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## TCS - Assignment No. : 05

Q.1 Define TM

→ TM is a simple model of a computer and it is considered to be more powerful machine.

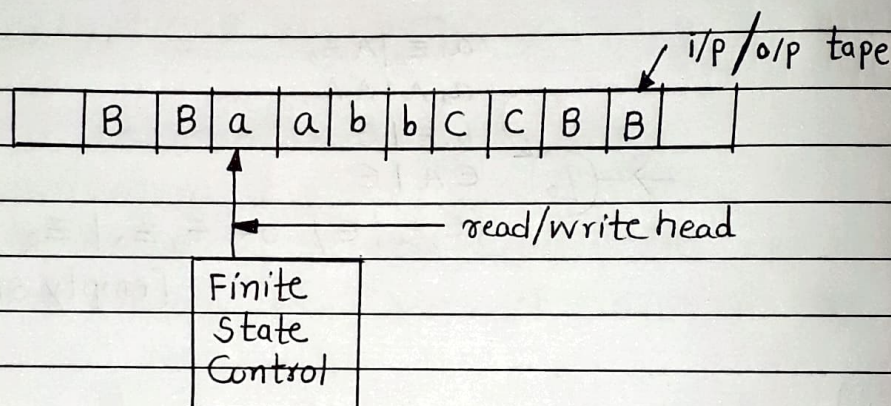


fig: Model of TM

TM can perform followings:-

- 1) Language recognition
- 2) Computation of some functions
- 3) Language generation

Representation of TM :-

- TM is represented using seven tuple representation & it is defined as follows

$$M = \{ Q, \Sigma, \Gamma, \delta, q_0, z_0, F \}$$

Where  $Q$  = Finite set of states  
 $\Sigma$  = Input alphabet



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$\Gamma$  = tape alphabet

$\delta$  = Transition function

$q_0$  = start state

$\emptyset$  = Blank symbol

$F$  = Finite set of final states.

- TM can change the state / remain in same state
- TM can change the tape symbol / keep it same.

Q.2 Write short note on variants of TM.

→ The different variants of Turing Machine (TM) are mentioned as follows :-

1. Turing Machine with Two-way Infinite Tape :-

In this variant of TM the input/output tape is a two way indefinite tape, i.e. there are unlimited blank cells on the left as well as right on the current non-blank portion on the tape.

2. Multi-tape Turing Machine :-

- In this variant of TM the machine has  $k$  tapes with  $k$ -heads i.e. each tape is controlled by separate head.
- On single move depending on the state of the finite control & the symbol.

3. Multi-track Turing Machine :-

- Multi-tracking Turing machine is a specific type of multi tape Turing machine.



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- Multi-track Turing Machines consists of multiple tracks but just one tape head which reads and writes  $k$  symbols from  $k$  tracks one by one.

#### 4. Multi-Dimensional TM :

- Multi-dimensional Turing machine has a multi-dimensional tape where head can move in any direction that is left, right, up & down.

#### 5. Semi-Infinite Tape :-

- A TM with semi-infinite tape has no cells on the left hand side of the initial position & infinite cells on the right hand side of the initial position.

#### 6. Non-deterministic Turing Machine :-

- Non-deterministic TM has a single one way infinite tape.
- In this variant of Turing from each state on each tape symbol there can be multiple choices or paths hence it is cannot be deterministic.



Q.3 Explain Applications, power, & limitations of TM.

### Applications of TM :-

- For solving any recursively enumerable problem.
- For understanding complexity theory
- For implementation of neural networks
- For implementation of Robotics Applications
- For implementation of artificial intelligence.

### Power of TM :-

The turing machine has a great computational capabilities so it can be used as a general mathematical model for modern computers. Turing machine can model even recursively enumerable languages.

Thus the advantage of turing machine is that it can model of all the computable functions as well as the languages for which the algorithm is possible.

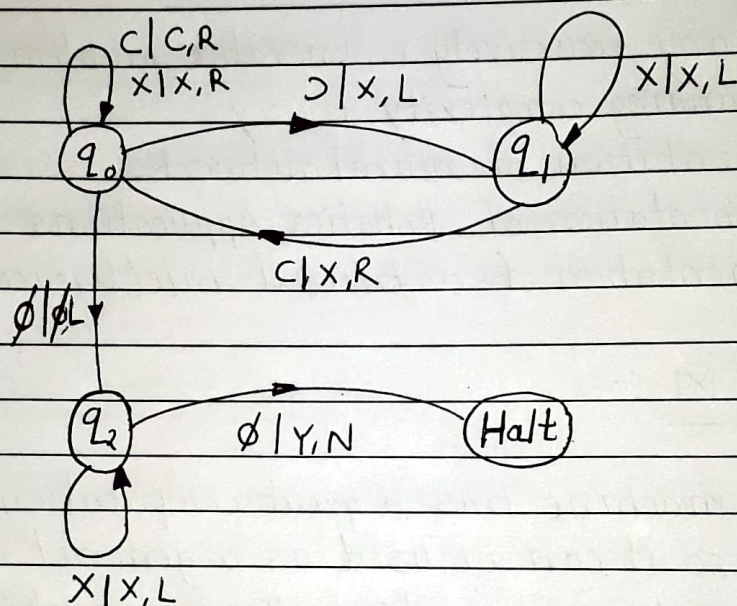
### Limitations of a Turing Machine :-

- Determining if a program will ever halt on a given input
- Determining if two programs compute same output.
- Determining the size of the smallest program that computes a given output (formally known as Kolmogorov complexity).



Q.4 Design TM for the following.

a. TM to check well formedness of paranthesis



b. TM to reserve string over  $\{a, b\}$

