

* Block diagram of Turing Machine:-

It consists of 3 components -

- 1> Infinite tape
- 2> R/W Header
- 3> Finite control unit.

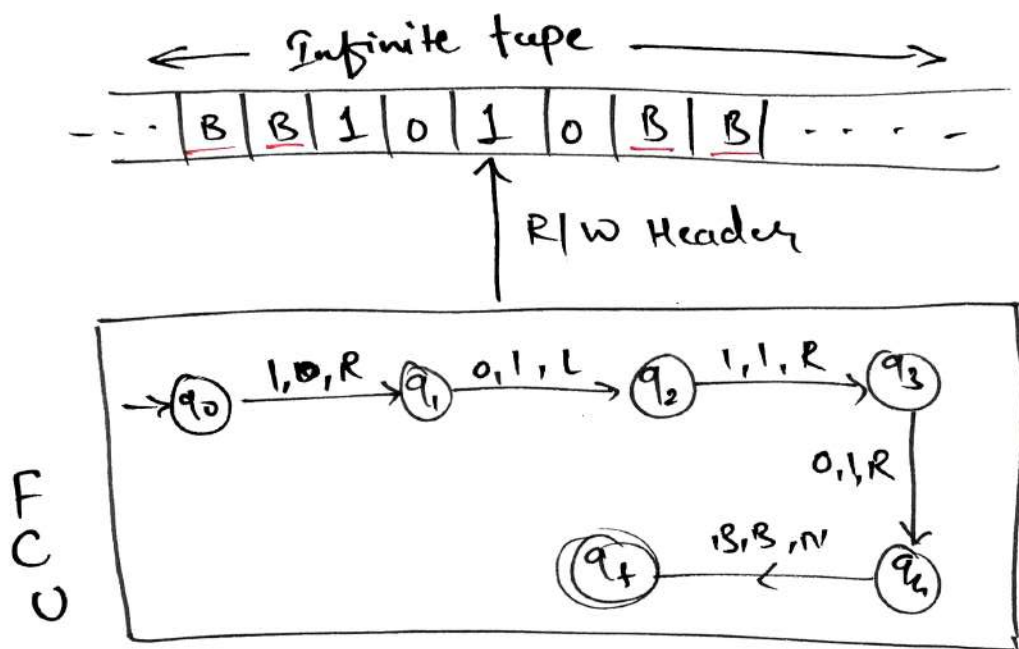


fig. Block dia. of TM.

① Infinite Tape:-

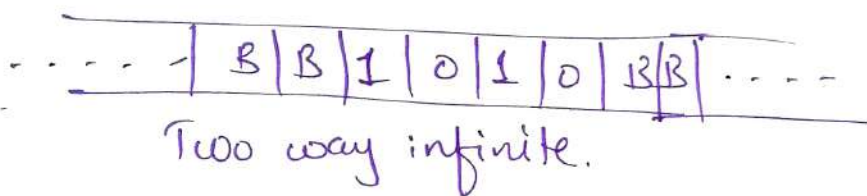
⇒ It is divided into cells where each cell can hold only one input symbol.

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

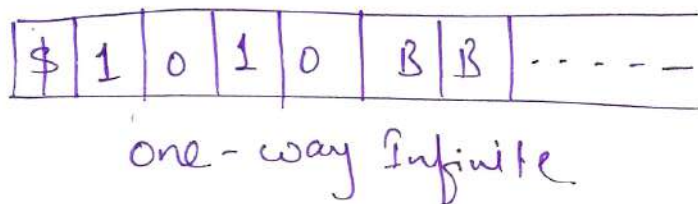
⇒ All the empty cells in the Blank portions are filled with Blank symbol 'B'

⇒ The tape can be two way infinite (or) one way infinite.

Ex:- ①



②



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 buisness logic.

