

## COMMON GROWTH CLASSES

## Why

We are regularly referring to a few common growth classes.

## **Definitions**

Let  $c \in \mathbb{R}$ . Then we name the following growth classes

growth class	name
O(1)	constant growth class
$O(\log(x))$	logarithmic growth class
$O((\log(x))^c)$	polylogarithmic growth class
O(x)	linear growth class
$O(x^2)$	quadratic growth class
$O(x^c)$	polynomial growth class
$O(c^x)$	exponential growth class

We have written these in order:

$$O(1) \subset O(\log(x)) \subset O((\log(x))^c) \subset \cdots \subset O(x^c) \subset O(c^x).$$

A function that grows faster (is in the upper growth class) of a power of x is called superpolynomial. One that grows slower than  $c^n$  for some  $c \in \mathbf{R}$  is called subexponential. The class  $O(\log(x^c)) = O(\log(x))$  since  $\log(x^c) = c \log x$ . Similarly, for all  $c_1, c_2 > 0$ ,  $O(\log_{c_1}(x)) = O(\log_{c_2}(x))$ .

This list is useful because of the following

**Proposition 1.** Let  $f,g: \mathbb{R} \to \mathbb{R}$  and defined  $h: \mathbb{R} \to \mathbb{R}$  by h = f + g. If  $O(f) \subset O(g)$ , then  $h \in O(g)$ .

In other words, if a function h is the sum of f and g and g is growing faster, then g (the one growing faster) determines the order of h.

