TOC
ESE
18/12/2021

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Q. No.: 1

1) c
2) c
3) d
4) b
5) c
6) b
7) a
8) a
9) d

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Q.No.: 1

B

a)

Deterministic Finite Automata	Non deterministic Finite Automata
- Each transition leads to exactly one state called as deterministic	- Each transition leads to a subset of states can be non deterministic
- Accepts input if the last state is in final	- Accepts input if one of the last states is in final
- Backtracking allowed	- Backtracking not always possible
- Requires more space	- Requires less space
- Empty string transitions not seen in DFA	- Permits empty string transition
- DFA is a subset of NFA	- Need to convert NFA to DFA in the design of compiler

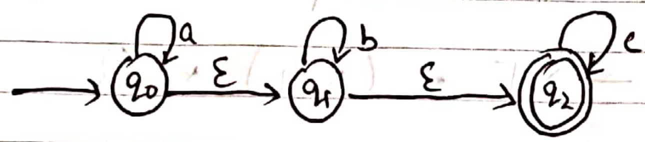
Q. No.: 1 B

b) The ε closure (P) is a set of states which are reachable from state P on ε - transitions.

The epsilon closure is as mentioned below:-

- ε - closure $(P) = P$ where $P \in Q$
- If there exists ε - closure $(P) = \{q\}$ and $\delta(q, \varepsilon) = r$ then ε - closure $(P) = \{q, r\}$

eg)



In this non - deterministic finite automata (NFA) with epsilon

Thus

ε - closure $(q_0) = \{q_0, q_1, q_2\}$ i.e. all the ε - reachable state + self state

Similarly, ε - closure $(q_1) = \{q_1, q_2\}$ where q_1 is self state and q_2 is a state obtained from q_1 with epsilon input.

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Q. No.: 1

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9) A Turing machine can be defined as a set of 7 ~~tuple~~ tuples

$$(Q, \Sigma, \Gamma, \delta, q_0, b, F)$$

where

Q is a non empty set of states
Σ is a non empty set of symbols
Γ is a non empty set of tape symbols
δ is a transition function defined as

$$Q \times \Sigma \longrightarrow \Gamma \times (R/L) \times Q$$

q_0 is the initial state
b is blank symbol
F is a set of final states

Thus, the production rule for turing machine can be written as

$$\delta(q_0, a) \longrightarrow (q_1, y, R)$$

Q. No.: 1b

d). • Theory of automata is a theoretical branch of computer science and mathematics. It is the study of abstract machines and the computation problems that can be solved using these machines.

• The abstract machine is called automata. The main motivation behind developing the automata theory was to develop methods to describe and analyse the dynamic behaviour of discrete systems.

• Automata is the kind of machine which takes some string as input and this input goes through a finite number of states and may enter the final state.

Q. No.: 1 b

f) If A is regular language, then A has a pumping length 'P' such that any string S where $|S| \geq P$ may be divided into 3 parts
S = xyz such that the following conditions must be true:-

i) $xy^iz \in A$ for every $i \geq 0$

ii) $|y| > 0$

iii) $|xy| \leq P$

In simple terms, this means if a string 'v' is pumped i.e. if v is inserted any number of times, the resultant string remains in regular language..

Pumping lemma is used as a proof for irregularity of a language. Thus if a language is regular, it always satisfies pumping lemma

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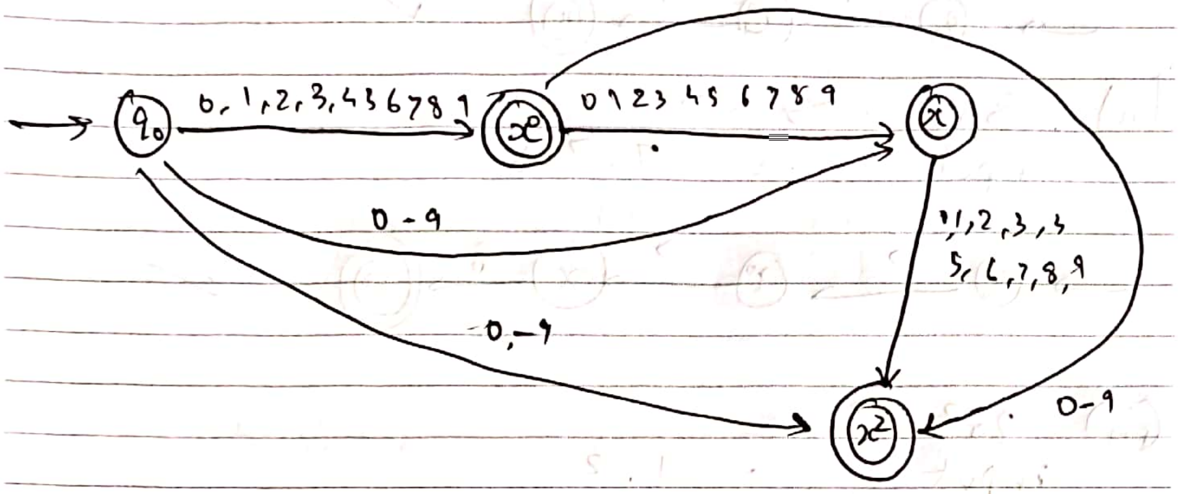
Q. No.: 2

