Chapter 6
Turing Machine.(TM)

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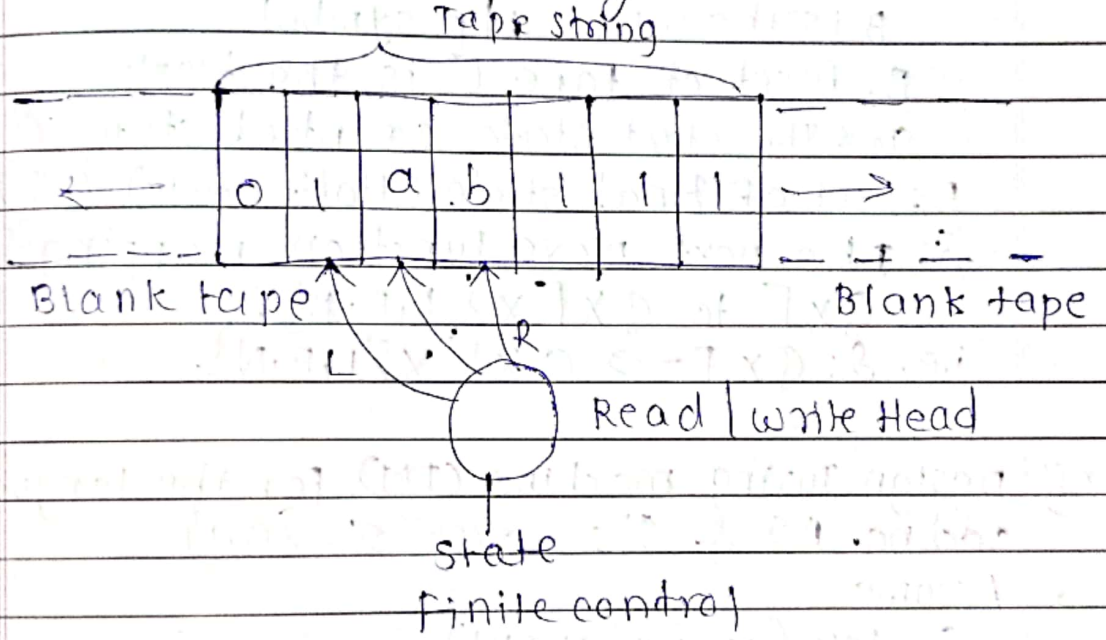
* TM consist of:
i) A head which can read & write a symbol & move left or right or stay in position corresponding to the square cell marked off on a tape
ii) An infinite tape extincting on either side of head marked off into a square cell on which the symbol from an alphabet set can be written. tape represented the unbounded one dimensional memory



A TM has finite set of symbol 'I' finite set of state 'S' It has 3 function namely 1) machine function (MAF), 2) state machine function (STF), DIF Direction function.

$I \times S \to I$ (MAF)
$I \times S \to S$ (STF)
$I \times S \to \{L, R, N\}$ (DIF)

where L: stands for left move
R: —"— right —"—
N: stands for No move.

Note: MAF for FSM
I X S → O
MAF for TM is I X S → I
In TM there is no distinction betn I/O symbol

Formal defn: Formally TM is denoted by
$m = (Q, \Sigma, \Gamma, \delta, q_0, B, F)$
where Q: Finite set of state.
Σ: A subset of Γ not including blank
B is the set of i/p symbol
B: A set of tape. Γ is the blank.
q_0 = The start state or intial state ($\in Q$)
F: set of Final state (Halt state) ($\subseteq Q$)
δ: The next move function mapping from
$Q \times \Gamma$ to $Q \times \Gamma \times \{L, R, N\}$.
i.e. $\delta: Q \times \Gamma \rightarrow Q \times \Gamma \times \{L, R, N\}$.

Ex:] Design Turing machine (TM) for the language odd no. 1's & 0's over $\Sigma = \{0, 1\}$

→ Assume
q_0 for (even 0, even 1)
q_1 for (even '0', odd 1)
q_2 for (odd '0', odd '1')
q_3 for (odd '0' even '1')

S / Σ	0	1	B
q_0	$q_3 R 0$		
q_1			
q_2		$q_3 R 1$	Accept
q_3	$q_0 R 0$	$q_2 R 1$	

BOOGIIIBq0
↑
BOOOIIIBq3
↑
BOOOIIIBq3
↑
BOOOIIIBq0
↑
BOOOIIIBq0
↑
BOOOIIIBq3
↑
BOOOIIIBq3
↑
BOOOIIIBq2

BOOOIIIBq2
↑
BOOOIIIBq3
↑
BOOOIIIBq3
↑
BOOOIIIBq2
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BOOOIIIBq2
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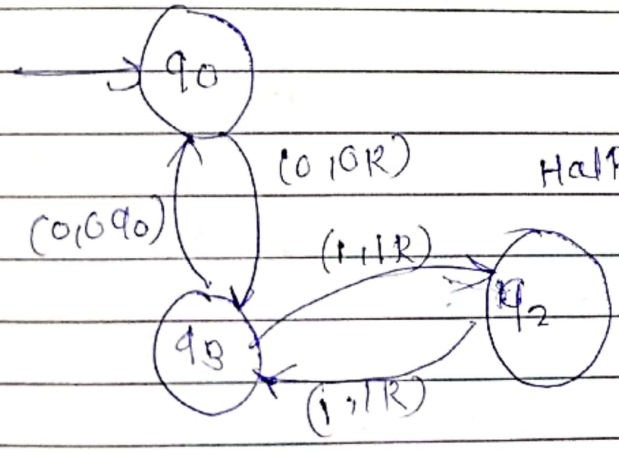
BOOOIIIBq2
↑
BOOOIIIB



2) Design a TM for the language consisting the input of odd no. of 0's & even of 1's over the input $\Sigma = \{0,1\}$.

→ Assume:
q_0 for (even 0, even 1)
q_1 for (even 0, odd 1)
q_2 for (odd 0, odd 1)
q_3 for (odd 0, even 1)

S / I	0	1	B
q_0	q_3 R 0		
q_1			
q_2		q_3 R 1	
q_3	q_0 R 0	q_2 R 1	Accept

B 0 0 0 1 1 B q_0

B 0 0 0 1 1 B q_3

B → 0 0 0 1 1 B q_3

B 0 0 0 1 1 B q_3

Accept

B 0 0 0 1 1 B q_0

B 0 0 0 1 1 B q_0

B 0 0 0 1 1 B q_3

B 0 0 0 1 1 B q_3

B 0 0 0 1 1 B q_2

B 0 0 0 1 1 B q_2

* Design TM for the language even no 0's & 1's over the input $\Sigma = \{0,1\}$

→ Assume

q_0 for (even 0 even 1)

q_1 for (even 0 odd 1)

q_2 For (odd 0 odd 1)

q_3 for (odd 0 even 1)

S \ I	0	1	B
q_0	$q_3 R_0$	$q_1 R_1$	
q_1		$q_0 R_1$	
q_2			
q_3	$q_0 R_0$		

B 0 0 1 1 B q_0

↑

B 0 0 1 1 B q_3

↑→

B 0 0 1 1 B q_3

↑

B 0 0 1 1 B q_0

↑→

B 0 0 1 1 B q_0

↑

B 0 0 1 1 B q_0 1

↑→

B 0 0 1 1 B q_0 1

↑

B 0 0 1 1 B q_0

↑→

B 0 0 1 1 B q_0

↑

Accept.

H.W 1's

H.W Unit 6.

1) Design Turing machine to find 2's complement of given binary no.

2) Design Turing m/c for ~~0's & 1's~~ 0^n & 1^n.

Unit 5

HW

1) construct a PDA that accept the language generated by CFG.

$S \to 0A1 \mid 0BA$

$A \to S0 \mid 0$

$B \to 1 \mid 1B$.

2) $S \to 0S \mid 1S \mid \epsilon$

3) $L = \{a^n b^m a^m \mid n, m \geq 1\}$

4) $S \to AB$
$A \to CD$
$B \to b$
$C \to a$
$D \to a$

5) $S \to SB$
$S \to AB$
$A \to CC$
$B \to b$
$C \to a$.

* Design Turing machine to find 2's complement of given binary no.

→ Assume

q_0 for (even 0, even 1)

q_1 for (even 0, odd 1)

q_2 for (odd 0, odd 1)

q_3 for (odd 0, even 1)

BB1110010101000BBq_0 ↑

BB1110010101000BBq_0 ↑→

BB1110010101000BBq_0 ↑

BB1110010101000BBq_0 ↑→

BB1110010101000BBq_0 ↑

BB1110010101000BBq_1 ←↑

BB1110010101000BBq_1 ↑

BB1110010101000BBq_1 ←↑

BB1110010101000BBq_1 ↑

BB1110010101000BBq_2 ←↑

BB1110010101000BBq_2 ↑

BB1110010101000BBq_2 ←↑

BB1110010101000BBq_2 ←↑

BB1110010111000BBq_2 ↑

BB1110001111000BBq_2 ←↑

BB1110000111000BBq_2 ↑

BB11101011000BBq_2 ←↑

BB11101011000BBq_2 ↑

BB11111011000BBq_2 ←↑

BB11111011000BBq_2 ↑

BB11011011000BBq_2 ←↑

BB11011011000BBq_2 ↑

BB10011011000BBq_2. ←↑

S \ I	0	1	B
q_0	q_0R0	q_0R1	q_1LB
q_1	q_1L0	q_2L1	
q_2	q_2L1	q_2L0	Accept

BB10011011000Bq_2 ↑

BB0001101011000Bq_2 ←↑

BB0001101011000Bq_2 ↑

Accept

$a^n b^n c^n$ ⇒ $0^1 1^n 2^n$

KLP Mishra p.g. 287 * solved this

Design turing machine 'M' to recognised the language $1^n, 2^n, 3^n$ where $n > 1$

Assume,

q_0 for (even 0, even 1)

q_1 for (even 0, odd 1)

q_2 for (odd 0, odd 1)

q_3 for (odd 0, even 1)

	1	2	3	b
q_1	q_2Rb			
q_2	q_2R1	q_3Rb		q_2Rb
q_3		q_3R2	q_4Rb	q_3Rb
q_4			q_5L3	q_7Lb
q_5	q_6L1	q_5L2		q_5Lb
q_6				q_1Rb
q_7				Accept

bb1122233bbq_1 ↑

bbb122233bbq_2 ↑→

bbb1222233bbq_2 ↑

bbb1222233bbq_2 ↑→

bbb1222233bbq_2 ↑

bbb1b2233bbq_3 ↑→

bbb1b22.33bbq_3 ↑

bbb1b2233bbq_4 ↑→

bbb1b22.33bbq_5 ↑←

bbb1b2233bbq_5 ↑

bbb1b22.33bbq_5 ↑←

bbb1b2233bbq_5 ↑

bbb1 b2b3bbq5
←↑

bbb1 b2b3bbq5
↑

bbb1b2b3bbq6
←↑

bbb1b2b3bbq6
↑

bbb1b2b3bbq61
↑→

bbb1b2b3bbq1
↑

bbb b2b2 b3bbq2
↑→

bbbbb2b3bbq2
↑

bbbbbbb3bbq3
↑→

bbbbbb b3bbq3
↑

bbbbbbb3bbq3
↑→

bbbbbbbbbbq4
↑

Accept.

* Design TM that copies string of 1's.
* Design TM that the given decimal no. divide by 3.

