final state in wxw^R is maintained by making a copy for the single length strings

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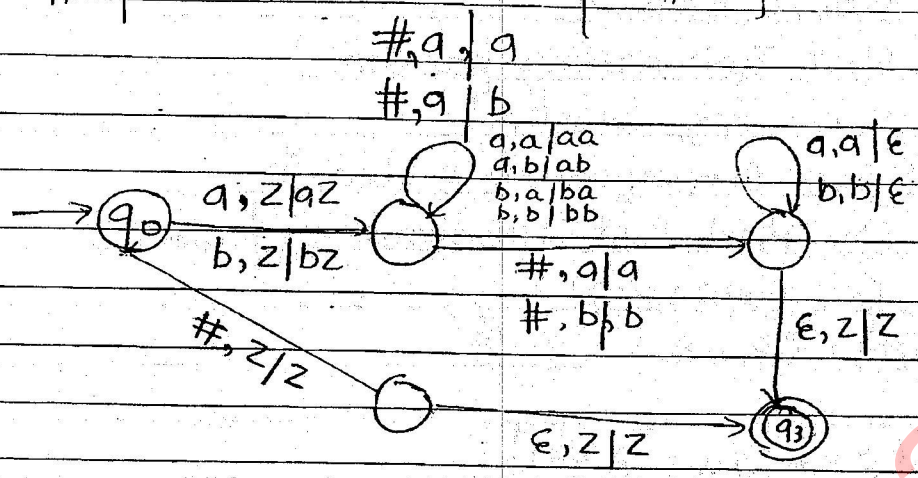
for # palindrome $\{w\#w^R\}$



GODEL, TURING, POST

Turing Machine, REC, RE, Not RE

Turing Machine - 1. Defmition
2. Machine to Language
3. L - M ? $\{a^n b^n c^n \mid n \geq 0\}$
4. Turing Machine as a transducer
$f(x,y) = x+y$
5. Church turning thesis
Imp 6. Variation of Turing Machine

"No Logical Machine can have more power than turing machine."

RE & REC language - • Definition of REC & RE.
• facts related REC & RE.
• Enumeration Procedure (EP) property
• Membership Algorithm (MA) property
• Lexigraphical ordering property
• Closure properties
• L, $\bar{L}$ theorem
• Examples of REC, RE, Not RE

RE but not REC - L_d, c.f.g. (self embedding)

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- Some Undecidable problems related to turing machine.
  - HP (Halting Problem)
  - BTHP (Blank Tape Halting problem)
  - SEP (State Entry problem)
  - PCP (Post Correspondence problem)
  - MPCP (Modified Post Correspondence problem)
  - REM (RE Membership)
- Reduction theorem's ($P_1 \leq P_2$)

Turing Machine - [FA + R/W + R ↔ L]

{FA + R/W ⇒ equivalent to FA}

- finite states
- single starting state

$(Q, \Sigma, \Gamma, \delta, q_0, \square, F)$

$\square$ → Blank symbol (b)

Γ → Tape alphabet

Σ → Input alphabet.

~~table~~ tape alphabet will contain input alphabet as well as output alphabet & blank symbol as well

if o/p are 0, 1

Input a, b

$\therefore \Gamma = \{a, b, 0, 1, \square\}$

tape alphabet is required for write operations here so that storage can be done.

B	B	a	b	a	b	B	B

B is used to show end of tape.

Σ can never contain $\square$.

$\therefore \Sigma \subseteq \Gamma$ (false it can contain $\square$)

$\therefore \boxed{\Sigma \subseteq \Gamma - \{\square\}}$

EXCELLENT

Deterministic Turing Machine

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δ format for DTM & NTM

DTM: $\delta(q_0, a) = (q_1, b, L)$

- q_0: current state
- a: I/P
- q_1: Next state
- b: change the I/P ie Write
- L: Movement of Head

$\delta(q_0, B) = (q_1, b, R)$

$\therefore \delta: \delta_{Q \times \Gamma} \rightarrow Q \times \Gamma \times \{L, R\}$

Γ is here as tape is acting as storage too, output symbol can also occur while mapping.

