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3.6

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Post subject: Re: 3.6

Posted: Thu, 07 May 2020 13:47

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Getting there.

Case 1: Isn't $f(x) = 1$, if x is rational? Also: How do you know $L > 1/2$, if you only assume $L \neq 0$?

The greater danger for most of us lies not in setting our aim too high and falling short; but in setting our aim too low, and achieving our mark. - Michelangelo Buonarroti

Joined: Sat, 26 Apr 2003
15:14
Posts: 2284
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Post subject: Re: 3.6

Posted: Thu, 07 May 2020 23:21

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Joined: Mon, 30 Mar 2020
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Let $f : (0, 1] \rightarrow \mathbb{R}$ be defined by

$$f(x) = \begin{cases} 1 & x \in \mathbb{Q} \\ 0 & x \in \mathbb{R} \setminus \mathbb{Q} \end{cases}$$

For which values of x_0 does $f(x)$ have a limit at x_0 ? What is the limit?

Based on some feedback from office hours. Based off the definition of f , then $f(x)$ is either 1 or 0 based on whether it is rational or irrational.

Assume that the limit exists.

Then $\exists c \in \{0, 1\}$ s.t. $\lim_{x \rightarrow x_0} f(x) = c$

By the definition of the limit (and borrowing Estefany's work from 3.3, and Abigail and Jocelyne's work from 4.6), we say

$\forall \varepsilon > 0, \exists \delta > 0$ such that $|f(x) - c| < \varepsilon$
 whenever $x \in (x_0 - \delta, x_0 + \delta) \cap (0, 1] \setminus \{x_0\}$
 and $0 < |x - x_0| < \delta$

Let $\varepsilon = \frac{1}{2}, \delta > 0$

Using what we know about the rational and irrational numbers being dense in $\mathbb{R}$ from 1.10 and 1.11, respectively,

$\forall a, b \in \mathbb{R} \exists x \in \mathbb{Q} \text{ s.t. } a < x < b$
 $\forall a, b \in \mathbb{R} \exists y \in \mathbb{R} \setminus \mathbb{Q} \text{ s.t. } a < y < b$

Since $(x_0 \pm \delta) \in \mathbb{R}$

Then $\exists x \in (x_0 - \delta, x_0 + \delta) \cap (0, 1] \setminus \{x_0\} \text{ s.t. } f(x) = 1$
 and $\exists y \in (x_0 - \delta, x_0 + \delta) \cap (0, 1] \setminus \{x_0\} \text{ s.t. } f(y) = 0$

Now for

$x, y \in (x_0 - \delta, x_0 + \delta) \cap (0, 1] \setminus \{x_0\}$
 such that $|x - x_0| < \delta$ and $|y - x_0| < \delta$

Then it should be the case $|f(x) - f(y)| < \varepsilon$ when $|x - y| < \delta$

Yet, for our given x, y values,

$$|f(x) - f(y)| < \varepsilon \iff |1 - 0| < \frac{1}{2} \iff 1 < \frac{1}{2}$$

which is false. Thus $|f(x) - f(y)| \geq \varepsilon$

This contradicts the given hypothesis, $\exists c \in \{0, 1\} \text{ s.t. } \lim_{x \rightarrow x_0} f(x) = c$,
 therefore,
 $\lim_{x \rightarrow x_0} f(x)$ does not exist.



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