CS & IT ENGINEERING

Theory of Computation

Turing Machine Recursively Enumerable

Lecture No. 2

By- DEVA Sir

01 Turing M/c construction

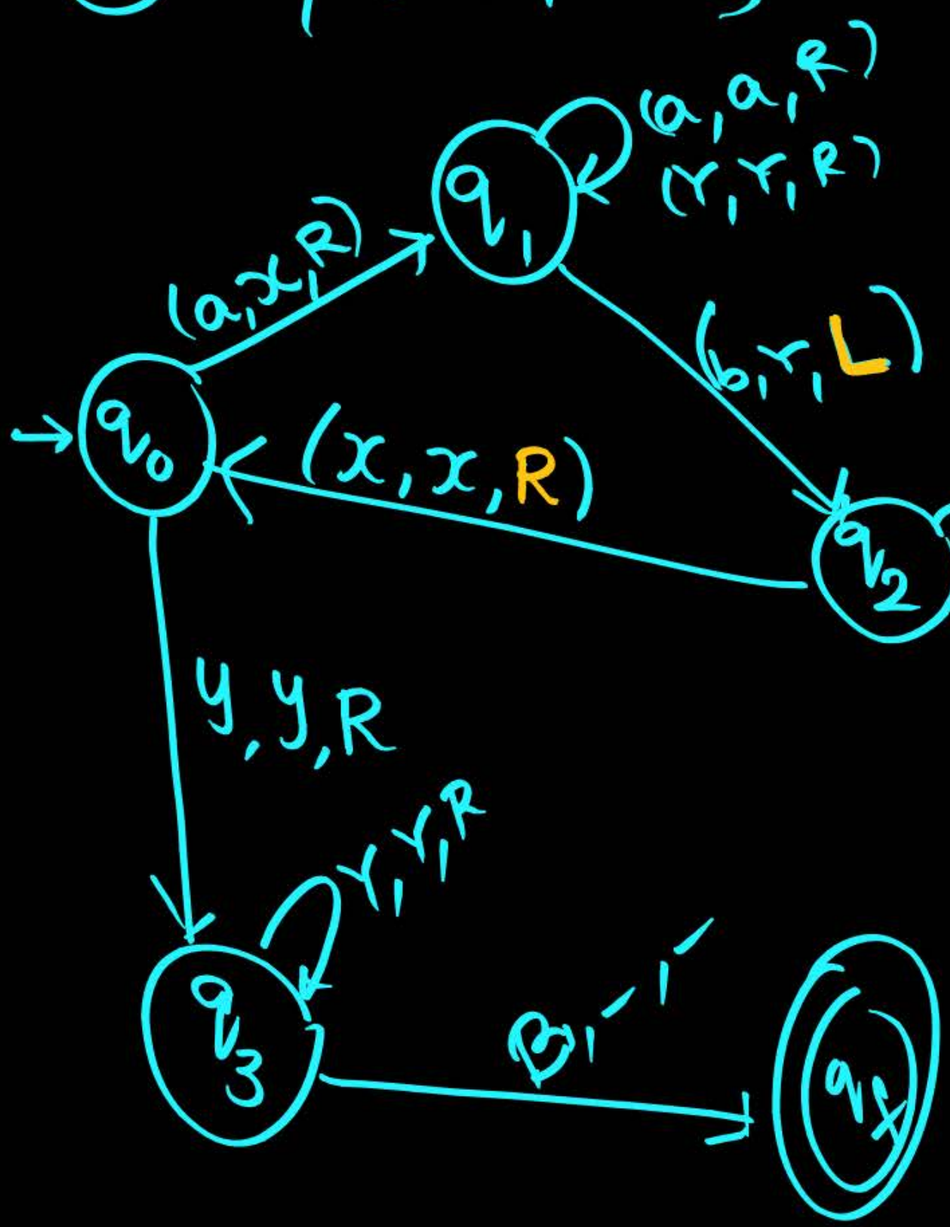
02

03

04

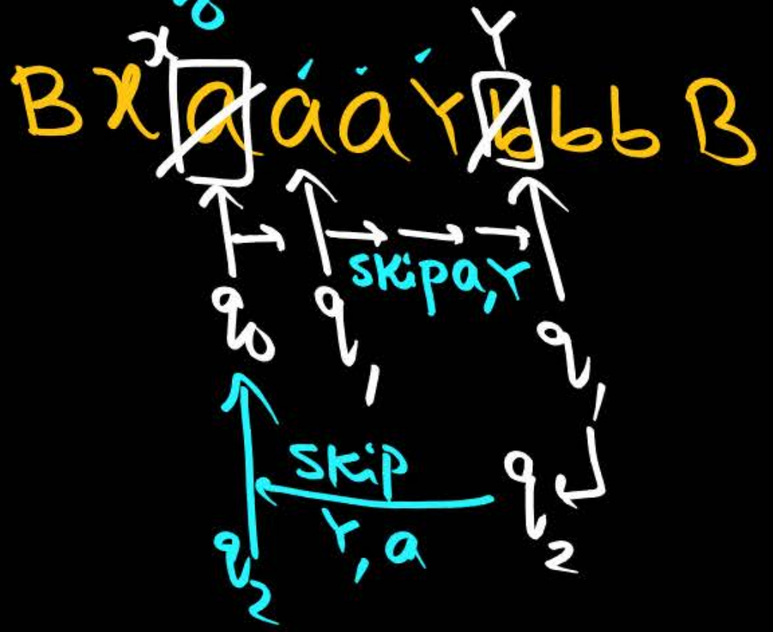
05

② $\{a^n b^n \mid n \geq 1\}$

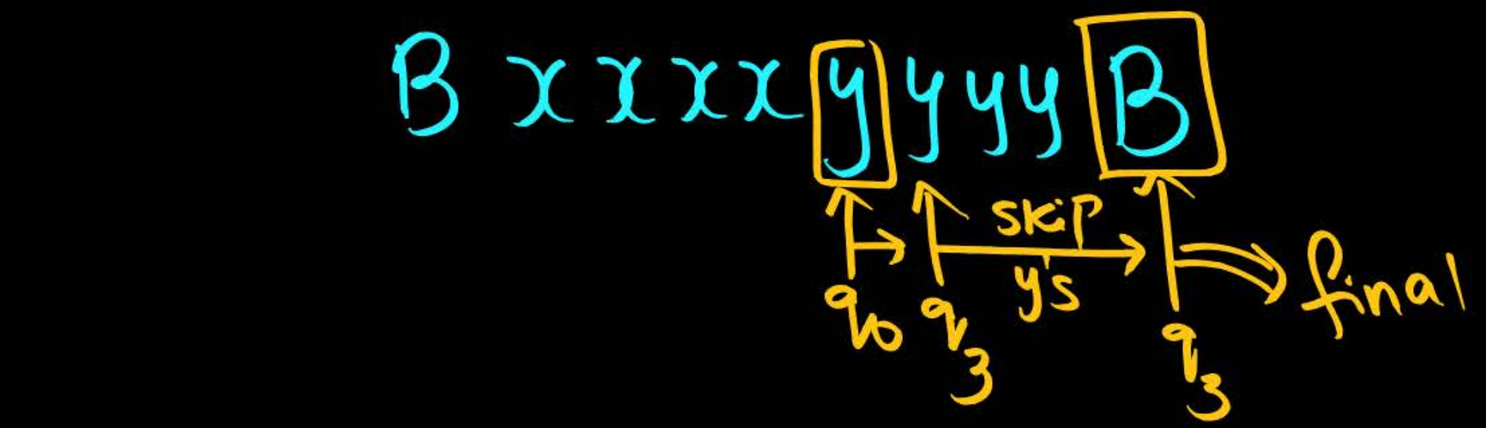


1st Scan:

2nd Scan:



Last scan:

