a / b$ $R \to PT$ $Z \to SF$ $W \to EC$ $T \to TZ / OW / IX_a / IX_b / a / b$ $F \to OW / IX_a / IX_b / a / b$ $I \to IX_a / IX_b / a / b$ $P \to +$ $C \to)$ - 8M $S \to *$ $X_a \to a$ $O \to ($ $X_b \to b$	10M
7b.	To prove it is not context free using pumping lemma - 4M	4M
7c.	To prove closed under union - 3M closed under concatenation - 3M	6M
8a.	Definition $A \to aX$ where $X \to V^*$ - 1Mark - No ε, No unit & no useless productions $S \to aAB / bBB / bB$ 5M $A \to aA / bB / b$ $B \to b$	6M
8b.	Definition - 2M. - Remove ε- production $S \to ABC / BaB$ 4M $A \to aA / BaC / aaa$ $B \to bBb / a$ $C \to CA / AC$ - 1M No unit production Remove useless $S \to BaB$ - 3M $B \to bBb / a$	10M

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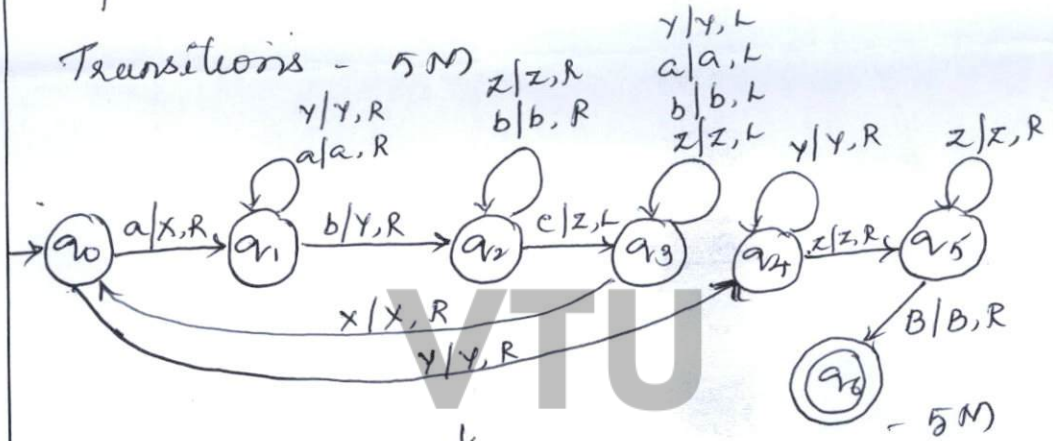
Question Number	Solution	Marks Allocated
8c.	Proving not a context free using pumping lemma. Each carries 2M	4M
9a.	Definition of turing m/c - 2M Diagram - 2M Explanation - 2M	6M
9b.	Transitions - 5M  - 5M $q_0, aabbcc \vdash X q_1 abbcc$ $\vdash Xa q_1 bbcc$ $\vdash Xa Y q_2 bcc$ $\vdash Xa Y b q_2 cc$ $\vdash Xa Y q_3 bzc$ $\vdash Xa q_3 Y bzc$ $\vdash X q_3 a Y bzc$ $\vdash q_3 X a Y bzc$ $\vdash X q_0 a Y bzc$ $\vdash X X q_1 Y bzc$ $\vdash X X Y q_1 bzc$ $\vdash X X Y Y q_2 zc$ $\vdash X X Y Y z q_2 c$ $\vdash X X Y Y z z q_3$ $\vdash X X Y Y q_3 zz$ $\vdash X X Y q_3 Yzz$ $\vdash X X q_3 Yyzz$ $\vdash X q_3 X Yyzz$ $\vdash X X q_0 Yyzz$ $\vdash X X Y q_4 Yzz$ $\vdash X X Y Y q_4 zz$ $\vdash X X Y Y z q_5 z$ $\vdash X X Y Y z z q_5 B$ $\vdash X X Y Y z z B q_6 B$ - 4M	14M.

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Question Number :	Solution	Marks Allocated
10 a.	$\delta(q_0, B) = (q_6, B, R)$ $\delta(q_0, a) = (q_1, X, R)$ $\delta(q_0, b) = (q_2, Y, R)$ $\delta(q_1, a) = (q_1, a, R)$ $\delta(q_1, b) = (q_1, b, R)$ $\delta(q_1, X) = (q_3, X, L)$ $\delta(q_1, Y) = (q_3, Y, L)$ $\delta(q_1, B) = (q_3, B, L)$ $\delta(q_3, a) = (q_5, X, L)$ $\delta(q_3, X) = (q_6, X, R)$ $\delta(q_3, Y) = (q_6, X, R)$ $\delta(q_5, a) = (q_5, a, L)$ $\delta(q_5, b) = (q_5, b, L)$ $\delta(q_5, X) = (q_0, X, R)$ $\delta(q_5, Y) = (q_0, Y, R)$ $\delta(q_2, a) = (q_2, a, R)$ $\delta(q_2, b) = (q_2, a, R)$ $\delta(q_2, X) = (q_4, X, L)$ $\delta(q_2, Y) = (q_4, Y, L)$ $\delta(q_4, b) = (q_5, Y, L)$ $\delta(q_4, X) = (q_6, X, R)$ $\delta(q_4, Y) = (q_6, X, R)$ $\delta(q_0, X) = (q_6, X, R)$ $\delta(q_0, Y) = (q_6, Y, R)$ — 8M Transition diagram - 4M.	12M
10.b.	Short note Explaining Recursively Enumerable language - 4M Explaining Multitape TM - 4M	8M

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24/11/25