Q : set of all states → x^2, x, x^0, q_0

non terminal states → 0, 1, 2, 3, 4, 5, 6, 7, 8, 9



Assumption - we read input string from right to left in quadratic eq^n

formal def^n

$Q = q_0, x^0, x, x^2$

$\Sigma = 0 - 9$

$q_0 = q_0$ (start state)

$F = x^0, x, x^2$

$\delta =$

	0 1 . . . 9
q_0	x^0
x^0	x
x	x^2

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(i) $3x - 1$

input string = 1, 3

$\rightarrow q_0 \xrightarrow{1} x^0 \xrightarrow{3} x$ ✓

(ii) $8x^2 + 7x - 7$

input = 7, 7, 8

$\rightarrow q_0 \xrightarrow{7} x^0 \xrightarrow{7} x \xrightarrow{8} x^2$ ✓

(iii) $2x^2 + 9$

input = 9, 2

$\rightarrow q_0 \xrightarrow{9} x \xrightarrow{2} x^2$ ✓

(iv) $5 - 4 = 1$ ✗

1 is linear and not quadratic or is constant $\therefore$ not accepted.

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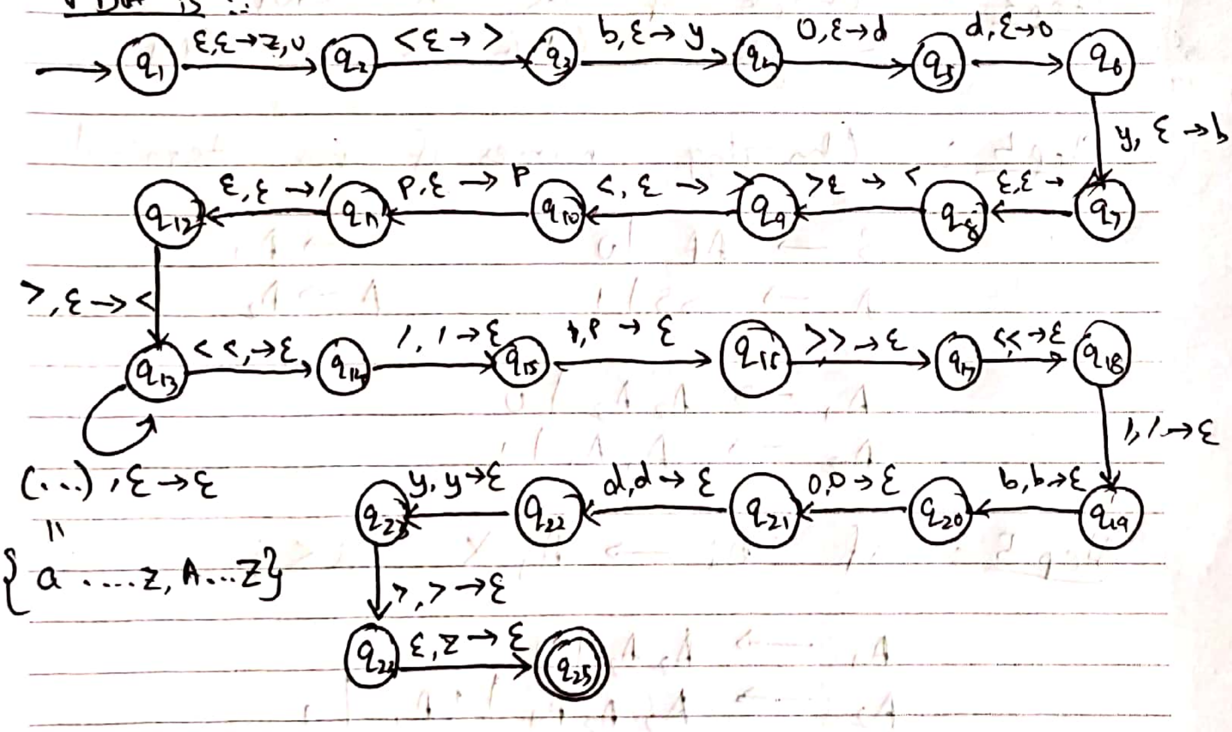
Q. No.: 3

a) PDA that accepts
<body>
<p>
...
</p>
</body>

input → capital or small case
(...) → can be over {a, b.... z, A, B... Z}

PDA is :-



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Q. No.: 3b

$S \rightarrow AA \mid 0$
$A \rightarrow SS \mid 1$

Step 1 : To remove null production
- there are no null productions.