Command -

1. Do Nothing $\delta(q_0, a) = (q_1, a, R)$
2. Replace $\delta(q_0, a) = (q_1, b, L)$

NTM: $\delta_{Q \times \Gamma} \rightarrow 2^{Q \times \Gamma \times \{L, R\}}$

Both NTM & DTM have same power & are interconvertable

Standard Turing Machine

1. Deterministic
2. Single tape
3. Infinite in both direction
4. Read Write
5. Left Right Movement

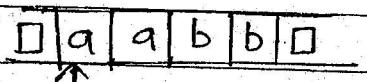
NTM- $\delta(q_0, a) = \{(q_1, a, L), (q_2, b, R)\}$

DTM	NTM
• It does not allow choices	• It allow choices
• ϵ-moves are not allowed	• ϵ-move are not allowed
• DC allowed	• DC allowed

{δ in Turing Machine is a partial function}

the configuration of TM is also known as ID (instantaneous description)

it give information ~~which~~ about parameter which can change
(state, Movement of head, content of tape)



ID-

string representation-

□ q_0 a a b b □

q_0 will move to right.

Ex - ID is □ q_0 a a b b □

and $\delta(q_0, a) = (q_1, b, R)$

$\delta(q_1, a) = (q_2, a, L)$

After two move what is the configuration of M/C →

□ q_0 a a b b □ ⊢ □ b q_1 a b b □ ⊢ □ q_2 b a b b □

□ q_0 b a b b □ — replace & then move right

□ b q_2 a b b □ — Move left

Ques - ~~□(q_0, a a b b)□~~ □ q_0 b a b b □ $\vdash^*$ ∞ ? check whether it is true.

it mean after some step machine will go to hang.

↳ False here.

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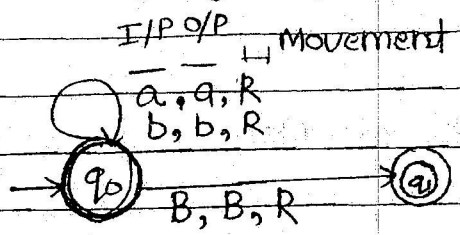
Machine to Language-

Ex 1 -



Ques - $L(M) = (a+b)^*$

What type of string it halt & hang? It always halt but never hang.

What is content of tape at end of expression. ⇒ Same as Input

Turing Machine
- HALT
  - Accept
  - Reject
- HANG (Hang is always considered as Rejection)

To reject a string in TM
1) Non final state
2) DC
3) Hang

Acceptance in TM - final state acceptance only

- In a turing Machine, final states are permanent accept. So No moves on final states are defined. FA can also halt without processing the whole Input if a dead final state occur it is also accept

aab
→ a lead to final state No move from a b then dead but final so accepted

Turing Machine halts only at dead configuration.

- TM with only left & right move, can never go into hang.

• final

2½ - 3
3 - 5
4,5

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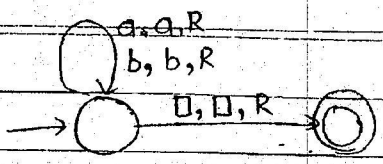
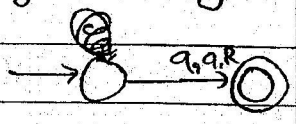
Ex 1 -



L(M) = (a+b)*

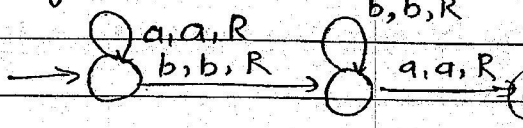
• To convert a FA to turing machine use blank moves only.

for string starting with a.