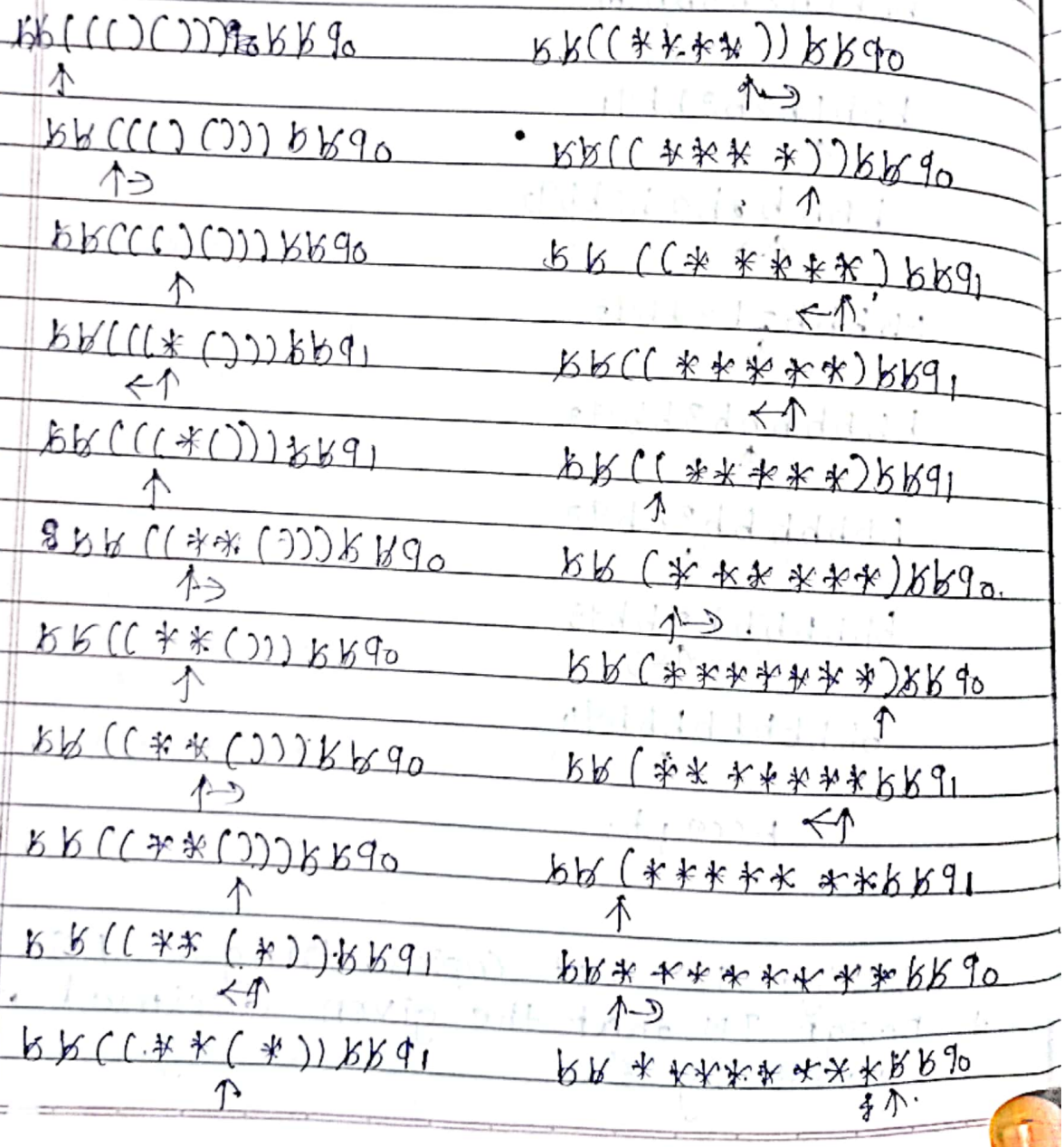
q_0 → search for)

q_1 → search for (

* Turing design turing machine to check for well parenthesis

→

S\I	(	)	*	B
q_0	$q_0 R($	$q_1 L *$	$q_0 R *$	$q_2 L *$
q_1	$q_0 R *$	Not possible	$q_1 L *$	error
q_2	error	Not possible	$q_2 B L *$	Accept.



bb * * * * * * * * bb q_2

bb * * * * * * * * * Bb q_2

Accept.

