UNIT-5

ONE SHOT VIDEO

T.A.F.L

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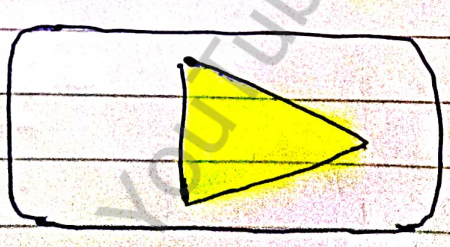
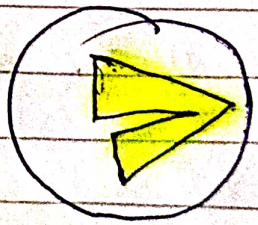




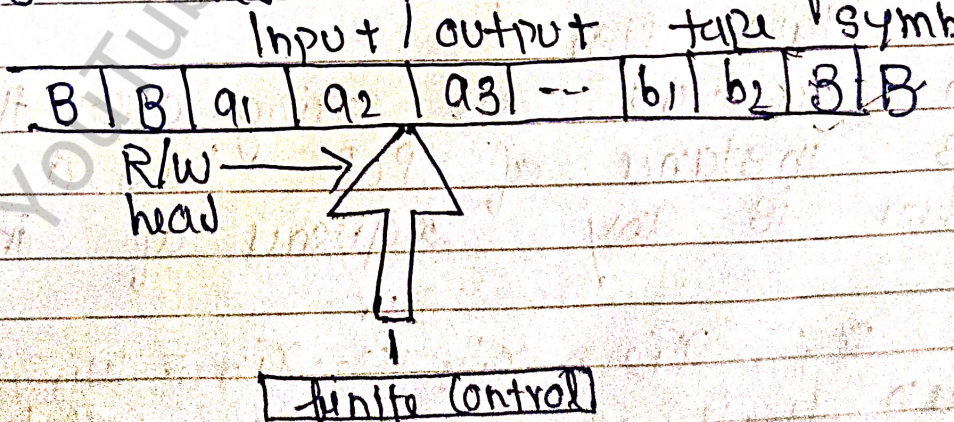
TURING MACHINE

- Turing Machine was invented by Alan Turing in 1936 and it is used to accept recursive, Enumerable language (Generated by Type-0 Grammar).

- A Turing machine is a computational model like, Automata (FA), Pushdown Automata (PDA), which works on unrestricted grammar.

- The turing machine is the most powerful computational model when compared with F.A and PDA.

- The turing machine has infinite central connected to R/W (Read/write) head it has one tap which is divided into a number of cells.



- Turing machine can move left and right from one cell to another

∵ It has 7 tuple.

$$M = (Q, X, \Sigma, \delta, q_0, B, F)$$

$Q \rightarrow$ represent the finite set of state.
Γ or $X \rightarrow$ set of tape alphabet
$\Sigma \rightarrow$ non-empty set of input alphabet
$\delta \rightarrow$ is transition function.
$\delta : Q \times X \rightarrow Q \times X \times$
$q_0 \rightarrow$ initial state of Machine
$B \rightarrow$ is the blank symbol
$F \rightarrow$ is the final state of Machine.

PCP :-

① It stands for Post Correspondance Problem

Definition :- Let $x_1, x_2, \ldots x_n$ & $w_1, w_2, \ldots w_k$ are two list.
Each x_i & w_i are string over the alphabet Σ
This instance of PCP has a solution if there is any sequence of integers

$$x_{i_1}, x_{i_2}, x_{i_3} \ldots x_{i_n} = w_{i_1}, w_{i_2}, w_{i_3} \ldots w_{i_n}$$

then $i_1, i_2, i_3 \ldots i_n$ is called Solution for instance of PCP

Q

i	w_i	x_i
1	1	111
2	10111	10
3	10	0

Sol

x (111, 10, 0)

w (1, 10111, 10)

$\Rightarrow$ ~~1 / 11~~ ~~10111 / 10~~ ~~10 / 0~~ (wrong)

$\Rightarrow$ ~~10111 / 10~~ 2 . ~~1 / 11~~ 1 . ~~1 / 1~~ 1 . ~~10 / 0~~ 3 (right)

$x_2 x_1 x_1 x_3 = 10\,111\,111\,0$

$w_2 w_1 w_1 w_3 = 10\,111\,111\,0$

$x_2 x_1 x_1 x_3 = w_2 w_1 w_1 w_3$

∴ It is the solution for the instance of PCP ② ① ① ③.