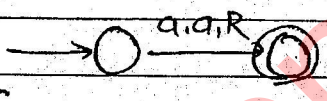
No Need to decide for all as it get accepted as it one reach to final state ~~& no need to show the~~

substring ab



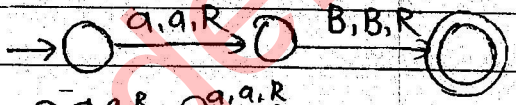
a* b b* a (a+b)*

to accept {a} only



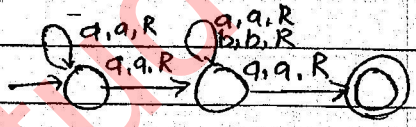
→ it will accept a(a+b)*

for a

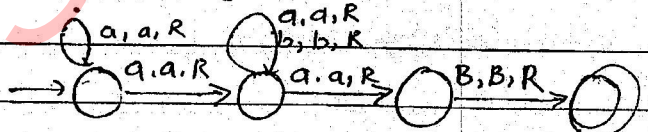


- Use blank symbol

for



a* a (a+b)* a (a+b)*



→ a* a (a+b)* a.

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Null string are not considered in TM.

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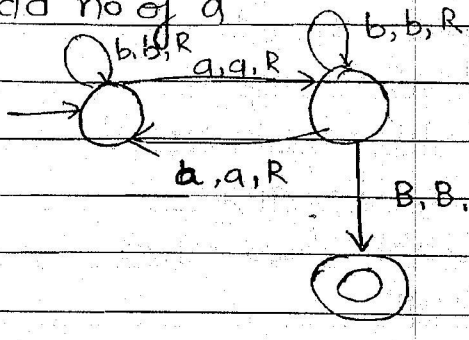
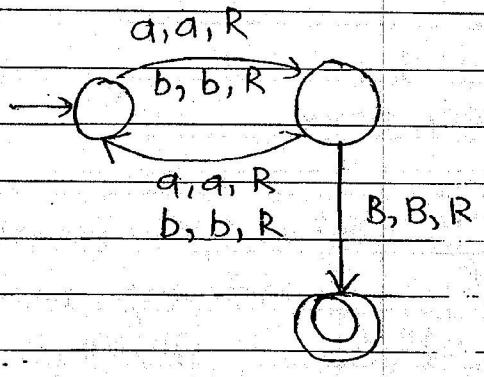
for odd no of a

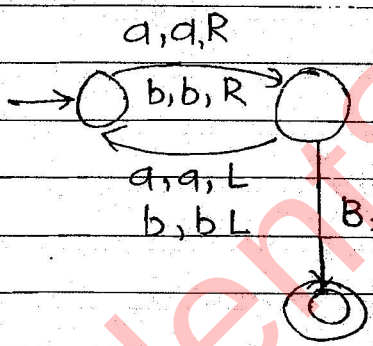


in turing machine after reaching final state it will accept everything so if specific o/p use B,B,R move.

Ques-



L(M) = odd length string
Halt - Halt on everything
Hang - ϕ
Content of tape - same as I/P



~~BaaB~~ □a□
□b□
□aa□
□ab□

When L & R are there, try to cover with taking string

□a□ |- accept □b□ |- accept □aa□ |- hang (reject)

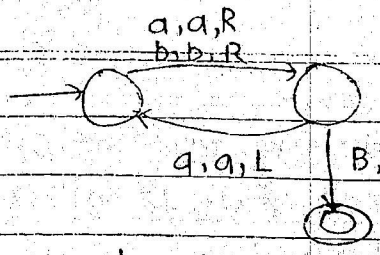
□ab□ |- reject due to hang

□ba□ |- hang □bb□ |- hang

□aba□ - ~~accept~~ always reject as two bit itself hanging

Language = {a,b}
Halt - {a,b}
Hang = $(a+b)^2(a+b)^*$
Content of tape - will remain same

Ques -



Language - {a, b}

Halt = {a, b, ab, bb}

~~Hang~~ ~~(a+b)b~~ ⇓

$a+b+(a+b)b(a+b)^*$

- □a□ - accept
- □b□ - accept
- □aa□ - hang
- □ab□ - halt & reject
- □ba□ - hang
- □bb□ - halt reject

Hang → $(a+b)a(a+b)^*$

↓ when 2nd bit is a

content of tape → it will remain same.

