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Sequences in $\mathcal{E}^N_{\rm T}$

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The articles [10], [11], [12], [2], [5], [6], [8], [9], [1], [3], [4], and [7] provide the notation and terminology for this paper.

Let N be a natural number. A sequence in $\mathcal{E}^N_{\rm T}$ is a sequence of $\mathcal{E}^N_{\rm T}$.

For simplicity, we follow the rules: N, n, m are natural numbers, q, r, r_1, r_2 are real numbers, x is a set, w, w_1, w_2, g are points of $\mathcal{E}^N_{\rm T}$, and s_1, s_2, s_3, s_4, s'_1 are sequences in $\mathcal{E}^N_{\rm T}$.

Next we state the proposition

(2)[1] Let f be a function. Then f is a sequence in $\mathcal{E}^N_{\rm T}$ if and only if $\operatorname{dom} f = \mathbb{N}$ and for every n holds $f(n)$ is a point of $\mathcal{E}^N_{\rm T}$.

Let us consider N and let I_1 be a sequence in $\mathcal{E}^N_{\rm T}$. We say that I_1 is non-zero if and only if:

(Def. 1) $\operatorname{rng} I_1 \subseteq (\text{the carrier of } \mathcal{E}^N_{\rm T}) \setminus \{0_{\mathcal{E}^N_{\rm T}}\}$.

One can prove the following propositions:

(3) s_1 is non-zero iff for every x such that $x \in \mathbb{N}$ holds $s_1(x) \neq 0_{\mathcal{E}^N_{\rm T}}$.

(4) s_1 is non-zero iff for every n holds $s_1(n) \neq 0_{\mathcal{E}^N_{\rm T}}$.

(5) For all N, s_1, s_2 such that for every x such that $x \in \mathbb{N}$ holds $s_1(x) = s_2(x)$ holds $s_1 = s_2$.

(6) For all N, s_1, s_2 such that for every n holds $s_1(n) = s_2(n)$ holds $s_1 = s_2$.

The scheme *ExTopRealNSeq* deals with a natural number $\mathcal{A}$ and a unary functor $\mathcal{F}$ yielding a point of $\mathcal{E}^{\mathcal{A}}_{\rm T}$, and states that:

There exists a sequence s_1 in $\mathcal{E}^{\mathcal{A}}_{\rm T}$ such that for every n holds $s_1(n) = \mathcal{F}(n)$

for all values of the parameters.

Let us consider N, s_2, s_3. The functor $s_2 + s_3$ yielding a sequence in $\mathcal{E}^N_{\rm T}$ is defined as follows:

(Def. 2) For every n holds $(s_2 + s_3)(n) = s_2(n) + s_3(n)$.

Let us consider r, N, s_1. The functor $r \cdot s_1$ yields a sequence in $\mathcal{E}^N_{\rm T}$ and is defined as follows:

(Def. 3) For every n holds $(r \cdot s_1)(n) = r \cdot s_1(n)$.

Let us consider N, s_1. The functor $-s_1$ yielding a sequence in $\mathcal{E}^N_{\rm T}$ is defined as follows:

[1] The proposition (1) has been removed.

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(Def. 4) For every n holds $(-s_1)(n) = -s_1(n)$.

Let us consider N, s_2, s_3. The functor $s_2 - s_3$ yields a sequence in $\mathcal{E}^N_{\mathrm{T}}$ and is defined by:

(Def. 5) $s_2 - s_3 = s_2 + -s_3$.

Let us consider N and let x be a point of $\mathcal{E}^N_{\mathrm{T}}$. The functor $|x|$ yielding a real number is defined by:

(Def. 6) There exists a finite sequence y of elements of $\mathbb{R}$ such that $x = y$ and $|x| = |y|$.

Let us consider N, s_1. The functor $|s_1|$ yields a sequence of real numbers and is defined as follows:

(Def. 7) For every n holds $|s_1|(n) = |s_1(n)|$.

One can prove the following propositions:

(8)[2] $|r| \cdot |w| = |r \cdot w|$.

(9) $|r \cdot s_1| = |r|\,|s_1|$.

(10) $s_2 + s_3 = s_3 + s_2$.

(11) $(s_2 + s_3) + s_4 = s_2 + (s_3 + s_4)$.

(12) $-s_1 = (-1) \cdot s_1$.

(13) $r \cdot (s_2 + s_3) = r \cdot s_2 + r \cdot s_3$.

(14) $(r \cdot q) \cdot s_1 = r \cdot (q \cdot s_1)$.

(15) $r \cdot (s_2 - s_3) = r \cdot s_2 - r \cdot s_3$.

(16) $s_2 - (s_3 + s_4) = s_2 - s_3 - s_4$.

(17) $1 \cdot s_1 = s_1$.

(18) $--s_1 = s_1$.

(19) $s_2 - -s_3 = s_2 + s_3$.

(20) $s_2 - (s_3 - s_4) = (s_2 - s_3) + s_4$.

(21) $s_2 + (s_3 - s_4) = (s_2 + s_3) - s_4$.

(22) If $r \neq 0$ and s_1 is non-zero, then $r \cdot s_1$ is non-zero.

(23) If s_1 is non-zero, then $-s_1$ is non-zero.