Q Prove that halting problem is undecidable

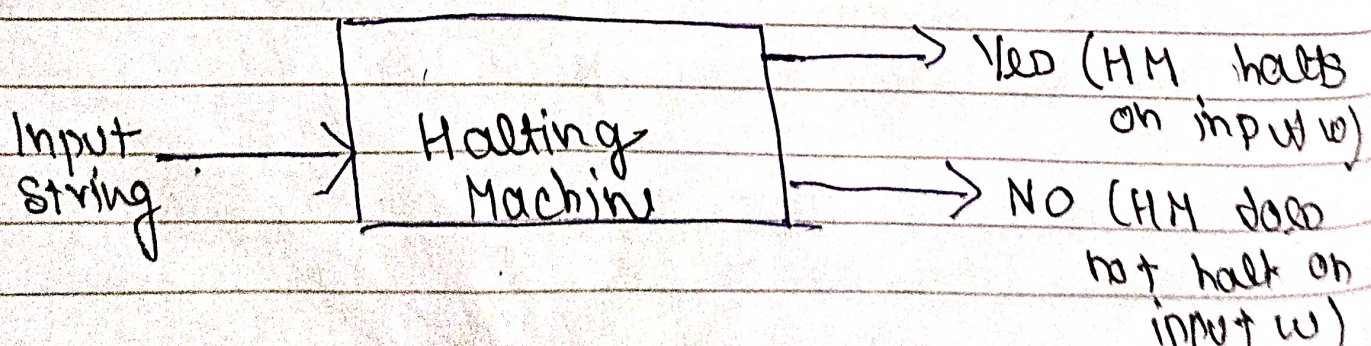
Sol Input :- A string machine and an input string w

Problem :- Does the Turing Machine finish computing of the string w in a finite number of steps ? The answer must be either Yes or no.

Proof :- At first we will assume that such a Turing Machine exists to solve this problem and then we will show it is contradicting itself.

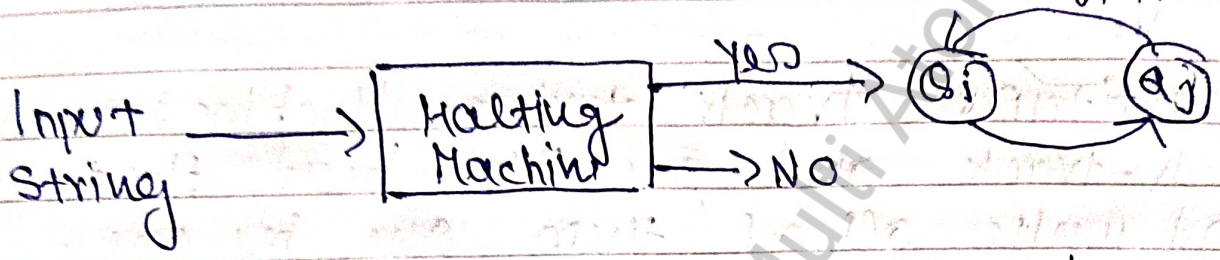
→ We will call this Turing Machine as a Halting machine that produces a yes or no in a finite amount of time.

→ If the halting machine finishes in a finite amount of time, the output comes as "Yes" otherwise as 'no'.



Now we will design an inverted halting Machine (HM)' as —

① If H returns Yes, then loop forever
① If H returns No, then halt



Further a machine $(HM)_2$ which input itself is constructed as follows

- If $(HM)_2$ Halt, loop forever
- Else Halt

Here we have got a contradiction, Hence the halting Machine is undecidable

VARIANTS OF TURING MACHINE

① A no. of variants of Turing Machine can be created by changing features of standard TM.

1] Multitape track turing Machine :-
→ A K-track and one R/W head that read and write all of them one by one.
→ A K-track turing machine can be simulated by a single track turing machine.

2] Two-way Infinite Tap Turing Machine :-
→ Infinite tape of two way infinite tape turing machine is unbounded in both direction left and right.
→ Two-way infinite tape turing machine can be simulated by one-way Infinite Turing machine (Standard Turing Machine).

3] Multi-tape Turing Machine :-
→ It has multiple tapes and is controlled by a single head.
→ The multi-tape turing machine is different from K-track Turing machine but power is same.

