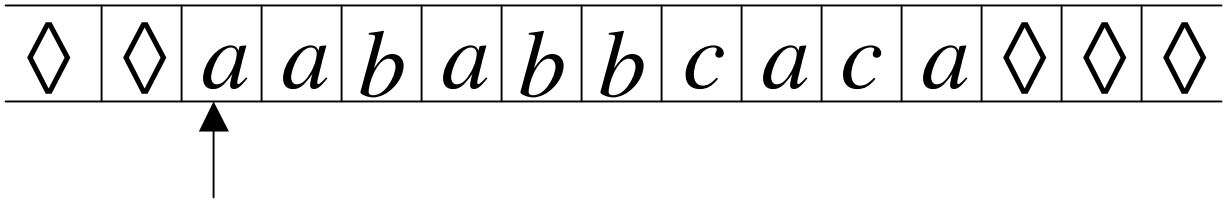
# Variations of the Turing Machine

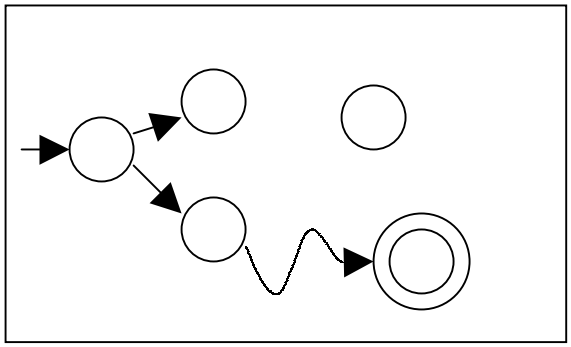
# The Standard Model

Infinite Tape




Read-Write Head (Left or Right)

Control Unit



Deterministic

# Variations of the Standard Model

- Turing Machines with Stay-Option
- Turing Machines with Semi-Infinite Tape
- The Off-Line Turing Machine
- Multitape Turing Machines
- Multidimensional Turing Machines
- Nondeterministic Turing Machines

The variations form different
Turing Machine **Classes**

We want to prove:

Each **Class** has the same
power with the Standard Model

Same Power of two classes means:

Take machine $M_1$ of first class

There is a machine $M_2$ of second class

such that: $L(M_1) = L(M_2)$

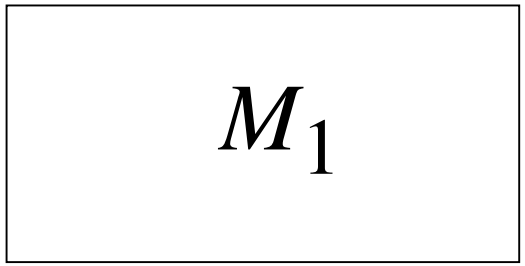
(second class is at least as powerful as first class)

And vice-versa

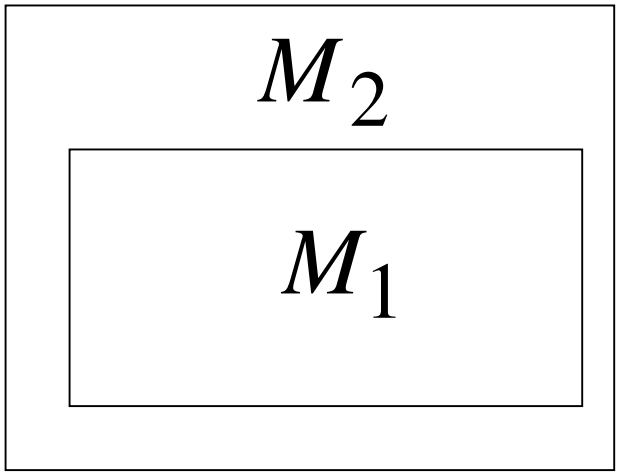
A technique to prove same power: **Simulation**

**Simulate** the machine of one class
with a machine of the other class

First Class
Original Machine




Second Class
Simulation Machine



Configurations in the Original Machine
correspond to configurations
in the Simulation Machine

