International Journal of Physics and Mathematical Sciences ISSN: 2277-2111 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jpms.htm
2014 Vol. 4 (1) January-March, pp. 170-175/Durge
Research Article

NATURE OF SEQUENCE

$$\left\{\frac{c(n^{-m}+q)}{(n^{-m}+p)} \;/\; c \neq 0, p > q, p, q, m \in N\right\}$$

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ABSTRACT
This is my sincere efforts towards realization of Unchanging Truth. This work is dedicated to my spiritual teacher Sri SriRamakrishana .first I proved that $\{S_n\} = \left\{\frac{1}{n+1}\right\}$ is not convergent. Second I proved $\{S_n\} = \left\{\frac{1}{n+1}\right\}$ is not Cauchy sequence. Third I proved $\left\{\frac{1}{Kn^m+1} \;/\; k, m \in N\right\}$ is a monotonic, bounded, not Cauchy & not convergent sequence.Fourth I proved $\left\{\frac{(n^{-m})}{(n^{-m}+k)} \;/\; k, m \in N\right\}$ is a monotonic, bounded not Cauchy & not convergent sequence. Fifth I Proved $\left\{\frac{(n^{-m}+q)}{(n^{-m}+p)} \;/\; p, q, m \in N \;\&\; q > p\right\}$ is a monotonic, bounded, not Cauchy & not convergent sequence. Sixth I proved $\left\{\frac{c(n^{-m}+q)}{(n^{-m}+p)} \;/\; c \neq 0, p > q, p, q, m \in N\right\}$ is again a monotonic, bounded, not Cauchy & not Convergent Sequence. Seventh I proved that any sequence monotonic and bounded need not be a Convergent sequence.

Keywords: *Cauchy Sequence, Convergent Sequence, Monotone Sequence, Bounded Sequence*

INTRODUCTION

Kreyszig in 2007 cotes that 1.4-1 Definition (Convergence of a sequence, limit).
A sequence (x_n) in a metric space X = (X,d) is said converge or to be convergent if there is an x ϵ X such that

$$\lim_{n\to\propto} d(x_n, x) = 0.$$

X is called the limit of (x_n) and we write

$$\lim_{n\to\infty} x_n = x.$$

Or, simply,

$$X_n \to x$$

Convergence of sequences and related concepts in normed spaces follow readily from the corresponding definitions 1.4-1 and 1.4-3 for metric spaces and the fact that now
$d(x,y) = \|x - y\|$:

(i) A sequence (x_n) in s normed space X is convergent if X

$$\lim_{X\to\infty} \|x_n - x\| = 0.$$

Then we write $x_n \to x$ and call x the limit of (x_n).

(1) A sequence (x_n) in a normed space X is Cauchy if for every ϵ > 0 there is an N such that $\|x_m - x_n\| < \epsilon$ for all m, n > N.

G.F.Simmons cotes in (1) that
We say that $\{x_n\}$ is convergent if there exists a point x in X such that either

(1) for each ϵ > 0, there exists a positive integer n_0 such that
$n \geq n_0 \Rightarrow d(x_n,x) < \epsilon$; or equivalently,

(2) for each open sphere $S_\epsilon(x)$ centered on x, there exists a positive integer n_0 such that x_n is in $S_\epsilon(x)$ for all $n \geq n_0$.

that x_n is in $S_\epsilon(x)$ for all $n \geq n_0$.
Karade and Bendre cotes in (No Date) that

Limit of a sequence

Definition. A real number ∫ is said to be a limit of a real sequence s = ‹s_n› if for any $\varepsilon > 0$, there is a positive number M depending on ε such that

$$n > M \Rightarrow |s_n - \int| < \varepsilon \quad (3.1)$$

We write

$$\int = \lim s \text{ or } \int = \lim \langle s_n \rangle \text{ or } \lim_{n\to\infty} s_n = \int \text{ or } s_n \to \int.$$

Convergent sequence. If the limit of a sequence exists, the sequence is said to be *convergent*. If the sequence has no limit it is *divergent.*

Theorem 17. (Monotone convergence theorem)

A monotone sequence of real numbers is convergent if and only if it is bounded.