4] Multi-tape Multihead Turing Machine

→ The multi-tape machine has multiple tapes and multiple heads
→ Each tap is controlled by separated Method
→ Multi-tape Multi-head Turing Machine can be simulated by standard Turing Machin

5] Multi-dimensional Tape Turing Machine

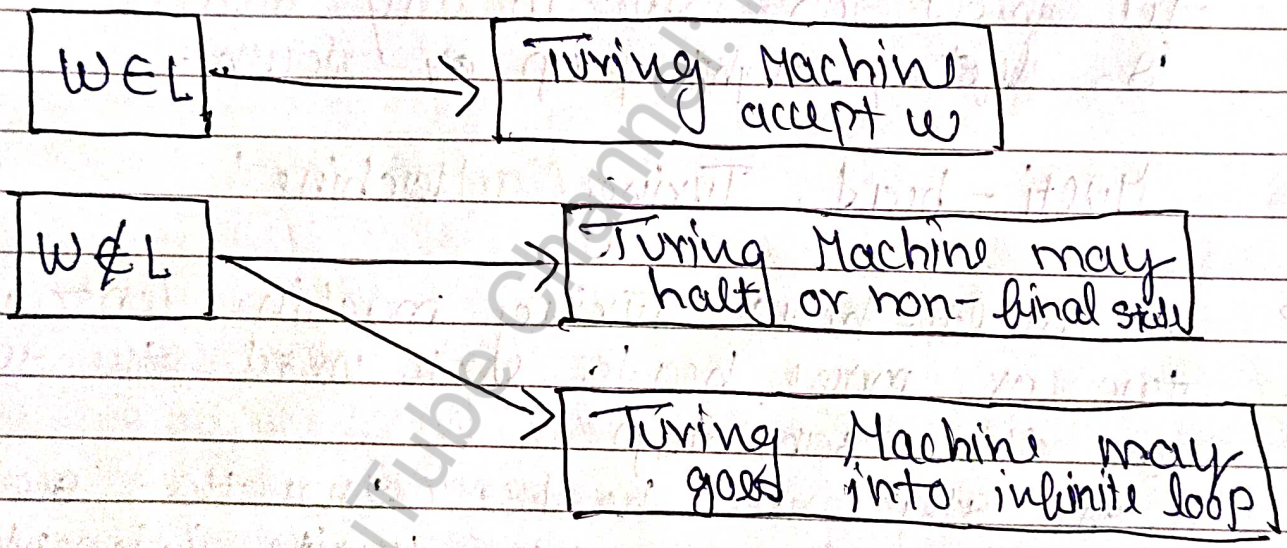
→ It has multiple-dimensional tape where the head can move in any direction that is left, right, up or down.

6] Multi-head Turing Machine

→ A multi-head Turing machine contains two or more heads to read the symbol on the same tap
→ In one step all heads sense the scanned symbols and move or write independently

RECURSIVE ENUMERABLE LANGUAGE

- A language is said to be recursive enumerable if there exist a turing machine that accept word $w \in L$ and for word $w \notin L$; turing machine either may halt in non-final state or may goes into infinite loop.



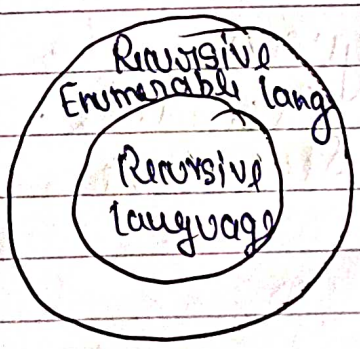
- Recursive Enumerable language is the superset of Recursive language.
- Complement of a recursive enumerable is may not recursive enumerable

RECURSIVE LANGUAGE

- A language is said to be recursive language if there exist a turing machine that accepts every word $w \in L$ and halt while rejects every word $w \notin L$ and halt

$w \in L$ → Turing Machine accept w and halts

$w \notin L$ → Turing Machine reject w and halts.



- Recursive language is the subset of recursive Enumerable language.
- Complement of a recursive language is recursive language

⇒ **Decidable language :-**

- A language 'L' is decidable if it is recursive language.
- All decidable language are recursive languages and vice-versa.

⇒ **Partialy Decidable language :-**

- A language 'L' is partially decidable if 'L' is a recursively enumerable language.

⇒ **Undecidable language :-**

- A language is undecidable if it is not decidable.
- For Recursive language

CHURCH HYPOTHESIS :-

- It is also known as church hypothesis
- It was given by church and Turing in 1930.
- According to church turing thesis, Every thing that can be computed by a Turing machine.
- This thesis cannot be proven but is belived on the basis of amount of evidance that suppor it.
- Computer scientist have decised several alternative model of computation but all have proved to be equivalent to the turing machine.
- According to it "any real word computation can be translated into an equivalent turing machine computation.

