Suppose  $(a_k)_{k=1}^{\infty}$  is a sequence of real numbers.

Suppose  $(a_k)_{k=1}^{\infty}$  is a sequence of real numbers. This is sequence is

▶ increasing if  $a_k < a_{k+1}$  for all k

- ▶ increasing if  $a_k < a_{k+1}$  for all k
- weakly increasing if  $a_k \leq a_{k+1}$  for all k

- ▶ increasing if  $a_k < a_{k+1}$  for all k
- weakly increasing if  $a_k \leq a_{k+1}$  for all k
- decreasing if  $a_k > a_{k+1}$  for all k

- ▶ increasing if  $a_k < a_{k+1}$  for all k
- weakly increasing if  $a_k \leq a_{k+1}$  for all k
- decreasing if  $a_k > a_{k+1}$  for all k
- weakly decreasing if  $a_k \ge a_{k+1}$  for all k

- increasing if  $a_k < a_{k+1}$  for all k
- weakly increasing if  $a_k \leq a_{k+1}$  for all k
- decreasing if  $a_k > a_{k+1}$  for all k
- weakly decreasing if  $a_k \ge a_{k+1}$  for all k
- ▶ constant if  $a_k = a_{k+1}$  for all *k*.

Suppose  $(a_k)_{k=1}^{\infty}$  is a sequence of real numbers. This is sequence is

- increasing if  $a_k < a_{k+1}$  for all k
- weakly increasing if  $a_k \leq a_{k+1}$  for all k
- decreasing if  $a_k > a_{k+1}$  for all k
- weakly decreasing if  $a_k \ge a_{k+1}$  for all k
- ▶ constant if  $a_k = a_{k+1}$  for all *k*.

We can put eventually before any of these properties to mean that the sequence has that property after a certain point.

# Examples

#### • The sequence $(a_k)_{k=1}^{\infty}$ where $a_k = 2^k$ : 2, 4, 8, 16, 32, ...

► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = 2^k$ : 2, 4, 8, 16, 32, ... This is increasing.

- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = 2^k$ : 2, 4, 8, 16, 32, ... This is increasing.
- The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = \lfloor k/2 \rfloor$ : 0, 1, 1, 2, 2, 3, 3, 4, 4, ...

- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = 2^k$ : 2, 4, 8, 16, 32, ... This is increasing.
- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = \lfloor k/2 \rfloor$ : 0, 1, 1, 2, 2, 3, 3, 4, 4, ... This is weakly increasing but not increasing.

- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = 2^k$ : 2, 4, 8, 16, 32, ... This is increasing.
- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = \lfloor k/2 \rfloor$ : 0, 1, 1, 2, 2, 3, 3, 4, 4, ... This is weakly increasing but not increasing.
- The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = (k-3)^2$ : 4, 1, 0, 1, 4, 9, 16, ...

- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = 2^k$ : 2, 4, 8, 16, 32, ... This is increasing.
- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = \lfloor k/2 \rfloor$ : 0, 1, 1, 2, 2, 3, 3, 4, 4, ... This is weakly increasing but not increasing.
- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = (k-3)^2$ : 4, 1, 0, 1, 4, 9, 16, ... This is not weakly increasing, but is eventually increasing.

► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = 2^k$ : 2, 4, 8, 16, 32, ... This is increasing.

- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = \lfloor k/2 \rfloor$ : 0, 1, 1, 2, 2, 3, 3, 4, 4, ... This is weakly increasing but not increasing.
- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = (k-3)^2$ : 4, 1, 0, 1, 4, 9, 16, ... This is not weakly increasing, but is eventually increasing.

• The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = \lfloor 6/k \rfloor$ : 6, 3, 2, 1, 1, 1, 0, 0, 0, ...

- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = 2^k$ : 2, 4, 8, 16, 32, ... This is increasing.
- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = \lfloor k/2 \rfloor$ : 0, 1, 1, 2, 2, 3, 3, 4, 4, ... This is weakly increasing but not increasing.
- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = (k-3)^2$ : 4, 1, 0, 1, 4, 9, 16, ... This is not weakly increasing, but is eventually increasing.
- ► The sequence  $(a_k)_{k=1}^{\infty}$  where  $a_k = \lfloor 6/k \rfloor$ : 6, 3, 2, 1, 1, 1, 0, 0, 0, ... This is weakly decreasing and eventually constant.

#### Rational numbers

### **Rational numbers**

We extended  $\mathbb N$  to  $\mathbb Z$  to make subtraction possible.

### **Rational numbers**

We extended  $\mathbb N$  to  $\mathbb Z$  to make subtraction possible.

Now we extend again to make division possible.

Now we extend again to make division possible.

Rational number: expression 
$$rac{a}{b}$$
 where  $a,b\in\mathbb{Z}$  and  $b
eq 0.$ 

Now we extend again to make division possible.

Rational number: expression  $\frac{a}{b}$  where  $a, b \in \mathbb{Z}$  and  $b \neq 0$ . But: we regard  $\frac{a}{b}$  and  $\frac{c}{d}$  as being the same if ad = bc.

Now we extend again to make division possible.

Rational number: expression 
$$rac{a}{b}$$
 where  $a, b \in \mathbb{Z}$  and  $b \neq 0$ .  
But: we regard  $rac{a}{b}$  and  $rac{c}{d}$  as being the same if  $ad = bc$ .

 ${\ensuremath{\mathbb Q}}$  denotes the set of rational numbers.

Now we extend again to make division possible.

Rational number: expression 
$$rac{a}{b}$$
 where  $a, b \in \mathbb{Z}$  and  $b \neq 0$ .  
But: we regard  $rac{a}{b}$  and  $rac{c}{d}$  as being the same if  $ad = bc$ .

 ${\ensuremath{\mathbb Q}}$  denotes the set of rational numbers.

In  $\mathbb{Q}$  we can add, subtract, multiply and divide (except by 0).

Now we extend again to make division possible.

Rational number: expression 
$$rac{a}{b}$$
 where  $a, b \in \mathbb{Z}$  and  $b \neq 0$ .  
But: we regard  $rac{a}{b}$  and  $rac{c}{d}$  as being the same if  $ad = bc$ .

 ${\ensuremath{\mathbb Q}}$  denotes the set of rational numbers.

In  $\mathbb{Q}$  we can add, subtract, multiply and divide (except by 0). These operations satisfy the familiar rules.