Turing machine:

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

Q - set of ~~final~~ finite states

Σ - set of input alphabet

Γ - set of ~~take~~ tape symbols

δ - Transition function

$Q \times \Gamma$ to $(Q \times \Gamma \times \{L, R\})$

q_0 - initial state

B - special symbol indicating (b, c, d) blank characters

$F \subseteq Q$ - set of final states.

i) Design turing machine, the given language is $L = \{a^n b^n \mid n \geq 1\}$

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

$Q = \{q_0, q_1, q_2, \overset{q_4}{q_3}\}$, $\Sigma = \{a, b\}$, $\Gamma = \{a, b, X, Y, B\}$

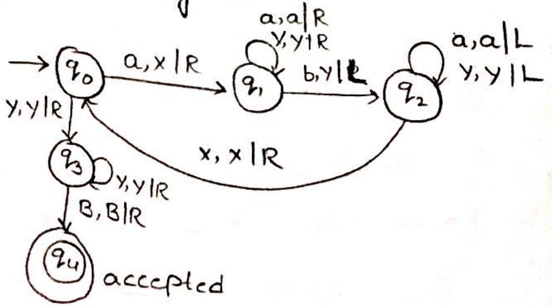
$q_0 \in Q$ is start state of machine.
initial state

$B \in F$ is blank symbol.

$F = q_4$ is final state.

(a|x,R)
(a,x|R)
(a,x,R)
any way.

Transition diagram:



X Y B
$\cancel{a}a\cancel{b}bB$
X Y
$X\cancel{a}Y\cancel{b}B$
XXYYB.

$w = aabbB$

$\vdash q_0 aabbB$

$\vdash X\underset{\downarrow q_1}{a}bbB$

$\vdash Xa\underset{\downarrow q_1}{b}bB$

$\vdash X\underset{\downarrow q_2}{a}YbB$

$\vdash \underset{\downarrow q_2}{X}aYbB$

$\vdash X\underset{\downarrow q_0}{a}YbB$

$\vdash XX\underset{\downarrow q_1}{Y}bB$

$\vdash XXY\underset{\downarrow q_1}{b}B$

$\vdash XX\underset{\downarrow q_2}{Y}YB$

$\vdash X\underset{\downarrow q_2}{X}YYB$

~~$\vdash \underset{\downarrow q_0}{X}\underset{q_0}{X}YYB$~~

$\vdash XX\underset{\uparrow q_0}{Y}YB$

$\vdash XXY\underset{\uparrow q_3}{Y}B$

$\vdash XXYY\underset{\uparrow q_3}{B}$

$\vdash XXYYB$ (accepted)

Transition functions:

$\delta(q_0, a) = (q_1, x, R)$ $\quad$ $\delta(q_2, y) = (q_2, y, L)$

$\delta(q_1, a) = (q_1, a, R)$ $\quad$ $\delta(q_2, x) = (q_0, x, R)$

$\delta(q_1, y) = (q_1, y, R)$ $\quad$ $\delta(q_0, y) = (q_3, y, R)$

$\delta(q_1, b) = (q_2, y, L)$ $\quad$ $\delta(q_3, y) = (q_3, y, R)$

$\delta(q_2, a) = (q_2, a, L)$ $\quad$ $\delta(q_3, B) = (q_4, B, R)$

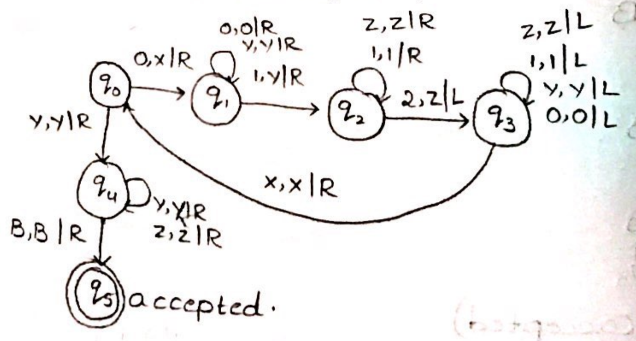
Transition table:

Q|Γ	a	b	x	y	B
$\rightarrow q_0$	(q_1, x, R)			(q_3, y, R)	
q_1	(q_1, a, R)	(q_2, y, L)		(q_1, y, R)	
q_2	(q_2, a, L)		(q_0, x, R)	(q_2, y, L)	
q_3				(q_3, y, R)	(q_4, B, R)
q_4					

2) Design turing machine to recognize the language $L = \{0^n 1^n 2^n \mid n \geq 1\}$

$\overset{X}{\cancel{0}}\,\overset{X}{\cancel{0}}\,\overset{Y}{\cancel{1}}\,\overset{Y}{\cancel{1}}\,\overset{Z}{2}\,\overset{Z}{2}\,B$

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



$Q - \{q_0, q_1, q_2, q_3, q_4, q_5\}$

$\Sigma = \{0, 1, 2\}$

$\Gamma - \{0, 1, 2, X, Y, Z, B\}$

$q_0 \in Q$

$F = \{q_5\}$

string acceptence:

$\omega = 001122B$

$\vdash q_0 001122B$

$\vdash X\underset{q_1}{0}1122B$

$\vdash X0\underset{q_1}{1}122B$

$\vdash X0Y\underset{q_2}{1}22B$

$\vdash X0Y1\underset{q_2}{2}2B$

$\vdash X0Y\underset{q_3}{1}Z2B$

$\vdash X0\underset{q_3}{Y}1Z2B$

$\vdash X\underset{q_3}{0}Y1Z2B$

$\vdash \underset{q_3}{X}0Y1Z2B$

$\vdash X\underset{q_0}{0}Y1Z2B$

$\vdash XX\underset{q_1}{Y}1Z2B$

$\vdash XXY\underset{q_1}{1}Z2B$

$\vdash XXYY\underset{q_2}{Z}2B$

$\vdash XXYYZ\underset{q_2}{2}B$

$\vdash XXYY\underset{q_3}{Z}ZB$

$\vdash XXY\underset{q_3}{Y}ZZB$

$\vdash XX\underset{q_3}{Y}YZZB$

$\vdash X\underset{q_3}{X}YYZZB$

$\vdash XX\underset{q_0}{Y}YZZB$

$\vdash XXY\underset{q_4}{Y}ZZB$

$\vdash XXYY\underset{q_4}{Z}ZB$

$\vdash XXYYZ\underset{q_4}{Z}B$

$\vdash XXYYZZ\underset{q_4}{B}$

$\vdash XXYYZZ\underset{(q_5)}{B}$ (accepted)

Transition function :

$\delta(q_0,0) = (q_1,X,R)$

$\delta(q_1,0) = (q_1,0,R)$

$\delta(q_1,1) = (q_2,Y,R)$

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

$\delta(q_2,1) = (q_2,1,R)$

$\delta(q_2,Z) = (q_2,Z,R)$

$\delta(q_2,2) = (q_3,Z,L)$

$\delta(q_3,0) = (q_3,0,L)$

$\delta(q_3,1) = (q_3,1,L)$

$\delta(q_3,Y) = (q_3,Y,L)$

$\delta(q_3,Z) = (q_3,Z,L)$

$\delta(q_3,X) = (q_0,X,R)$

$\delta(q_0,Y) = (q_4,Y,R)$

$\delta(q_4,Y) = (q_4,Y,R)$

$\delta(q_4,Z) = (q_4,Z,R)$

$\delta(q_4,B) = (q_5,B,R)$

Transition table.