Step 2 : Remove any unit production
- there are no unit production

Step 3 : Check if its in CNF
- given CFG is in CNF

Step 4 : Changing names of non terminal

$S \rightarrow AA \mid 0$ $\qquad$ $S \rightarrow A_1$
$A \rightarrow SS \mid 1$ $\qquad$ $A \rightarrow A_2$

$A_1 \rightarrow A_2 A_2 \mid 0$
$A_2 \rightarrow A_1 A_1 \mid 1$

Step 5 : if $A_i \rightarrow A_j X$ $\quad i < j$

$A_1 \rightarrow A_2 A_2 \mid 0$
$A_2 \rightarrow A_2 A_2 A_1 \mid 0A_1 \mid 1$

left recursion

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Q. No.: 3b

Step 6 : Remove left recursion

given :
$A_1 \rightarrow A_2A_2 \mid 0$
$A_2 \rightarrow A_2A_2A_1 \mid 0A_1 \mid 1$
$Z \rightarrow A_2A_1Z \mid A_2A_1$
$A_2 \rightarrow 0A_1 \mid 0A_1Z \mid 1Z \mid 1$

Now the grammar is :-

$A_1 \rightarrow A_2A_2 \mid 0$
$A_2 \rightarrow 0A_1 \mid 0A_1Z \mid 1Z \mid 1$
$Z \rightarrow A_2A_1Z \mid A_2A_1$

$\Rightarrow$
$A_1 \rightarrow 0A_1A_2 \mid 0A_1ZA_2 \mid 1ZA_2 \mid 1A_2 \mid 0$
$A_2 \rightarrow 0A_1 \mid 0A_1Z \mid 1Z \mid 1$
$Z \rightarrow 0A_1A_2Z \mid 0A_1ZA_1Z \mid 1ZA_1Z \mid 1A_1Z \mid$
$0A_1A_1 \mid 0A_1ZA_1 \mid 1ZA_1 \mid 1A_1$

$\therefore$ The final grammar is (in GNF)

$A_1 \rightarrow 0A_1A_2 \mid 0A_1ZA_2 \mid 1ZA_2 \mid 1A_2 \mid 0$
$A_2 \rightarrow 0A_1 \mid 0A_1Z \mid 1Z \mid 1$

$Z \rightarrow 0A_1A_1Z \mid 0A_1ZA_1Z \mid 1ZA_1Z \mid 1A_1Z \mid$
$0A_1A_1 \mid 0A_1ZA_1 \mid 1ZA_1 \mid 1A_1$

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Q. No.: 4

i) Turing Acceptable Language

- A language is said to be decidable or recursive if there is a turing machine which accepts and halts on every input string.
- Every decidable language is Turing acceptable. A language of a turing machine is the set of all the strings that are acceptable by the turing machine.
- If the string is in that language, the machine terminates and accepts that string and if the string is not in that language, it terminates and rejects or does not terminate at all.

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Q. No.: 4

i) Undecidability

- An undecidable problem is a decision problem for which it is proved to be impossible to construct an algorithm that always leads to a correct yes or no answer.
- Hence a problem is undecidable if there is no turing machine which will always halt in finite amount of time to give answer as yes or no.

- eg) Ambiguity of context free languages, completeness of CFG, equivalence of two context free languages

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iii) P and NP

1) P - polynomial time

- If we have a deterministic algorithm, which can make the decision by only checking a polynomial number of possibilities then the task is in P (polynomial time)

- P = those problems which can be decided in polynomial time.
- Problems in P are efficient.

2) NP - non deterministic polynomial time

- If we must test an exponential number of cases, then task is in NP (non deterministic polynomial time) class NP are those problems that can be solved in polynomial time on a non deterministic machine.

- Non deterministic machine basically gives all the alternatives in parallel, with the time complexity being equal to the longest path, in the potentially wide search tree. Thus the class NP are those problems that can be tested / verified in polynomial time.

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eg) Hard problems (NP complete)
- 3SAT
- Travelling salesman problem
- Longest path
- Knapsack

eg) Easy problems (in P)
- 2SAT
- Minimum spanning tree
- Shortest path
- unary knapsack.

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Q. No.: 4

iv) Church turing theorem first came up to answer the question, " What does calculable mean ? "

→ To answer this question, Alonzo church came up with an idea of lambda calculus and stated that whatever could be calculable by a lambda calculus.

→ later, Allen turing came up with turing machine and stated whatever could be calculated by a turing machine is said to be computable.

→ Upon further studies, it was discovered that ~~through~~ lambda calculus and turing machines operate differently, they are equivalent in power so nowadays as we need either of the two, we use turing machines as a benchmark of checking whether something is calculable or not.

→ The church turing theorem states that :-

- Any mechanical computation can be performed by a turing machine.
- There is a TM-n corresponding to every computable problem.
- We can model any mechanical computer with a TM.

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- The set of languages that can be decided by a TM is identical to the set of languages that can be decided by any mechanical computing machine.
- If there is no TM that decides problem P, there is no algorithm that solves problem P.

eg).
- (Church) → lambda calculus is equivalent to Turing machine
- (PST) → Making two tape infinite in both directions adds no power
- (SOON) → Adding a second tape adds no power.

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