Higher Order derivatives

**Distance** - \( f(x) \)
- **Velocity** - \( f'(x) \)
- **Acceleration** - \( f''(x) \)

**Example**

\[ f(x) = 8x^3 + 4x^2 - 7x + 2 \]
- \( f'(x) = 24x^2 + 8x - 7 \)
- \( f''(x) = 48x + 8 \)
- \( f'''(x) = 48 \) or \( f^{(n)}(x) = 48 \)
- \( f^{(n)}(x) \) to denote derivative

If we can have the form

\[
\frac{0}{0} \quad \text{or} \quad \frac{\infty}{\infty}
\]

we use L'Hopital's Rule

\[
\lim_{x \to a} \frac{f(x)}{g(x)} = \lim_{x \to a} \frac{f'(x)}{g'(x)}
\]

**Example**

\[
\lim_{x \to 5} \frac{x^2 - 25}{x^2 - 10x + 5} = \lim_{x \to 5} \frac{2x}{2x - 10} = \frac{2(5)}{2(5) - 10} = \frac{10}{10} = 1
\]

\[
\lim_{x \to \infty} \frac{x^2 + e^x}{x^3} = \lim_{x \to \infty} \frac{2x + e^x}{3x^2} = \frac{\infty}{\infty}
\]

\[
\lim_{x \to \infty} \frac{2 + e^x}{6x} = \frac{\infty}{\infty}, \quad \lim_{x \to \infty} \frac{e^x}{6x} = \text{DNE}
\]
\[
\lim_{x \to 0} x \ln(x) \Rightarrow \lim_{x \to 0} \frac{\ln(x)}{x} = \frac{1}{\infty} = L'Hôpital's \frac{\infty}{\infty} \Rightarrow \lim_{x \to 0} \frac{\frac{1}{x}}{\frac{-1}{x^2}} \Rightarrow \lim_{x \to 0} \frac{-x^2}{x} \Rightarrow \lim_{x \to 0} -x = 0
\]