

1. Language theory deals with how computations are expressed, focusing on the structure, rules, and properties of the language. Automata Theory deals with how the computations are carried out and how they manipulate languages to be processed. Computability Theory deals with what is and is not computable. Complexity Theory deals with how hard computations are or how expensive they are.

2. $L_1 \cup L_2 = \{10\}$

$$L_1 \cap L_2 = \{0, 1, 011\}$$

$$L_1 L_2 = \{0 \cdot 10, 0 \cdot 1, 011 \cdot 10, 011 \cdot 1, 10 \cdot 10, 10 \cdot 1\} = \{010, 01, 01110, 0111, 1010, 101\}$$

$$L_2^* = \{e, 1, 10, 11, 101, 1010, 110, 111, \dots\}$$

3. A. $S \rightarrow$

B.

$$S \rightarrow A \mid B$$

$$A \rightarrow 0 A 1 \mid C$$

$$C \rightarrow 2 C \mid \varepsilon$$

$$B \rightarrow 0 B \mid D$$

$$D \rightarrow 1 D 2 \mid \varepsilon$$

C.

$$S \rightarrow \varepsilon \mid 1 S \mid 0 A$$

$$A \rightarrow 1 S \mid 0 B$$

$$B \rightarrow 1 S$$

D.

$$1) S \rightarrow \varepsilon$$

$$2) S \rightarrow a a S b$$

$$3) S \rightarrow S S$$

E.

$$1) S \rightarrow \varepsilon$$

$$2) S \rightarrow a S B$$

$$3) B a \rightarrow a B$$

$$4) B b \rightarrow b C$$

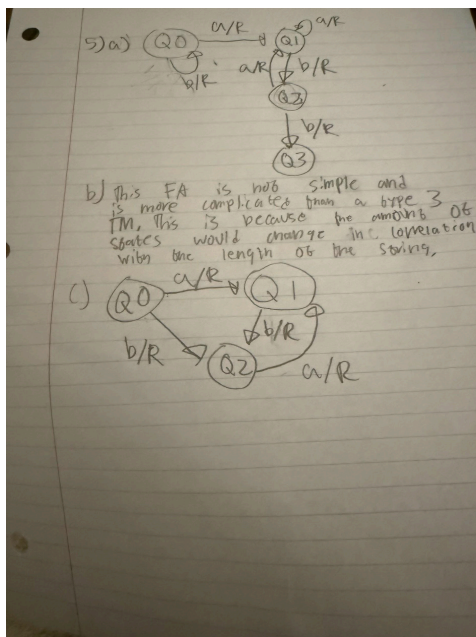
$$5) C b \rightarrow b C$$

$$6) C \rightarrow a b$$

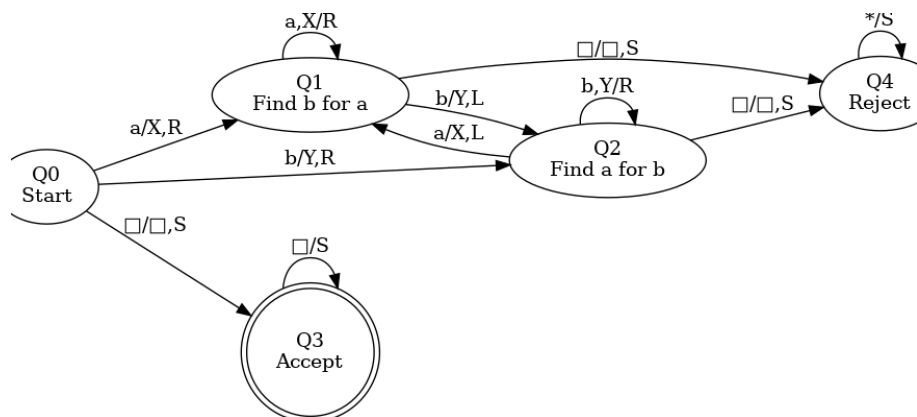
4.

