# Turing Machine

DATE: / /
PAGE:

⇒ Turing M/c has infinite size tape and it is used to accept Recursive Enumerable languages.

⇓

means same set of rules have been accepted

→ A turing m/c (TM) can move in both directions. Also it doesn't accept ε.

→ If the string inserted is not in language, m/c will halt in non-final state.

⇒ TM is a mathematical model which consists of an infinite length tape divided into cells on which i/p is given.

⇒ It is consists of a head which reads the i/p tape.

⇒ A state register stores the state of TM.

⇒ After reading an i/p symbol, it is replaced with another symbol, its internal state is changed, & it moves from one

DATE: / /
PAGE:

to the right or left.

⇒ If the TM reaches the final state, the i/p string is accepted, otherwise rejected.

## Formal Definition

A TM can be formally described as 7-tuples.
$(Q, X, \Sigma, \delta, q_0, B, F)$ where

$Q \rightarrow$ finite set of states

$X \rightarrow$ is the tape alphabet (inputs stored in the tape)

$\Sigma \rightarrow$ is the i/p alphabet

$\delta \rightarrow$ is a transition function;
$\delta : Q \times X \rightarrow Q \times X \times \{\text{left shift}, \text{Right shift}\}$

$q_0 \rightarrow$ is the initial state

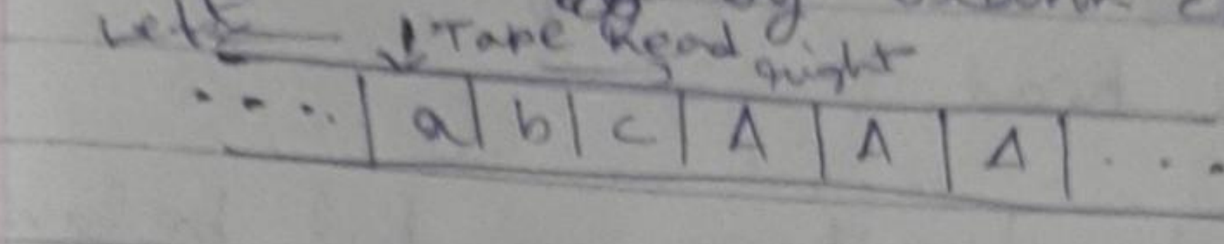
$B \rightarrow$ Blank symbol (Represeted by A or ⊔

$F \rightarrow$ set of final states.

# Basic Model of TM

DATE: / /
PAGE:

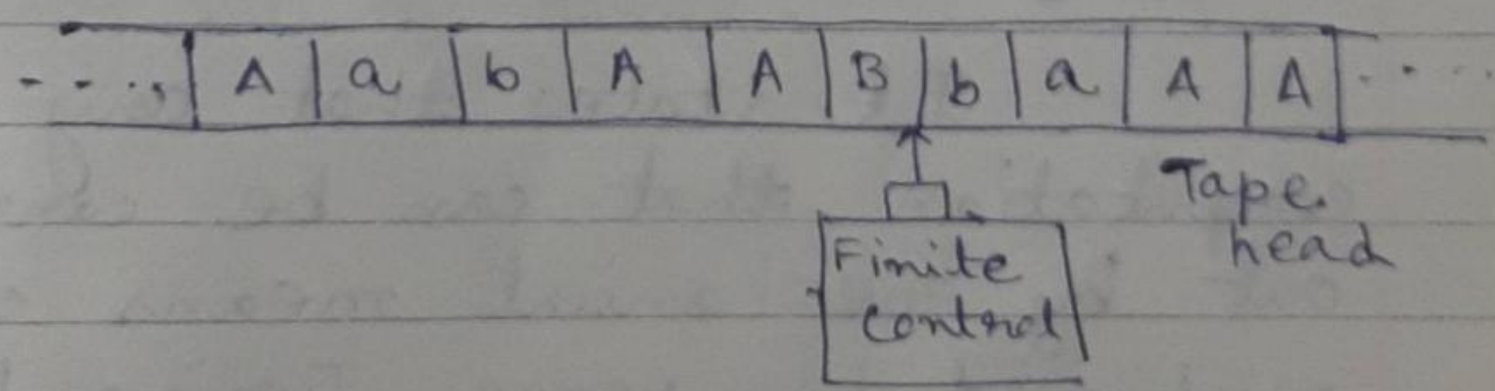
① The i/p tape is having an infinite no. of cells, Each cell containing one i/p symbol. The empty tape is filled by blank characters.




