3.1 Higher-Order Derivatives, Velocity, and Acceleration

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- finding derivatives of derivatives

  $f'(f'(x))$

  $f''(x)$

- ex derivative of derivative of

  $f(x) = \frac{x}{x+1}$ at $x=2$

$$f'(x) = \frac{(x+1)-x}{(x+1)^2} = \frac{1}{(x+1)^2}$$

$$= (x+1)^{-2}$$

$$f''(x) = -2(x+1)^{-3}$$

$$= \frac{-2}{(x+1)^3} = \frac{-2}{(2+1)^3} = \frac{-2}{3^3} = \frac{-2}{27}$$

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Motion on a Straight Line

- An object that moves along a straight line with its position determined by a function of time, $s(t)$, has a velocity of $v(t) = s'(t)$ and an acceleration of $a(t) = v'(t) = s''(t)$ at time t.
- In Leibniz notation,

  $$\left[v = \frac{ds}{dt} \text{ and } a = \frac{dv}{dt} = \frac{d^2s}{dt^2} \right]$$

  The speed of the object is $|v(t)|$

- The derivative of the derivative function is called the second derivative.
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- Negative velocity, $v(t)<0$ or $s'(t)<0$ → object ~~ ~~ is moving in (−) direction (left or down)
- (+) velocity → moving in (+) direction (up or right)
- Zero velocity, $v(t)=0$ or $s'(t)=0$ → object is stationary and that a possible change in direction may occur at time t.
- Notations for the second derivative →
  - $f''(x)$
  - $\frac{d^2y}{dx^2}$
  - $\frac{d^2}{dx^2}[f(x)]$
  - y'' of a function $y=f(x)$"

- (−) acceleration → velocity decreases
- (+) " → " increases
- 0 " → " is constant

  object neither accelerates nor deccelerates

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- An object is accelerating (speeding up) when its velocity and acceleration have the same signs
- An object is deccelerating (slowing down) when its velocity and acceleration have opposite signs

- The speed of an object is the magnitude of its velocity at time t.

  $\text{speed} = |v(t)| = |s'(t)|$