

## \* Block diagram of Turing Machine:-

It consists of 3 components -

- 1) Infinite tape
- 2) R/W Header
- 3) Finite control Unit.

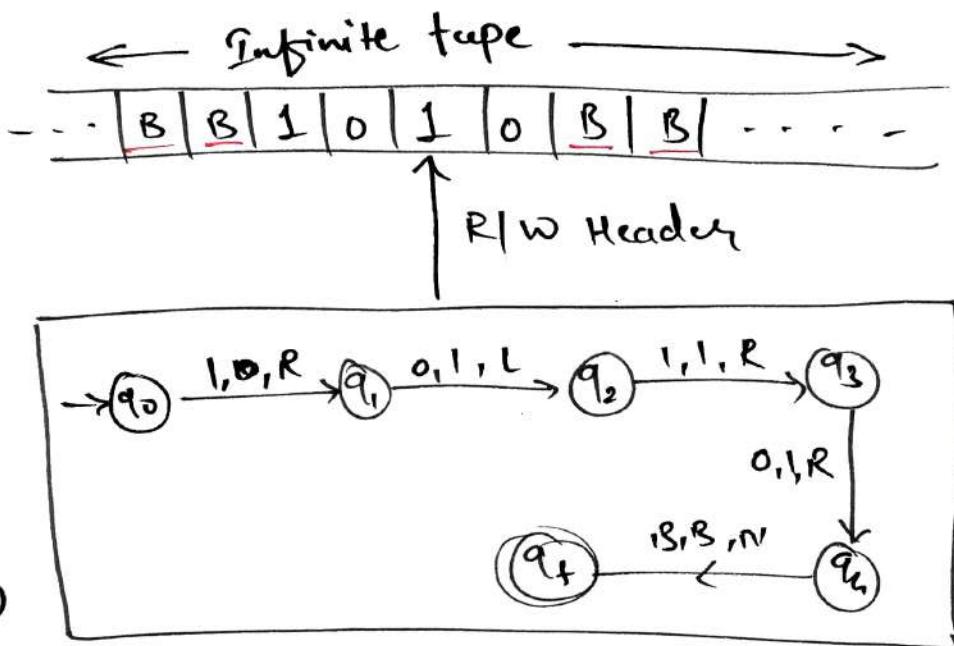


fig. Block dia. of TM.

### ① Infinite Tape:-

⇒ It is divided into cells where each cell can hold only one input symbol.

⇒ At any point of time only finite no. of cells will be occupied, hence the tape is divided into two regions i.e. non-blank region & blank region. Where non-blank region is always finite.

- ⇒ All the empty cells in the Blank portions are filled with Blank symbol 'B'
- ⇒ The tape can be two way infinite (or) one way infinite.

Ex:- ①

..... | B | B | 1 | 0 | 1 | 0 | 1 | B | B | .....

Two way infinite.

②

| \$ | 1 | 0 | 1 | 0 | B | B | .....

one-way Infinite

## ② Read/Write Header:-

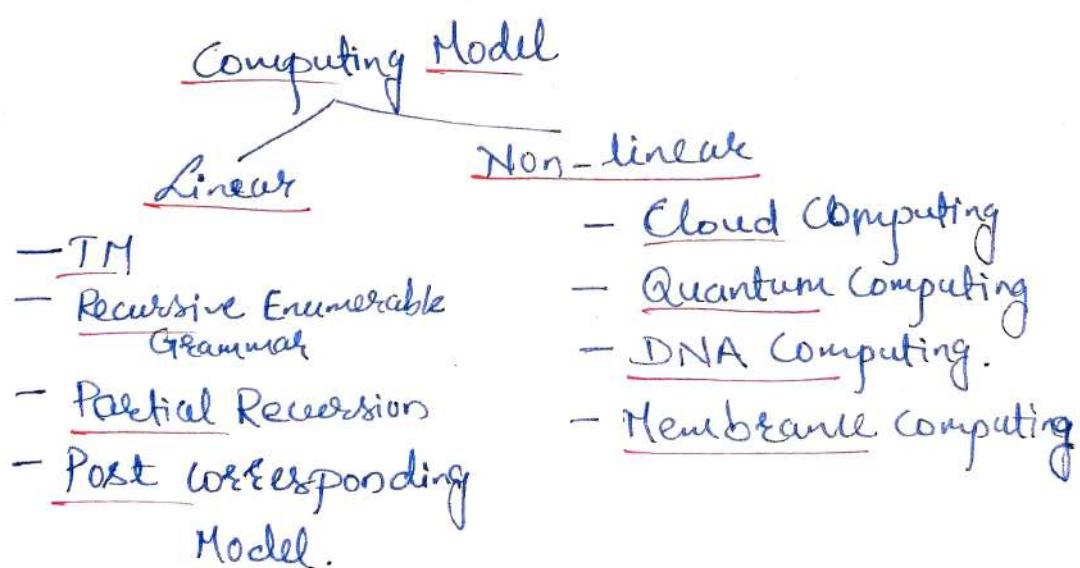
- ⇒ The header can read the symbol from the tape (or) modify symbols from over the tape.
- ⇒ And It will point to only one cell.
- ⇒ R/W header can move to only one cell in both right & left directions along with infinite tape.
- ⇒ The movement of R/W header is bidirectional.