Cauchy sequence

A sequence ‹s_n› is called a Couchy sequence if for any $\varepsilon > 0, \exists\ a\ M \epsilon N$ such that

$$|s_m - s_n| < \epsilon, \forall\, m, n \geq M. \quad (6.1)$$

Theorem 21. Every convergent sequence of real numbers is a Cauchy sequence.

Walter Rudin cotes in 1976

3.1 Definition A sequence $\{p_n\}$ in a metric space X is said to converge if there is a point $p\ \varepsilon\ X$ with the following property: For every $\varepsilon > 0$ there is an integer N such that $n \geq N$ implies that $d(p_n,p) < \varepsilon$. (Here d denotes the distance in X.)

In this case we also say that $\{p_n\}$ converges to p, or that p is the limit of
(p_n) [see Theorem 3.2(b)], and we write $p_n \to p$, or

$$\lim_{n\to\infty} p_n = p.$$

if $\{p_n\}$ does not converge, it is said to *diverge.*

Cauchy Sequences

3.8 Definition A sequence $\{p_n\}$ in a metric space x is said to be a Cauchy sequence if for every $\varepsilon > 0$ there is an integer N such $d(p_n, p_m) < \varepsilon\ if\ n \geq N$
and $m \geq N$.

In our discussion of Cauchy sequences, as well as in other situations which will arise later, the following geometric concept will be useful.

3.14 Theorem Suppose $\{s_n)$ is monotonic. Then $\{s_n\}$ is converges if and only if it is bounded.

Hardy cotes in 2010

The meaning of the above equation, expressed roughly, is that by adding more and more of the u's together we get nearer and nearer to the limit s. More precisely, if any small positive number ∂ is chosen, we can choose $n_0\ (\partial)$ so that the sum of the first $n_0\ (\partial)$ terms, or of any greater number of terms, lies between
$s - \partial$ and $s + \partial$; or in symbols

$$s - \partial < s_n < s + \partial,$$

if $n \geqq n_0(\partial)$. In these circumstances we shall call the series

$$u_1 + u_2 + \ldots$$

A convergent infinite series, and we shall call s the sum of the series, or the sum of all the terms of the series.

Khanna cotes in 1995

2.7 Limit of a Sequence:

Definition. Assume $<s_n: n \in N>$ is a sequence of real numbers. Then s_n approaches the limit '∫' as n approaches infinity, if for each $\in > 0$ there exists a positive integer m such that $n \geq m \Rightarrow | s_n - \int | < \in$

We observe that $| s_n - \int | < \in$ means

$$\int - \in < s_n < \int + \in$$

or equivalently s_n belonges to the open interval $] \int - \in, \int + \in [$ containing '∫'.

If: S_n approaches the limit '∫', we write

$$\lim_{n \to \infty} S_n = \int$$

$$\text{or } n \to \infty \Rightarrow s_n \to \int$$

2.11. Divergent Sequences:

Definition. Assume $<s_n>$ is a sequence of real numbers.

Then $<s_n>$ is said to diverge to ∞ or is said to be divergent to ∞ if for a real number $r > 0$ there exists a positive integer $m(\epsilon)$ such that

$$n \geq m \Rightarrow s_n > r$$

In this case, we write $n \to \infty \Rightarrow s_n \to \infty$

(i1) A sequence $<s_n>$ is said to diverge to $-\infty$ if for a real number $r < 0$, there exists a positive integer $m(\epsilon) > 0$ such that

$$n \geq m \Rightarrow s_n > r$$

We then write $n \to \infty \Rightarrow s_n \to -\infty$.

Theorem11. (Monotone Convergence Theorem).

A monotone sequence which is bounded is convergent.

Equivalently, a necessary and sufficient condition for convergence of a monotone sequence is that it is bounded (Bihar 1980).

2.21 Cauchy Fundamental Sequence.

Definition. Assume $<s_n: n \in N <$ is a sequence of real numbers. Then $<s_n>$ is called a Cauchy sequence if for any $\epsilon > 0$ there exists a positive integer p such that

$$m, n \geq p \Rightarrow | s_m - s_n | < \epsilon.$$

Roughly, $<s_n>$ is Cauchy if s_m and s_n are close together when m and n are large.

DISCUSSION

1) Sequence $\left\{\frac{1}{n+1}\right\}$ is monotonic.