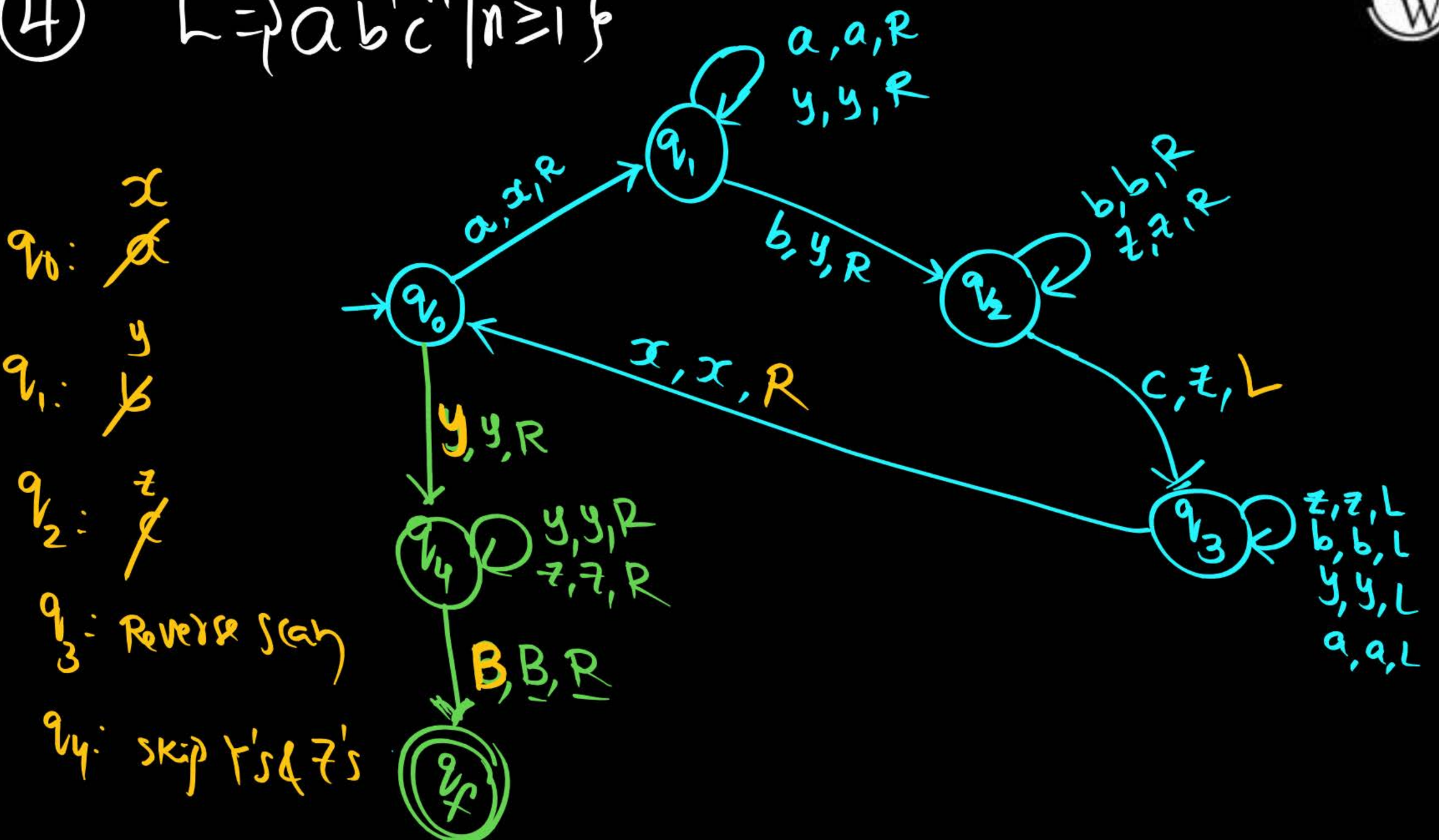


③ $L = \{\varepsilon\}$

TM accepts only ε.

