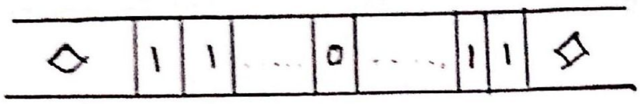
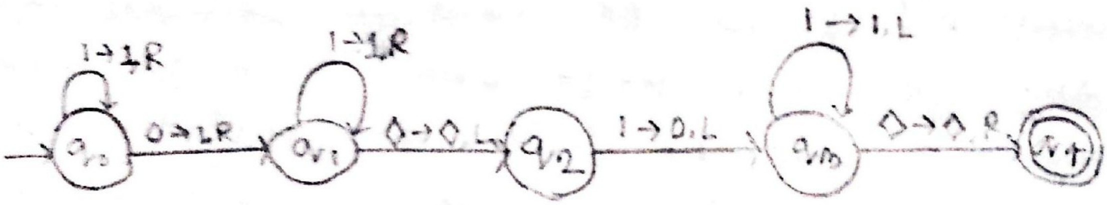
Turing machine for $f(x,y) = x+y$

Input : $x0y$

Output : $xy0$





Diagonalization Languge : The diagonalization languge L_d is the set of strings wi such that wi is not L(mi). That is L consists of all strings w such that the TM M, whose code is w, doesn't accept w, when w is the given input

$$L_d = \{ w_i \mid w_i \notin L(M_i) \}$$

Polynomial time reducibility : Polynomial time reducibility is the relation between two language that says one language can be convert to the other in polynomial time. This means that if we have an algorithm that can solve the 1st language then we also can solve the second one using the algorithm and a polynomial time transformation.

Let L & R be two languges, L is polynomial time reducible to R ($L \le_P R$) if and only if there exists a polynomial time function f, such that :- for all x in L, f(x) is R.

- for all x in R, if x is in L then f(x) = x.

The Greibach normal form is referred to GNF. A context-free grammer (CFG) is in GNF if and only all of it's production rules meet one of the criteria listed below :

- A non-terminal generates a terminal. For an example : $X \to x$

- A start symbol that generates ε.

  Such as : $S \to \varepsilon$

- A non-terminal that generates a terminal followed by any number of non-terminal.

  For instances, $S \to xXSY$.

Example :

$G_A = \{S \to xXY \mid xY,\ X \to xX,\ Y \to yY \mid y\}$

$G_B = \{S \to xXY,\ X \to xX \mid \varepsilon,\ Y \to yY \mid \varepsilon\}$

Here, G_A grammar is in GNF but G_B is not because of $X \to \varepsilon$ and $Y \to \varepsilon$.

In left recursion,

$$A \to A\alpha \mid \beta$$

and after eliminate left recursion.

$$A \rightarrow \beta A'$$
$$A' \rightarrow \alpha A' / \varepsilon$$

Here, Given,

$$S \rightarrow S0S1S | 01$$

Here, $\alpha = 0S1S$

$\beta = 01$

$\therefore S \rightarrow 01S'$

$S' \rightarrow 0S1SS' | \varepsilon$

Given,

$S \rightarrow aAa \mid bBb \mid \varepsilon$

$A \rightarrow c \mid a$

$B \rightarrow C \mid b$

$C \rightarrow CDE \mid \varepsilon$

$D \rightarrow A \mid B \mid ab$

(i) Elimination of null production :

Symbol that are Nulloble = $\{S, A, B, C, D\}$

New production rules :

$S \rightarrow aAa \mid bBb \mid aa \mid bb$

$A \rightarrow C \mid a$

$B \rightarrow C \mid b$

$C \rightarrow CDE \mid CE \mid DE \mid E$

$D \rightarrow A \mid B \mid ab$

(ii) Elimination unit production :

we have,

$A \rightarrow C$

$B \rightarrow C$

$C \rightarrow E$

$D \rightarrow A$

$D \rightarrow B$

New production rules:

$S \to aAa \mid bBb \mid aa \mid bb$
$A \to a \mid CDE \mid CE \mid DE$
$B \to b \mid CDE \mid CE \mid DE$
$C \to CDE \mid CE \mid DE$
$D \to a \mid b \mid ab \mid CDE \mid CE \mid DE$

(iii) Remove useless symbol

E is useless.

Step-1: $S \to aAa \mid bBb \mid aa \mid bb$
$A \to a$
$B \to b$
C has no rules left.
$D \to a \mid b \mid ab$

C and D will be eliminated because they are unreachable from S.

New production:

$S \to aAa \mid bBb \mid aa \mid bb$
$A \to a$
$B \to b$

(iv) CNF :

Step-1 :

$S \rightarrow Xa \mid Yb \mid aa \mid bb$

$A \rightarrow a$

$B \rightarrow b$

$X \rightarrow aA$

$Y \rightarrow bB$

Step 2:

$S \rightarrow XA \mid YB \mid AA \mid BB$

$A \rightarrow a$

$B \rightarrow b$

$X \rightarrow AA$

$Y \rightarrow BB$