Let $S_n = \frac{1}{n+1}$, $S_{n+1} = \frac{1}{n+2}$

$$S_{n+1} - S_n = \frac{1}{n+2} - \frac{1}{n+1} = \frac{-1}{(n+2)(n+1)} \leq 0$$

$\Rightarrow S_{n+1} \leq S_n, \forall n \in N$

$\Rightarrow \{S_n\} = \left\{\frac{1}{n+1}\right\}$ is monotonic decreasing.

2) Sequence $\left\{\frac{1}{n+1}\right\}$ is bounded.

Let $S_n = \frac{1}{n+1}$

$\Rightarrow S_1 = \frac{1}{2}, S_2 = \frac{1}{3}, \ldots\ldots$

$\Rightarrow |S_n| \leq \frac{1}{2}, \forall n \in N$

Hence $\left\{\frac{1}{n+1}\right\}$ is bounded.

3) $\{S_n\} = \left\{\frac{1}{n+1}\right\}$is not convergent.

Let $S_n = \frac{1}{n+1}$

Now we assume that $\{S_n\}$ is convergent and converges to l.

∴ Bydefinition ,For each $\varepsilon > 0$, there exist a positive integer M

Such that $|S_n - l| < \varepsilon , \forall n > M$

i.e.$l - \varepsilon < S_n < l + \varepsilon , \forall n > M$

i.e. $\frac{1}{l-\varepsilon} > \frac{1}{S_n} > \frac{1}{l+\varepsilon}$,

i.e.$\frac{1}{l-\varepsilon} > (n+1) > \frac{1}{l+\varepsilon}$

i.e.$\frac{1}{l-\varepsilon} - 1 > n > \frac{1}{l+\varepsilon} - 1$

i.e.$\frac{1-l+\varepsilon}{l-\varepsilon} > n > \frac{1-l-\varepsilon}{l+\varepsilon}$

i.e.$\frac{1-(l-\varepsilon)}{l-\varepsilon} > n > \frac{1-(l+\varepsilon)}{l+\varepsilon}$
when$(1-l) - \varepsilon < 0$, i.e. $1 - l < \varepsilon$,

$$i.e. 1 - (l - \varepsilon) < 2\varepsilon$$

$$\frac{1-(l-\varepsilon)}{l+\varepsilon} = -ve \ \&$$

When $(1-l) - \varepsilon < 0$,
i.e. $-l < \varepsilon$, $i.e. 1 - (l-\varepsilon) < 2\varepsilon$ $i.e. 1 - 2\varepsilon < (l - \varepsilon)$

$\frac{1-(l-\varepsilon)}{l-\varepsilon} < \frac{2\varepsilon}{l-\varepsilon}$, Hence$\frac{2\varepsilon}{l-\varepsilon} > n > (-ve)$ quantity $= \frac{1-(l-\varepsilon)}{l+\varepsilon}$

Now selecting $\varepsilon = (1-l) + 0.0025$

a) $\frac{1-(l-\varepsilon)}{l+\varepsilon} = \frac{-0.00225}{l+1-l+0.00225}$

$$= \frac{-0.00225}{1.00225} = (-ve)\ quantity$$

b) $\frac{2\varepsilon}{l-\varepsilon} = \frac{2\{(1-l)+0.0025\}}{l-\{(1-l)+0.0025} = \frac{2-2l+00.0050}{2l-1+0.0025}$

$$= \frac{2.0050 - 2l}{2l - 1.0025} = \frac{-(2.0050 - 2l)}{1.0025 - 2l}$$

$$= (-ve)\ quantity$$

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Hence no $+ve$ integer exist for $\varepsilon = (1 - l) + 0.0025$

i.e. definition does not hold.
$=> \{S_n\} = \left\{\frac{1}{n+1}\right\}$is not convergent.

4) $\{S_n\} = \left\{\frac{1}{n+1}\right\}$is not Cauchy sequence.

Let $S_n = \frac{1}{n+1}$&$S_m = \frac{1}{m+1}$, = >$|S_m - S_n| = \frac{m-n}{(m+n)(m-n)}$

Now we assume $\left\{\frac{1}{n+1}\right\}$ is a Cauchy sequence

∴ By definition of Cauchy sequence , For each > 0 , there exist a +ve integer M

Such that $|S_m - S_n| < \varepsilon , \forall\, n, m \geq M$.