UNIVERSAL TURING MACHINE (UTM)

- A turing machine is said to be universal turing machine if it can simulate the behaviour of any turing Machine.
- A standard turing Machine can stimulate only a single computation problem, so if we want to solve another computation problem, then another turing machine is required to be constructed.
- In case of Universal Turing Machine (UTM), same UTM can be used to solve any computation problem.
- Standard TM is "Unprogrammable TM as it works only for one computation problem. However Universal TM is "Programmable TM" as it works for all solvable computation problem.

NUMERICALS

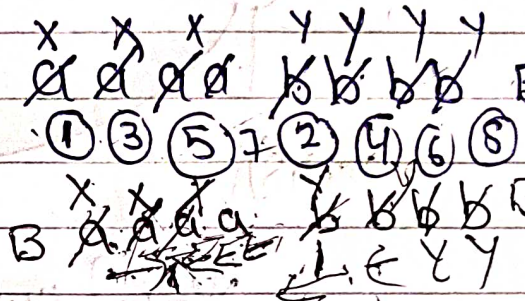
Q Design a TM to recognise $L = \{a^n b^n \text{ where } n >= 1\}$

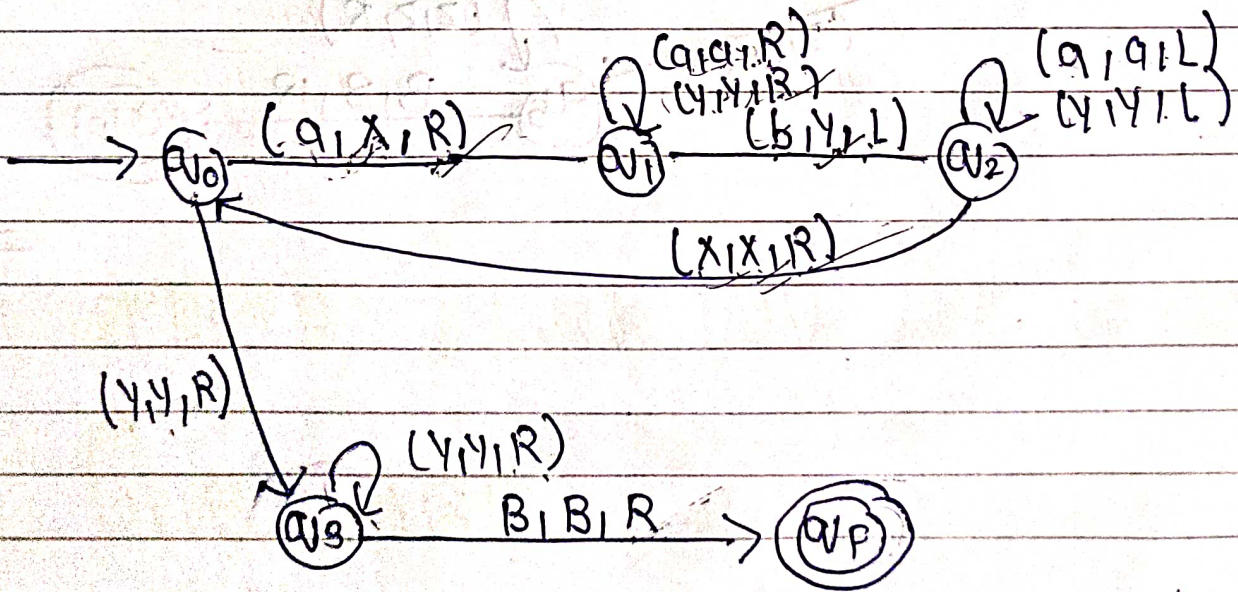
Sol $L = \{a^n b^n \mid n >= 1\}$

$L = \{ab, aabb, aaabbb - \ldots\}$

We take

$\Rightarrow$ (input, output, Head)





