Assignment 2

Q.1) Design a NPDA for accepting the Language WW^R where W belongs to $\{a,b\}^*$ and W^R is the reverse of string W.

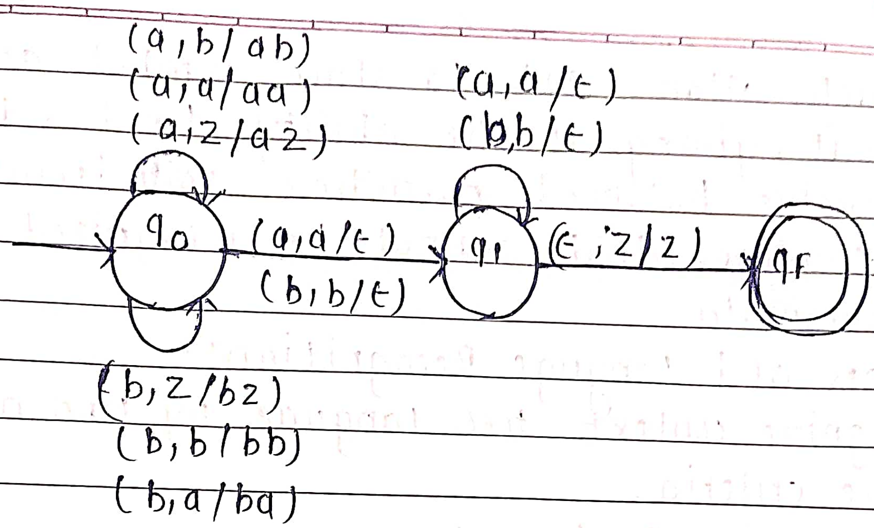
→ ∴ $L = \{ww^R \mid w \in \{a,b\}^*\}$ Where W^R is the Reverse string w

- The NPDA will push characters from 'w' onto stack, and when it reaches the middle of the input, it will pop character off the stack to match with w^R
- Formal defination of NPDA:-

  $M = \langle Q, \Sigma, \Gamma, \delta, q_0, Z_0, F \rangle$, where.

  - $Q = \{q_0, q_1, q_2, q_F\}$: set of states.
  - $\Sigma = \{a, b\}$: input alphabet
  - $\Gamma = \{a, b, Z_0\}$: stack alphabet (where Z_0 is the intial stack)
  - q_0 = start state.
  - Z_0 = Initial stack symbol
  - $F = \{q_F\}$: set of accepting states
- Pushing Phase :- (W Part)
  - $\delta(q_0, a, Z_0) = \{(q_0, aZ_0)\}$
  - $\delta(q_0, b, Z_0) = \{(q_0, bZ_0)\}$
  - $\delta(q_0, a, a) = \{(q_0, aa)\}$
  - $\delta(q_0, b, b) = \{(q_0, bb)\}$
  - $\delta(q_0, a, b) = \{(q_0, ab)\}$
  - $\delta(q_0, b, a) = \{(q_0, ba)\}$
  - $\delta(q_0, \epsilon, Z_0) = \{(q_1, Z_0)\}$.
- Popping phase. (W^R part).
  - $\delta(q_1, a, a) = \{(q_1, \epsilon)\}$
  - $\delta(q_1, b, b) = \{(q_1, \epsilon)\}$
  - $\delta(q_1, \epsilon, Z_0) = \{(q_F, Z_0)\}$
- Accepting state:- q_F.
- NPDA:-

ϵ - indicates pop operation.



∴ Required NPDA.

Q:2) Write a short note on recognition of language by PDA.

⟶ - A Pushdown Automata (PDA) is a computational model used to recognize context-free language (CFL), which are generated by context-free grammar.

- PDA are an extension of finite automata equipped with an additional data structure: a stack which provides memory capability for storing symbols.
- This symbol enables PDAs to process nested and recursive patterns, making them suitable for recognising language that require more complex structure than regular language.
- Key Feature of PDA:-

A PDA is formally defined a 7-tuple $M = (Q, \Sigma, \Gamma, \delta, q_0, Z_0,$

Where, Q is a set of states

Σ is input symbol

Γ is a stack alphabet

δ is a transition function

q_0 is the initial state

Z_0 is the stack symbol

F is the of accepting state

The stack allows PDA to store symbol as it reads the input, giving it the ability to handle Languag that involve balanced parenthese, palindromes and nested structure Which cannot be recognized by simpler finite automata.

- PDA Types and Langugе Recognition:-

PDA recognize context free Languge by two main acceptance criteria.

1. Acceptance by Final state:-
   The PDA accepts the input if, after reading the entire string, it reaches an accepting state F.
2. Acceptance by Empty stack:-
   The PDA accept the Input if, after Reading the entire string the stack is empty.

- A PDA is non-deterministic (NPDA) if it can choose betn multiple transition at each step, Which gives it more power than a deterministic PDA (DPDA). NPDA are equivalent in power to context-Free grammar, meaning they can recognize all CFL's While DPDA cannot recognize all CFLs.

Q.3) Write and explain any 3 closure properties of CFL.

→ CFL have several closure properties, Which means that applying certain Operation on CFL result new Language that is also context-free.

1. Union:-

Property:- If L1 and L2 are CFL then $L1 \cup L2$ is also CFL

Ex:- $S1 \rightarrow aS1b \mid \epsilon$

$S_2 \rightarrow bS_2c \mid \epsilon$

Union:- $S \rightarrow S1 \mid S2$

2. Concatenation:-

Property:- if L_1 and L_2 are ~~a~~ CFL, then L_1L_2 is also a CFL.

3. Kleene Star:-

Property:- If L is a context-free Language the L^* is also a ~~Kleen~~ CFL.