<u>Def</u>: A <u>Turing Machine</u> (TM)
is a tuple

$$M := \langle Q, \Sigma, \Gamma, \delta, q_0, q_{acc}, q_{rej} \rangle$$

where

Q is a finite set
(<u>state set</u>)

Σ is an alphabet
(the <u>input alphabet</u>)

Γ is an alphabet
(the <u>tape</u> <u>alphabet</u>)

q_0, q_{acc}, q_{rej} are states
(elements of Q)

q_0 — <u>start state</u>

the $\begin{bmatrix} q_{acc} - \text{accept state} \\ q_{rej} - \text{reject state} \end{bmatrix}$
halting
states

and

$$\delta : Q \times \Gamma \longrightarrow Q \times \Gamma \times \{L, R\}$$

except, $\delta(q_{acc}, -)$ and
$\delta(q_{rej}, -)$ are undefined

Furthermore
- $q_{acc} \neq q_{rej}$
- $\Sigma \subseteq \Gamma$, $\sqcup \in \Gamma - \Sigma$ ← <u>blank symbol</u>
- $Q \cap \Gamma = \emptyset$ //

cell	0	1	2	...
				...

comp goes in discrete time
steps $0, 1, 2 \cdots$.
　　　↑
　　initial

At each time step,
- every cell of the tape
  contains a unique symbol
- the TM is in a unique state
- the TM's head is scanning
  a unique cell.

0	1	1	X	3	2	$\sqcup$	... ~

　　　　　↑
　　　| q |

<u>Initially</u>: on input $w \in \Sigma^*$:
- the symbols of w are on
  the leftmost portion of the
  tape (cells $0, \ldots, n-1$ if $n = |w|$)
- cell 0 (leftmost cell)
  is scanned
- state is q_0 (start state)

At any time: suppose
- M is in state $q \in Q$
- symbol being scanned ← non-
  is $a \in \Gamma$, then　　　halting
in the next time step:

If $\delta(q, a) = (r, b, R)$
then: a is replaced by b
  in that cell,
  state becomes r, and
  head moves one cell
  to the right.

If $\delta(q, a) = (r, b, L)$,
  then same except head
  moves one cell left.
  (exception: if head is
  scanning cell 0, it
  does not move).

When or if state is a
halting state, computation
stops (accepts if q_{acc} and
rejects if q_{rej}).

<u>Def</u>: $M = \langle Q, \Sigma, \Gamma, \delta, q_0, q_{acc}, q_{rej} \rangle$
be a TM. A <u>configuration</u>
of M (aka an instantaneous
description (<u>ID</u>)) is of
the form

$$\alpha q \beta \in (Q \cup \Gamma)^*$$

where $\alpha, \beta \in \Gamma^*$
and $q \in Q$.

$\alpha q \beta$ gives a complete
snapshot of the state of the
computation an any given time
(so that the next step is uniquely
determined).
$\alpha q \beta$ means: M is in
　　　　　state q,
$\alpha \beta$ is the contents of the
tape, starting at cell 0 & incl. all nonblank cells