1. $N \rightarrow I$
2. $N \rightarrow IF$
3. $N \rightarrow IE$
4. $N \rightarrow IFE$
5. $I \rightarrow D'I$
6. $I' \rightarrow D'I$
7. $I' \rightarrow \epsilon$
8. $F \rightarrow .I$
9. $E \rightarrow ES_{opt}I$
10. $E \rightarrow eS_{opt}I$
11. $S_{opt} \rightarrow Sgn$
12. $S_{opt} \rightarrow \epsilon$
13. $Sgn \rightarrow +$
14. $Sgn \rightarrow -$
15. $D \rightarrow 0$
16. $D \rightarrow 1$
17. $D \rightarrow 2$
18. $D \rightarrow 3$
19. $D \rightarrow 4$
20. $D \rightarrow 5$
21. $D \rightarrow 6$
22. $D \rightarrow 7$
23. $D \rightarrow 8$
24. $D \rightarrow 9$

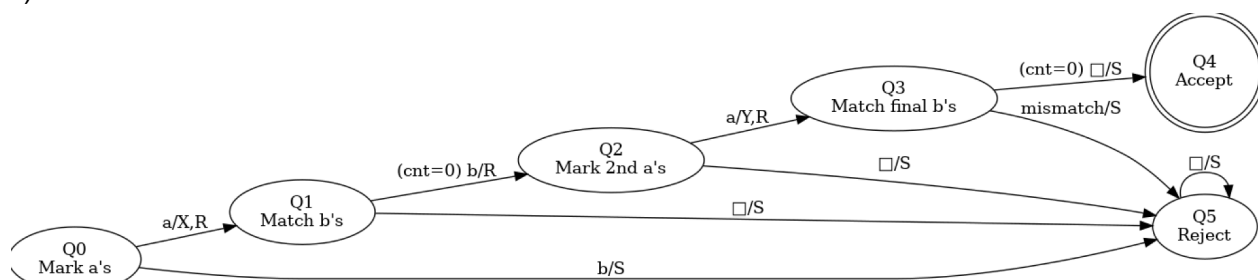
5.



