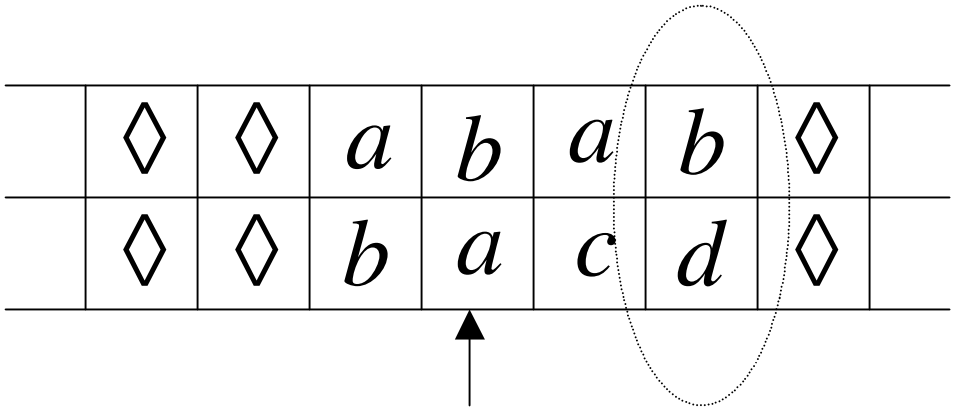
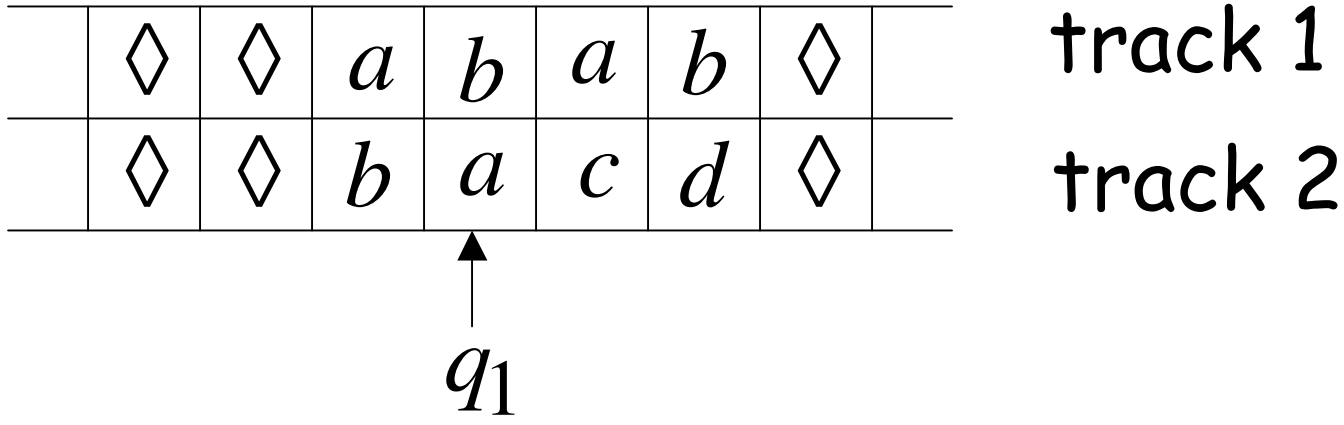
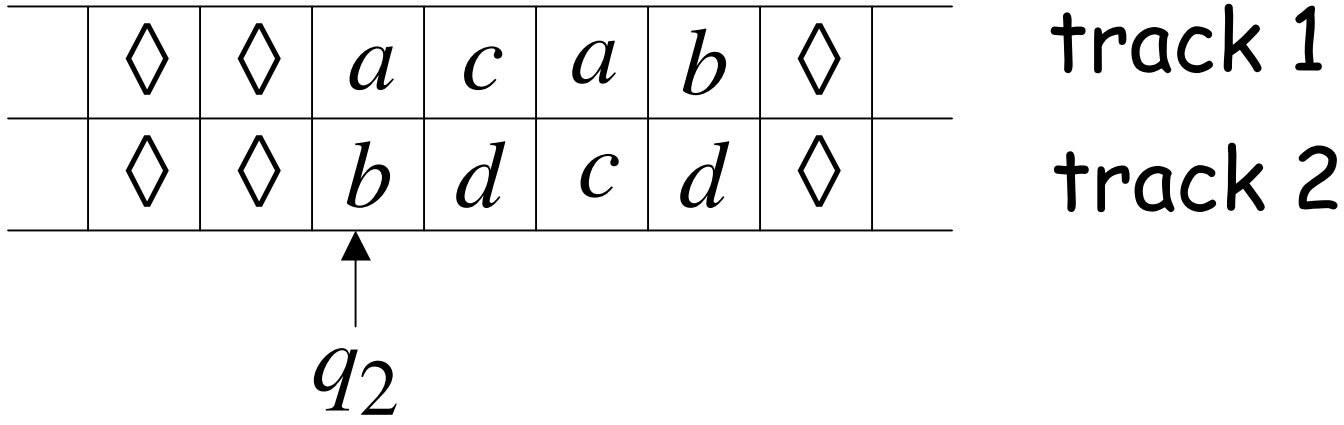
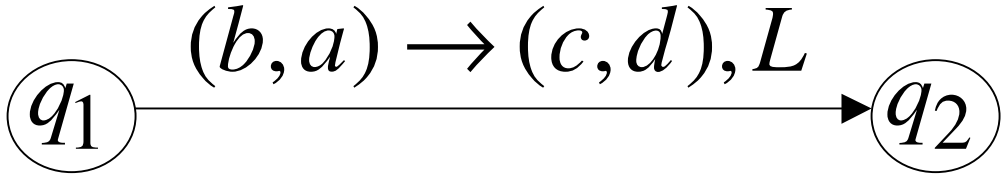
Variations of the Turing Machine part2

