

Analysis of an infinite sequence

Assignment

Now we will expand our investigation to determine the sum of the infinite sequence t_n , where $t_0=1, t_1=(x \ln a), t_2=(x \ln a)^2 2x, t_3=(x \ln a)^3 3x^2, \dots$

Define $T_n(a, x)$ as the sum of the first n terms, for various values of a and x .

e.g. $T_9(2, 9)$ is the sum of the first nine terms when $a=2$ and $x=5$.

Let $a=2$. Calculate $T_9(2, x)$ for various positive values of x . Using technology, plot the relation between $T_9(2, x)$ and x . Describe what you notice from your plot.

Let $a=3$. Calculate $T_9(3, x)$ for various positive values of x . Using technology, plot the relation between $T_9(3, x)$ and x . Describe what you notice from your plot.

Continue with this analysis to find the general statement for $T_n(a, x)$ as n approaches ∞ .

Test the validity of the general statement with other values of a and x .

Discuss the scope and/or limitations of the general statement.

Explain how you arrived at the general statement.

Work

1. First we will use the mathematical program Derive™ 6 to calculate the sum of the first 9 terms of the sequence when $a=2$, for various values of x .

The expression has the following form:

SUM(Expression, summation parameter, lower boundary, upper boundary)

Which in our case makes:

SUM(((x*ln(2))^n)/n!, n, 0, 9)

Derive™ 6 then shows the following:

$$n=09(x \cdot \text{LN}(2))n!$$

Option Simplify gives us the expanded form of the sum:

$$x^9 \text{LN}(a)^9 362880 + x^8 \text{LN}(a)^8 40320 + x^7 \text{LN}(a)^7 5040 + x^6 \text{LN}(a)^6 6720 + x^5 \text{LN}(a)^5 5120 + x^4 \text{LN}(a)^4 424 + x^3 \text{LN}(a)^3 36 + x^2 \text{LN}(a)^2 22 + x \cdot \text{LN}(a) + 1$$

By using the button \approx , the following results were reached for arbitrarily chosen values of x:

n	a	x	Tn(a,x)
9	2	0.1	1.071773462
9	2	0.2	1.148698354
9	2	0.5	1.414213562
9	2	1	2
9	2	2	3.999991747
9	2	3	7.999488457
9	2	8	241.6244730
9	2	10	857.4734736

TABLE 1. Calculated sums of 9 terms of the sequence for various values of x when a=2

The calculated value for x=1 stands out, being an integer.

We now write a MATLAB© program to plot the sum as a function of x.

The main program code:

```
a=2;
```

```
n=9; % the number of terms contained in the sum
```

```
L=log(a); % To avoid needless calculation in each iteration,
```

```
% the natural logarithm is calculated at the beginning.
```

```
Tn=0; % Setting the initial sum of the sequence to zero.
```

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