0 1

$q_0 \to q_1 \to q_2 \to q_3 \to q_0$

* Design turing machine to check for $0^n 1^n$

→

S\I:	0	1	*	B
q_0	q_1 R *			
q_1	q_1 R 0 (skip zero)	q_2 L *	q_1 R *	
q_2	q_3 L 0		q_2 1 *	q_4 R b
q_3			q_0 R *	
q_4			q_4 R *	Accept.

bb 0 0 0 1 1 1 bb q_0

bb * 0 0 1 1 1 bb q_1

bb * 0 0 1 1 1 bb q_1

bb * 0 0 1 1 bb q_1

bb * 0 0 * 1 1 bb q_2

bb * 0 0 * 1 1 bb q_2

bb * 0 0 * 1 1 bb q_3

bb * 0 0 * 1 1 bb q_3.

bb * 0 0 * 1 1 bb q_0

bb * 0 0 * 1 1 bb q_0

bb * * 0 * 1 1 bb q_1

bb * * 0 * 1 1 bb q_1

bb * * 0 * 1 1 bb q_1

bb * * 0 * * 1 bb q_2

bb * * 0 * * 1 bb q_2

bb * * 0 0 * 1 bb q_2

bb**0**1bbq2

bb**0**1bbq3

bb**0**1bbq3

bb*0**1bbq0

bb*0**1bbq0

bb*0**1bbq1

bb*****1bbq1

bb*****1bbq2

bb*****1bbq3

bb*****1bbq4

bb*****1bbq4

bb*****1bbq4

Accept.

* Design turing machine for $0^n 1^n 0^n$

→

S\I	0	1	a	b	c	B
q_0	q_1Ra		q_0Rb	q_0Rc	q_4L0	
q_1	q_1R0	q_2Rb		q_1Rb		
q_2	q_3L0	q_2R1			q_2Rc	
q_3	q_3L0	q_3L1	q_0Ra	q_3Lb	q_3Lc	
q_4			q_4La	q_4Lb	q_4Lc	Accept

BBa011c0BBq0

BBa011c0BBq0

BBa011c0BBq1

BBa011c0BBq1

BBa011c0BBq2

BBa011c0BBq2

BBaObICOBBq2

BBaaObICqBBq3

BBaaObICOBBq3

BBaaObICOBBq3

BBaaObICOBBq3

BBaaObICOBBq4

BBaaObICOBBq3

BBaaObICOBBq3

BBaaObICOBBq0

BBaaObICOBBq0

BBaaObICOBBq1

BBaaObICOBBq1

BBaaabbCOBBq2

BBaaabbCOBBq2

BBaaabbCOBBq2

BBaaabbCCBBq3

BBaaabbCCBBq3

BBaaabbCCBBq3

BBaaabbCCBBq3

BBaaabbCCBBq0

BBaaabbCCBBq0

BBaaabbCCBBq0

BBaaabbCCBBq0

BBaaabbCCBBq4

BBaaabbCCBBq4

Accept.

* Design TM for string containing equal no. of 0's & 1's

0110 →

BBa0110110BBq0
↑

BBa0110110BBq1
↑→

BBa0110110BBq1
↑→

BBa0110110BBq1
↑

BBa0110110BBq1
↑→

BBa0110110BBq1
↑

BBa0110110BBq2
←↑

BBa0110110BBq2
↑

BBa0110110BBq2
←↑

BBa0110110BBq2
↑

BBa0110b0BBq3
←↑

BBa0

S\I	0	1	a	b	B
q_0	$q_1 R q$				$q_4 L B$
q_1	$q_1 R 0$	$q_1 R 1$		$q_2 L b$	$q_2 L B$
q_2	$q_2 L 0$	$q_3 L B$	$q_2 L a$	$q_2 L B$	
q_3	$q_3 L 0$	$q_3 L 1$	$q_0 R a$		
q_4	–	–	$q_4 L a$	$q_4 L b$	Accept