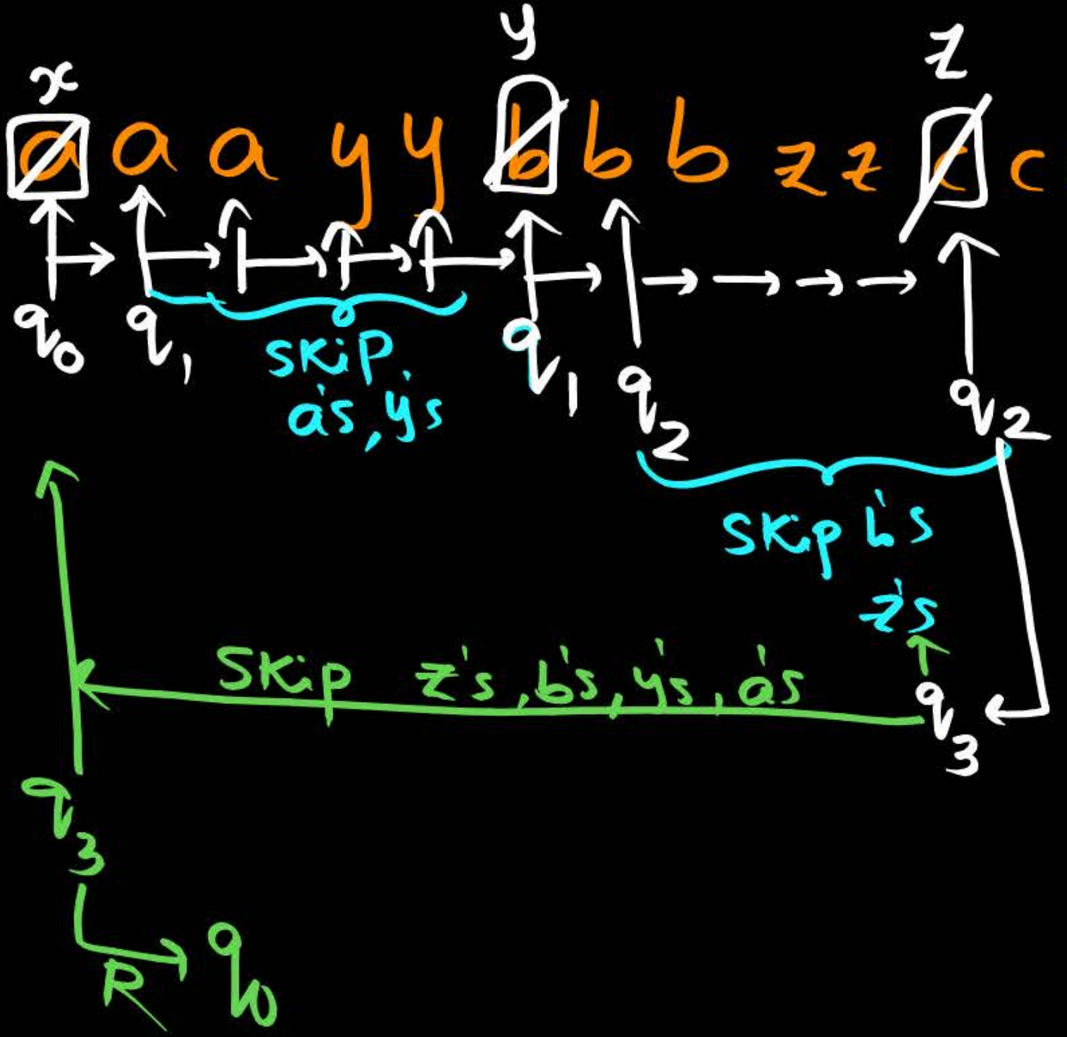
$L(TM) = \{\varepsilon\}$

④ $L = \{a^n b^n c^n \mid n \geq 1\}$

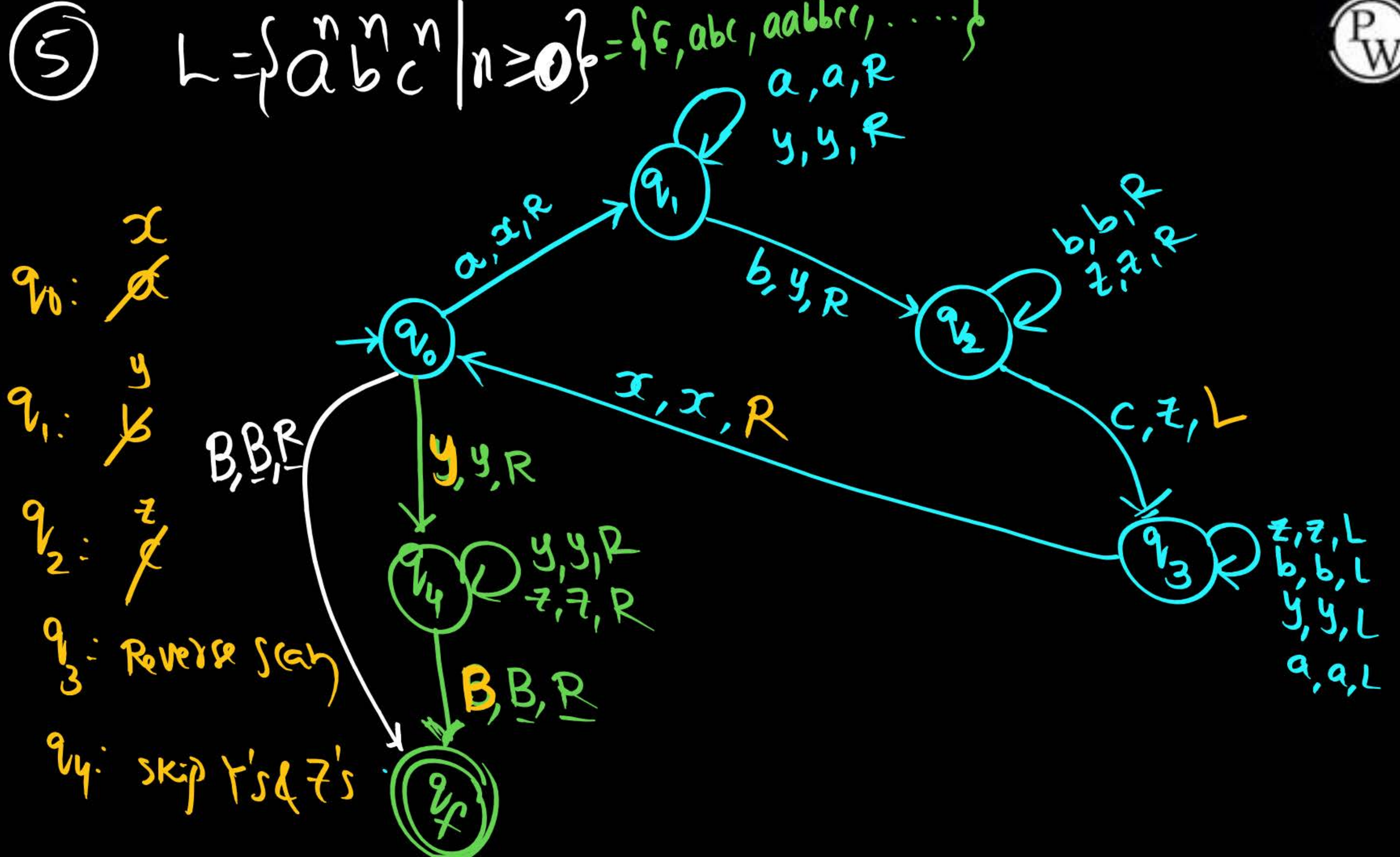


B a a a a a b b b b b c c c c c B

3rd scan: B x x a a a y y b b b z z c c B



(5) $L = \{a^n b^n c^n \mid n \geq 0\} = \{\varepsilon, abc, aabbcc, \ldots\}$



q_0 : x

q_1 : y

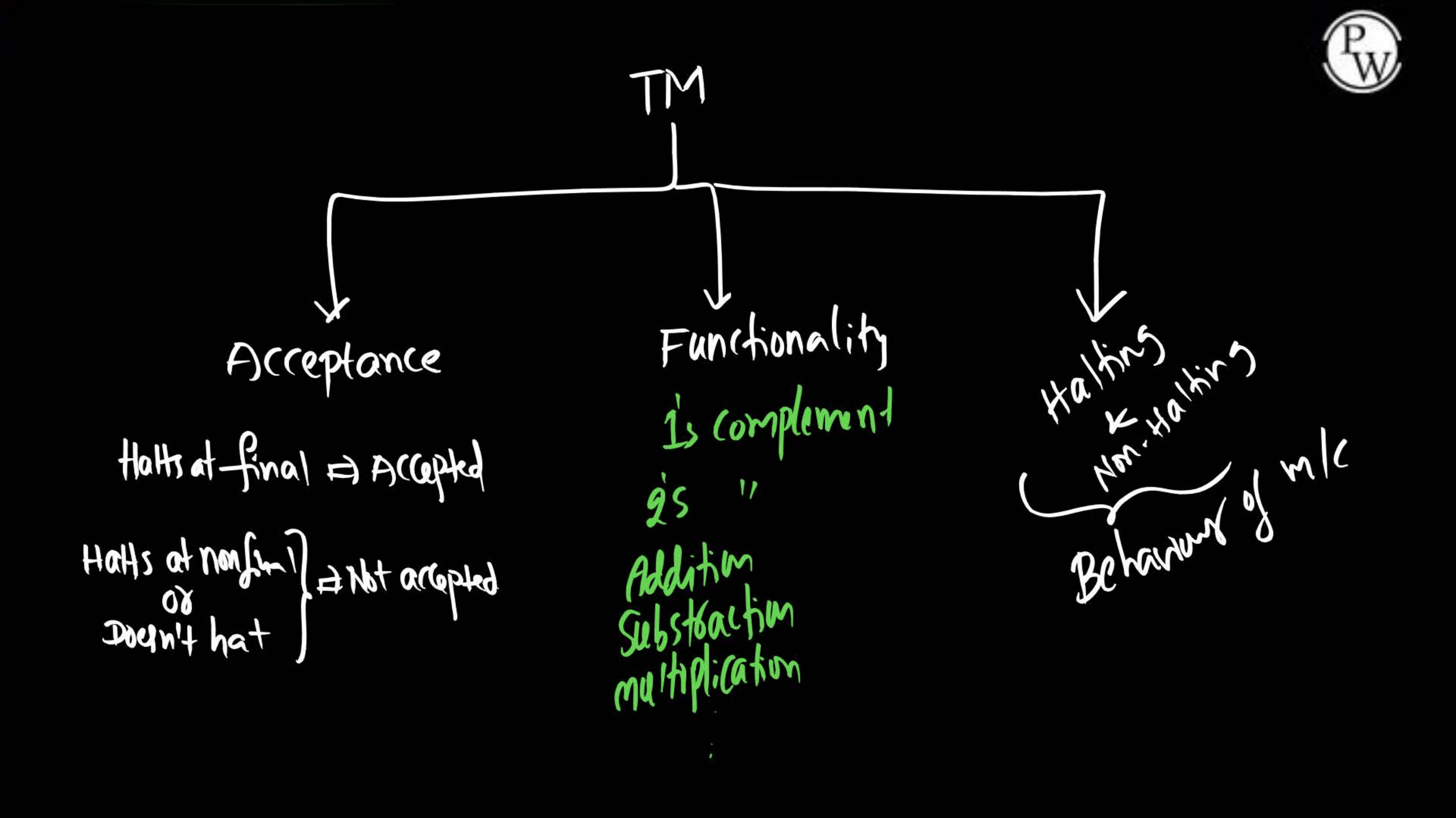
q_2 : z