Original Machine: $d_0 \succ d_1 \succ \cdots \succ d_n$

Simulation Machine: $d'_0 \succ^* d'_1 \succ^* \cdots \succ^* d'_n$

Final Configuration

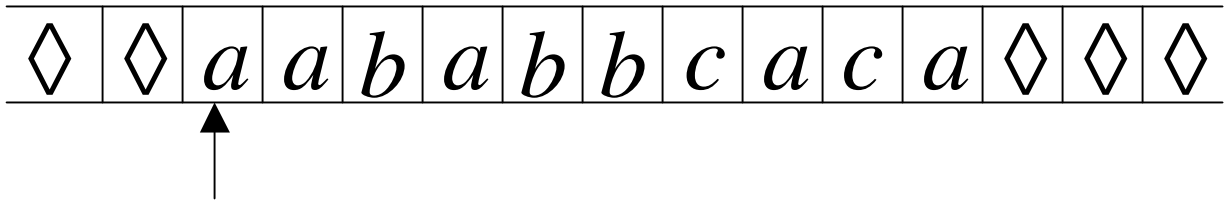
Original Machine: $d_f$

Simulation Machine: $d'_f$

The Simulation Machine
and the Original Machine
will accept the same language

# Turing Machines with Stay-Option

The head can stay in the same position

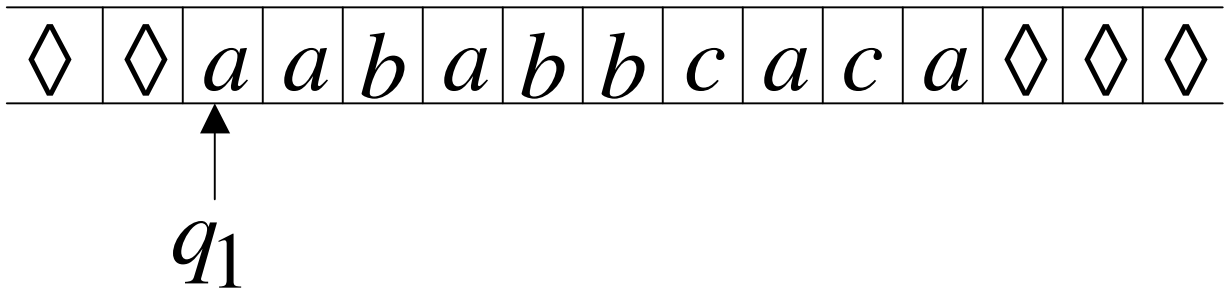



Left, Right, Stay

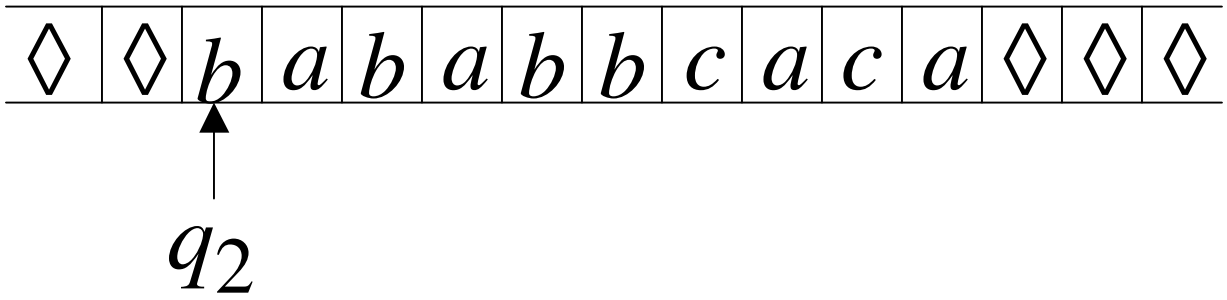
L,R,S: moves

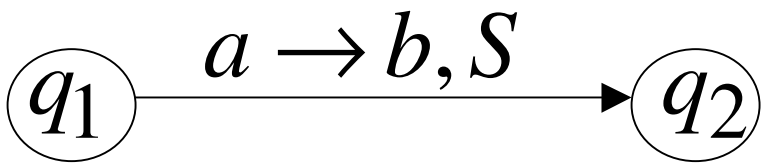
Example:

Time 1




Time 2



Theorem:

Machines with Stay-Option

have the same power

with the standard Turing machines

**Proof:**

Part1 -- Stay-Option Machines
are at least as powerful as
standard machines

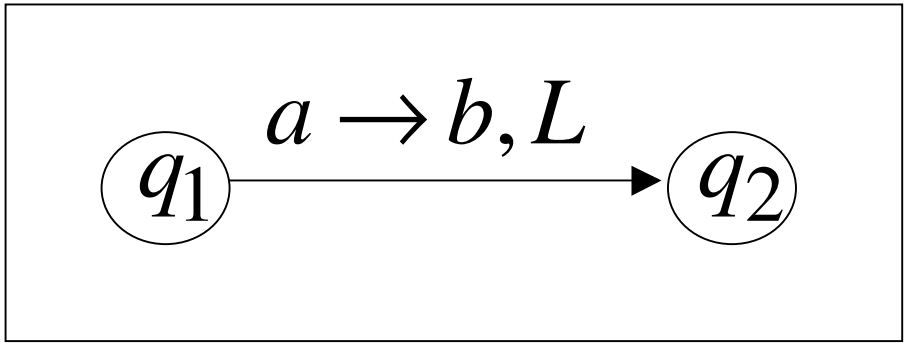
Trivial proof:

A standard machine is also
a Stay-Option machine
(that never uses the S move)

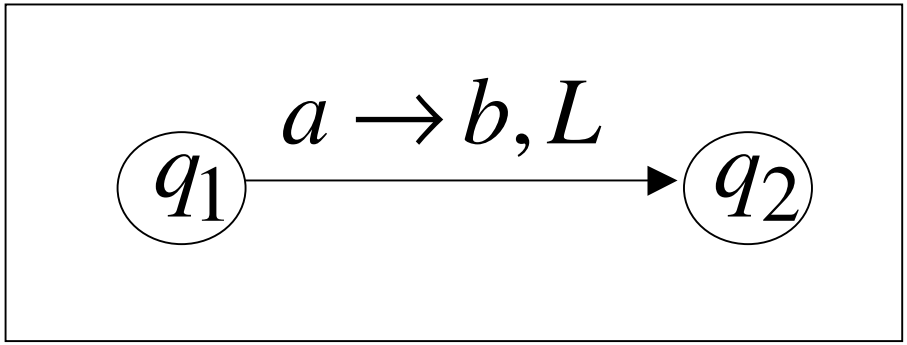
Part2 -- Standard Machines
are at least as powerful as
Stay-Option machines

Proof: a standard machine
can simulate
a Stay-Option machine

## Stay-Option Machine

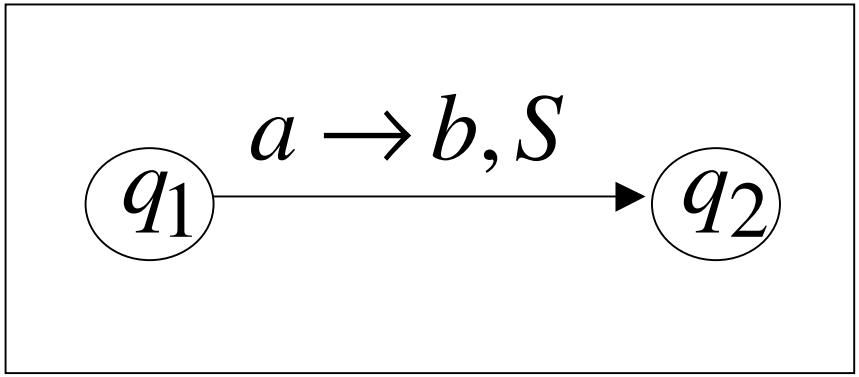



## Simulation in Standard Machine

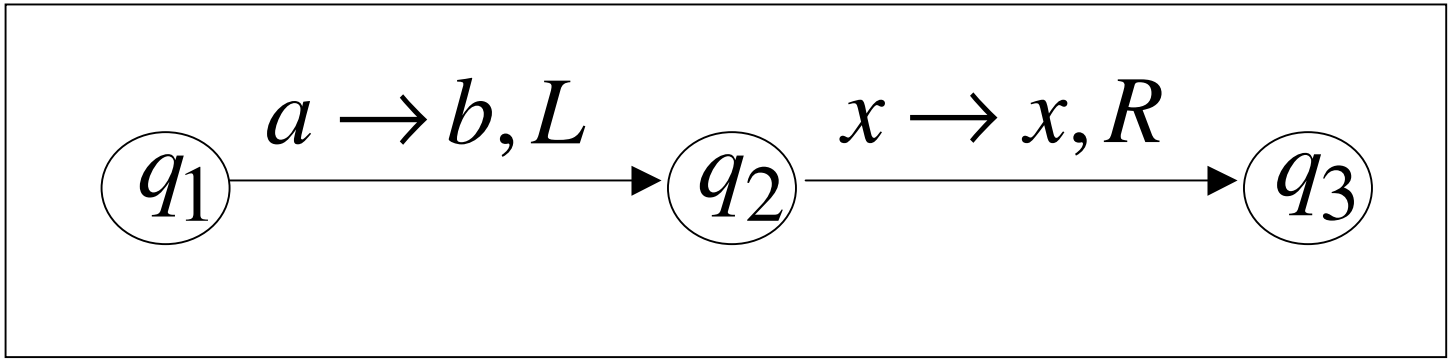