② The finite control & the tape head which is responsible for reading the current i/p symbol. The tape head can move to left to right.

③ A finite set of states through which m/c has to undergo.

④ Finite set of symbols called external symbols which are used in building the logic of TM.



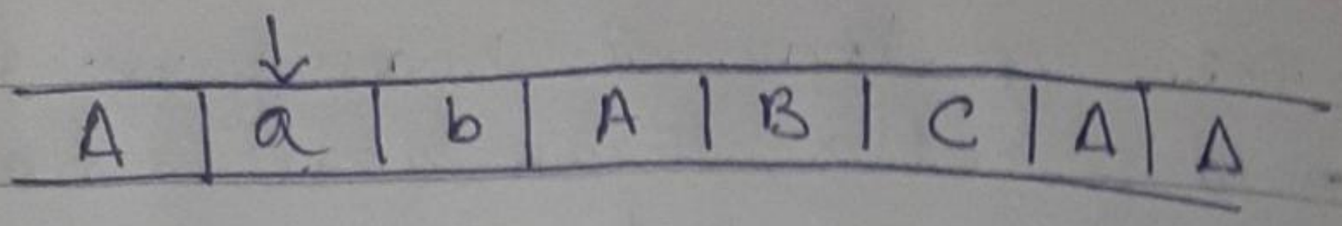

Δ - is a blank symbol

Δ ∉ Σ used to fill the infinite tape.

Δ is not a part of Σ.

## Operations on the tape

DATE: / /
PAGE:

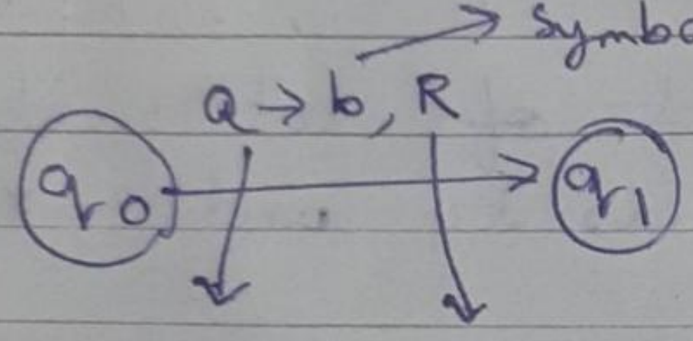



(1) Read / scan the symbol below tape head.

(2) Update / write a symbol below tape head.

(3) Move the tape head one step left.

(4) Move the tape head one step right.




## Turing Thesis

It states that any computation that can be carried out by mechanical means can be performed by some Turing Machin

The arguments for accepting this thesis are :-

(1) Anything that can be done on

existing digital computer can also be done by TM.

(2) No one has yet been able to suggest a problem solution by what we consider an algorithm, for which a T.M. program can not be written.

(3) The language that is accepted by TM is Recursively Enumerable language. ← List of elements.

A lang L ⊆ Σ is said to be recursively enumerable if there exists a T.M. that accepts it.

↳ Replacing same set of rules for any no. of time.