(24) $|0_{\mathcal{E}^N_{\mathrm{T}}}| = 0$.

(25) If $|w| = 0$, then $w = 0_{\mathcal{E}^N_{\mathrm{T}}}$.

(26) $|w| \geq 0$.

(27) $|-w| = |w|$.

(28) $|w_1 - w_2| = |w_2 - w_1|$.

(29) $|w_1 - w_2| = 0$ iff $w_1 = w_2$.

(30) $|w_1 + w_2| \leq |w_1| + |w_2|$.

(31) $|w_1 - w_2| \leq |w_1| + |w_2|$.

[2] The proposition (7) has been removed.

(32) $|w_1| - |w_2| \leq |w_1 + w_2|$.

(33) $|w_1| - |w_2| \leq |w_1 - w_2|$.

(34) If $w_1 \neq w_2$, then $|w_1 - w_2| > 0$.

(35) $|w_1 - w_2| \leq |w_1 - w| + |w - w_2|$.

(36) If $0 \leq r_1$ and $|w_1| < |w_2|$ and $r_1 < r_2$, then $|w_1| \cdot r_1 < |w_2| \cdot r_2$.

(38)[3] $-|w| < r$ and $r < |w|$ iff $|r| < |w|$.

Let us consider N and let I_1 be a sequence in $\mathcal{E}^N_{\mathrm{T}}$. We say that I_1 is bounded if and only if:

(Def. 8) There exists r such that for every n holds $|I_1(n)| < r$.

The following proposition is true

(39) For every n there exists r such that $0 < r$ and for every m such that $m \leq n$ holds $|s_1(m)| < r$.

Let us consider N and let I_1 be a sequence in $\mathcal{E}^N_{\mathrm{T}}$. We say that I_1 is convergent if and only if:

(Def. 9) There exists g such that for every r such that $0 < r$ there exists n such that for every m such that $n \leq m$ holds $|I_1(m) - g| < r$.

Let us consider N, s_1. Let us assume that s_1 is convergent. The functor $\lim s_1$ yielding a point of $\mathcal{E}^N_{\mathrm{T}}$ is defined by:

(Def. 10) For every r such that $0 < r$ there exists n such that for every m such that $n \leq m$ holds $|s_1(m) - \lim s_1| < r$.

One can prove the following propositions:

(41)[4] If s_1 is convergent and s'_1 is convergent, then $s_1 + s'_1$ is convergent.

(42) If s_1 is convergent and s'_1 is convergent, then $\lim(s_1 + s'_1) = \lim s_1 + \lim s'_1$.

(43) If s_1 is convergent, then $r \cdot s_1$ is convergent.

(44) If s_1 is convergent, then $\lim(r \cdot s_1) = r \cdot \lim s_1$.

(45) If s_1 is convergent, then $-s_1$ is convergent.

(46) If s_1 is convergent, then $\lim(-s_1) = -\lim s_1$.

(47) If s_1 is convergent and s'_1 is convergent, then $s_1 - s'_1$ is convergent.

(48) If s_1 is convergent and s'_1 is convergent, then $\lim(s_1 - s'_1) = \lim s_1 - \lim s'_1$.

(50)[5] If s_1 is convergent, then s_1 is bounded.

(51) If s_1 is convergent, then if $\lim s_1 \neq 0_{\mathcal{E}^N_{\mathrm{T}}}$, then there exists n such that for every m such that $n \leq m$ holds $\frac{|\lim s_1|}{2} < |s_1(m)|$.

[3] The proposition (37) has been removed.
[4] The proposition (40) has been removed.
[5] The proposition (49) has been removed.

REFERENCES

[1] Grzegorz Bancerek and Krzysztof Hryniewiecki. Segments of natural numbers and finite sequences. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/finseq_1.html.

[2] Czesław Byliński. Functions and their basic properties. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/funct_1.html.

[3] Czesław Byliński. Finite sequences and tuples of elements of a non-empty sets. *Journal of Formalized Mathematics*, 2, 1990. http://mizar.org/JFM/Vol2/finseq_2.html.

[4] Agata Darmochwał. The Euclidean space. *Journal of Formalized Mathematics*, 3, 1991. http://mizar.org/JFM/Vol3/euclid.html.

[5] Krzysztof Hryniewiecki. Basic properties of real numbers. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/real_1.html.

[6] Jarosław Kotowicz. Real sequences and basic operations on them. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/seq_1.html.

[7] Beata Padlewska and Agata Darmochwał. Topological spaces and continuous functions. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/pre_topc.html.

[8] Jan Popiołek. Some properties of functions modul and signum. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/absvalue.html.

[9] Jan Popiołek. Real normed space. *Journal of Formalized Mathematics*, 2, 1990. http://mizar.org/JFM/Vol2/normsp_1.html.

[10] Andrzej Trybulec. Tarski Grothendieck set theory. *Journal of Formalized Mathematics*, Axiomatics, 1989. http://mizar.org/JFM/Axiomatics/tarski.html.

[11] Andrzej Trybulec. Subsets of real numbers. *Journal of Formalized Mathematics*, Addenda, 2003. http://mizar.org/JFM/Addenda/numbers.html.

[12] Edmund Woronowicz. Relations and their basic properties. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/relat_1.html.

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