

Title

D. Zack Garza

August 21, 2019

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0.1 Exercises

Problem 1.

Let C denote the Cantor set.

1. Show that C contains point that is not an endpoint of one of the removed intervals.
2. Show that C is nowhere dense, meager, and has measure zero.
3. Show that C is uncountable.

Solution 1.

1. First we will characterize the endpoints of the removed intervals. Let C_n be the n th stage of the deleting process used to define the Cantor set; then what remains is a union of intervals:

$$C_n = [0, \frac{1}{3^n}] \cup [\frac{2}{3^n}, \frac{3}{3^n}] \cup \cdots \cup [\frac{3^n - 1}{3^n}, 1],$$

and so the endpoints are precisely the numbers of the form $\frac{k}{3^n}$ where $0 \leq k \leq 3^n$. Moreover, any endpoint appearing in C_n is never removed in any later step, and so all endpoints remaining in C are of this form where we allow $0 \leq n < \infty$.

Thus, our goal is to produce a number $x \in [0, 1]$ such that $x \neq \frac{k}{3^n}$ for any k or n , but also satisfies $x \in C$.

To this end, we will use the fact that if $x \in C$, then one can take its ternary expansion and find that all of its digits are either 0 or 2, i.e.

$$x = \sum a_k 3^{-k} \text{ where } a_k \in \{0, 2\}.$$