Similar for Right moves

## Stay-Option Machine



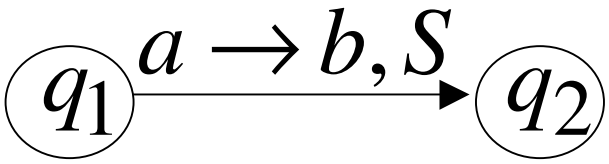

## Simulation in Standard Machine

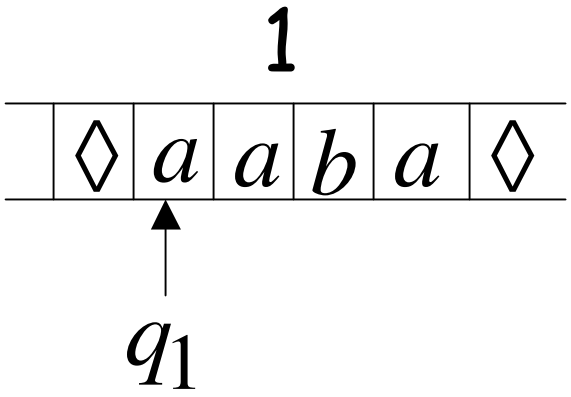


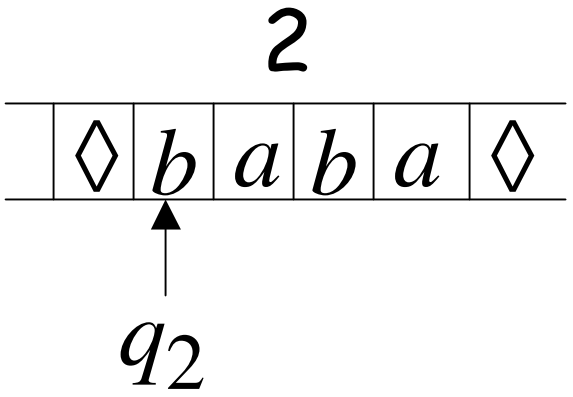

For every symbol $x$

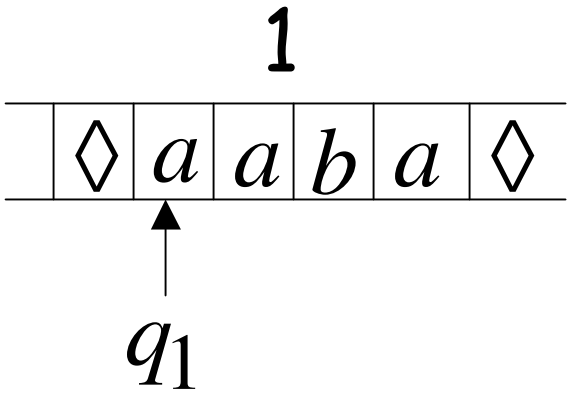
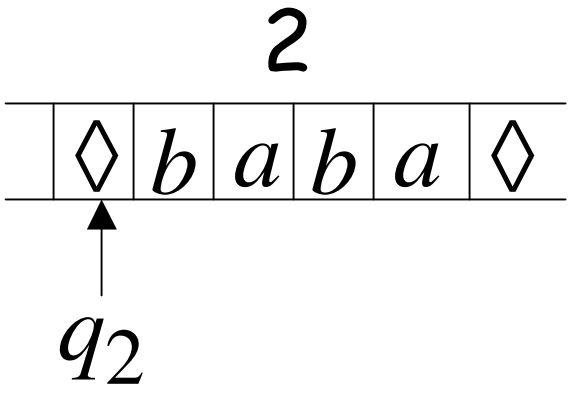
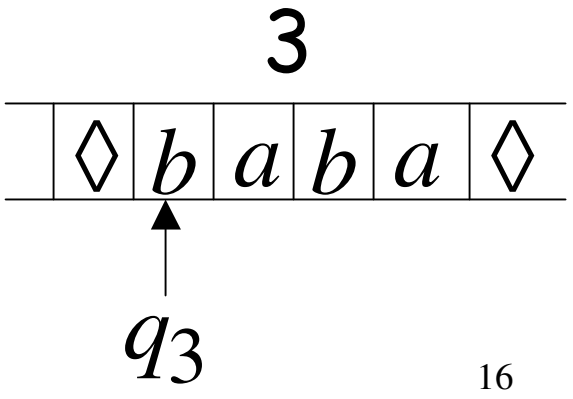
# Example

Stay-Option Machine:




Simulation in Standard Machine: