
Homework 1

Exercise 1 Consider two real sequences $(a_n)_{n \in \mathbb{N}}$ and $(b_n)_{n \in \mathbb{N}}$ such that $\lim_{n \rightarrow \infty} a_n = 0$ and $|b_n| \leq C$ for one $C > 0$ and all $n \in \mathbb{N}$ (we say that the sequence $(b_n)_{n \in \mathbb{N}}$ is bounded). Show that $\lim_{n \rightarrow \infty} a_n b_n = 0$.

Exercise 2 Show that the sequence $(a_n)_{n \in \mathbb{N}}$ given by $a_1 = 1$ and $a_{n+1} = 3 - \frac{1}{a_n}$ for any $n \geq 1$ is increasing and bounded from above by 3. Deduce that this sequence is convergent and give its limit.

Exercise 3 Consider the sequences $(a_n)_{n \in \mathbb{N}^*}$ defined below and show (with ε and N) that these sequences are convergent. Can you find their limit ?

(i) $a_n = \frac{1}{n^2}$,

(ii) $a_n = \sqrt{n+1} - \sqrt{n}$,

(iii) $a_n = \sqrt{n^2 + 5n} - n$.

More challenging: Consider $a_n = \left(1 + \frac{1}{n}\right)^n$ and show that the corresponding sequence is convergent. In your proof you can use the equality

$$(x + y)^n = \sum_{k=0}^n \binom{n}{k} x^k y^{n-k} = \sum_{k=0}^n \binom{n}{k} x^{n-k} y^k$$

with $\binom{n}{k} = \frac{n!}{k!(n-k)!}$.