### ③ Finite Control Unit :- (FCU)

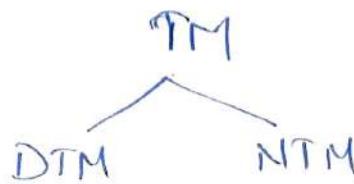
- ⇒ FCU is control system where we can implement the business logic.
- ⇒ To compute any transition function, the state movements are defined by instantaneous description & controlled by FCU i.e. transitions of TM is implemented by FCU.

#### Note:-

- 1) TM is a abstract model of real computer system
- 2) The capabilities of TM equal ♦ to capabilities of Computer.
- 3) TM is a linear computing model and powerful among all the models of the same type.



⇒ TM can also be defined in both deterministic & non-deterministic mode.



⇒ DTM is more efficient than NTM.

⇒ The language which is accepted by TM is called as recursively enumerable language ( $L_1$ ) TM recognizable language.

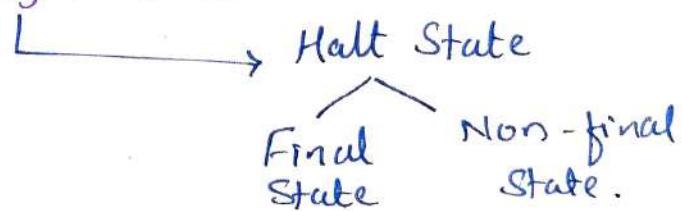
⇒ As a language acceptor (LA) TM is more powerful than FA & PDA.

Halt:-

The state where transition is not

defined is called as Halt.

$$\delta(q_i, a) = (q_j, \alpha, R)$$



## \* Behaviour of TM:-

TM works as -

1) Language Acceptor

2) Language Generation

3) Input/Output Device [or] Computing Model (or) Transducer.

• \* TM as a language Acceptor:-

⇒ The language accepted by ~~TM~~ TM is called as RES (RS - Recursive set)

⇒ TM accepts all the RL, CFL & also some of the Non CFL.

⇒ ~~E(TM)~~  $E(TM) = E(FA + 2 \text{ stack}) = E(FA + n \text{ stack})$

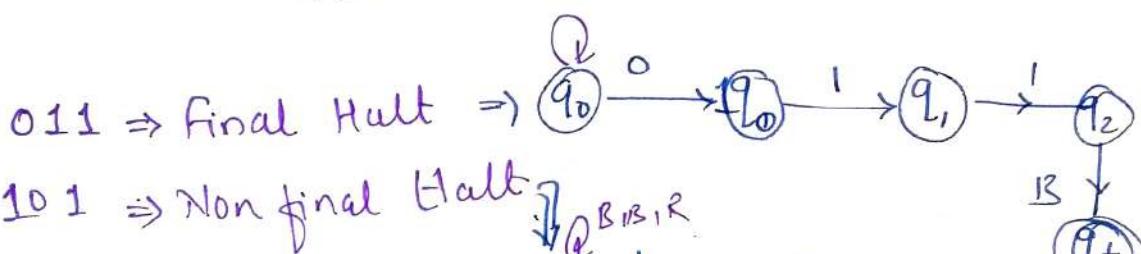
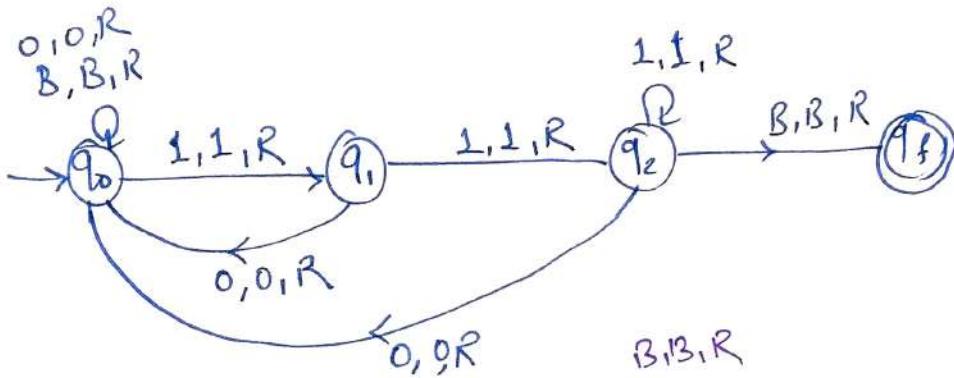
$n \geq 2$   
→ Different types of TM