q_3 : Reverse scan

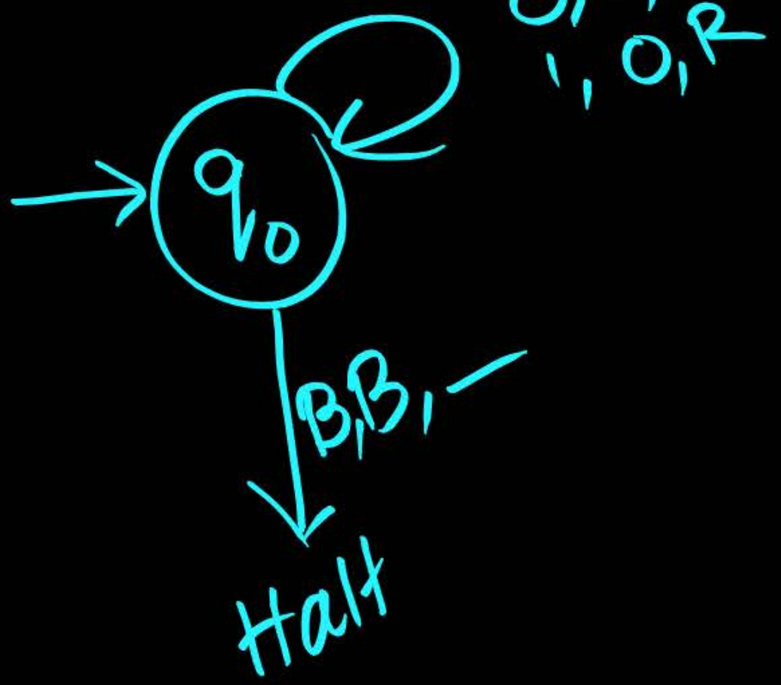
q_4 : skip Y's & Z's

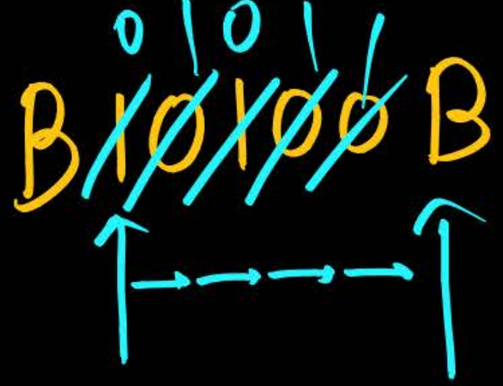
Accept : Halts at final
↳ valid string

Halt :
↳ M/c stopped


TM
Acceptance
Halts at final ⇒ Accepted
Halts at non-final or Doesn't halt ⇒ Not accepted
Functionality
1's complement
2's "
Addition
Substraction
multiplication
Halting & Non-Halting
Behaviour of m/c