Standard Machine--Multiple Track Tape

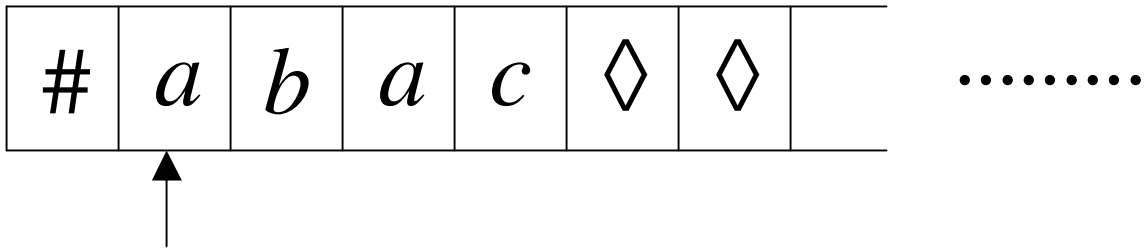



track 1
track 2
◊ ◊ a b a b ◊
◊ ◊ b a c d ◊
q_1


track 1
track 2
◊ ◊ a c a b ◊
◊ ◊ b d c d ◊
q_2


$(b,a) \rightarrow (c,d), L$
q_1
q_2

Semi-Infinite Tape



Standard Turing machines

simulate

Semi-infinite tape machines

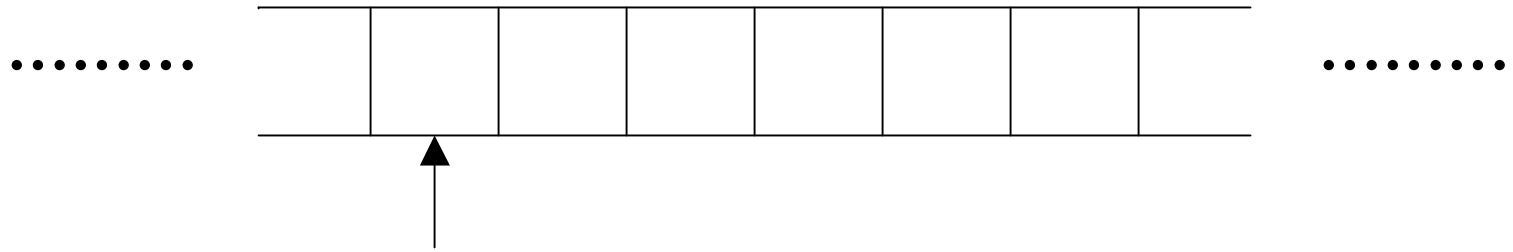
Trivial

Semi-infinite tape machines

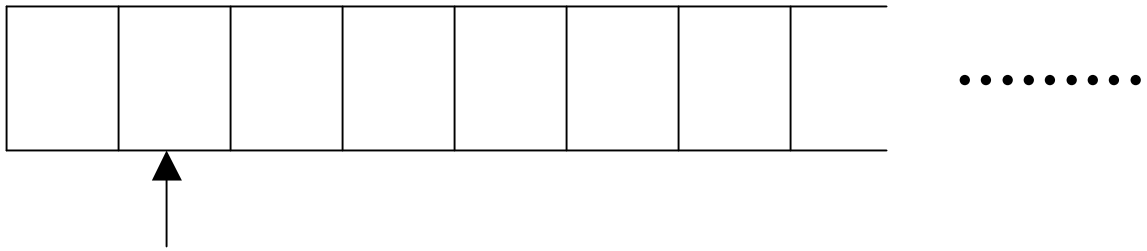
simulate

Standard Turing machines

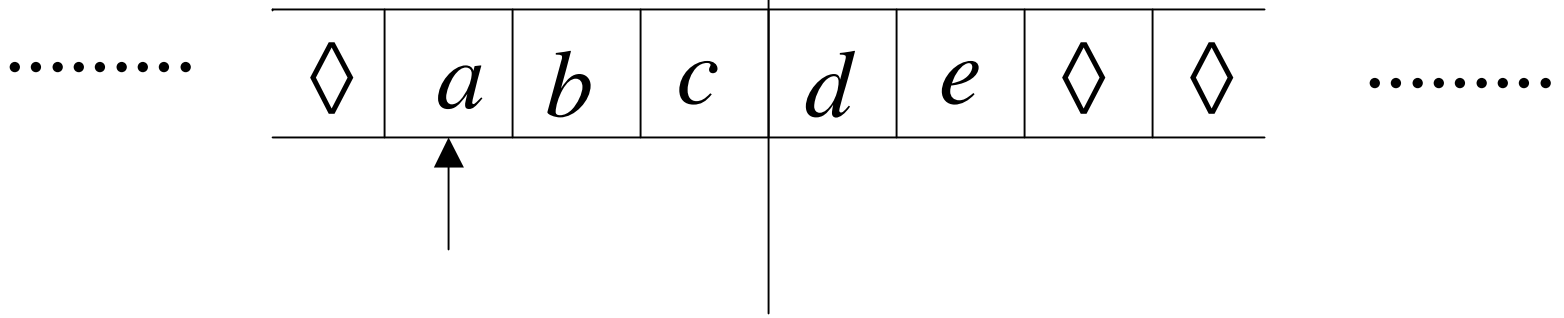
Turing machine



Semi-infinite tape machine

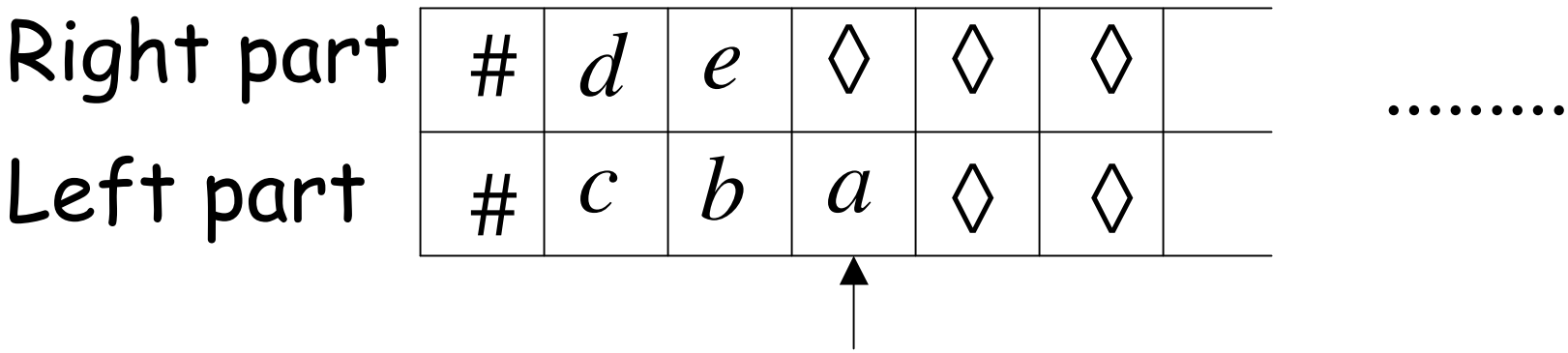


Turing machine

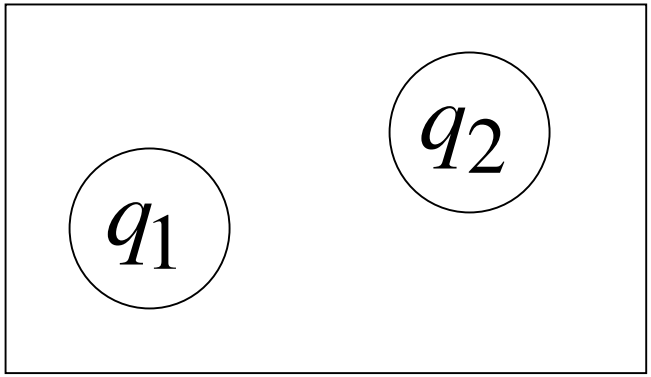


reference point

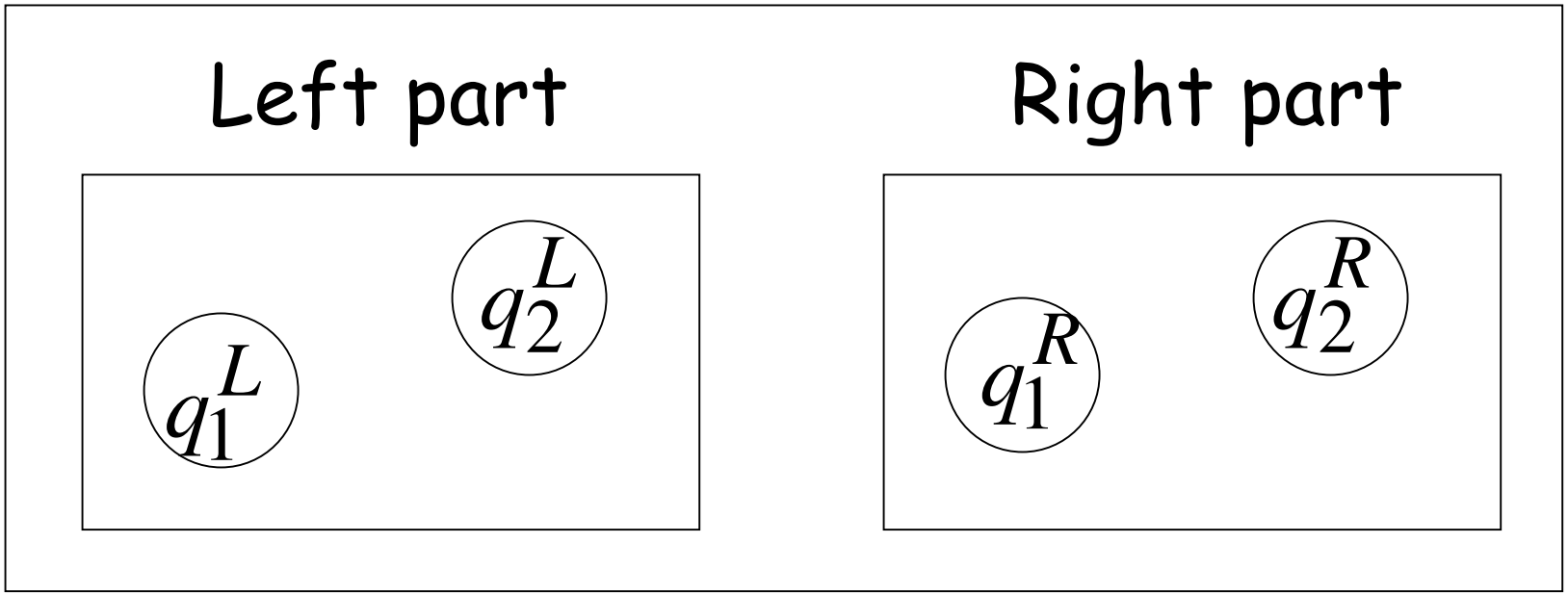