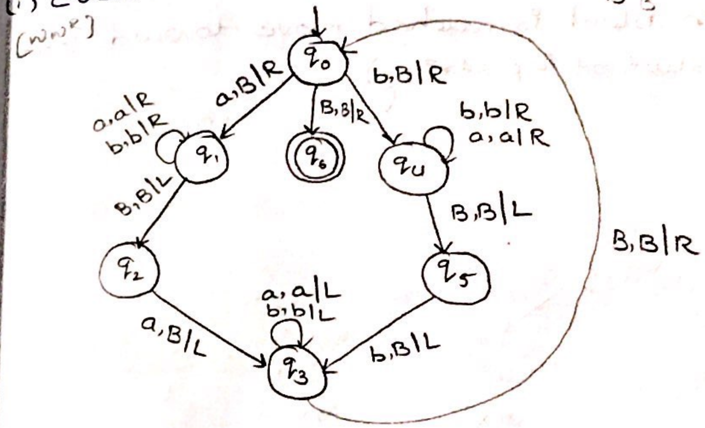
Q/Γ	0	1	2	X	Y	Z	B
→q_0	(q_1,X,R)				(q_4,Y,R)		
q_1	$(q_1,0,R)$	(q_2,Y,R)			(q_1,Y,R)		
q_2	$(q_2,1,R)$		(q_3,Z,L)			(q_2,Z,R)	
q_3	$(q_3,0,L)$	$(q_3,1,L)$		(q_0,X,R)	(q_3,Y,L)	(q_3,Z,L)	
q_4					(q_4,Y,R)	(q_4,Z,R)	$(q_5,B,R$

3) Design turing machine to recognize lang of palidrome consists of a's & b's.

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

ω = abbbbaB
aabbaaB
baaaabB
~~b~~~~b~~aab~~b~~~~B~~
B B BB

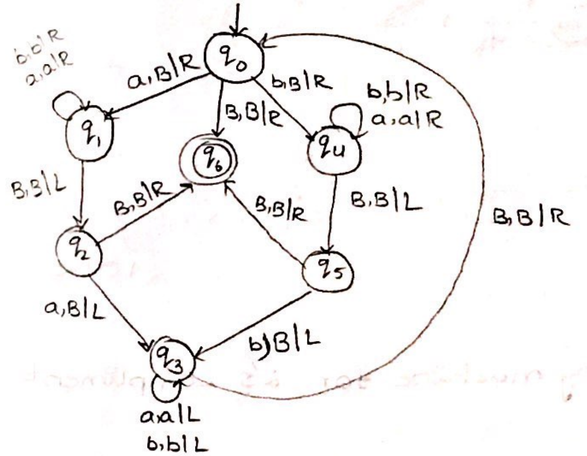
i) even:
$[ww^r]$



ii) odd :
$[wcw^r]$

ω = ababaB

B B B B B B
~~a~~ ~~b~~ ~~a~~ ~~b~~ ~~a~~ ~~B~~



4) Design turing machine for 1's compliment.

method-II

step1: Scan i/p string from L to R.

step2: convert 1 to 0

step3: convert 0 to 1

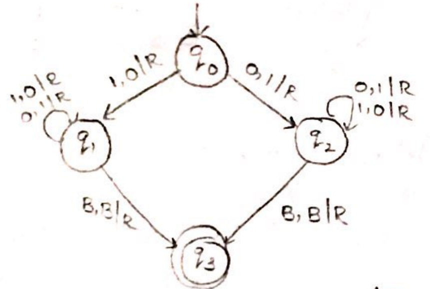
step4: when blank is reached move towards left of start of i/p string)

ω = 1101B ω = 0010B

ω = 1011B

ω = 0111B

Method-I:

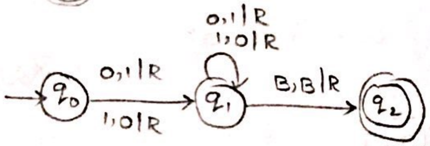


(or)

Ex: 011B

(c#)

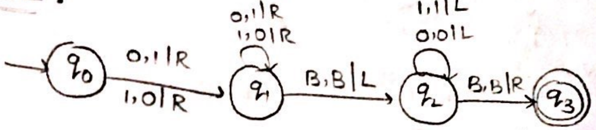
Method I:



accepted.

Method II:

(?)



Ex: B101B

B

5) Design turing machine for 2's compliment.