(6) 1's complement of Binary

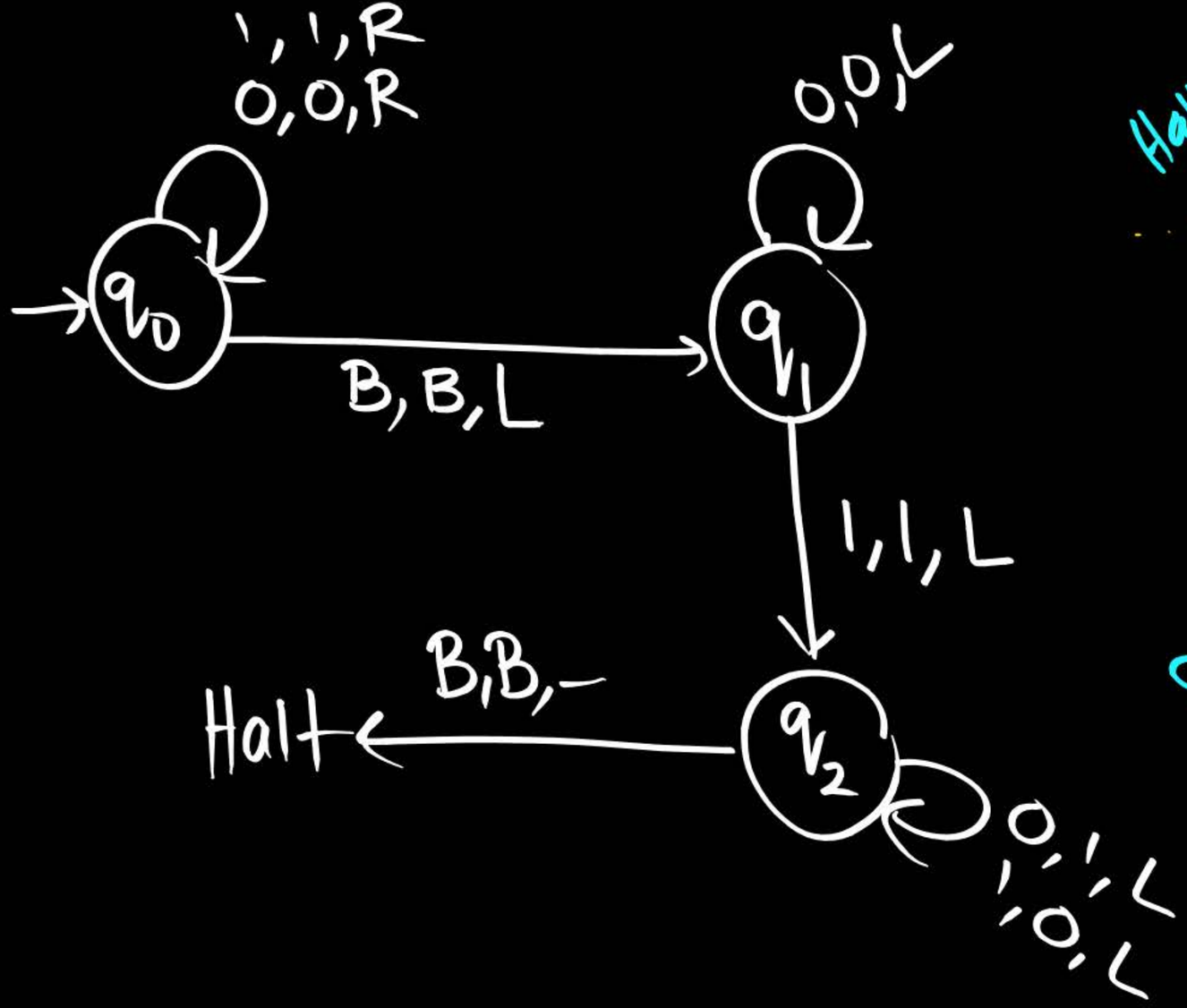


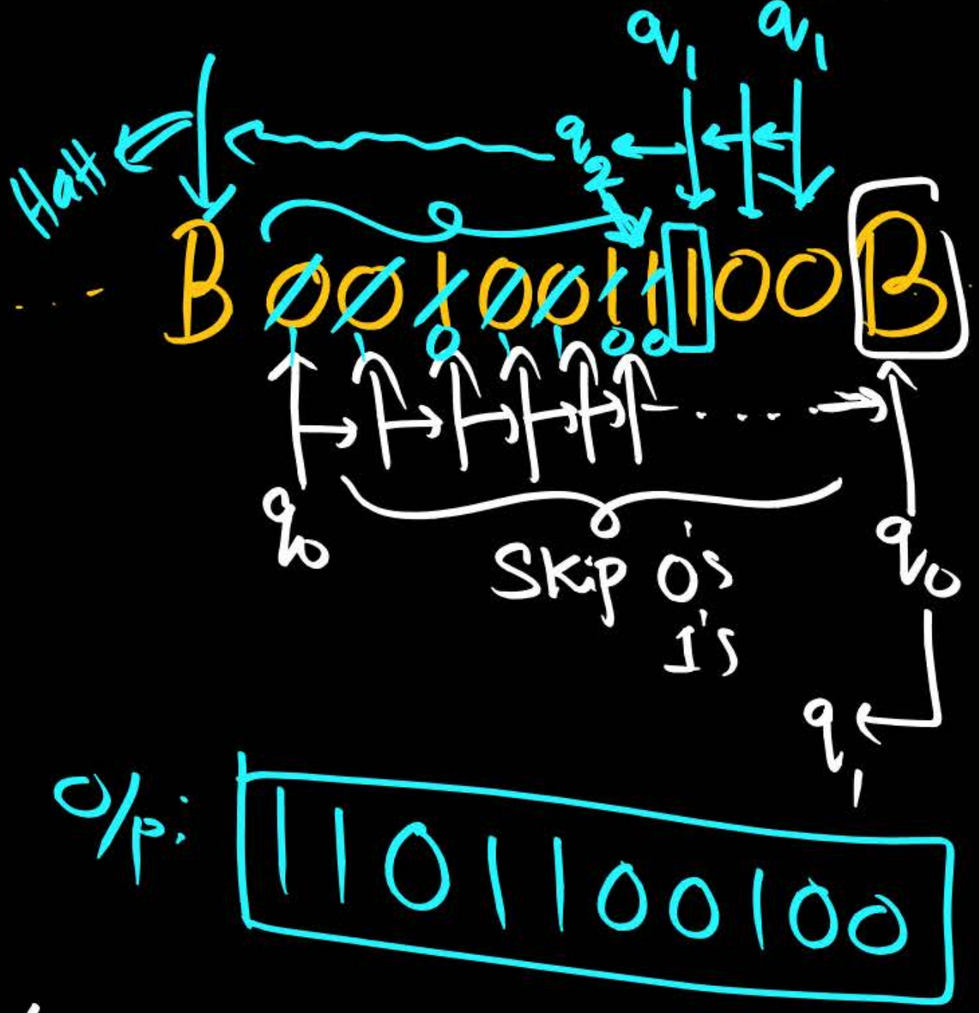


We do not need final state

There is no concept of valid & invalid i/p

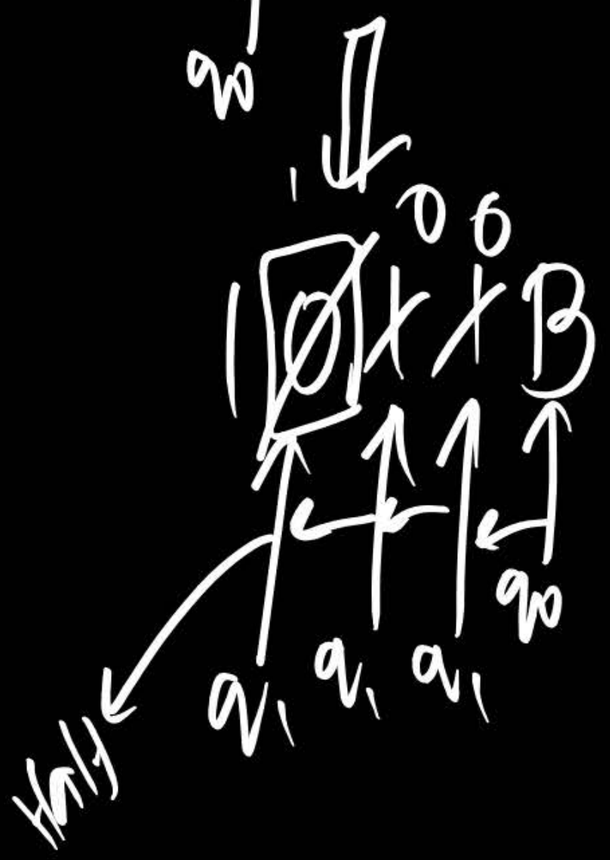
(7) 2's complement of binary i/p.

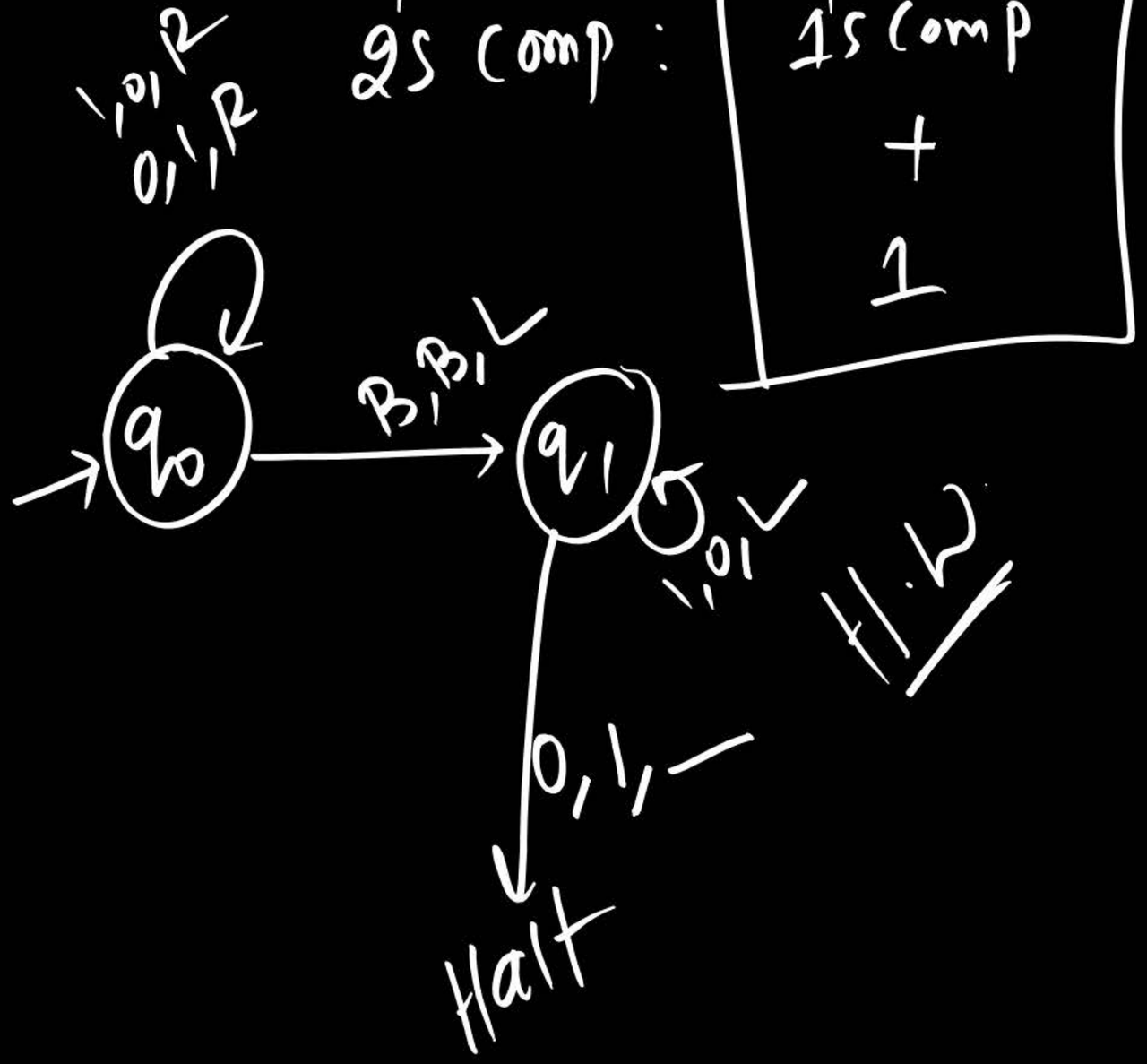


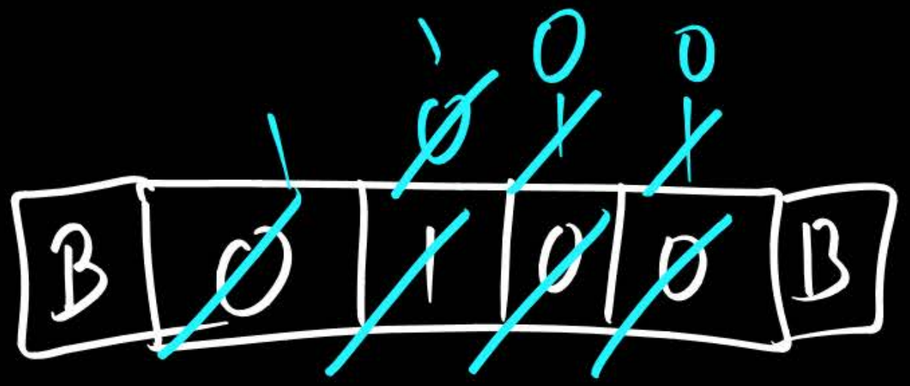


o/p: 1 1 0 1 1 0 0 1 0 0

Method 2:

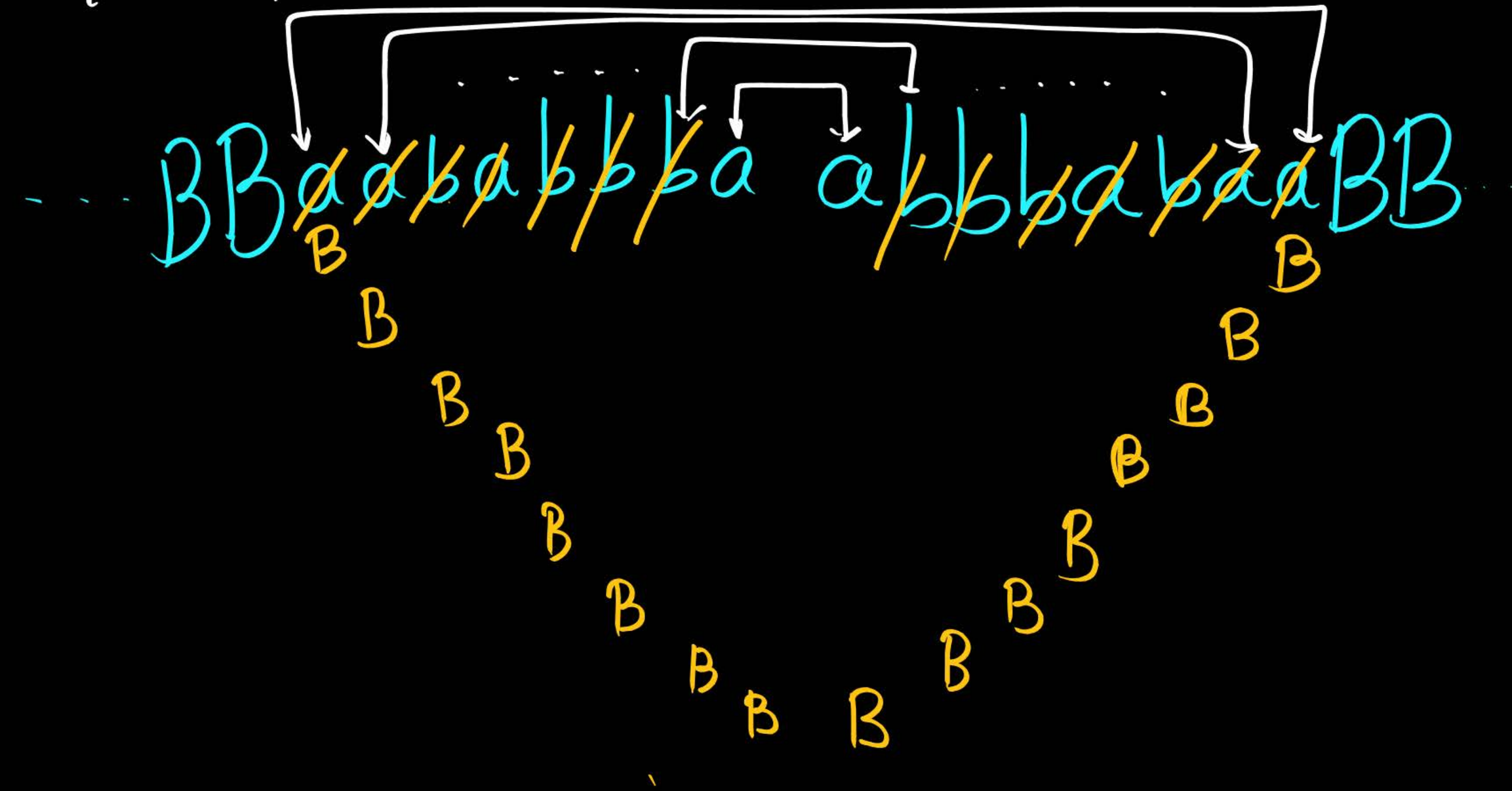

q0
Halt
q1 q1 q1 q1
q0


1,0,R
0,1,R
2's comp :
1's Comp
+
1
B,B,L
q0
q1
1,0,L
H.W
0,1,—
Halt

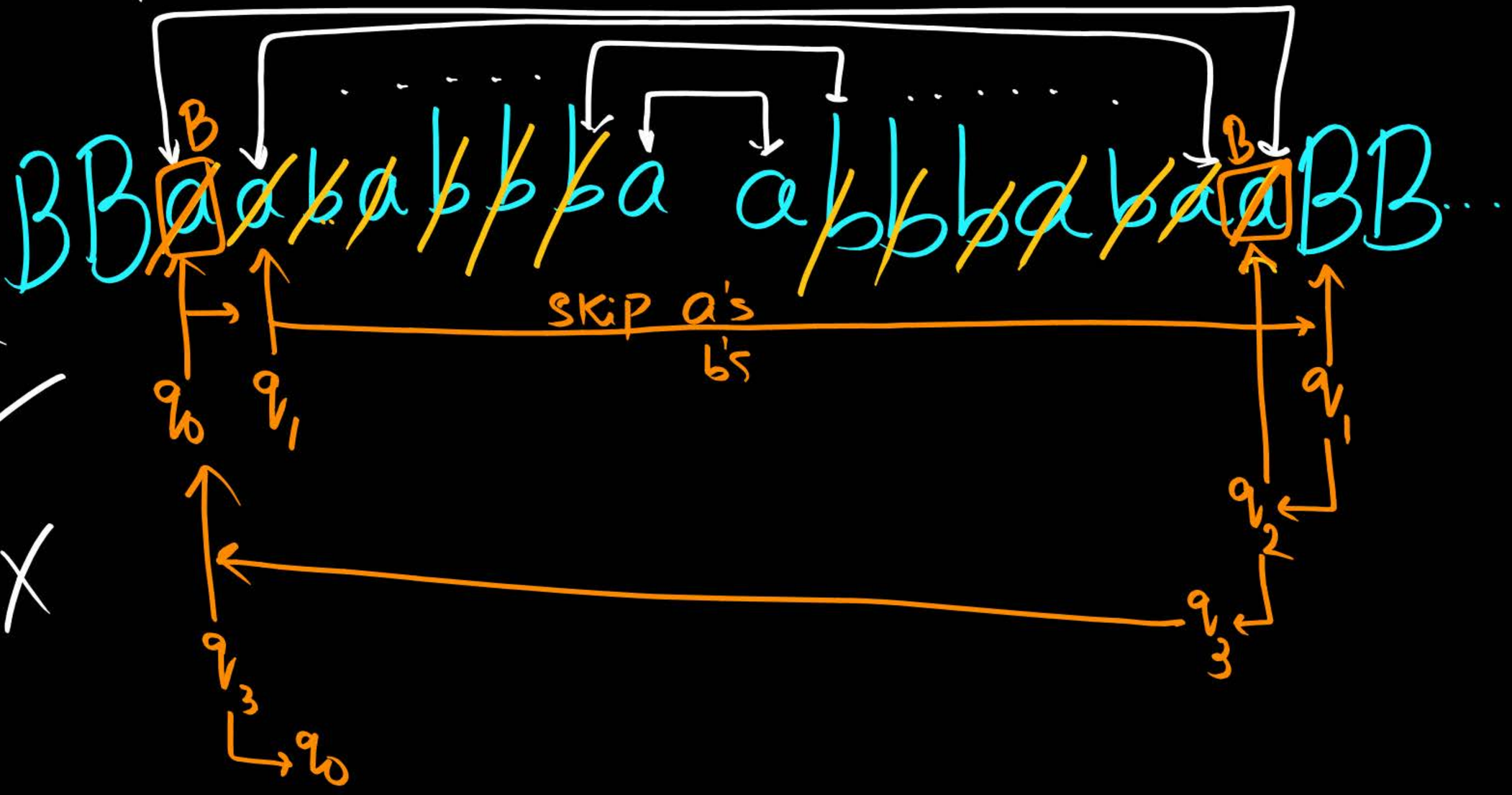


O/P: 1100

⑧ $\{ww^R \mid w \in \{a,b\}^*\}$



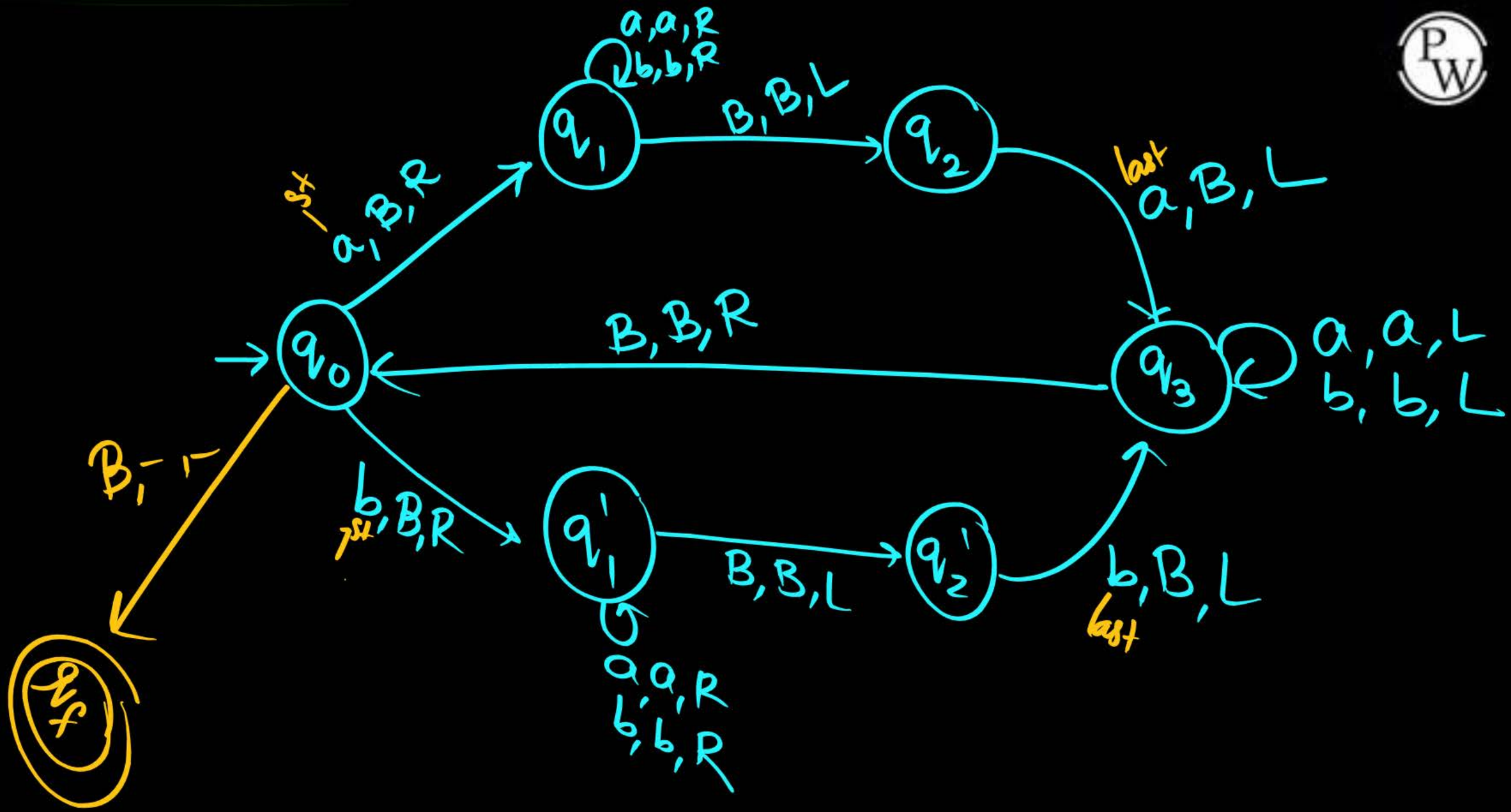
⑧ $\{ww^R \mid w \in \{a,b\}^*\}$



$O(2^n)$ ×

$O(n)$ ✓

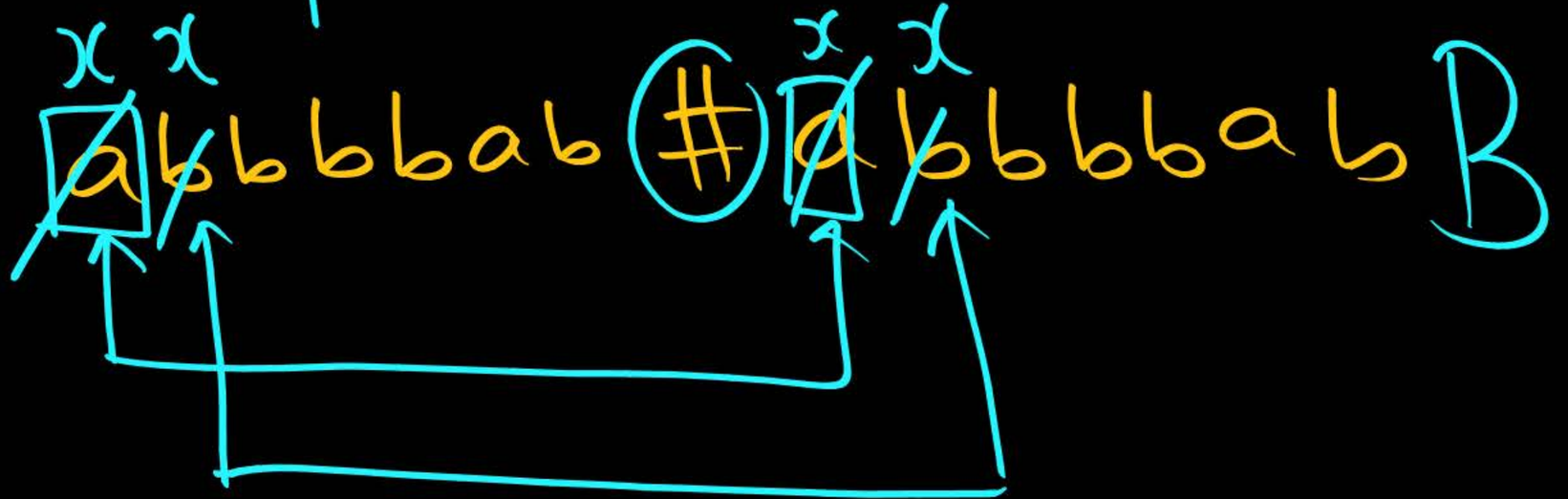
$O(n^2)$ ×


a, a, R
