

Recitation #4 - 2.3: Limit Laws

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Warm up: Below is a table listing all of the Limit Laws, followed by an argument of what the limit of $\frac{5x^3 - 4\sqrt{x}}{\sqrt{x^5 - 87}}$ as x approaches 3 must be. State which limit law is used to justify each step.

THEOREM 2.3 Limit Laws

Assume $\lim_{x \rightarrow a} f(x)$ and $\lim_{x \rightarrow a} g(x)$ exist. The following properties hold, where c is a real number and $m > 0$ and $n > 0$ are integers.

1. **Sum** $\lim_{x \rightarrow a} [f(x) + g(x)] = \lim_{x \rightarrow a} f(x) + \lim_{x \rightarrow a} g(x)$
2. **Difference** $\lim_{x \rightarrow a} [f(x) - g(x)] = \lim_{x \rightarrow a} f(x) - \lim_{x \rightarrow a} g(x)$
3. **Constant multiple** $\lim_{x \rightarrow a} [c f(x)] = c \lim_{x \rightarrow a} f(x)$
4. **Product** $\lim_{x \rightarrow a} [f(x) g(x)] = \left[\lim_{x \rightarrow a} f(x) \right] \left[\lim_{x \rightarrow a} g(x) \right]$
5. **Quotient** $\lim_{x \rightarrow a} \left[\frac{f(x)}{g(x)} \right] = \frac{\lim_{x \rightarrow a} f(x)}{\lim_{x \rightarrow a} g(x)}$, provided $\lim_{x \rightarrow a} g(x) \neq 0$
6. **Power** $\lim_{x \rightarrow a} [f(x)]^n = \left[\lim_{x \rightarrow a} f(x) \right]^n$
7. **Fractional power** $\lim_{x \rightarrow a} [f(x)]^{n/m} = \left[\lim_{x \rightarrow a} f(x) \right]^{n/m}$, provided $f(x) \geq 0$, for x near a , if m is even and n/m is reduced to lowest terms

$$\begin{aligned}
 & \lim_{x \rightarrow 3} \left(\frac{5x^3 - 4\sqrt{x}}{\sqrt{x^5 - 87}} \right) \\
 &= \frac{\lim_{x \rightarrow 3} (5x^3 - 4\sqrt{x})}{\lim_{x \rightarrow 3} \sqrt{x^5 - 87}} \\
 &= \frac{5 \lim_{x \rightarrow 3} (x^3) - 4 \lim_{x \rightarrow 3} \sqrt{x}}{\sqrt{\lim_{x \rightarrow 3} (x^5 - 87)}} \\
 &= \frac{5(\lim_{x \rightarrow 3} x)^3 - 4\sqrt{3}}{\sqrt{\lim_{x \rightarrow 3} (x^5) - \lim_{x \rightarrow 3} (87)}} \\
 &= \frac{5(3)^3 - 4\sqrt{3}}{\sqrt{3^5 - 87}} \\
 &= \frac{135 - 4\sqrt{3}}{\sqrt{156}}
 \end{aligned}$$

Know: $\lim_{x \rightarrow a} (x) = a$
 and $\lim_{x \rightarrow a} (c) = c$, where c is a constant

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Group work:

Problem 1 Evaluate the following limits algebraically using the limit laws.

(a) $\lim_{x \rightarrow 6} \frac{4x^2 - 144}{x - 6}$

(b) $\lim_{x \rightarrow 6} \frac{x - 6}{\sqrt{2x - 8} - 2}$

(c) $\lim_{x \rightarrow 2} \frac{(3x - 2)^2 - 16}{x - 2}$

(d) $\lim_{x \rightarrow 1} \frac{\sqrt{5x - 2} - \sqrt{3}}{x - 1}$

Problem 2 Suppose $f(x) = \begin{cases} x^2 - ax & \text{if } x < 3 \\ a2^x + 7 + a & \text{if } x > 3 \end{cases}$

Find a so that $\lim_{x \rightarrow 3} f(x)$ exists.

Problem 3 Sketch the graph of a function with the given properties. You need not find a formula for the function:

$$f(3) = -2, f(-2) = 3, f(5) = 6, \lim_{x \rightarrow 5^-} f(x) = -1, \lim_{x \rightarrow 5^+} f(x) = 4, \lim_{x \rightarrow 3} f(x) = 7$$

$$\lim_{x \rightarrow -2^-} f(x) = 3, \lim_{x \rightarrow -2^+} f(x) = 0, \lim_{x \rightarrow 1^+} f(x) = 5$$