Semi-infinite tape with two tracks



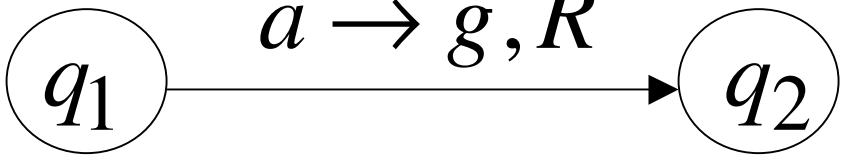
Turing machine



Semi-infinite tape machine

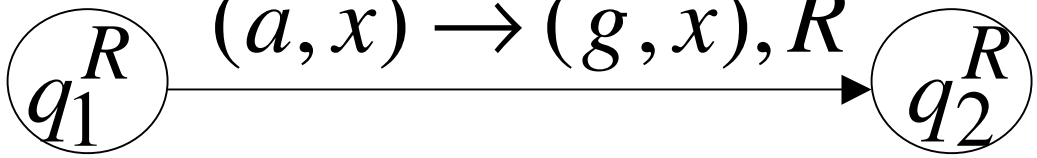


Turing machine

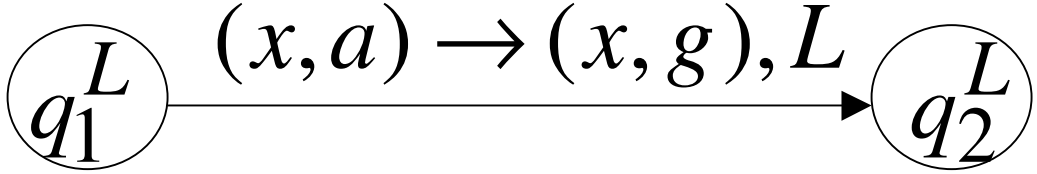


Semi-infinite tape machine

Right part

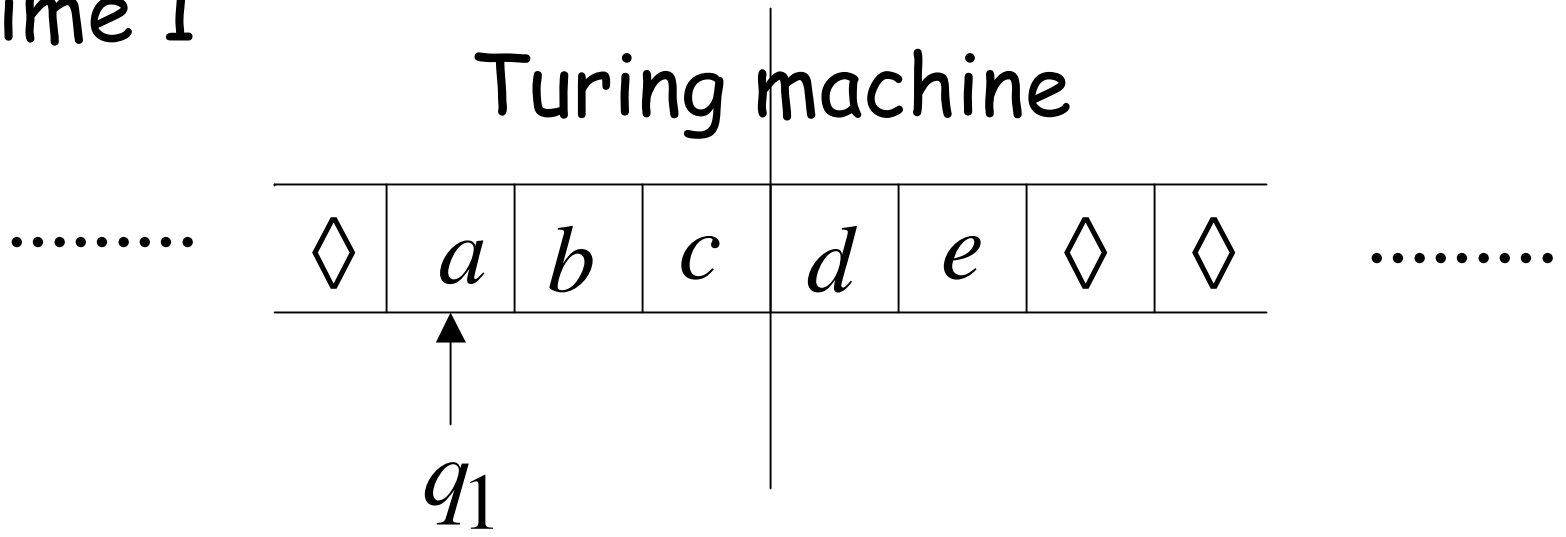


Left part

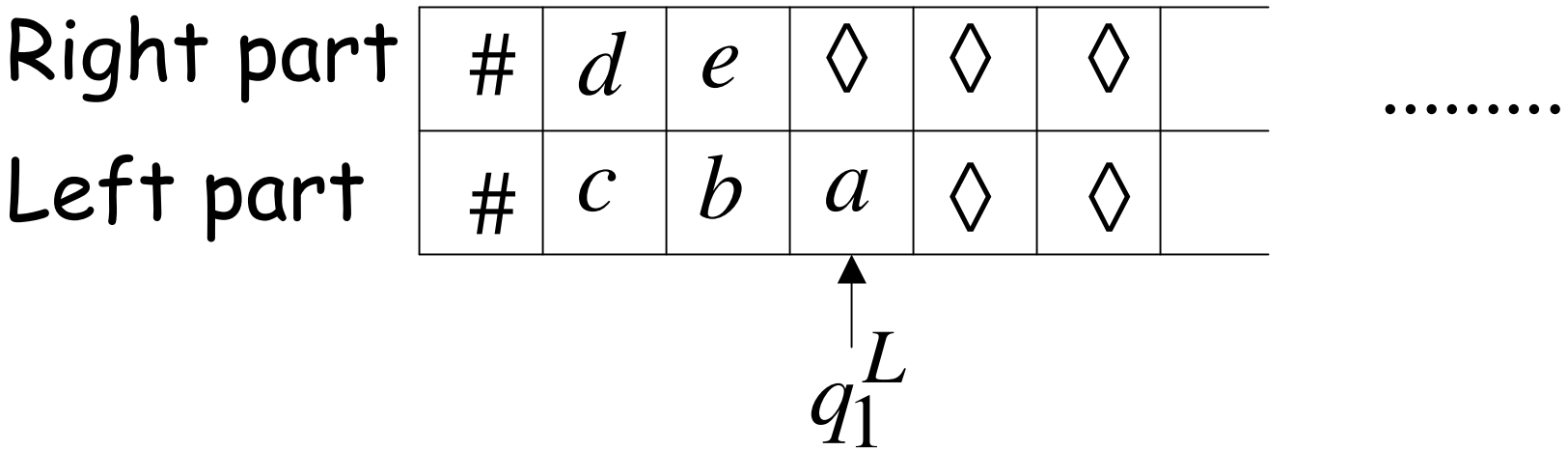


For all symbols x

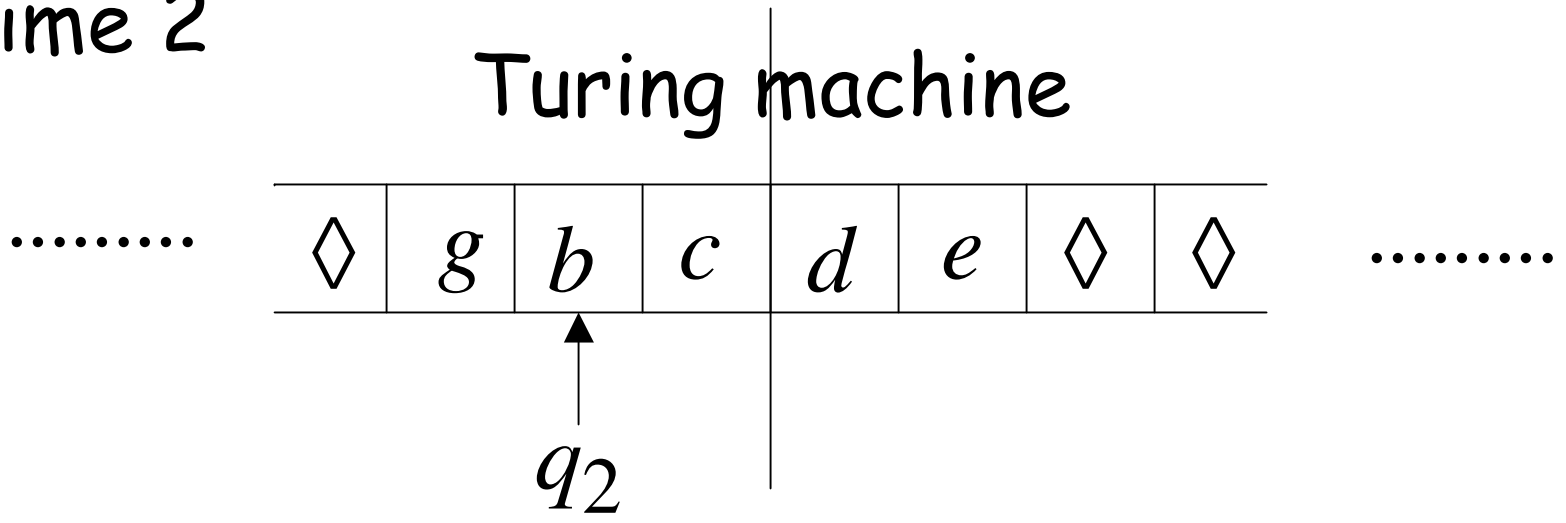
Time 1

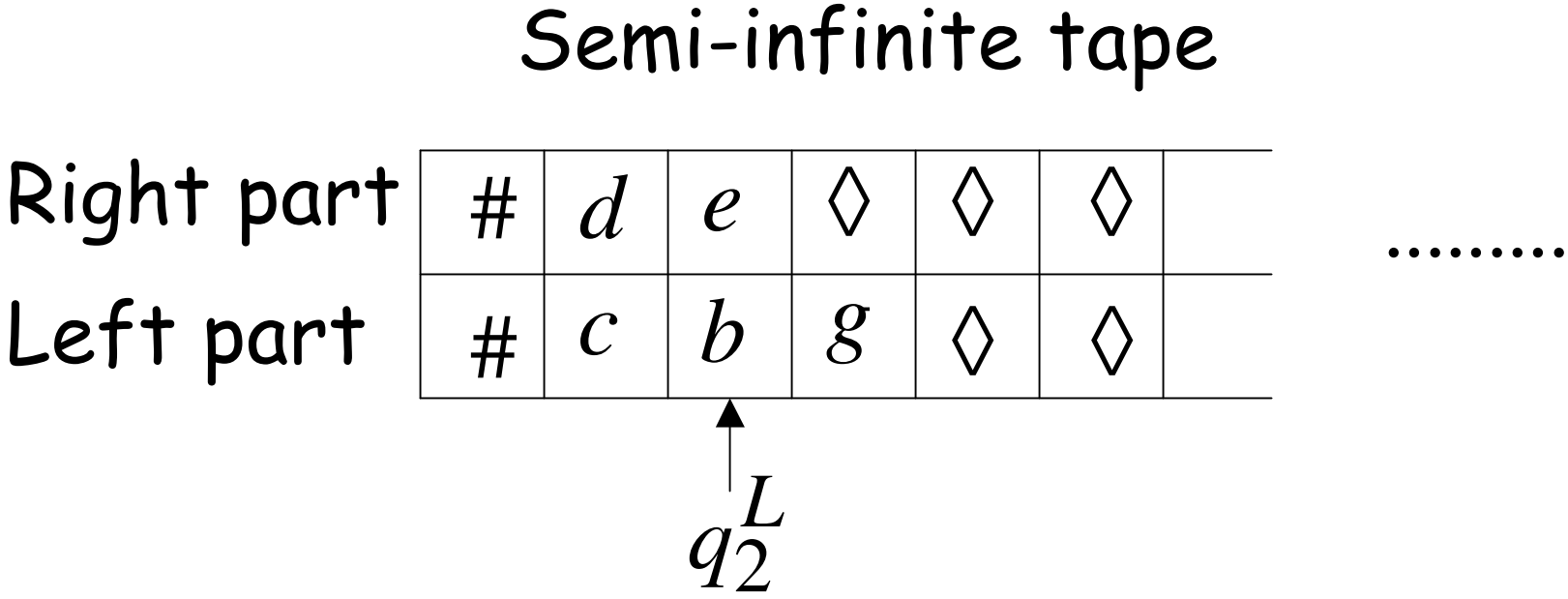


Semi-infinite tape



Time 2

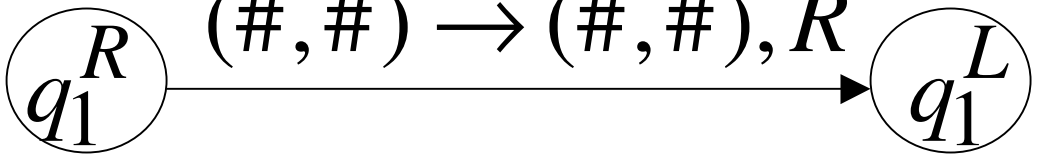

Turing machine
◊ g b c d e ◊ ◊
q_2


Semi-infinite tape
Right part
Left part
d e ◊ ◊ ◊
c b g ◊ ◊
q_2^L

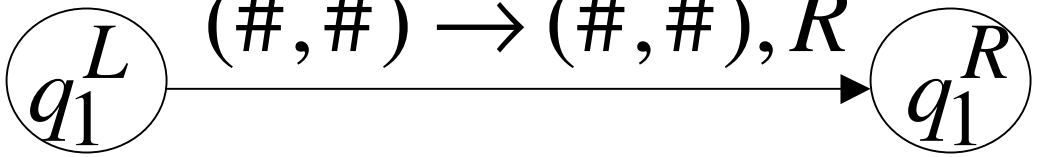
At the border:

Semi-infinite tape machine

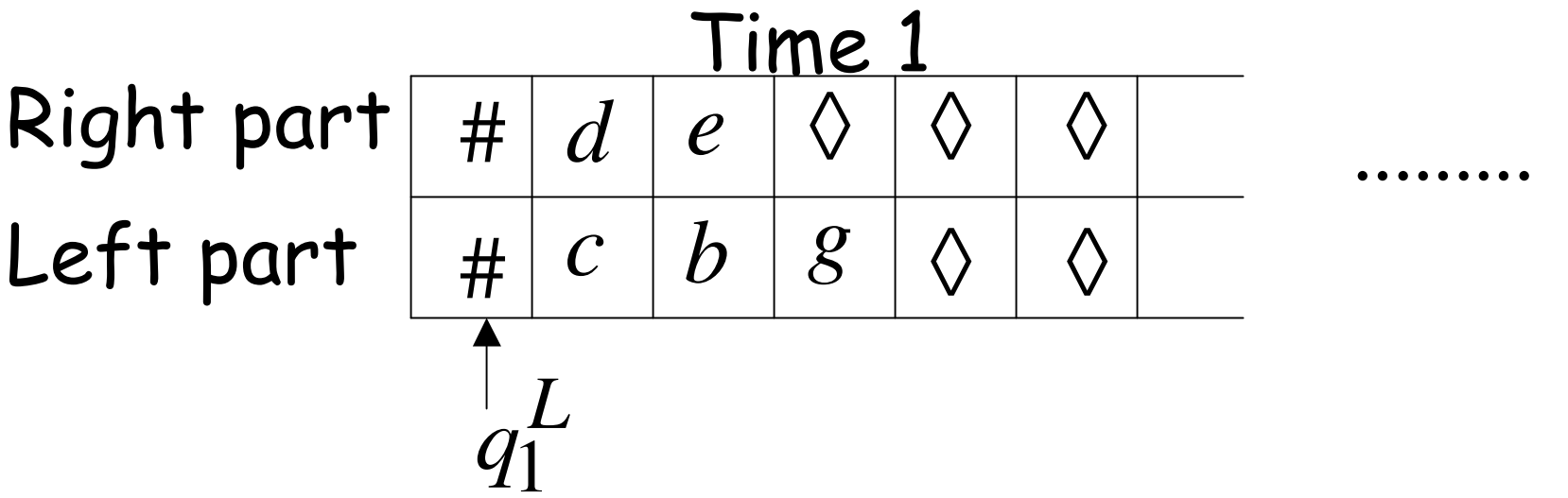
Right part

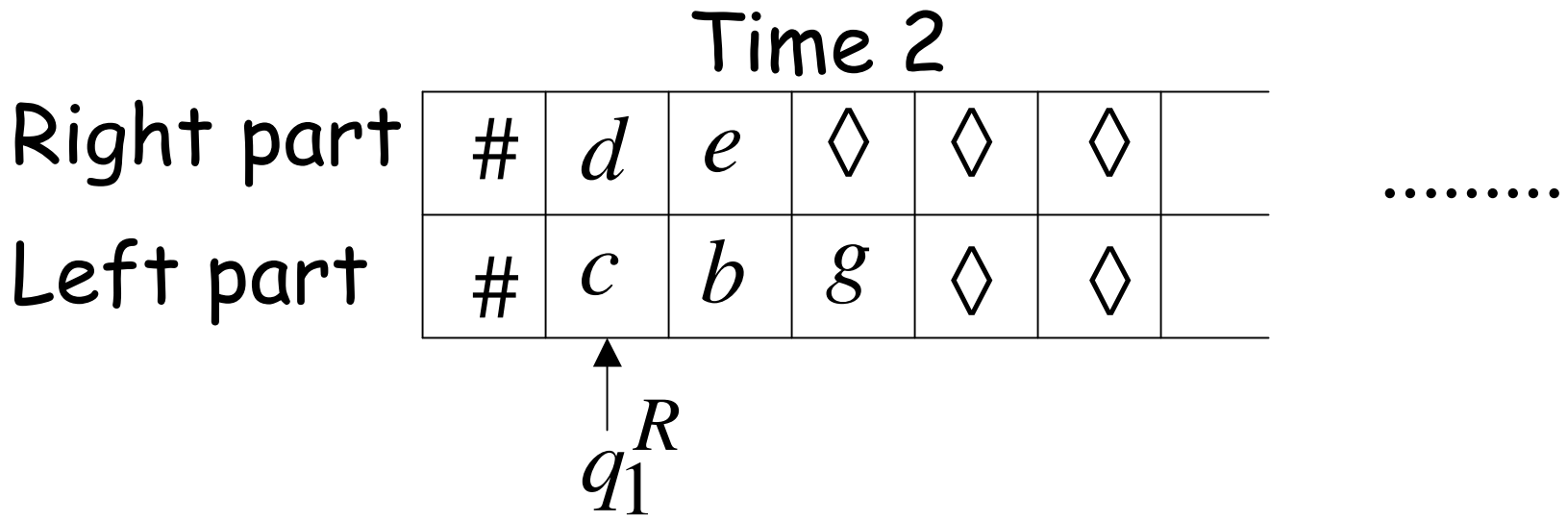


Left part



Semi-infinite tape

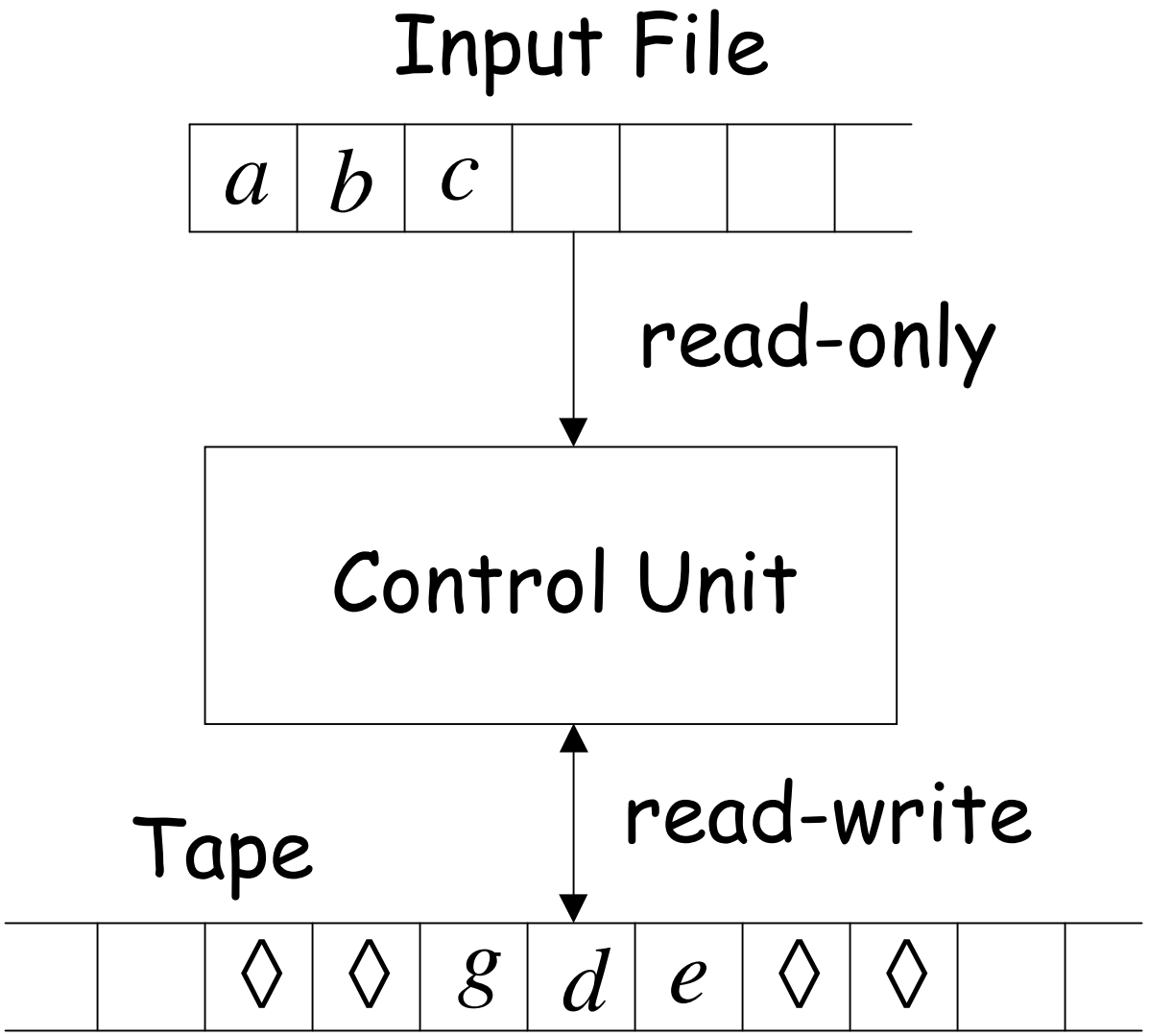




Theorem:

Semi-infinite tape machines have the same power with Standard Turing machines

The Off-Line Machine



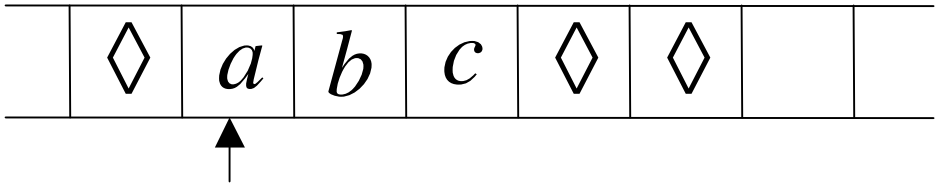
Off-line Machines simulate Turing Machines

Off-line machine:

1. Copy input file to tape

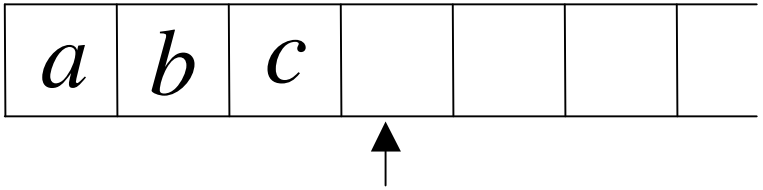
2. Continue computation as in Standard Turing machine

Turing Machine

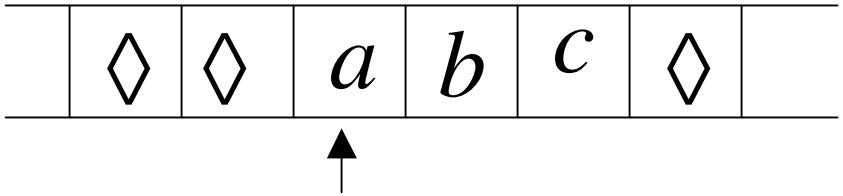


Off-line Machine

Input File

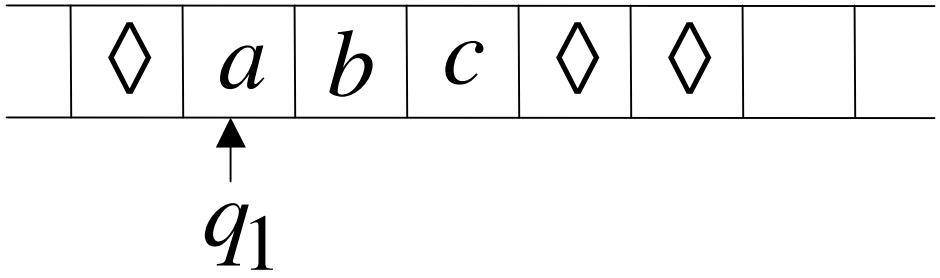


Tape



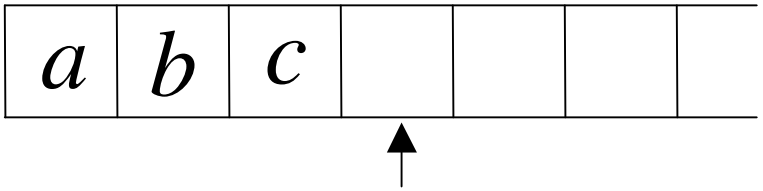
1. Copy input file to tape

Turing Machine

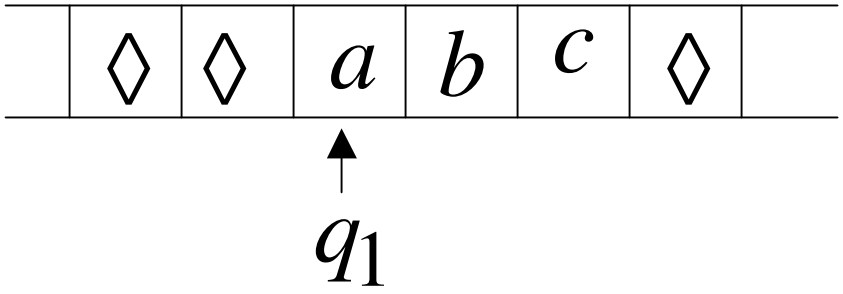


Off-line Machine

Input File



Tape



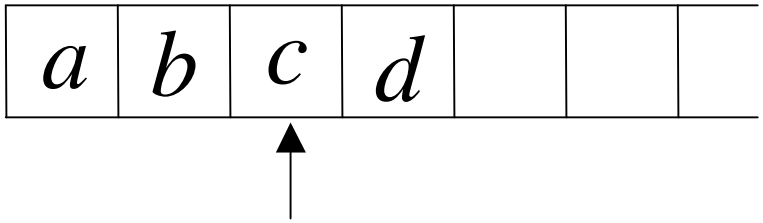
2. Do computations as in Turing machine

Turing Machines simulate Off-line machines

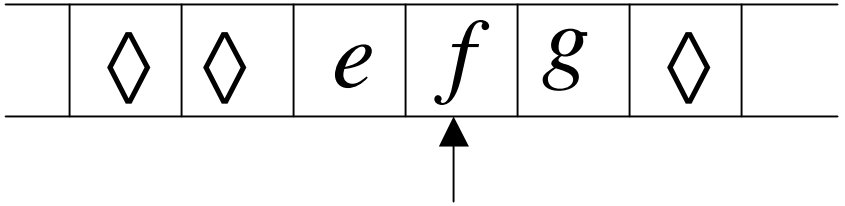
Use a Standard machine with four track tape
to keep track of
the Off-line input file and tape contents