$E(TM) > E(PDA) > E(FA)$

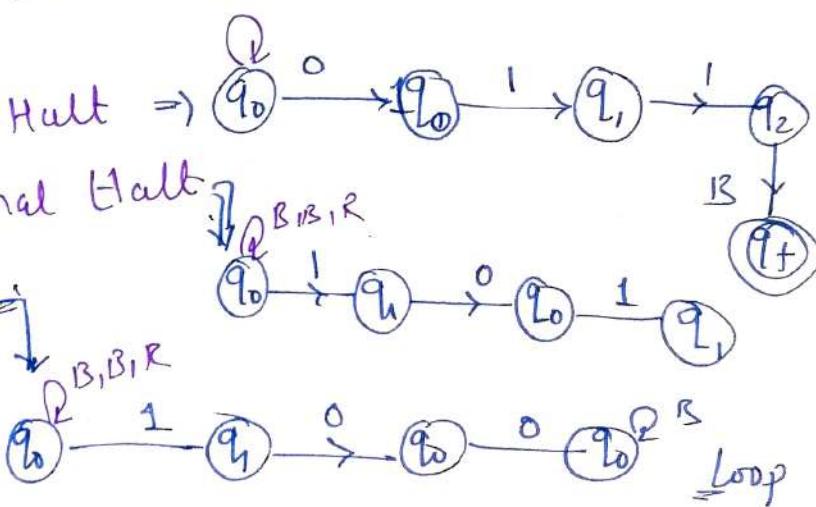
## \*Acceptance by TM :-

$$1) L = (0+1)^* 11$$

$\dots | B | B | q_1 | 0 | 1 | B | B | \dots$



$100 \Rightarrow$  Loop



There are three possibilities for the TM after taking the input string.

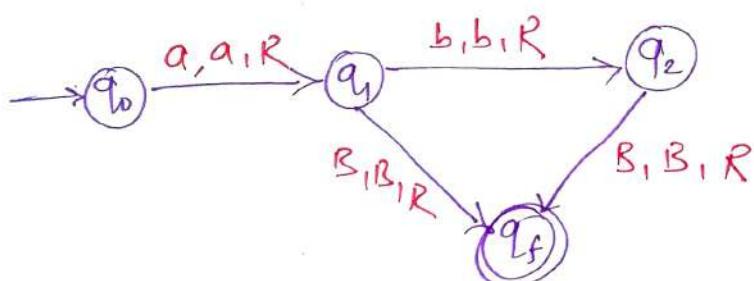
- ① May go to Final Halt.  $\Rightarrow$  String is accepted by TM
- ② May go to non-final Halt.  $\Rightarrow$  If string is rejected by TM.
- ③ May go to loop.  $\Rightarrow$  String is neither accepted nor rejected

Note:-

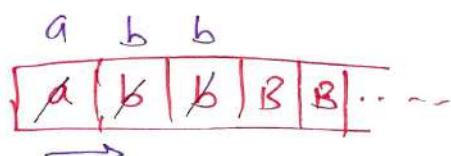
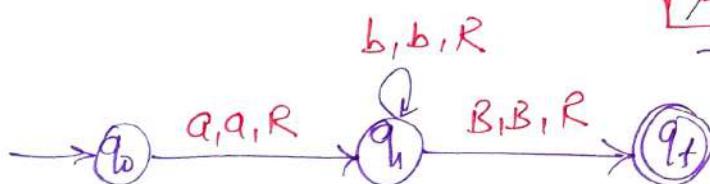
No algorithm exist to decide the nature of TM for input string  $w$  i.e. the TM halt (or) does not halt can not be decided. Hence halting problem of TM is undecidable.