Language to Machine $L=\{a^n b^n c^n \mid n \geq 1\}$ as ε is not considered in turing machine.

B	B	a	a	a	b	b	b	c	c	B	B

TM can do any no of comparison

TM for $a^n b^n \mid n \geq 1$

- tick for a & search for its b & tick it too
- if finally not a & b equal $a^n = b^n$ replace a by x & then one b by y & so on.

□	□	a	a	a	b	b	b	□	□

$\delta(q_0, a) = (q_1, x, R)$ — q_1 will search for b & make it y.

$\delta(q_1, a) = (q_1, a, R)$

~~$\delta(q_1, x) = (q_1, x, R)$~~

$\delta(q_1, y) = (q_1, y, R)$ — because at second round you have to leave A

$\delta(q_1, b) = (q_2, y, L)$

$\delta(q_2, y) = (q_2, y, L)$

$\delta(q_2, a) = (q_2, a, L)$

$\delta(q_2, x) = (q_0, x, R)$

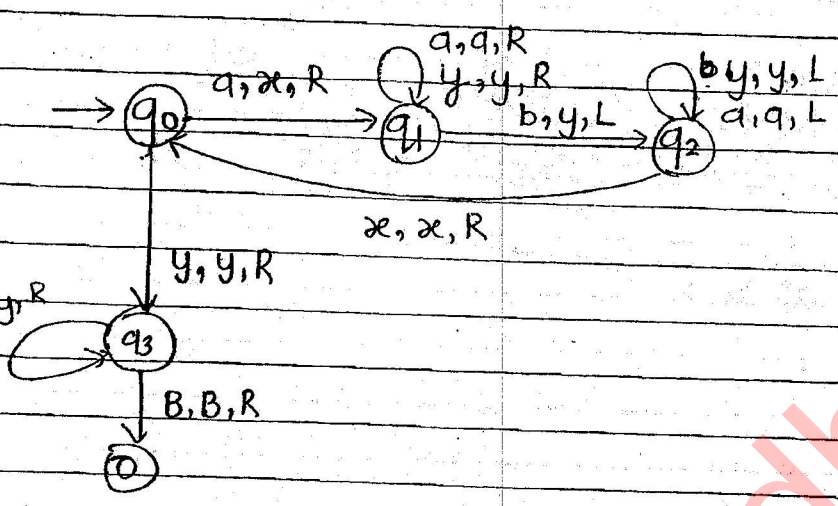
$\delta(q_0, y) = (q_3, y, R)$ $\quad \delta(q_3, □) = \delta(q_f, □)$

$\delta(q_3, y) = (q_3, y, R)$

EXCELLENT

$a^n b^n c^n$

$\delta(q_0, a) = (q_1, x, R)$



$\{ a^n b^n c^n \mid n \geq 1 \}$

$\delta(q_0, a) = (q_1, x, R)$
$\delta(q_1, a) = (q_1, a, R)$
$\delta(q_1, y) = (q_1, y, R)$
~~$\delta(q_1, b) = (q_2, y, R)$~~ $\delta(q_1, b) = (q_2, y, R)$
$\delta(q_2, b) = (q_2, b, R)$
$\delta(q_2, z) = (q_2, z, R)$
$\delta(q_2, c) = (q_3, z, L)$
$\delta(q_3, z) = (q_3, z, L)$
$\delta(q_3, y) = (q_3, y, L)$
$\delta(q_3, b) = (q_3, b, L)$
$\delta(q_3, a) = (q_3, a, L)$
$\delta(q_3, x) = (q_0, x, R)$
$\delta(q_0, y) = (q_4, y, R)$
$\delta(q_4, y) = (q_4, y, R)$
$\delta(q_4, z) = (q_5, z, R)$
$\delta(q_5, z) = (q_5, z, R)$
$\delta(q_5, \square) = (q_f, \square, R)$