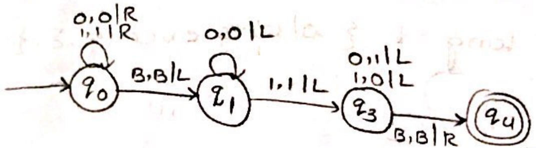
Algorithm:

1) Scan i/p string from R to L

2) pass all consecutive 0's

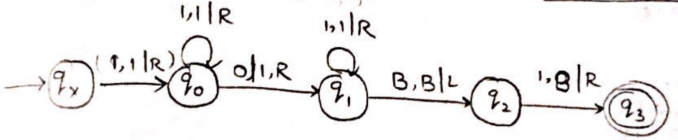
3) when 1's come do nothing.

4) After, take compliment of every digit Coverflow is not taken care in this approach).



accepted.

6) Design a turing machine to add two numbers



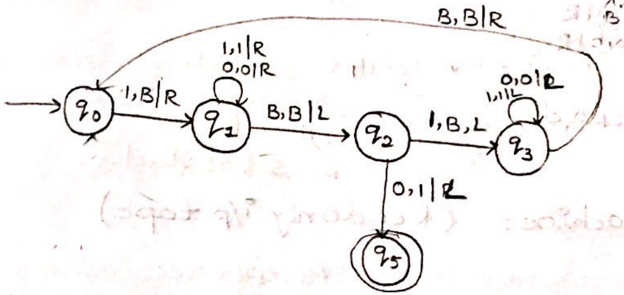
2+1

110 1 B

1 1 1 B

3

7) subtract two numbers

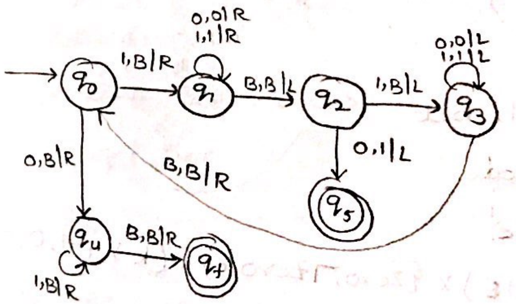


11

X,X | 0 X B

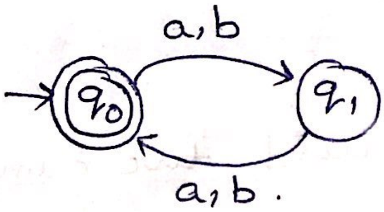
B B B B

m<n:

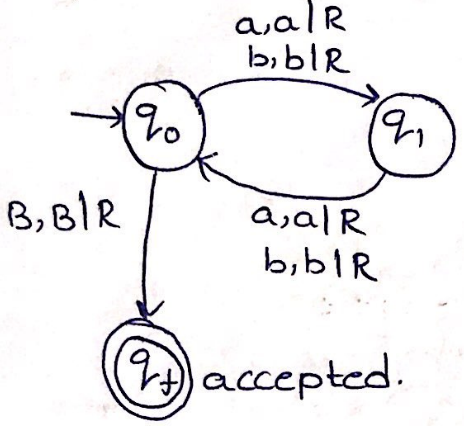


8) To accept the lang $L = \{$ even $\}, \Sigma = \{a$

DFA :



TM :



k - set of stacks.

Counter Machine : (Readonly i/p tape)

⇓

Multi-stack machine

Accepts reccursively ennumerable lang. only

$M = (Q, \Sigma, \Delta, \overset{q_0}{\underline{s}}, F)$

Counter Machine

⇓

Multi-stack machine

⇓

multi-tape machine

Q - states

Σ - Input alphabet

$q_0 \, \underline{s} \in Q$ - start state

F - final state

$\Delta \subseteq ((k \times (\Sigma \cup \varepsilon) \times \{zero, \neg zero\}) \times (k \times \{-1, 0, +1$

Accepted state - empty counter.

Operations:

1) Increment the counter by 1

2 2) Decrement the counter by 1

3 3) check, counter is zero.

4 (number stored is zero)

⟶ Counter can sto