### \* Construction of Turing Machine:-

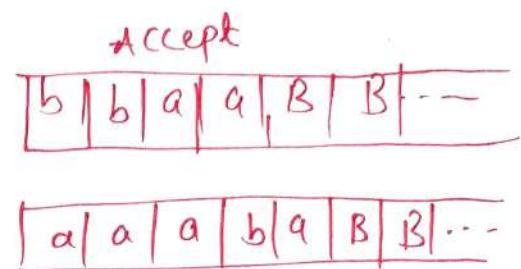
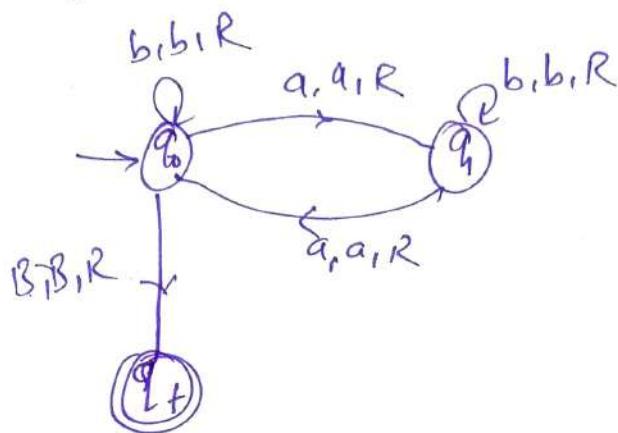
$$1) L = \{a, ab\}$$



$$2) L = ab^*$$

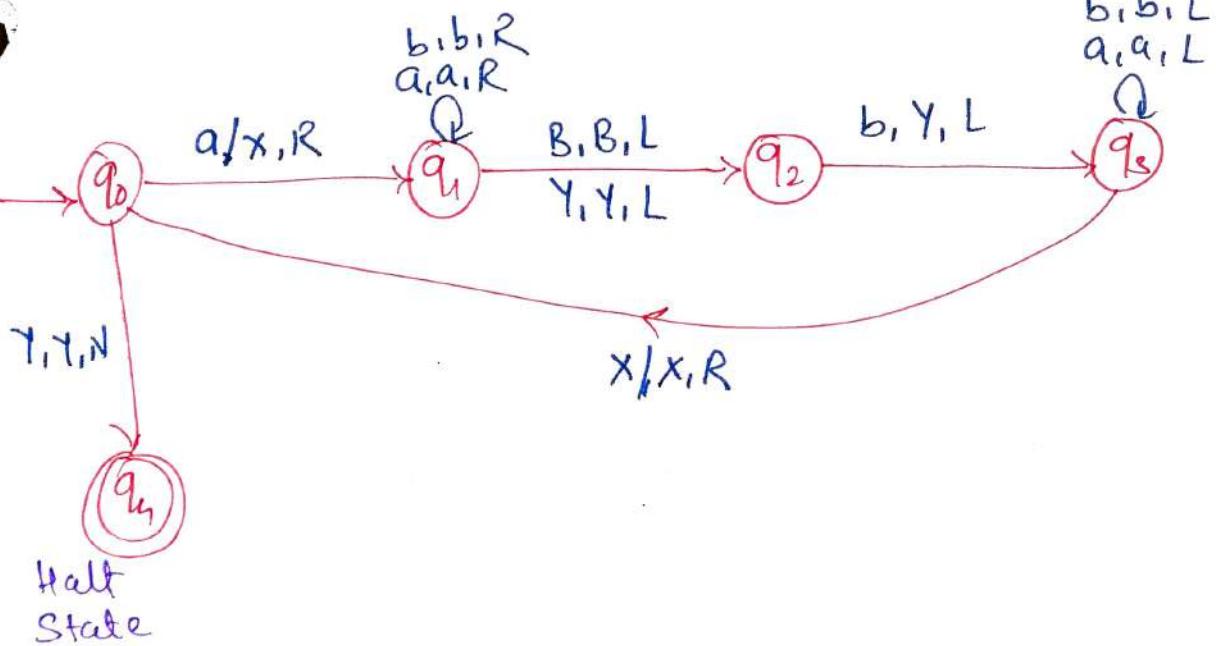
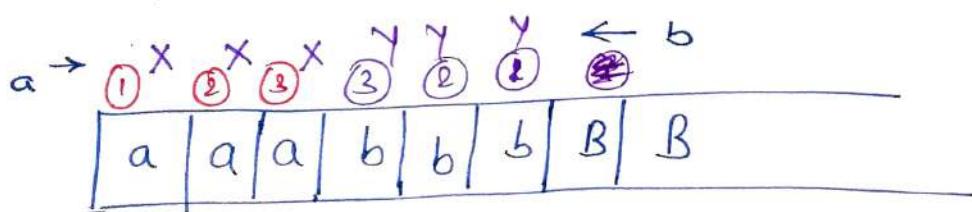