Off-line Machine

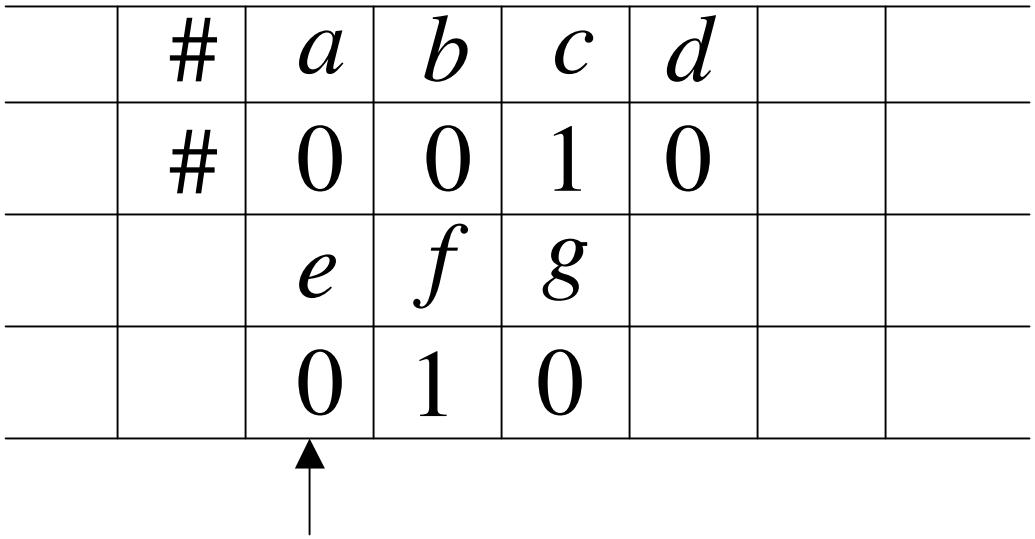
Input File



Tape



Four track tape -- Standard Machine



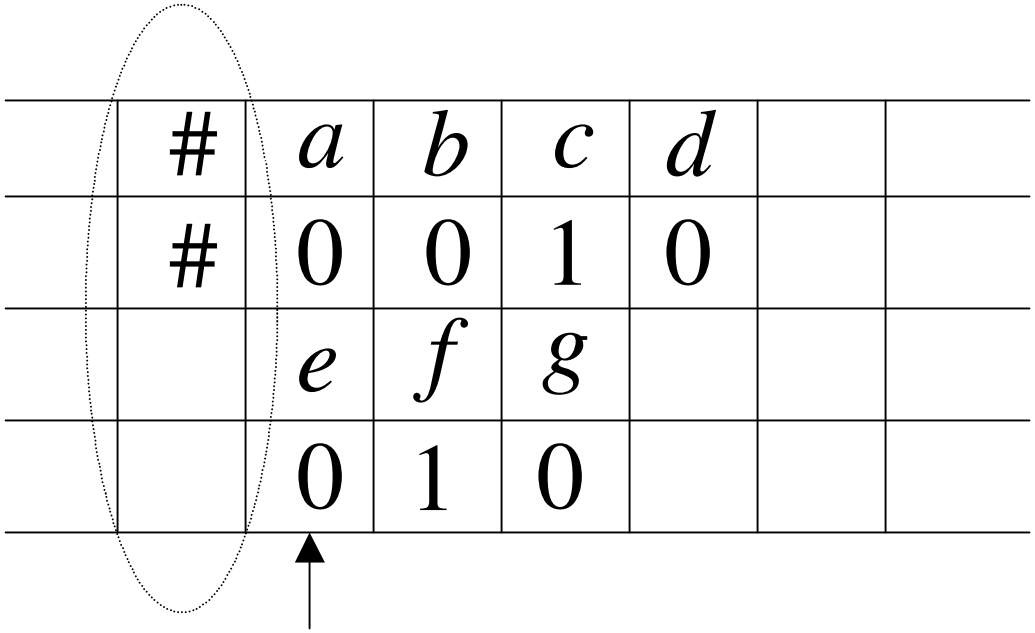
input file

head position

tape

head position

Reference point



Repeat for each state transition:

Return to reference point

Find current input file symbol

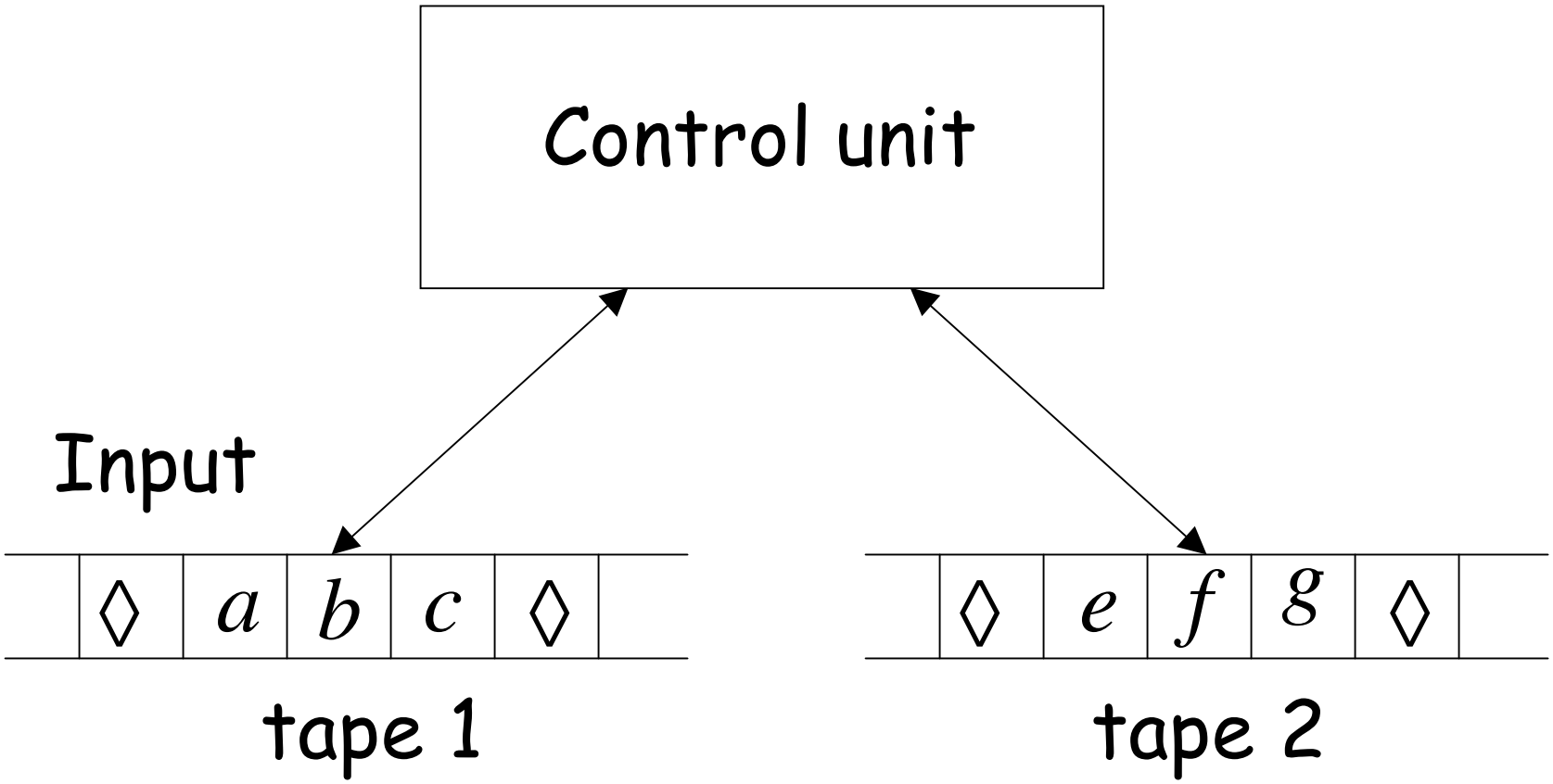
Find current tape symbol

make transition

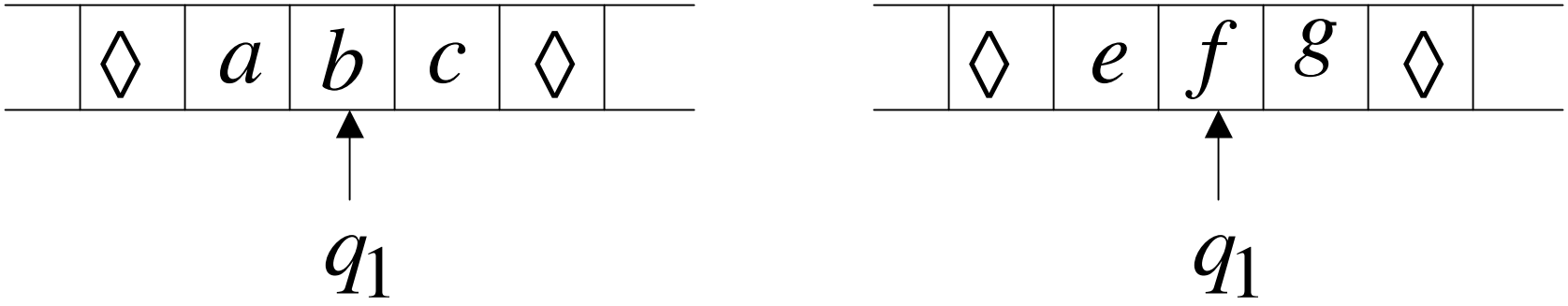
Theorem:

Off-line machines
have the same power with
Stansard machines

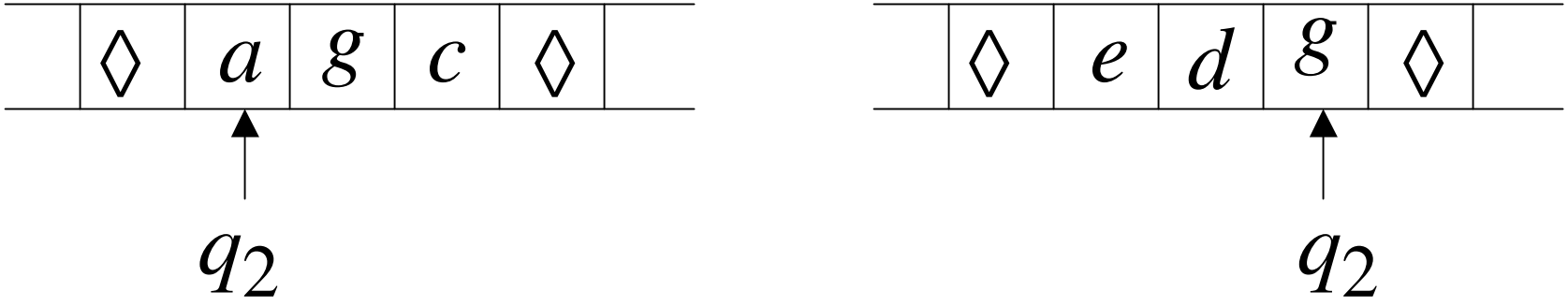
Multitape Turing Machines

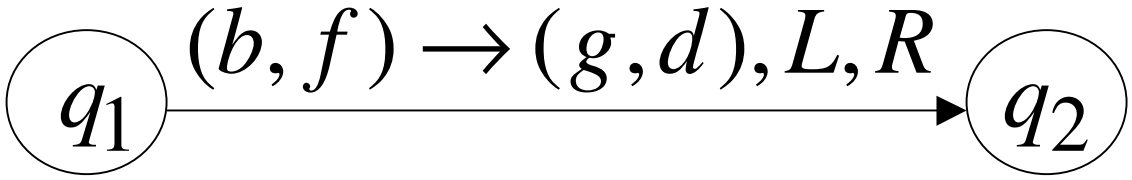


Time 1



Time 2





Multitape machines simulate Standard Machines

Just use one tape

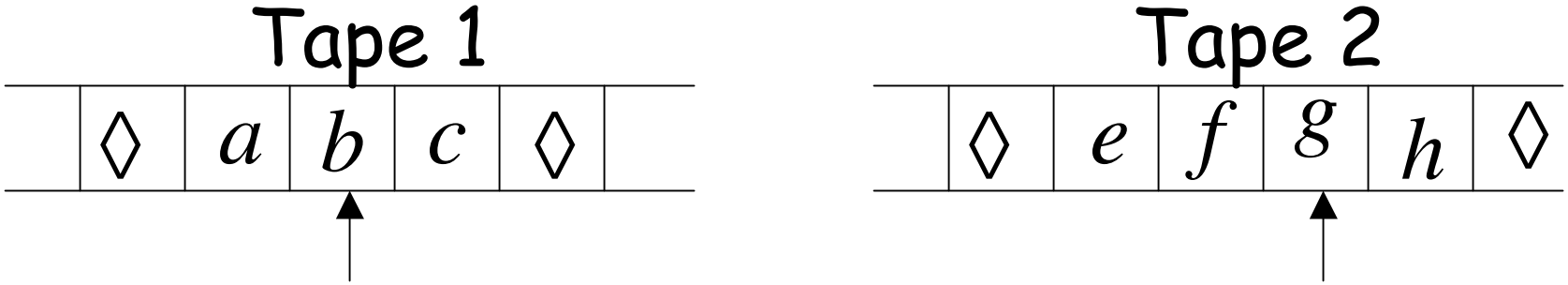
Standard machines simulate Multitape machines

Standard machine:

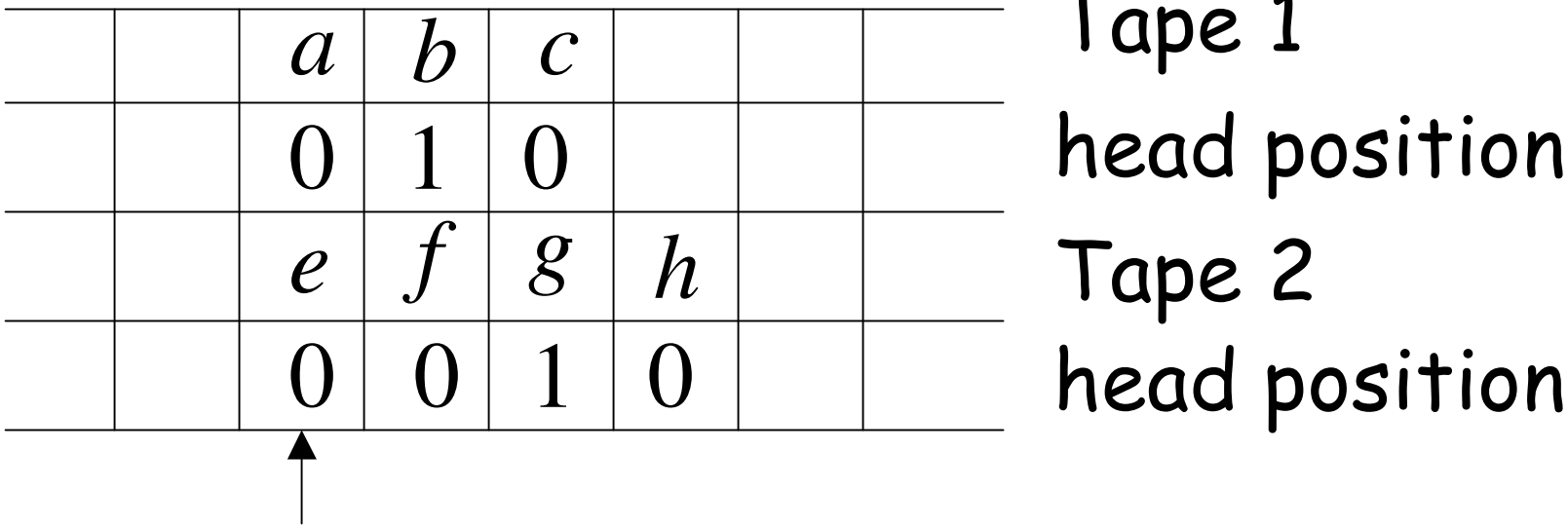
Use a multi-track tape

A tape of the Multiple tape machine corresponds to a pair of tracks

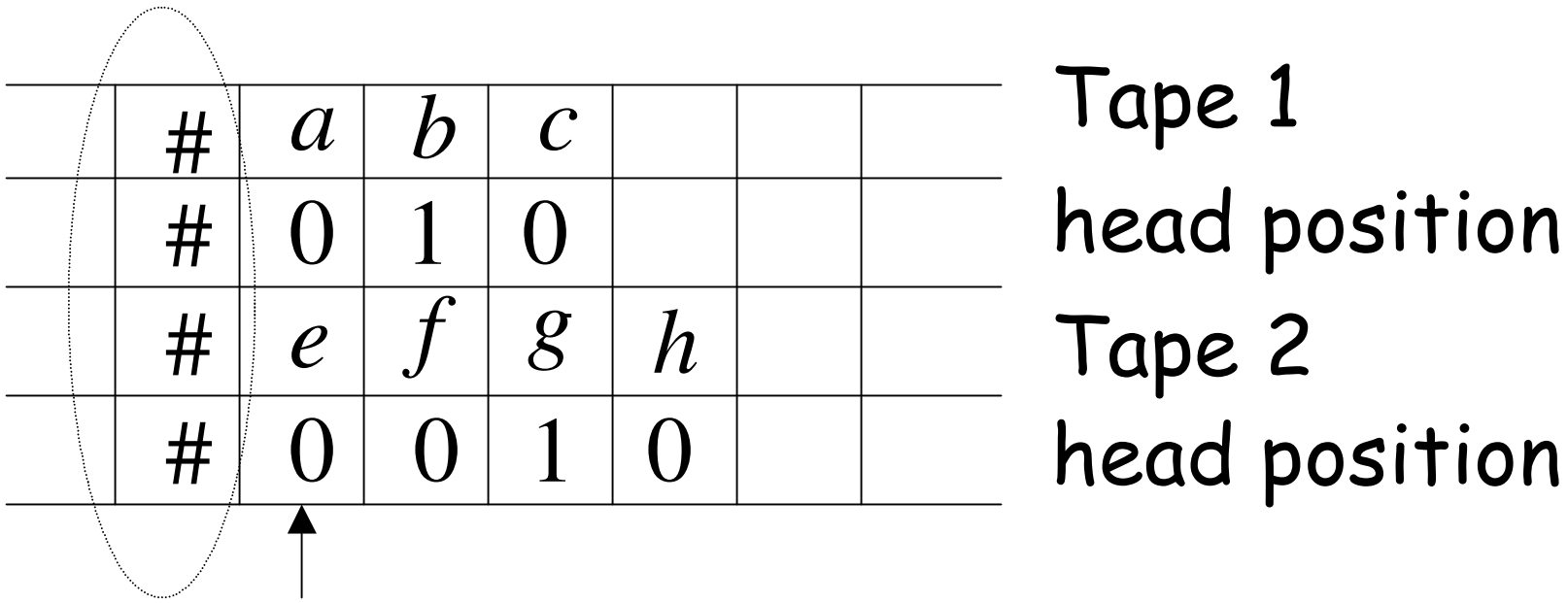
Multitape Machine



Four track tape -- Standard Machine



Reference point



	#	a	b	c			
	#	0	1	0			
	#	e	f	g	h		
	#	0	0	1	0		

Repeat for each state transition:

Return to reference point

Find current symbol on Tape 1

Find current symbol on Tape 2

make transition

Theorem:

Multi-tape machines
have the same power with
Standard Turing Machines

Same power doesn't mean same speed:

Language $L = \{a^n b^n\}$

	Acceptance Time
Standard machine	n^2
Two-tape machine	n

$$L = \{a^n b^n\}$$

Standard machine:

Go back and forth n^2 times

Two-tape machine:

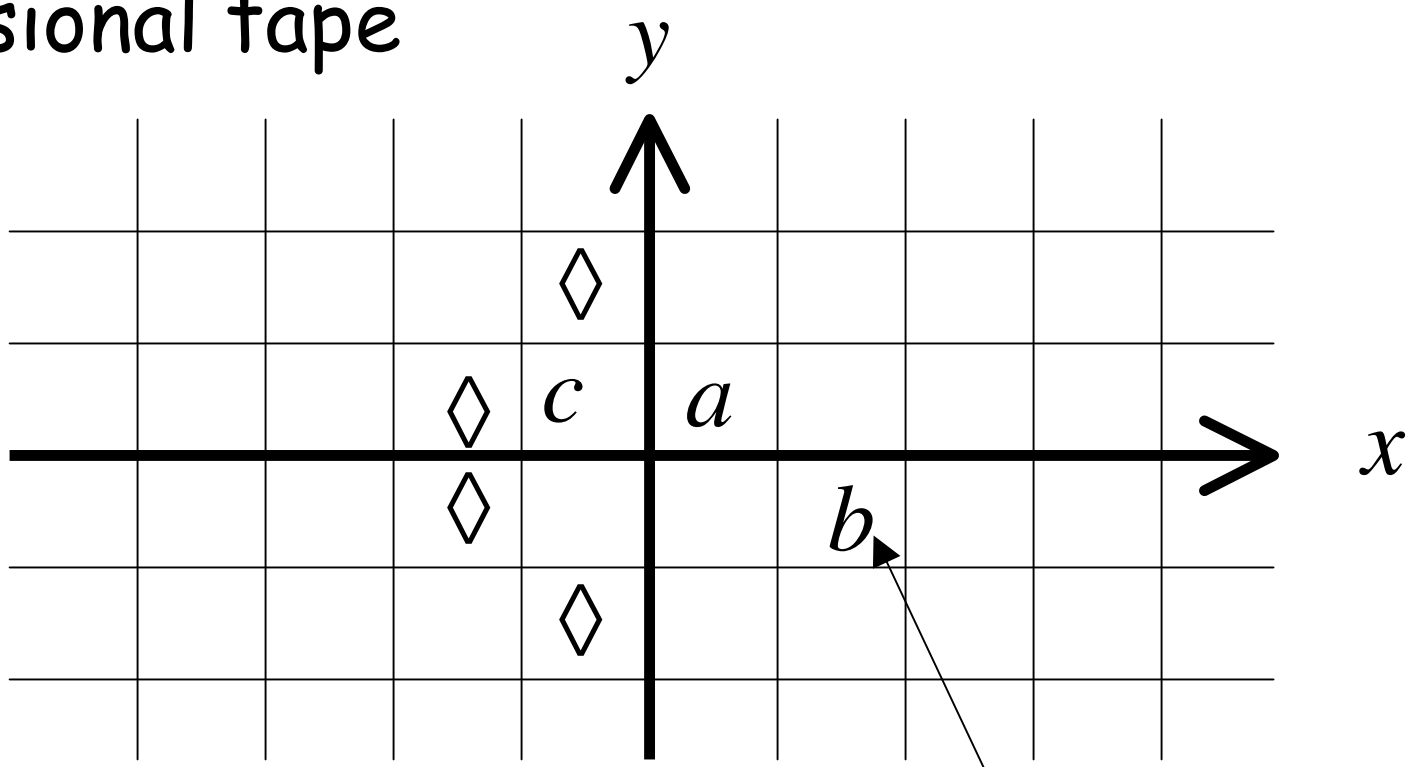
Copy b^n to tape 2 (n steps)

Leave a^n to tape 1 (n steps)

Compare tape 1 and tape 2 (n steps)

MultiDimensional Turing Machines

Two-dimensional tape



MOVES: L,R,U,D

U: up D: down

HEAD
Position: +2, -1

Multidimensional machines

simulate

Standard machines

Just use one dimension

Standard machines

simulate

Multidimensional machines

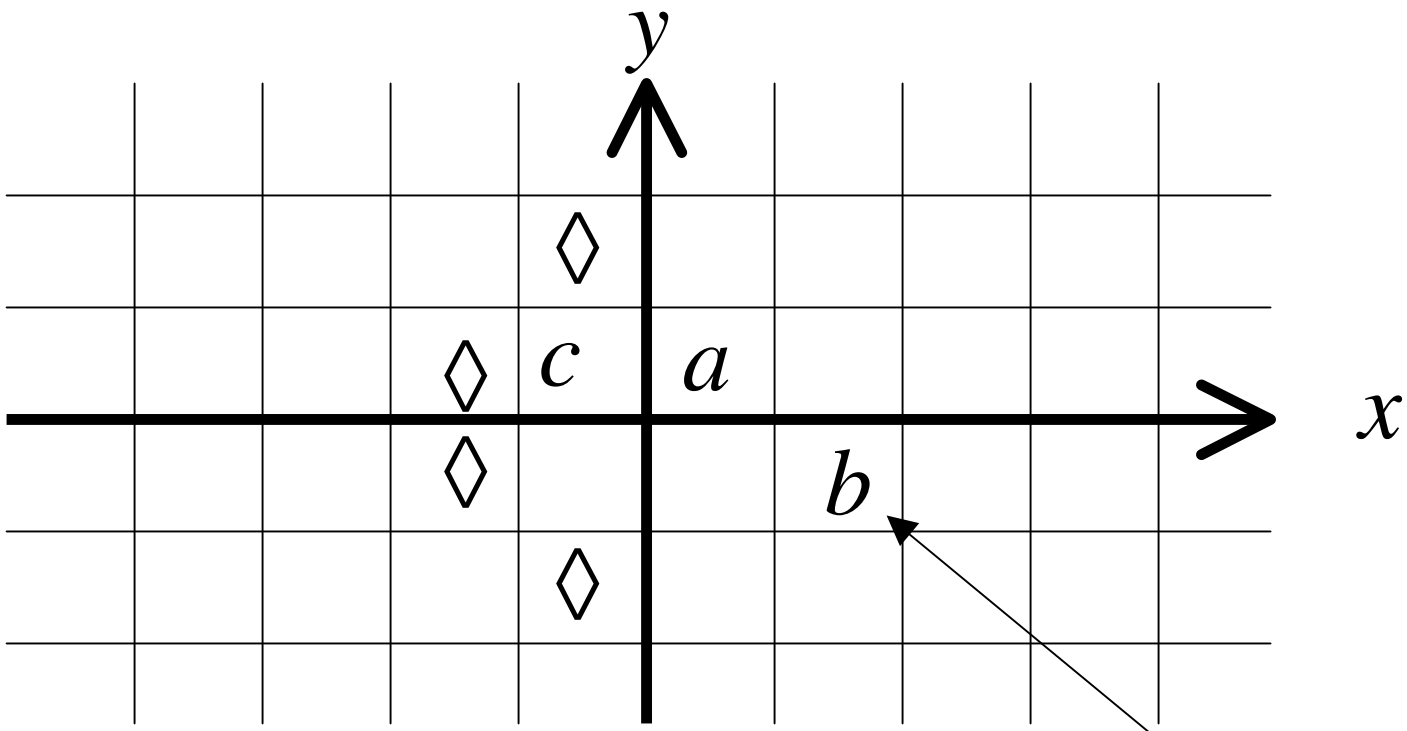
Standard machine:

Use a two track tape

Store symbols in track 1

Store coordinates in track 2

Two-dimensional machine



Standard Machine

	a				b					c		
	1	#	1	#	2	#	−	1	#	−	1	

q_1

symbols

coordinates

Simulation:

Repeat for each transition

Update current symbol

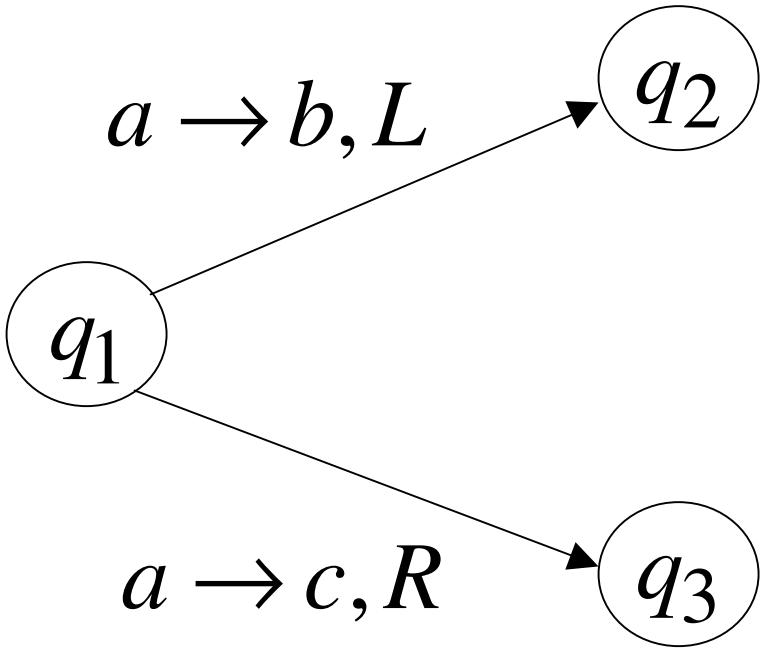
Compute coordinates of next position

Go to new position

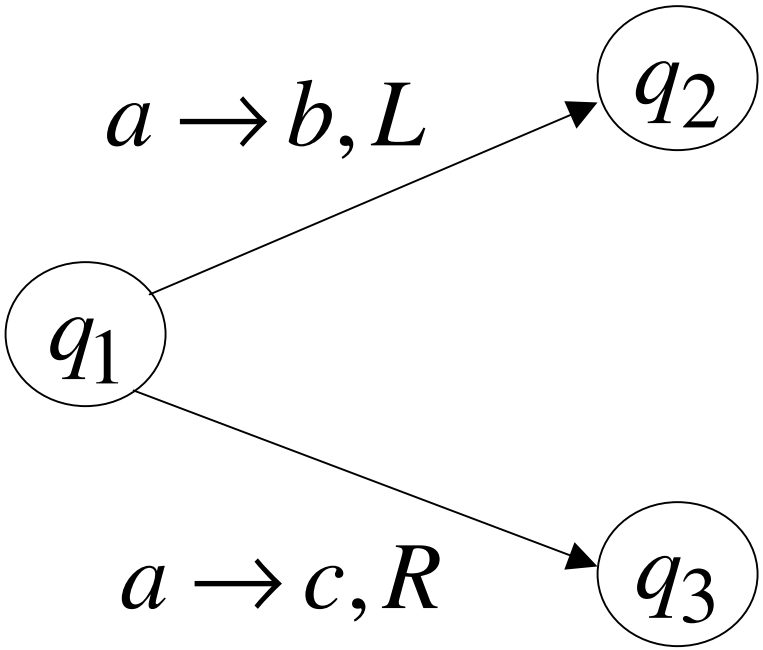
Theorem:

MultiDimensional Machines
have the same power
with Turing Machines

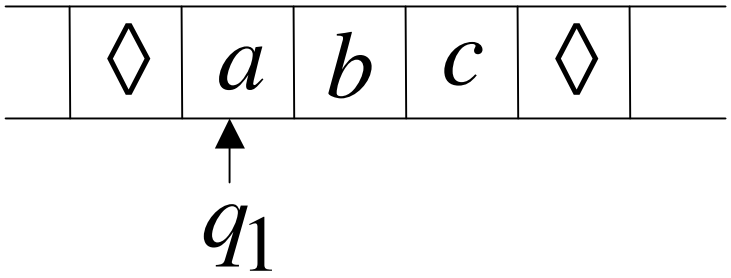
NonDeterministic Turing Machines



Non Deterministic Choice

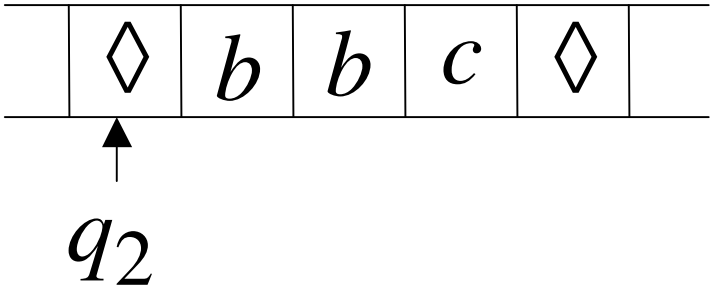


TIME 0

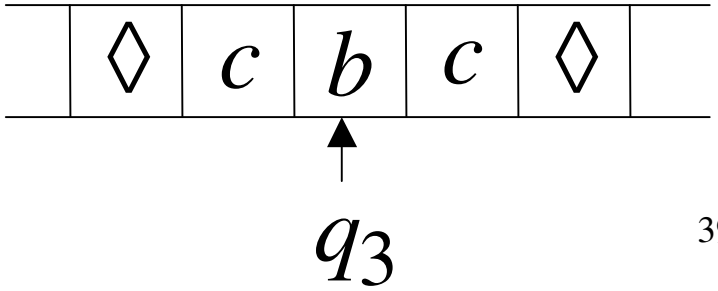


TIME 1

Choice 1



Choice 2



Input w is accepted if
this a possible computation

$$q_0 w \overset{*}{\succ} x\, q_f\, y$$

Initial configuration

Final state

Final Configuration

NonDeterministic Machines
simulate
Standard (deterministic) Machines

Every deterministic machine
is also a nondeterministic machine

Deterministic machines

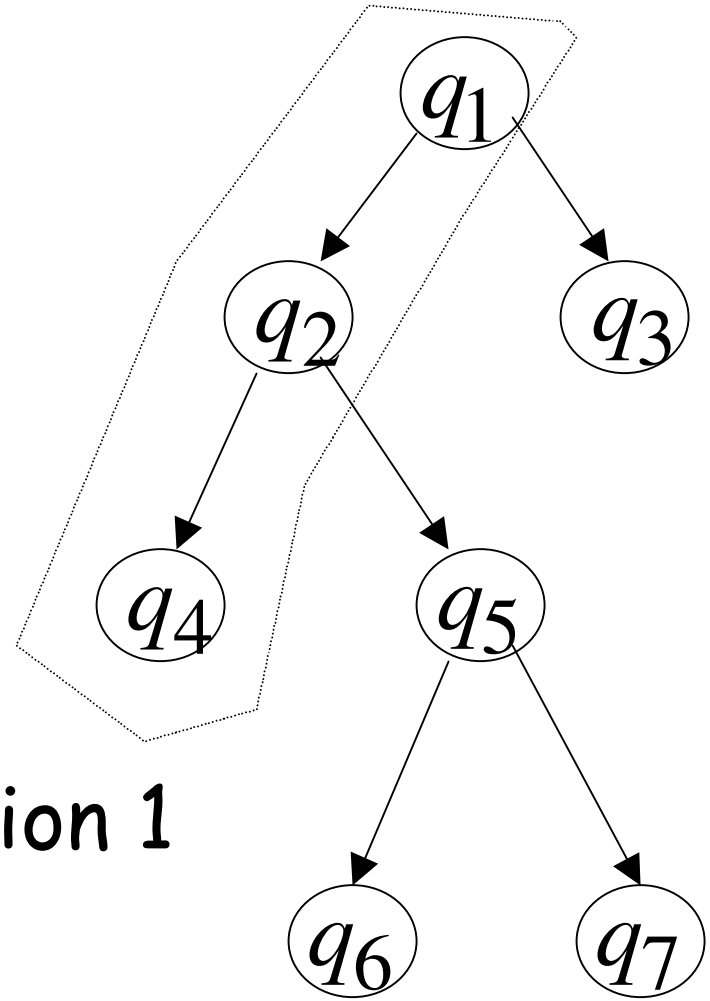
simulate

NonDeterministic machines

Deterministic machine:

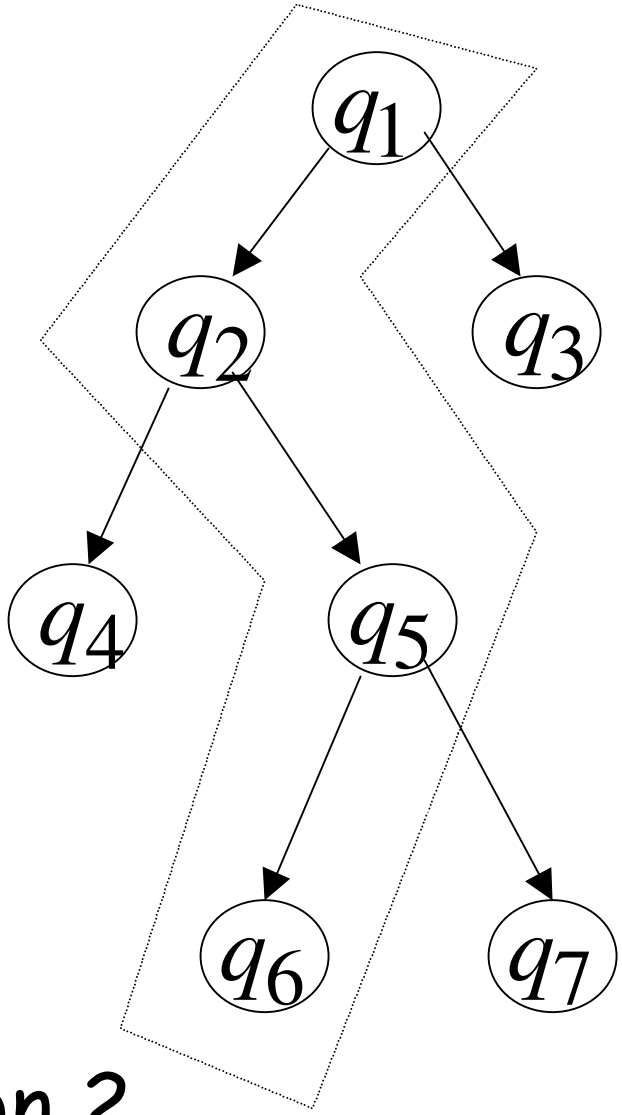
Keeps track of all possible computations

Non-Deterministic Choices



Computation 1

Non-Deterministic Choices



Computation 2

Simulation

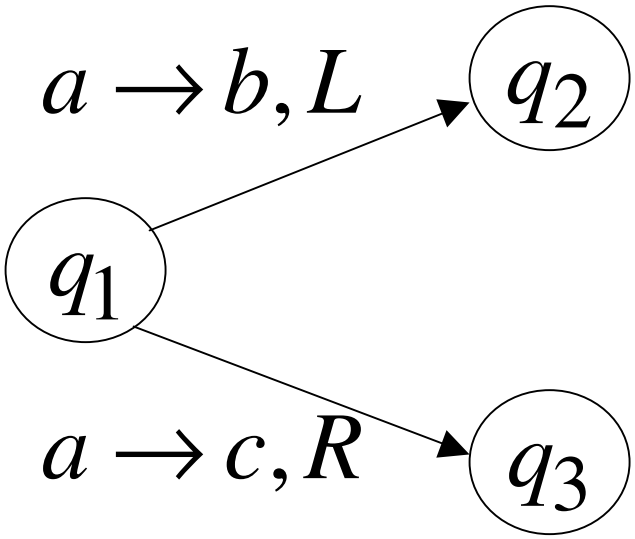
Deterministic machine:

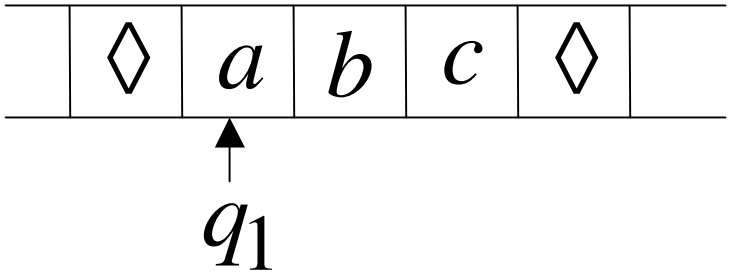
Keeps track of all possible computations

Stores computations in a
two-dimensional tape

TIME 0

NonDeterministic





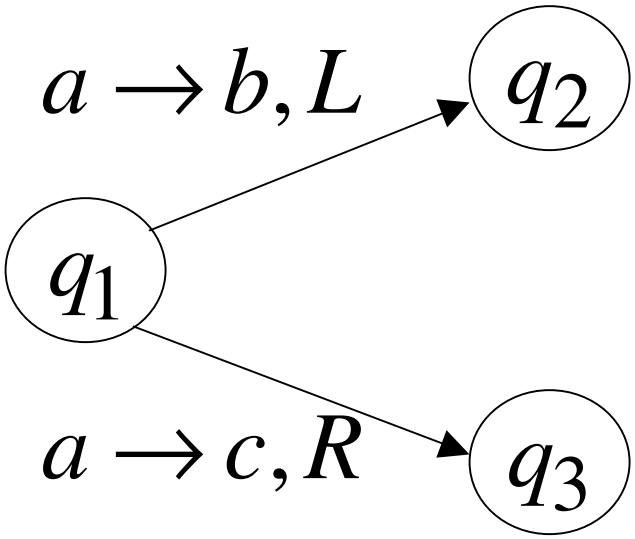
Deterministic

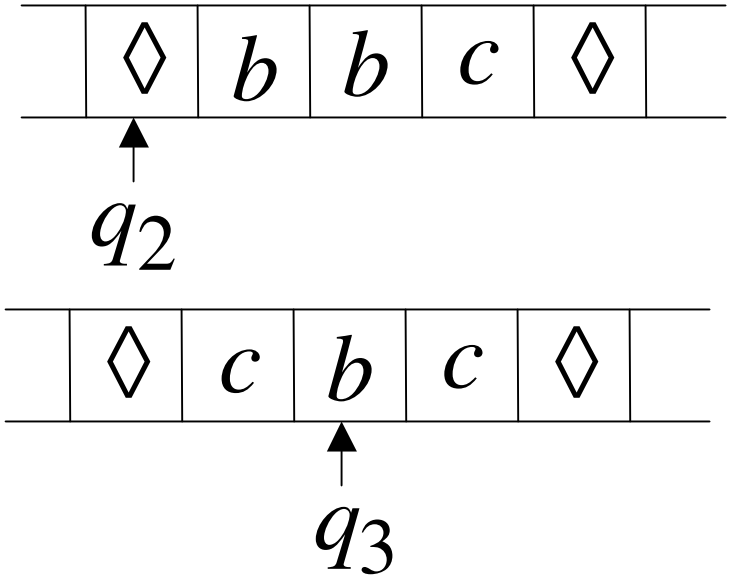
	#	#	#	#	#	#	
	#	a	b	c	#		
	#	q_1			#		
	#	#	#	#	#		

Computation 1

TIME 1

NonDeterministic





Deterministic

	#	#	#	#	#	#	
#		b	b	c	#		
#	q_1				#		
#		c	b	c	#		
#			q_3		#		

Computation 1

Computation 2

Repeat

Execute a step in each computation:

If there is a choice

in current computation:

replicate configuration

change the state in the replica

Theorem:

NonDeterministic Machines have the same power with deterministic machines

Remark:

The simulation
in the deterministic Machine
takes time exponential time compared
to NonDeterministic machines

Polynomial Time in NonDeterministic Machine

NP-Time

Polynomial Time in Deterministic Machine

P-Time

Fundamental Problem: P = NP ?