Let n = M & m = 2M
$$=> |S_m - S_n| = \frac{M}{(2M+1)(M+1)} = \frac{M}{2M^2 + 3M + 1} < \varepsilon$$

$$=> \ 2M^2 + (3 - \frac{1}{\varepsilon})M + 1 > 0$$

$$\text{i.e.} M^2 + \left(\frac{3}{2} - \frac{1}{2\varepsilon}\right) M + \frac{1}{2} > 0$$

$$\text{i.e.} M = \frac{-\left(\frac{3}{2} - \frac{1}{2\varepsilon}\right) \pm \sqrt{\left(\frac{3}{2} - \frac{1}{2\varepsilon}\right)^2 - 4.\frac{1}{2}}}{2}$$

$$= -\left(\frac{3}{4} - \frac{1}{4\varepsilon}\right) \pm \sqrt{\left(\frac{3}{4} - \frac{1}{4\varepsilon}\right)^2 - \frac{1}{2}}$$

$$=> \ M = -\left(\frac{3}{4} - \frac{1}{4\varepsilon}\right) \pm \sqrt{\frac{1}{16}\left(3 - \frac{1}{\varepsilon}\right)^2 - \frac{1}{2}}$$

Is negative for $\varepsilon = \frac{1}{16}\left(3 - \frac{1}{\varepsilon}\right)^2 - \frac{1}{2} > 0$ if I select $= \frac{1}{3}$, Then M definitely a Complex quantity.Hence M is not a +ve integer

$=> definition\ fails.$
$=> \left\{\frac{1}{n+1}\right\}$is not Cauchy sequence.

5) $\left\{\frac{1}{An+1}\right\}$ has a similar behaviour as that of $\left\{\frac{1}{n+1}\right\}$ if $A_n \geq n , \forall\, n \in N.$

$i.e.\left\{\frac{1}{An+1}\right\}$ is monotonic, bounded, not convergent and not Cauchy.

$i.e.\left\{\frac{1}{Kn^m+1} \ / \ k, m \in N\right\}$ is a monotonic, bounded, not Cauchy & not convergent sequence.

$\left\{\frac{(n^{-m})}{(n^{-m}+k)} \ / \ k,m \in N\right\}$is a monotonic, bounded not Cauchy & not convergent sequence.

6) $\left\{\frac{(n^{-m}+q)}{(n^{-m}+p)} \ / \ p,q,m \in N \ \& \ q > p\right\}$is in the form of $\left\{\frac{n}{n+k}\right\}ifn^{-m}+q = N_0$.

Hence $\left\{\frac{(n^{-m}+q)}{(n^{-m}+p)} \ / \ p,q,m \in N \ \& \ q > p\right\}$ is a monotonic, bounded, not Cauchy & not convergent sequence.

7) $\left\{\frac{c(n^{-m}+q)}{(n^{-m}+p)} \ / \ c \neq 0, p > q, p,q,m \in N\right\}$ is again a

monotonic, bounded , not Cauchy & not Convergent Sequence.

Conclusion

From the discussion (1) to (7) and method of Counter example in mathematical analysis I come to the following conclusions first I proved that $\{S_n\} = \left\{\frac{1}{n+1}\right\}$ is not convergent. Second I proved $\{S_n\} = \left\{\frac{1}{n+1}\right\}$ is not Cauchy sequence. Third I proved $\left\{\frac{1}{Kn^m+1} \ / \ k,m \in N\right\}$ is a monotonic, bounded, not Cauchy & not convergent sequence.Fourth I proved $\left\{\frac{(n^{-m})}{(n^{-m}+k)} \ / \ k,m \in N\right\}$ is a monotonic, bounded not Cauchy & not convergent sequence. Fifth I Proved $\left\{\frac{(n^{-m}+q)}{(n^{-m}+p)} \ / \ p,q,m \in N \ \& \ q > p\right\}$ is a monotonic, bounded, not Cauchy & not convergent sequence. Sixth I proved $\left\{\frac{c(n^{-m}+q)}{(n^{-m}+p)} \ / \ c \neq 0, p > q, p,q,m \in N\right\}$ is again a monotonic, bounded , not Cauchy & not Convergent Sequence. Seventh I proved that any sequence monotonic and bounded need not be a Convergent sequence.

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