b, b, R
q_1
B, B, L
q_2
last
a, B, L
1st
a, B, R
q_0
B, B, R
q_3
a, a, L
b, b, L
B, —
b
1st, B, R
q_1'
B, B, L
q_2'
b, B, L
last
a, a, R
b, b, R
q_f

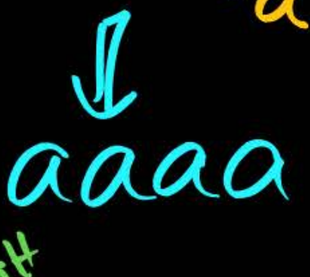
H.W. :

(9) $\{w\#w^R \mid w \in \{a,b\}^*\}$

(10) $\{w\#w \mid w \in \{a,b\}^*\}$



(11) unary addition

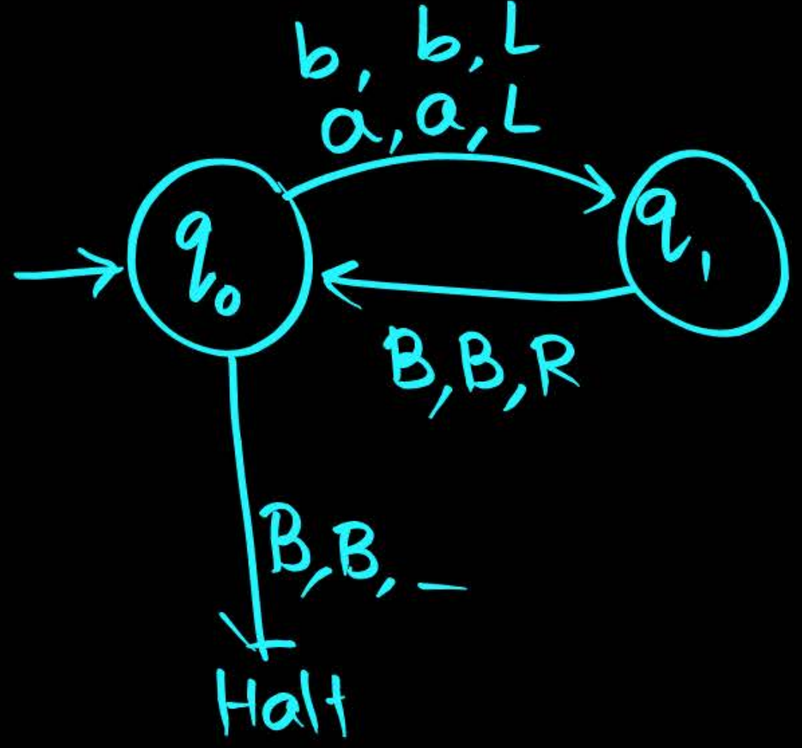


(12) Unary Subtraction

I/p: BaaaB

O/p:

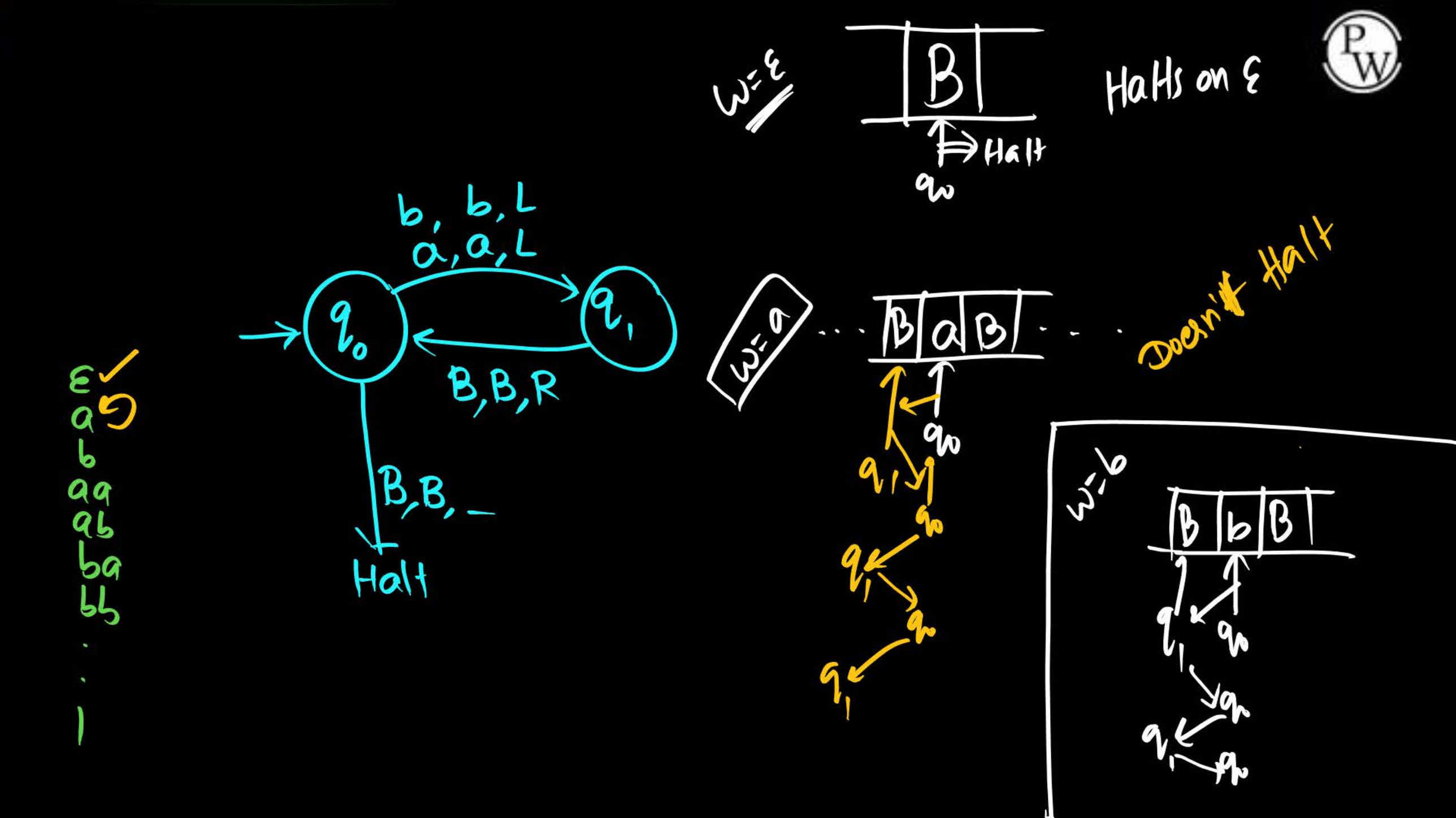
What is the language accepted by TM?
What is the functionality of TM?



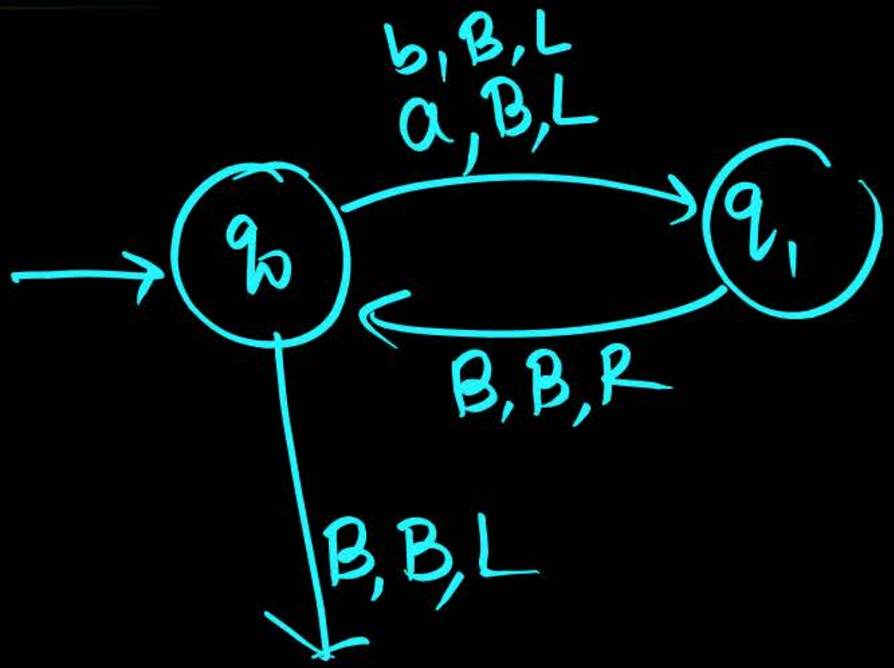
1

ε ✓
a ✗
b ✗
aa ✗
ab ✗
ba ✗
bb ✗

A) ~~Halts only on ε~~
B) Halts only on $(a+b)^+$
C) ~~Doesn't halt on $(a+b)^+$~~
D) Doesn't halt on $(a+b)^*$


w=ε
B
Halt
q0
Halts on ε
b, b, L
a, a, L
q0
q1
B, B, R
B, B, —
Halt
ε
a
b
aa
ab
ba
bb
.
.
.
w=a
B a B
Doesn't Halt
q0
q1
q0
q1
q0
q1
w=b
B b B
q0
q1
q0
q1
q0

(2)



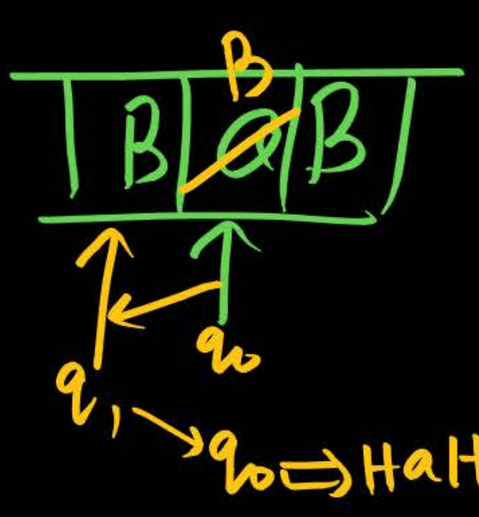
ε ✓

a ✓

b ✓

a . . . . ✓

b . . . . ✓



A) ~~Halts only on ε~~

B) ✓ Halts on every string (Σ^*)

C) ~~Halts only on $(a+b)^+$~~

D) None

LBA

Lower Bound Automata

- It is TM
- It is HTM
- It has bounded tape
- It has Linearly bounded tape

HTM

(Turing M/c that always Halts)

It is TM, but always halts.

I) Valid ⇒ Halts at final

II) Invalid ⇒ Halts at nonfinal

TM

Turing M/c

I) For every valid string, Halts at final

For every Invalid string, either Halts at nonfinal OR Never halts.

Logic exist for valid strings

But don't know about invalid

LBA	HTM	TM
Accepts CSL	Accepts Decidable language	Accepts REL
Linearly Bounded tape	Infinite tape (unbounded)	Infinite tape (unbounded)
Always Halts	Always Halts	

CSLs

Every Regular

Every CFL

$a^n b^n c^n$

a^{prime}

$\{ww \mid w \in \{a,b\}^*\}$

$a^{n!}$

Recursives

Every CSL

$\{\langle r_1, r_2 \rangle \mid r_1, r_2$ are regular Expression $L(r_1) = L(r_2)\}$

RELs

Every CSL

Every Recursive

Set of all regular languages

$\{Reg_1, Reg_2 \ldots\}$

Summary

- TM Construction
- Closure properties (Next)
  - Rec ?
  - REL ?
  - REL but not rec ?
  - Not REL & undecidable ?


THANK YOU
GW
SOLDIERS !