

## mac.1 Turing Machines

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sec The formal definition of what constitutes a Turing machine looks abstract, explanation but is actually simple: it merely packs into one mathematical structure all the information needed to specify the workings of a Turing machine. This includes (1) which states the machine can be in, (2) which symbols are allowed to be on the tape, (3) which state the machine should start in, and (4) what the instruction set of the machine is.

**Definition mac.1** (Turing machine). A *Turing machine*  $T = \langle Q, \Sigma, q_0, \delta \rangle$  consists of

1. a finite set of *states*  $Q$ ,
2. a finite *alphabet*  $\Sigma$  which includes  $\triangleright$  and  $0$ ,
3. an *initial state*  $q_0 \in Q$ ,
4. a finite *instruction set*  $\delta: Q \times \Sigma \rightarrow Q \times \Sigma \times \{L, R, N\}$ .

The partial function  $\delta$  is also called the *transition function* of  $T$ .

We assume that the tape is infinite in one direction only. For this reason explanation it is useful to designate a special symbol  $\triangleright$  as a marker for the left end of the tape. This makes it easier for Turing machine programs to tell when they're "in danger" of running off the tape.

**Example mac.2.** *Even Machine:* The even machine is formally the quadruple  $\langle Q, \Sigma, q_0, \delta \rangle$  where

$$\begin{aligned} Q &= \{q_0, q_1\} \\ \Sigma &= \{\triangleright, 0, 1\}, \\ \delta(q_0, 1) &= \langle q_1, 1, R \rangle, \\ \delta(q_1, 1) &= \langle q_0, 1, R \rangle, \\ \delta(q_1, 0) &= \langle q_1, 0, R \rangle. \end{aligned}$$

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## Bibliography