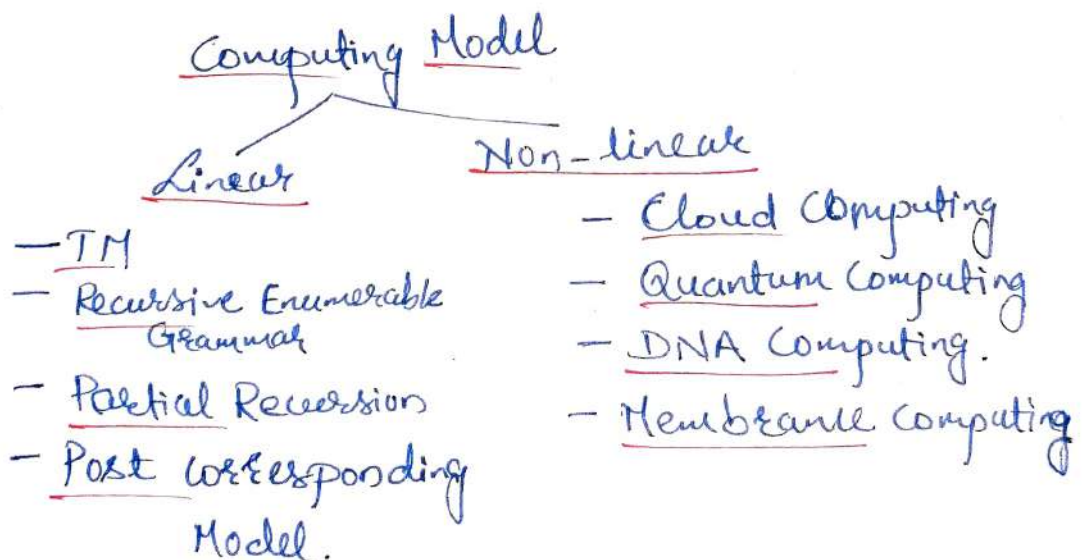
⇒ To compute any transition function, the state movements are defined by instantaneous description & controlled by FCU i.e. transitions of TM is implemented by FCU.

Note:-

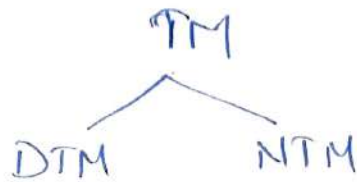
1) TM is a abstract model of real Computer System

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 recursive enumerable language (r.e.) 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 Generator
- 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.

⇒ ~~PDA~~

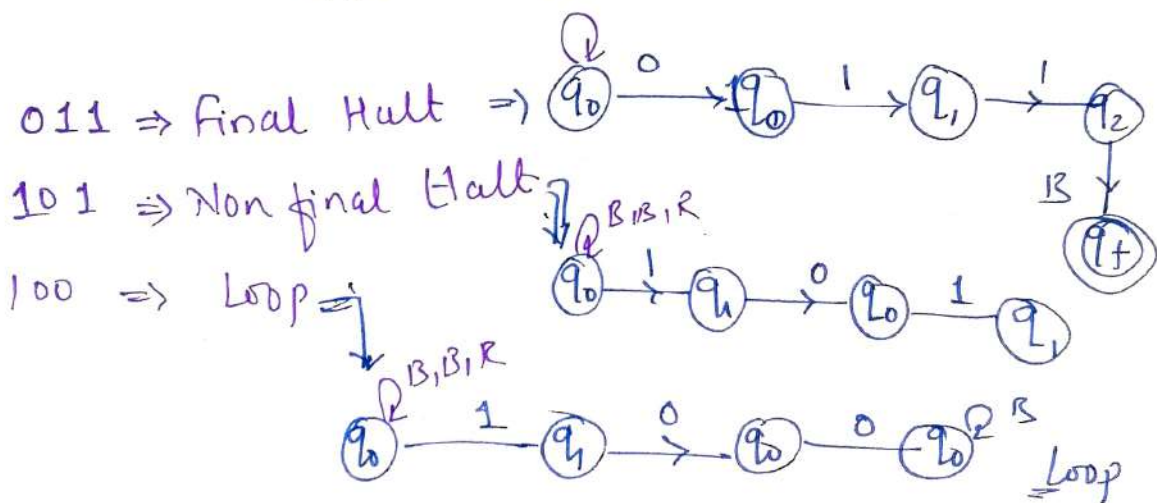
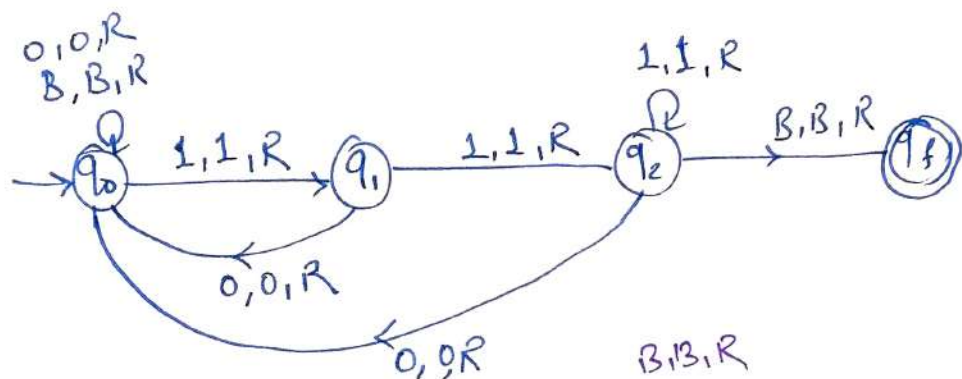
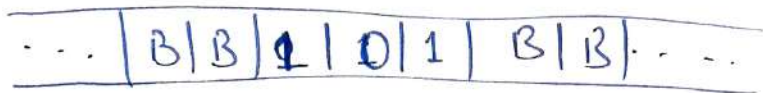
$$\underline{E(TM)} = \underline{E(FA + 2\text{Stack})} = \underline{E(FA + n\text{Stack})},$$

$\xrightarrow{n \times 2}$
→ Diffⁿ types of TM

$$\underline{E(TM) > E(PDA) > E(FA)}$$

* Acceptance by TM :-

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



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

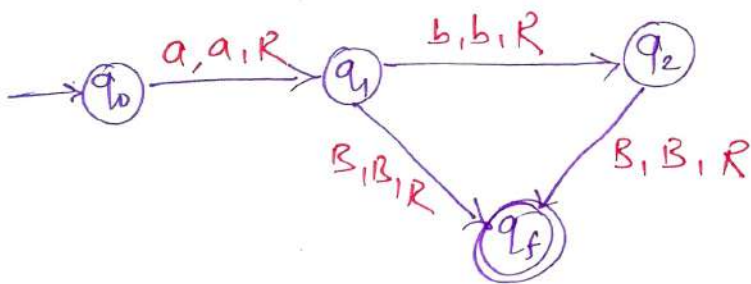
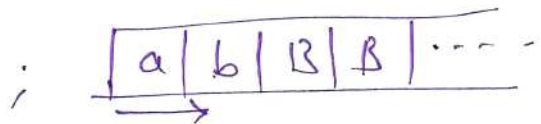
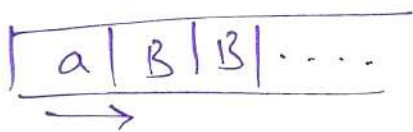
- ① May go to Final Halt. \Rightarrow string is accepted by TM
- ② May go to non-final Halt. \Rightarrow If string is rejected by TM.
- ③ May go to loop. \Rightarrow String is neither accepted nor rejected

Note:-

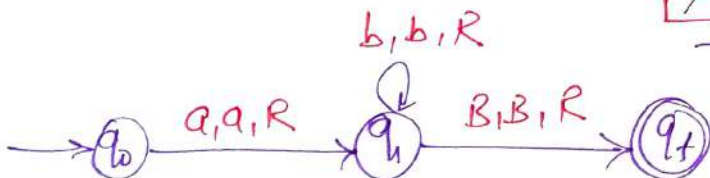
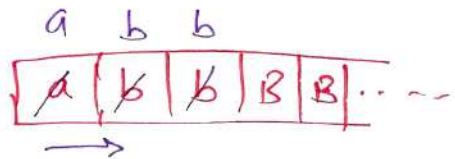
No algorithm exist to decide the nature of TM for input string w i.e. the TM halt (or) doesn't halt can not be decided. Hence halting problem of TM is undecidable.