B, B, R specify end of string as B is only placed at the end of tap

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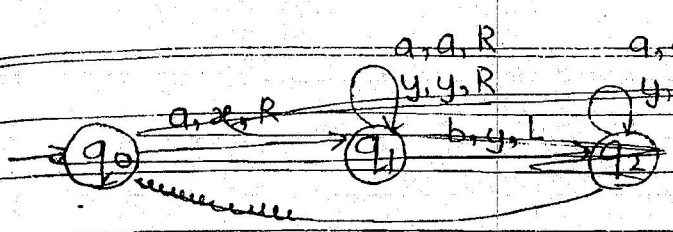
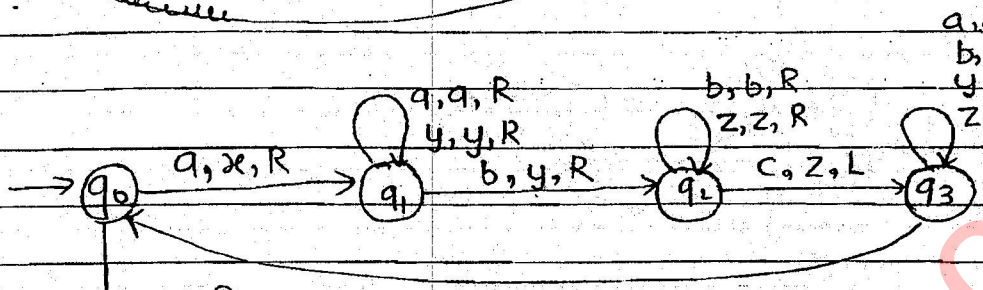
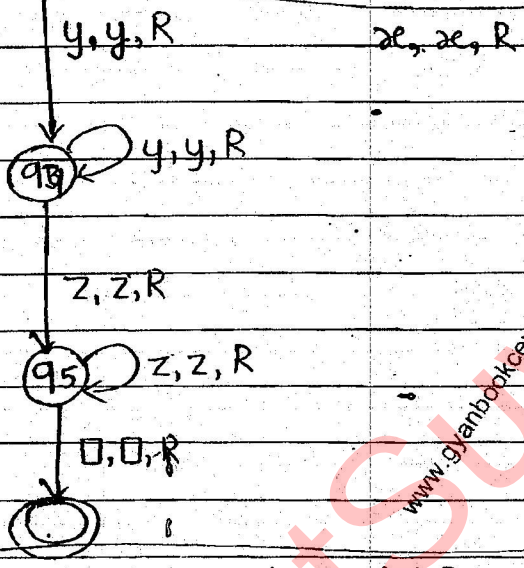




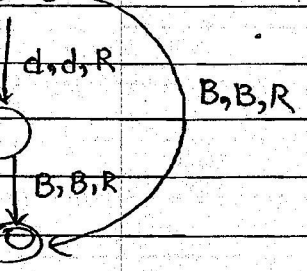


$a^n b^n c^n d$ – $a^n b^n c^n$ — d, d, R → B, B, R → ◎

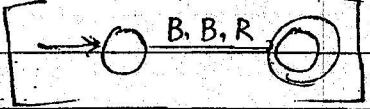
It is specify important to specify Blank no at final state

$a^n b^n c^n d d^*$ $a^n b^n c^n$ — d, d, R → B, B, R → ◎, d, d, R

$a^n b^n c^n d^*$ $a^n b^n c^n$



to accept null through TM



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Turing Machine as a transducer - A set of function accepted by turing machine is partial recursive function.

A set of function represented by HTM is called Recursive fn.

"EVERY LOGICALLY COMPUTABLE FUNCTION IS PARTIAL RECURSIVE."

RE - Turing recognizable language
REC - Turing decidable language

EXCELLENT

Theory