$$③ L = \{ w \in (a+b)^* \mid |w|_a = \text{even} \}$$



$$④ L = \{ a^n b^n \mid n \geq 1 \}$$

Let,  $a^3 b^3$



$$\Rightarrow \text{aabbbB} \rightarrow q_0$$

$$x^{\alpha} bbbB - q_1$$

$$x^{\alpha} bbbB \rightarrow q_1$$

$$x^{\alpha} bbbB - q_1$$

$$x^{\alpha} bbbB - q_1$$

$$x^{\alpha} b^y B - q_2$$

$$x^{\alpha} b^y B - q_3$$

$$x^{\alpha} b^y B - q_3$$

$$x^{\alpha} b^y B - q_3$$

$$x^{\alpha} b^y B - q_0$$

$$x^{\alpha} b^y B - q_1$$

$$x^{\alpha} b^y B - q_1$$

$$x^{\alpha} b^y B - q_2$$

$$\downarrow$$

$$x^{\alpha} b^y B - q_3$$

$$\uparrow$$

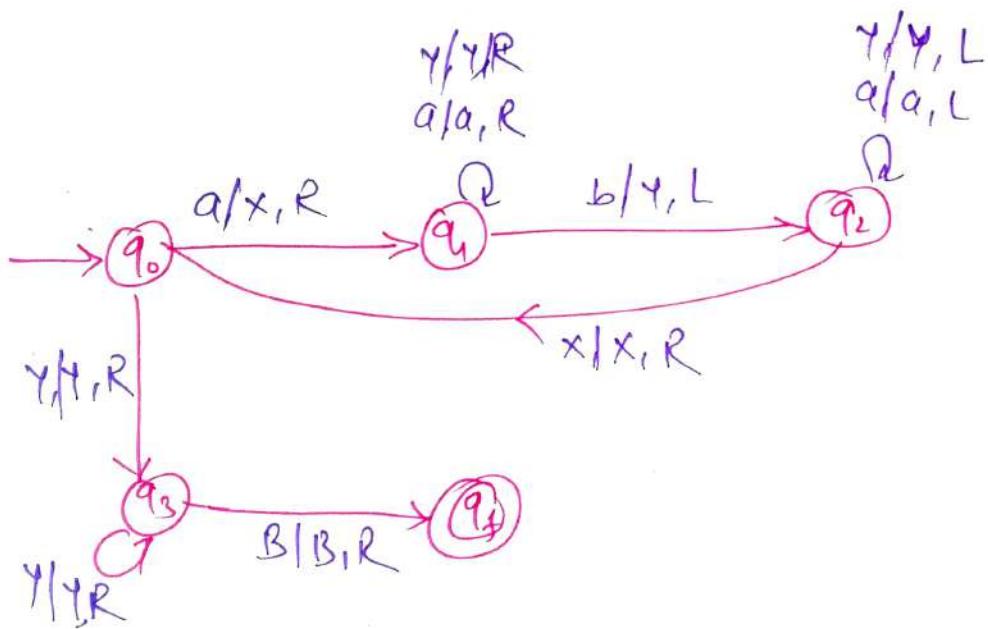
$$x^{\alpha} b^y B - q_0$$

$$\downarrow$$

$$x^{\alpha} b^y B - \underline{\underline{q_4}}$$

$\delta$	a	b	x	y	B
$\rightarrow q_0$	$(q_1, x, R)$	—	—	$(q_4, t, N)$	—
$q_1$	$(q_1, a, R)$	$(q_1, b, R)$	—	$(q_2, Y, L)$	$(q_2, B, L)$
$q_2$	—	$(q_3, Y, L)$	—	—	—
$q_3$	$(q_3, a, L)$	$(q_3, b, L)$	$(q_0, X, R)$	—	—
$q_4^*$	$q_4$	$q_4$	$q_4$	$q_4$	$q_4$ Halt State

OR



$x \ x \ ③x \ y \ y \ ③y$   
 $x \ ②x \ a \ y \ ①y \ b$   
 $①x \ a \ a \ y \ ①b \ b$   

a	a	a	b	b	b	B	B	...
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