* Construction of Turing Machine:-

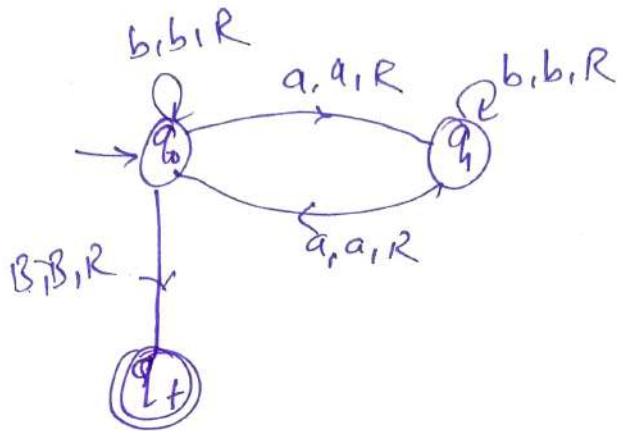
1) $L = \{a, ab\}$



② $L = ab^*$



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

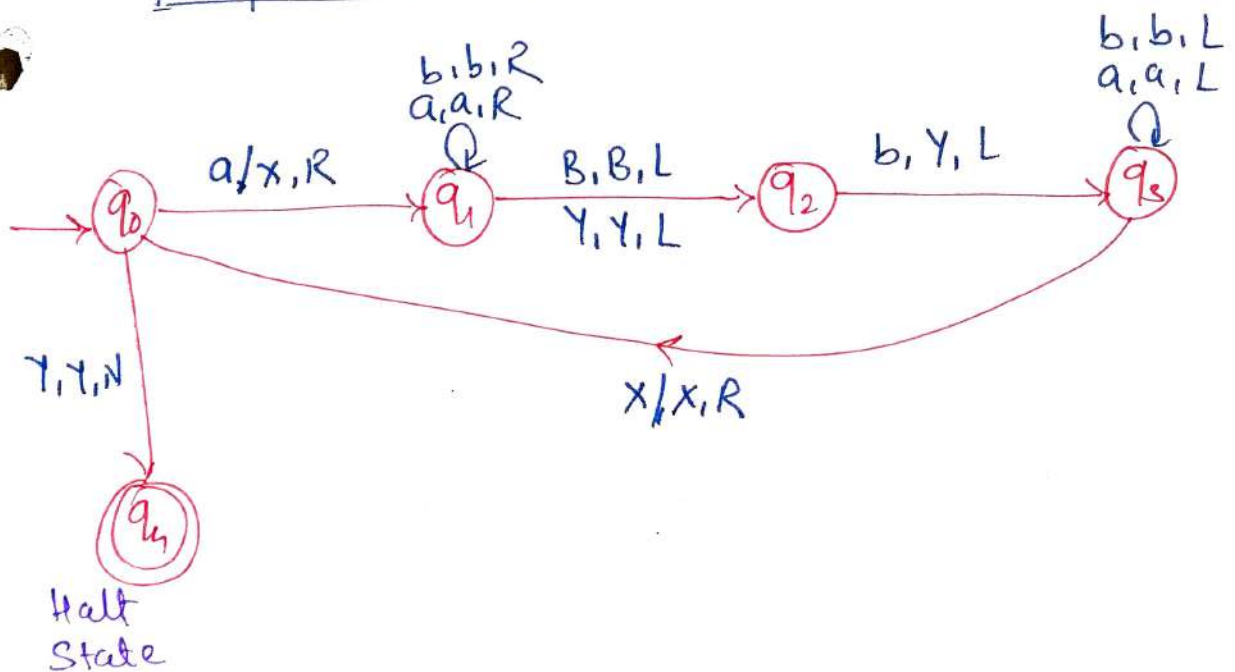
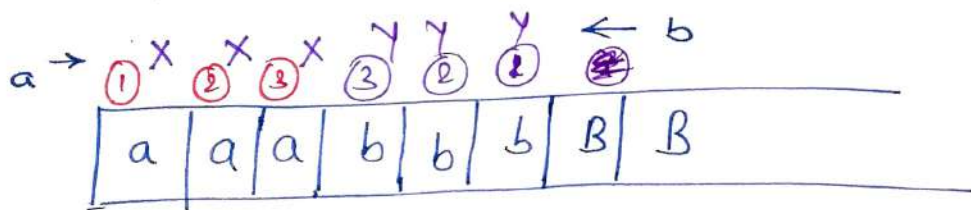


Accept

b	b	a	a	B	B	...	
a	a	a	b	a	B	B	...

④ $L = \{ a^n b^n \mid n \geq 1 \}$

\Rightarrow Let, $a^3 b^3$



$$\Rightarrow \underset{\uparrow}{a} a b b B \Rightarrow q_0$$

$$x \underset{\uparrow}{a} b b B - q_1$$

$$x a \underset{\uparrow}{b} b B - q_1$$

$$x a b \underset{\uparrow}{b} B - q_1$$

$$x a b b \underset{\uparrow}{B} - q_1$$

$$x a b \underset{\uparrow}{Y} \underset{\leftarrow}{B} - q_2$$

$$x a \underset{\uparrow}{b} Y B - q_3$$

$$x \underset{\uparrow}{a} b Y B - q_3$$

$$\underset{\uparrow}{x} a b Y B - q_3$$

$$\rightarrow \underset{\uparrow}{x} \underset{\uparrow}{x} b Y B - q_0$$

$$x x \underset{\uparrow}{b} Y B - q_1$$

$$x x b \underset{\uparrow}{Y} B - q_1$$

$$x x \underset{\uparrow}{\cancel{Y}} \underset{\leftarrow}{Y} B - q_2$$

$$x x \underset{\uparrow}{Y} Y B - q_3$$

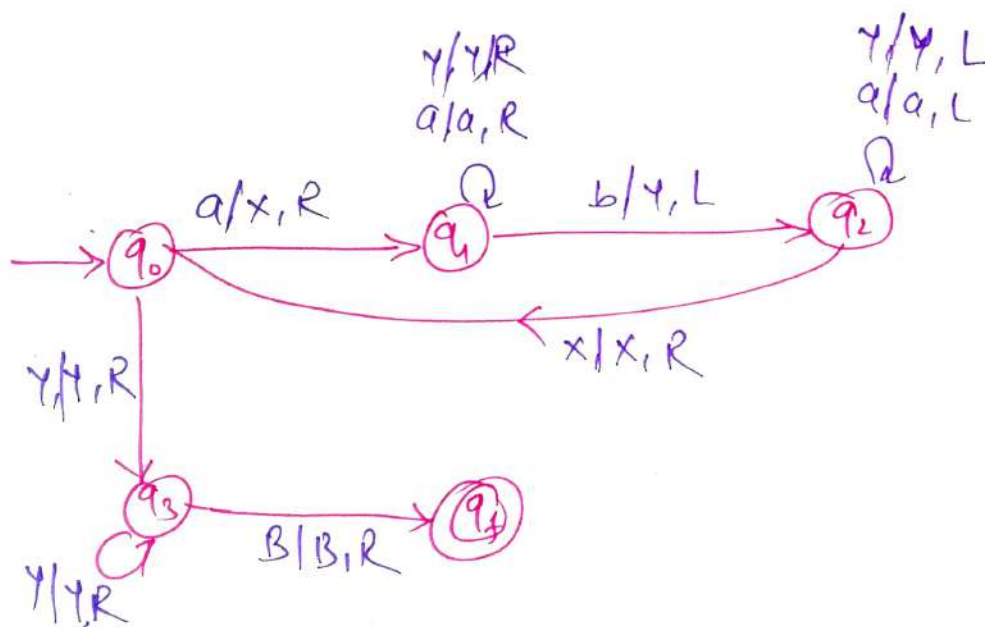
$$\rightarrow x x \underset{\rightarrow}{Y} Y B - q_0$$

$$x x Y Y B - \underline{\underline{q_4}}$$

δ	a	b	x	y	B
$\rightarrow q_0$	(q, x, R)	—	—	(q_4, y, 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 ③ x y y y ③
 x ② x a y ② y b
 ① x a a y ① b b

a	a	a	b	b	b	B	B	...
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