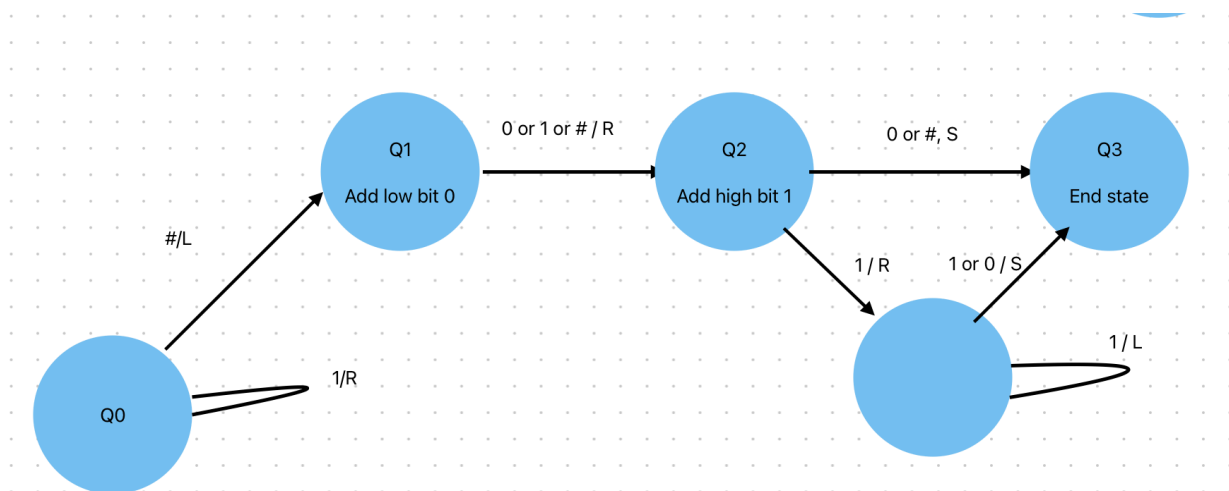
b) ignore part b in the photo



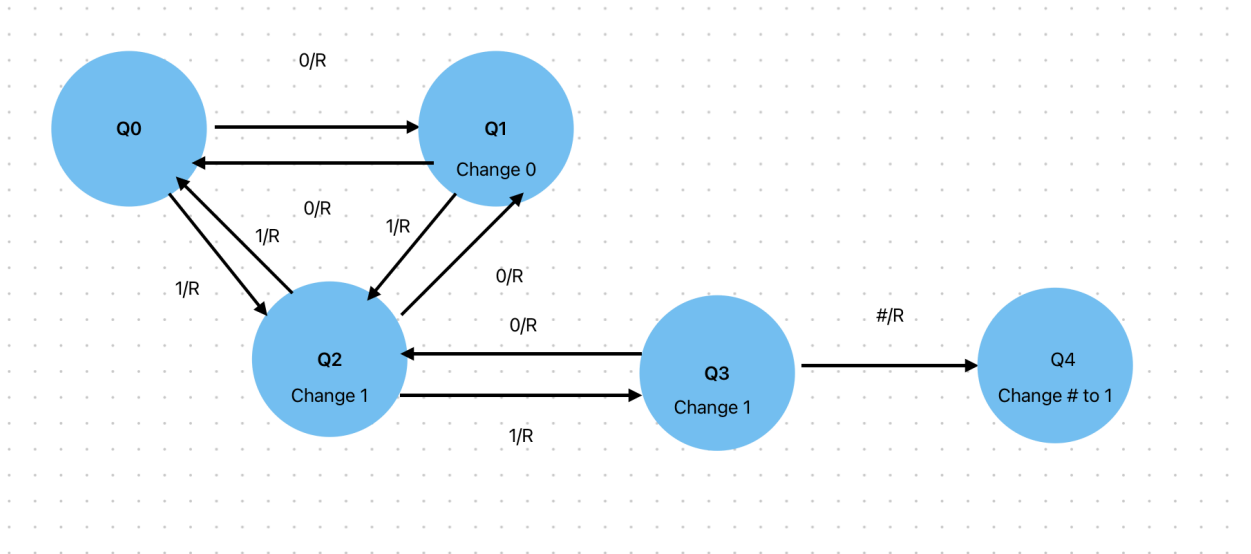
d)



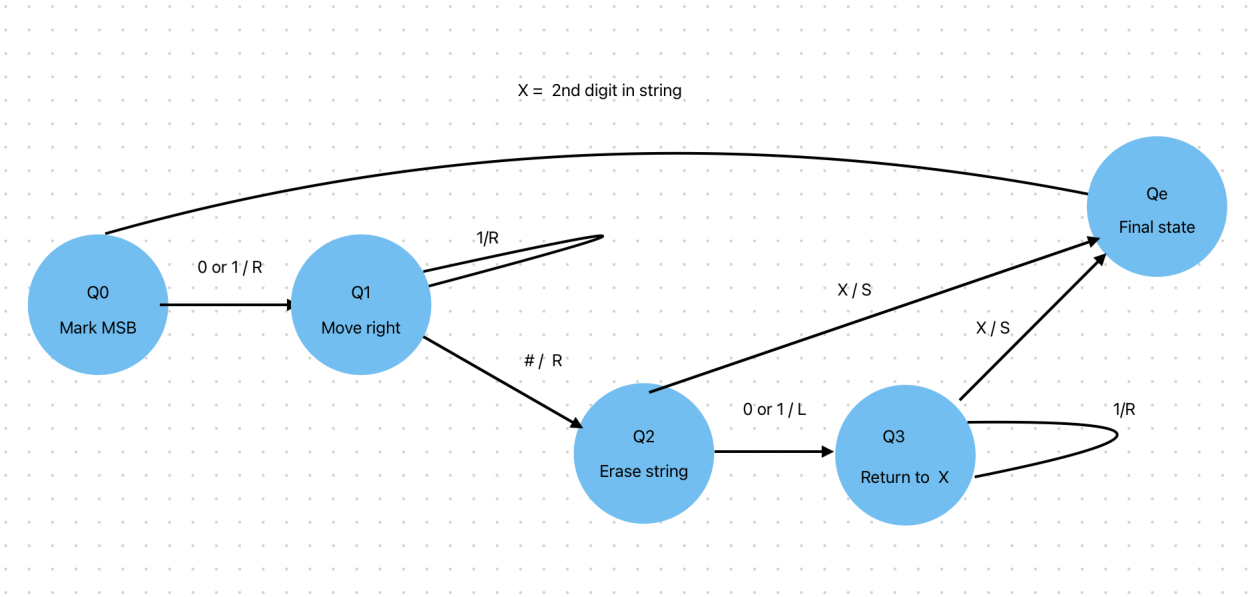
6. A.



B.



C.



7. a.

1	$t1 := 1 ** 3$	exponentiation ($1^3 \rightarrow 1$)
2	$t2 := 5 * 3$	multiplication ($5 \times 3 \rightarrow 15$)
3	$t3 := t2 - t1$	subtraction ($15 - 1 \rightarrow 14$)
4	$R0 := t3$	result in designated register

b.

PUSH 5 ; stack: 5

PUSH 3 ; stack: 5 3
MUL ; stack: 15
PUSH 1 ; stack: 15 1
PUSH 3 ; stack: 15 1 3
POW ; stack: 15 1 ($1^3 = 1$)
SUB ; stack: 14 ($15 - 1 = 14$)

8.

- A. recursive but not context-free
- B. recursive but not context-free
- C. recursively enumerable but not recursive
- D. recursive but not context-free
- E. regular
- F. not recursively enumerable
- G. regular
- H. recursive but not context-free