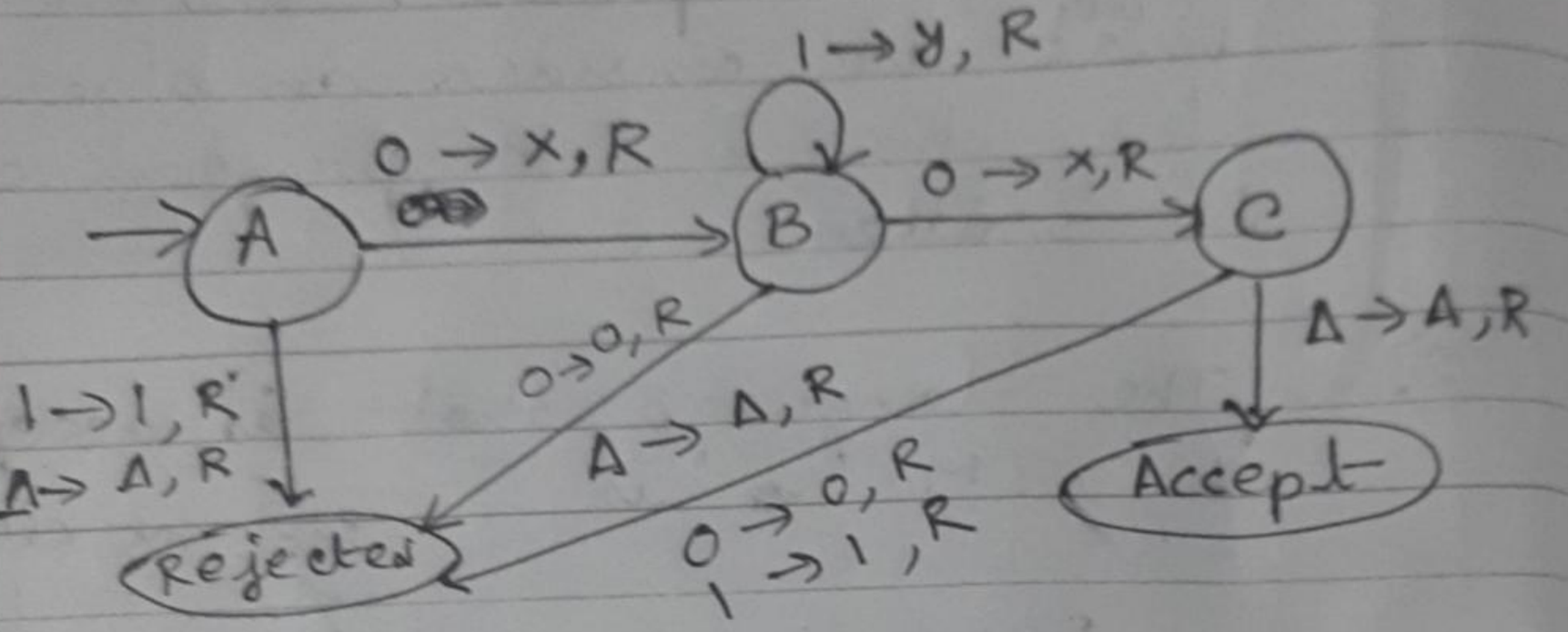
DATE:
PAGE:

## Example

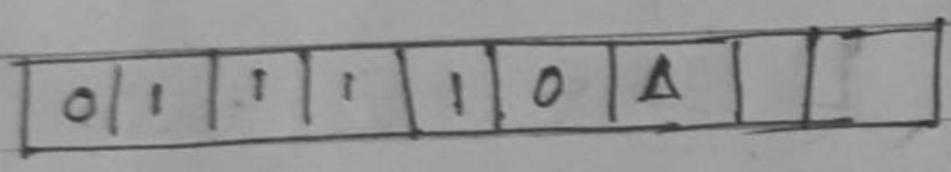
Design a TM which recognize the language

~~0 0 0 1 * 0~~ $L = 01^*0$

Sol:-




eg. 0 1 1 1 1 0



# Language accepted by Turing Machine

DATE: / /
PAGE:

→ The TM accepts all the lang even though they ~~are~~ are recursively enumerable.

→ Recursive means repeating same set of rules for any no. of times.

→ Enumerable means a list of elements.

→ TM also accepts the ~~com~~ computable functions, such as ~~addiontat~~ addition, subtraction multiplication, division and many role.

Example Construct a TM which accept a language of 'aba' over $\Sigma = \{a, b\}$.

