# Chapter 1

## 1      What is an algorithm

An algorithm is a sequence of computational steps that transforms an input into an output, generally to solve a well-defined computational problem.

## 2      What is a data structure

Data structures are a way to store and organize data in memory to facilitate efficient access and modification (e.g., to enhance the speed of an algorithm).

## 3      How to quantitatively measure algorithm efficiency

Intuitively, it takes $c$ units of time to perform a given computational operation. Typically the number of operations required by an algorithm corresponds to the size of the input $n$; therefore, algorithmic efficiency is expressed as a function of input size.

     For instance, to sort $n$ integers in increasing order, the *insertion sort* algorithm takes $c \cdot n^2$ units time, whereas the *merge sort* takes $c \cdot n \lg n$. Comparably speaking then, the $n \lg n$ algorithm will outperform the $n^2$ algorithm for large input sizes $n$.

     There's an entire mathematical notation for identifying and comparing these input-efficiency functions for algorithms, called *asymptotic notation*; it's discussed at length in chapter 3. Observe following input sizes $n$ which could be completed in time $t$ for each efficiency function $f_n$:

|            | 1 second   | 1 minute   | 1 hour     | 1 day      | 1 month    | 1 year     | 1 century  |
|------------|------------|------------|------------|------------|------------|------------|------------|
| $\lg n$    | $2^{10^6}$ | $2^{10^7}$ | $2^{10^9}$ | $2^{10^{10}}$ | $2^{10^{12}}$ | $2^{10^{13}}$ | $2^{10^{15}}$ |
| $\sqrt{n}$ | $10^{12}$  | $10^{15}$  | $10^{19}$  | $10^{21}$  | $10^{24}$  | $10^{26}$  | $10^{30}$  |
| $n$        | $10^6$     | $10^7$     | $10^9$     | $10^{10}$  | $10^{12}$  | $10^{13}$  | $10^{15}$  |
| $n \lg n$  | $10^4$     | $10^6$     | $10^8$     | $10^9$     | $10^{10}$  | $10^{11}$  | $10^{13}$  |
| $n^2$      | $10^3$     | $10^3$     | $10^4$     | $10^5$     | $10^6$     | $10^6$     | $10^7$     |
| $n^3$      | 100        | 400        | 1500       | 4000       | $10^4$     | $10^4$     | $10^5$     |
| $2^n$      | 20         | 25         | 30         | 35         | 40         | 45         | 50         |
| $n!$       | 9          | 11         | 12         | 13         | 15         | 16         | 17         |