Sol

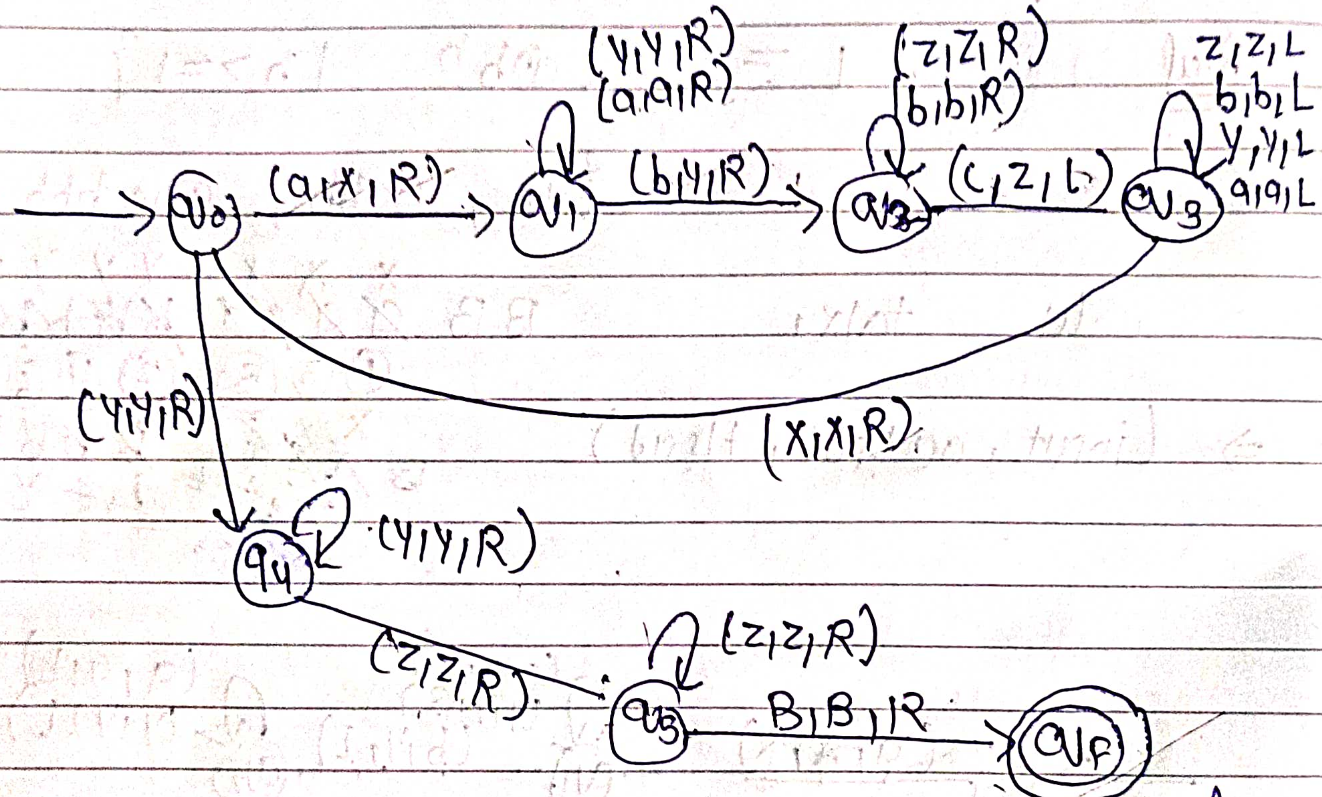
Q Design a TM to recognise $L = \{a^n b^n c^n \mid n \geq 1\}$

Sol

L = --B B a a a b b b c c c B B

(with X X X, Y Y Y, Z Z Z written above, and steps ① ④ ⑦ ② ⑤ ⑧ ③ ⑥ ⑨ below)

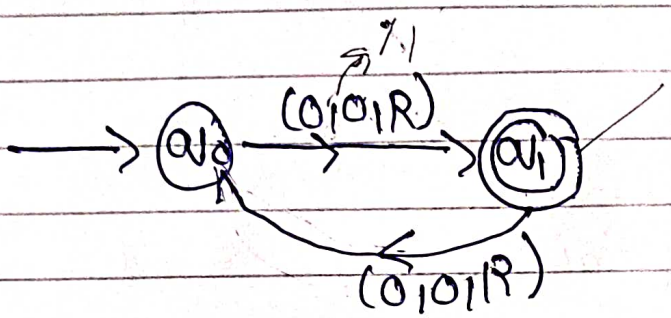
⇒



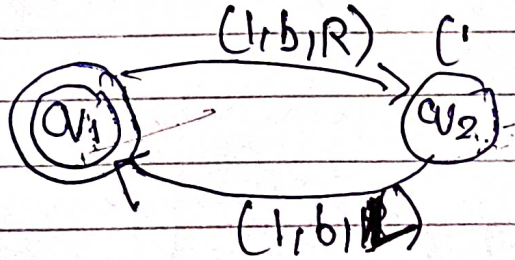
Q Design a TM to recognize all string consisting of an odd number of 0's.

Sol

S = BB000BB



Q Design a TM to recognize all string consisting of an even number of 1's



COMPLETE- THANK YOU FOR WATCHING

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