Sol

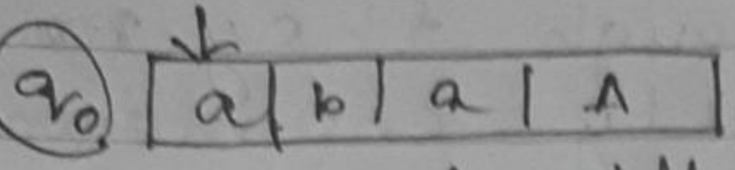
| a | b | a | Δ | ... |
|---|---|---|---|---|

We will ~~assume~~ assume that i/p tape the string 'aba' is placed

If the tape head is 'readout' 'aba' string then TM will halt after reading Δ.

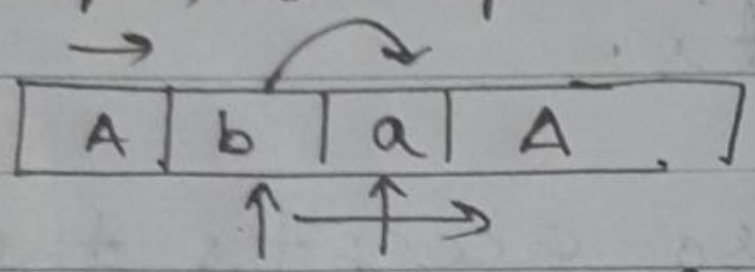
DATE: / /
PAGE:

⇒ Initially, state is $q_0$ & head points to 'a' as

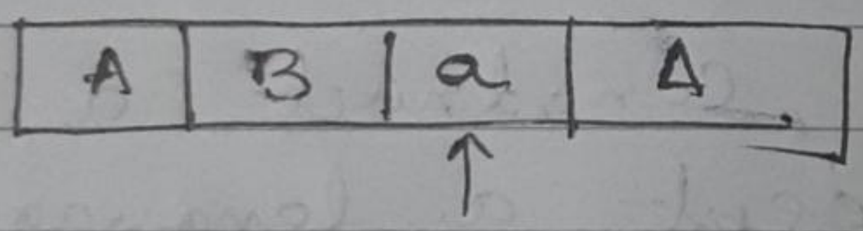



Now the head will be moved to right side.

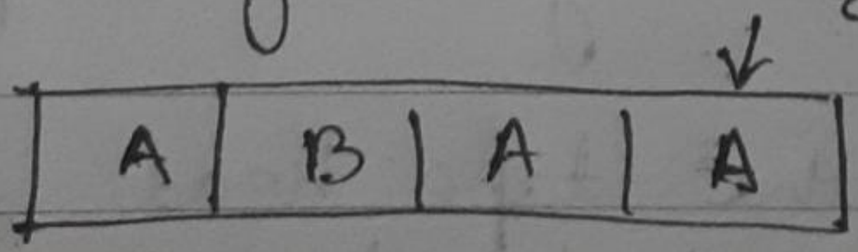
⇒ The move will be $\delta(q_0, a) = \delta(q_1, A, R)$ which means it will go to state $q_1$, replaced 'a' by




→ The move will be $\delta(q_1, b) = \delta(q_2, B, R)$ which means it will go to state $q_2$, replaced 'b' by 'B' and head will move to right as:




⇒ The move will be $\delta(q_2, a)$ $= \delta(q_3, A, R)$ which means it will go to state $q_3$, replaced 'a' by 'A' and head will move to right as:



DATE: / /
PAGE:

⇒ The move $\delta(q_3, \Delta) = \delta(q_4, \Delta, S)$ which means it will go to state $q_4$ which is HALT state which is accepted by th TM.

Transition Table:

| states | a | b | Δ |
|---|---|---|---|
| $q_0$ | $(q_1, A, R)$ | — | — |
| $q_1$ | — | $q_2, B, R$ | — |
| $q_2$ | $(q_3, A, R)$ | — | — |
| $q_3$ | — | — | $(q_4, \Delta, S)$ |
| $q_4$ | — | — | — |