

# 1-3 Study Guide and Intervention

## Continuity, End Behavior, and Limits

**Continuity** A function  $f(x)$  is **continuous** at  $x = c$  if it satisfies the following conditions.

- (1)  $f(x)$  is defined at  $c$ ; in other words,  $f(c)$  exists.
- (2)  $f(x)$  approaches the same function value to the left and right of  $c$ ; in other words,  $\lim_{x \rightarrow c} f(x)$  exists.
- (3) The function value that  $f(x)$  approaches from each side of  $c$  is  $f(c)$ ; in other words,  $\lim_{x \rightarrow c} f(x) = f(c)$ .

Functions that are not continuous are **discontinuous**. Graphs that are discontinuous can exhibit **infinite discontinuity**, **jump discontinuity**, or **removable discontinuity** (also called **point discontinuity**).

**Example:** Determine whether each function is continuous at the given  $x$ -value. Justify using the continuity test. If discontinuous, identify the type of discontinuity as *infinite*, *jump*, or *removable*.

a.  $f(x) = 2|x| + 3$ ;  $x = 2$

- (1)  $f(2) = 7$ , so  $f(2)$  exists.
- (2) Construct a table that shows values for  $f(x)$  for  $x$ -values approaching 2 from the left and from the right.

$x$	$y = f(x)$
1.9	6.8
1.99	6.98
1.999	6.998

$x$	$y = f(x)$
2.1	7.2
2.01	7.02
2.001	7.002

The tables show that  $y$  approaches 7 as  $x$  approaches 2 from both sides.

It appears that  $\lim_{x \rightarrow 2} f(x) = 7$ .

(3)  $\lim_{x \rightarrow 2} f(x) = 7$  and  $f(2) = 7$ .

The function is continuous at  $x = 2$ .

b.  $f(x) = \frac{2x}{x^2 - 1}$ ;  $x = 1$

The function is not defined at  $x = 1$  because it results in a denominator of 0.

The tables show that for values of  $x$  approaching 1 from the left,  $f(x)$  becomes increasingly more negative.

For values approaching 1 from the right,  $f(x)$  becomes increasingly more positive.

$x$	$y = f(x)$
0.9	-9.5
0.99	-99.5
0.999	-999.5

$x$	$y = f(x)$
1.1	10.5
1.01	100.5
1.001	1000.5

The function has infinite discontinuity at  $x = 1$ .

### Exercises

Determine whether each function is continuous at the given  $x$ -value.

Justify your answer using the continuity test. If discontinuous, identify the type of discontinuity as *infinite*, *jump*, or *removable*.

1.  $f(x) = \begin{cases} 2x + 1 & \text{if } x > 2 \\ x - 1 & \text{if } x \leq 2 \end{cases}$ ;  $x = 2$


2.  $f(x) = x^2 + 5x + 3$ ;  $x = 4$

$\lim_{x \rightarrow 2^-} f(x) = 1$  and  $\lim_{x \rightarrow 2^+} f(x) = 5$ ,  
so the function is not continuous;  
it has jump discontinuity.

$\lim_{x \rightarrow 4^-} f(x) = 39$  and  $\lim_{x \rightarrow 4^+} f(x) = 39$ ,  
so the function is continuous.

# Cpcb Branch 3 Study Guide

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