

Series Convergence Tests
Math 122 Calculus III
D Joyce, Fall 2012

Some series converge, some diverge.

Geometric series. We've already looked at these. We know when a geometric series converges and what it converges to. A geometric series $\sum_{n=0}^{\infty} ar^n$ converges when its ratio r lies in the interval $(-1, 1)$, and, when it does, it converges to the sum $\frac{a}{1-r}$.

The harmonic series. The standard harmonic series $\sum_{n=1}^{\infty} \frac{1}{n}$ diverges to ∞ . Even though its terms $1, \frac{1}{2}, \frac{1}{3}, \dots$ approach 0, the partial sums S_n approach infinity, so the series diverges.

The main questions for a series.

Question 1: given a series does it converge or diverge?

Question 2: if it converges, what does it converge to?

There are several tests that help with the first question and we'll look at those now.

The term test. The only series that can converge are those whose terms approach 0. That is, if $\sum_{k=1}^{\infty} a_k$ converges, then $a_k \rightarrow 0$.

Here's why. If the series converges, then the limit of the sequence of its partial sums approaches the sum S , that is, $S_n \rightarrow S$ where S_n is the n^{th} partial sum $S_n = \sum_{k=1}^n a_k$. Then

$$\lim_{n \rightarrow \infty} a_n = \lim_{n \rightarrow \infty} (S_n - S_{n-1}) = \lim_{n \rightarrow \infty} S_n - \lim_{n \rightarrow \infty} S_{n-1} = S - S = 0.$$

The contrapositive of that statement gives a test which can tell us that some series diverge.

Theorem 1 (The term test). If the terms of the series don't converge to 0, then the series diverges.

Note, however, the terms converging to 0 doesn't imply the series converges, as the harmonic series gives a counterexample to that.

The term test can be used to show that the following series don't converge

$$\sum \frac{n}{n+1} \quad \sum \frac{n!}{n^2} \quad \sum (-1)^n \frac{n}{2n+1}$$

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Series Convergence Tests Math 122 Calculus Iii Clark U Book Review: Unveiling the Power of Words

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