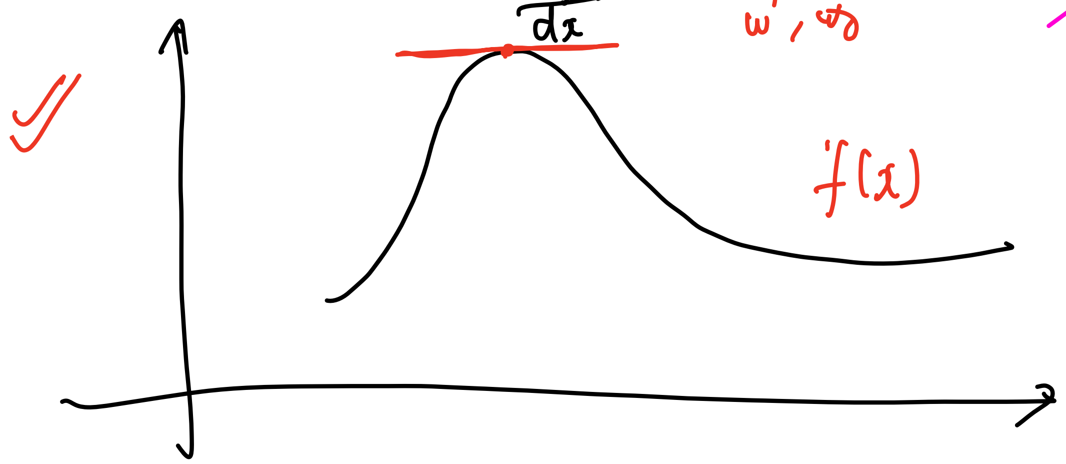
$$\underset{\bar{w}, w_0}{\operatorname{argmax}} \; G(D, \bar{w}, w_0)$$

$$\underset{x}{\operatorname{argmax}} \; -(x-2)^2$$

$$\underset{\vec{w}, w_0}{\operatorname{arg\,max}} \sum_{i=1}^{n} y_i \cdot \frac{w^T x_i + w_0}{\|w\|}$$ → optimization problem

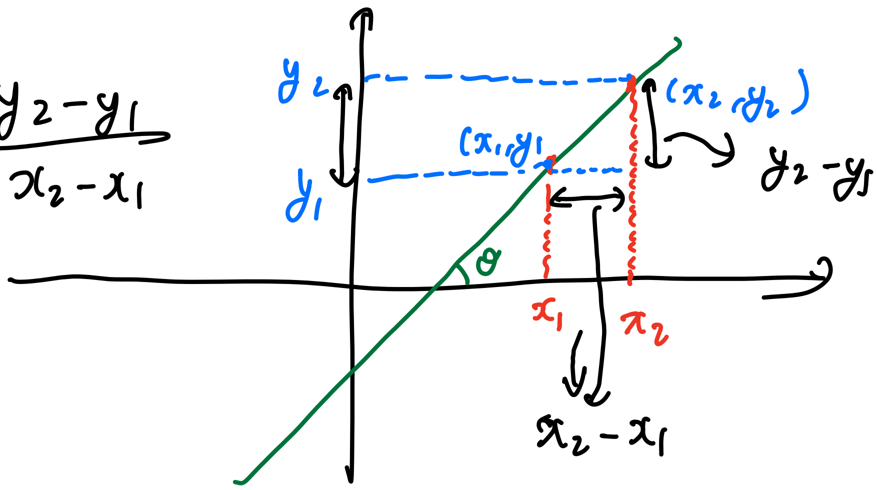
$$\frac{df(x)}{dx} = 0 \quad \vec{w}, w_0$$



$d f(x)$

$$f(x) = mx + c$$

$$\frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$



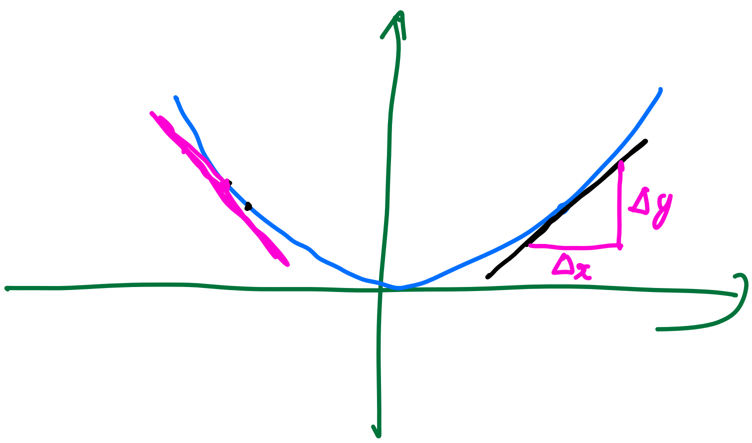
$$\frac{d f(x)}{dx}$$

$$x_1 = 5.000000$$

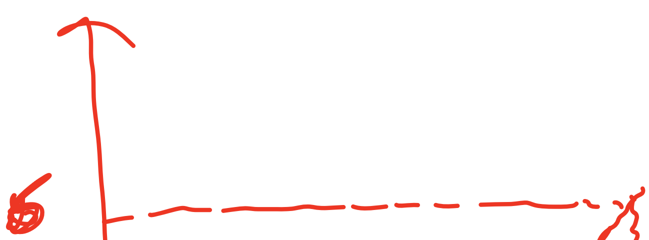
$$x_2 = 5.000000001$$

$$\Delta x \to 0$$

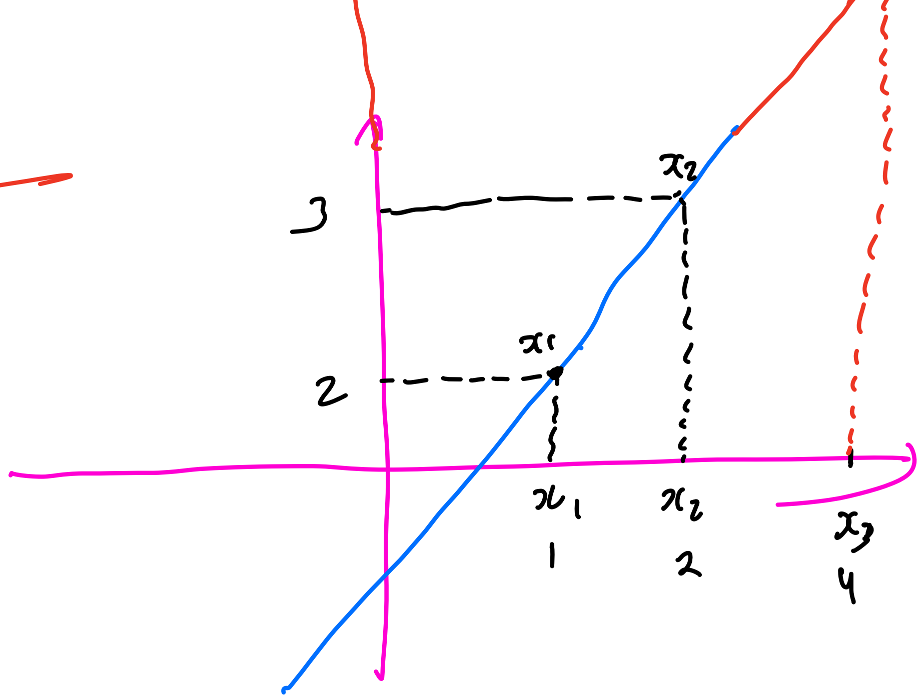
$$\Delta x \to .000000001$$



$$y = x^2$$



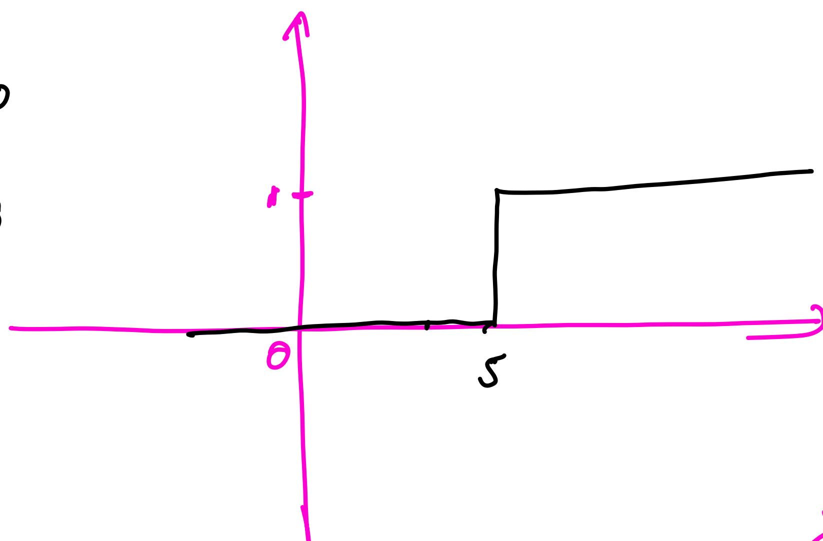
$$\frac{y_3 - y_1}{x_3 - x_1}$$



$x'(4) = 0$

$x'(7) = 0$

$x'(5)$



$\lim_{5^+}$ $\lim_{5^-}$

$\Delta x \to 0.000000002$

4.99999999

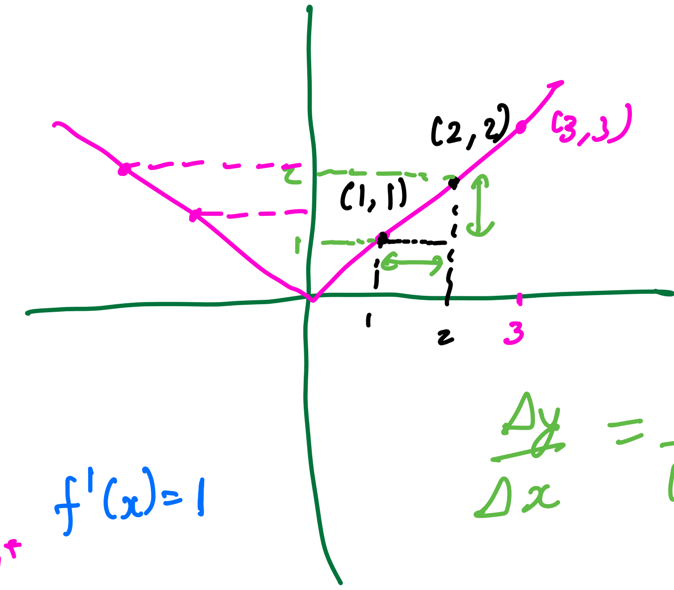
5.000000001

$$\frac{f(5.000000001) - f(4.999999999)}{0.000000002}$$

$$\frac{1-0}{0.00000002} \simeq \infty$$

Q2 $\Rightarrow$ $f(x) = |x|$

$$|x| = \begin{cases} x, & x > 0 \\ -x, & x < \end{cases}$$



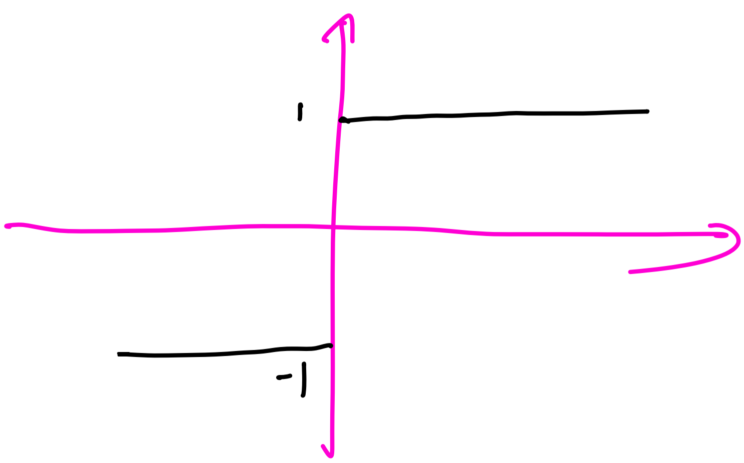
$$\frac{\Delta y}{\Delta x} = \frac{1}{1} = 1$$

$$\frac{d|x|}{dx} = \quad \lim_{x\to 0^+} f'(x) = 1$$

$$\lim_{x\to 0^-} f'(x) = -1$$

$y = x$

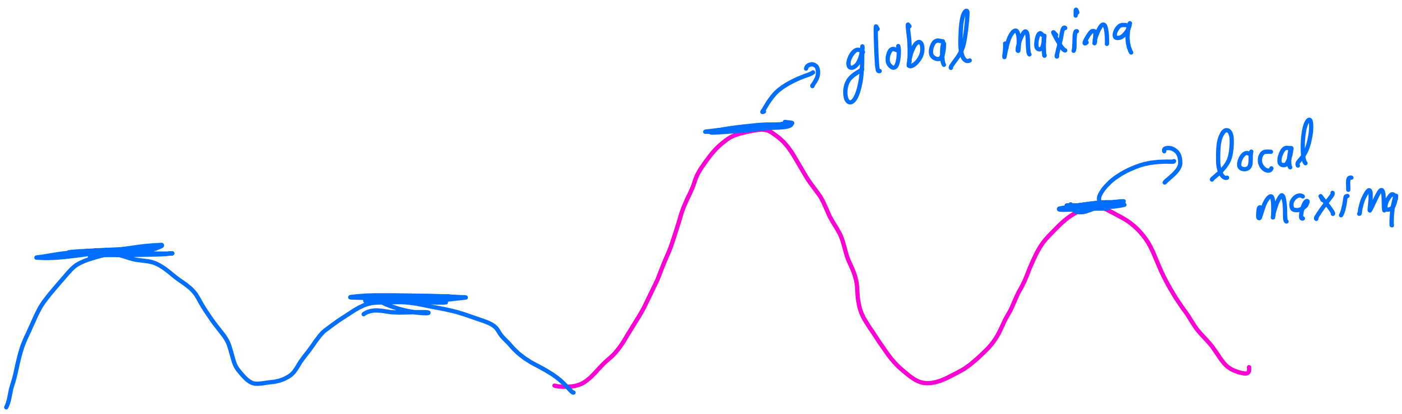
$$\frac{d|x|}{dx} = \begin{cases} 1, & x > 0 \\ -1, & x < 0 \end{cases}$$



2 cond for diffrentiability

→ $f(x)$ is continous

→ $f'(x)$ is continous



$$\frac{d f(x)}{dx} = \frac{\Delta y}{\Delta x} = \frac{f(x+\Delta x) - f(x)}{\Delta x}$$

Ex: $f(x) = x^2$

$$= \frac{(x+\Delta x)^2 - x^2}{\Delta x}$$

$$= \frac{\cancel{x^2} + \Delta x^2 + 2\,\Delta x \cdot x - \cancel{x^2}}{\Delta x}$$

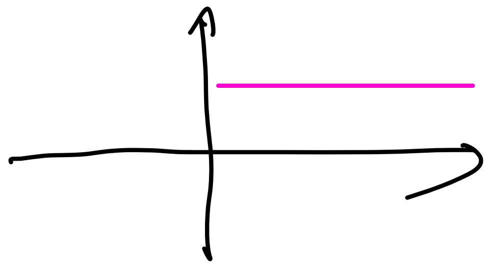
$$= \frac{\Delta x^2 + 2\Delta x \cdot x}{\Delta x}$$

$$= \frac{\cancel{\Delta x}(\Delta x + 2x)}{\cancel{\Delta x}}$$

$$= \Delta x + 2x$$

$$\Delta x \sim 0$$

$$\frac{dx^2}{dx} = 2x$$



$$\frac{dx^2}{dx} = 2x^{2-1}$$

$$\frac{dx^n}{dx} = n x^{n-1}$$

$$\frac{dc}{dx} = 0$$

$$\frac{d \sin x}{dx} = \cos x$$

$$\frac{d \cos x}{dx} = -\sin x$$

$$\frac{d \log x}{dx} = \frac{1}{x}$$

Sum Rule

$$\frac{d}{dx}[f(x) + g(x)] = f'(x) + g'(x)$$

ex: $x^2 + 7x + 12$

$\downarrow \quad \downarrow \quad \downarrow$

$2x \quad 7 \quad 0$

$\Rightarrow 2x + 7$

Product Rule

$$\frac{d}{dx}[f(x) \cdot g(x)]$$

$$= f(x) \cdot g'(x) + g(x) \cdot f'(x)$$

ex: $(x+3)(x+4)$

$\Rightarrow x^2 + 4x + 3x + 12$

$\Rightarrow x^2 + 7x + 12$ ✓

$\Rightarrow 2x + 7$

$$(x+3)\frac{d}{dx}(x+4) + (x+4)\frac{d}{dx}(x+3)$$

$$(x+3)\,1 + (x+4)\cdot 1$$

$$x+3+x+4$$

$$2x+7$$

Ex3

$$x\cdot\log(x)$$

$$x\cdot\frac{d\log(x)}{dx} + \log(x)\cdot\cancel{\frac{dx}{dx}}\;1$$

$$x\cdot\frac{1}{x} + \log(x)$$

$$1+\log(x)$$

Break : 8:11am

Quotient Rule

$$\frac{d}{dx} f(x)/g(x) \Rightarrow f(x) \cdot g^{-1}(x)$$

$$\Rightarrow \frac{g(x) \cdot f'(x) - g'(x) \cdot f(x)}{g(x)^2}$$

Ex:

$$\frac{d}{dx}\left[\frac{\log(x)}{x}\right]$$

$$\frac{x \cdot \frac{d}{dx} \log x - \frac{dx}{dx} \cdot \log x}{x^2}$$

$$\boxed{\frac{1 - \log x}{x^2}}$$

Chain Rule

$$\frac{d}{dx} f(g(x)) = f'(g(x)) \cdot g'(x)$$

$$e^{5x^2+2} \Rightarrow e^{5x^2+2} \cdot \frac{d}{dx}(5x^2+2)$$

$$\Rightarrow e^{5x^2+2}(10x)$$

$\Theta \Rightarrow$ $$f(x) = \frac{1}{1+e^{-x}}$$

$$\Rightarrow \frac{(1+e^{-x}) \cdot \frac{d1}{dx} - 1 \cdot \frac{d(1+e^{-x})}{dx}}{(1+e^{-x})^2}$$

$$\Rightarrow \frac{-e^{-x} \cdot \frac{d(-x)}{dx}}{(1+e^{-x})^2}$$

$$\Rightarrow \frac{e^{-x}}{(1+e^{-x})^2}$$

$$\Rightarrow \frac{1}{(1+e^{-x})} \cdot \frac{e^{-x}}{(1+e^{-x})}$$

$$\Rightarrow \frac{1}{(1+e^{-x})} \cdot \left(1 - \frac{1}{1+e^{-x}}\right)$$

$\Rightarrow$ $\boxed{f(x)\,(1 - f(x))}$

where $f(x)$ is a sigmoid function

$\Rightarrow$

$f(x)$

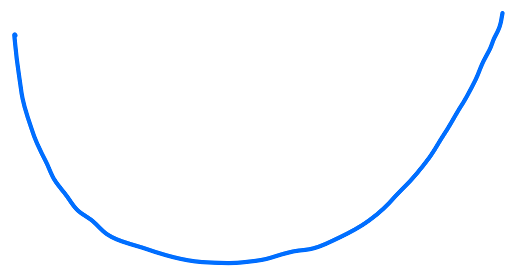
$f'(x) = 0$

pt of inflection

$f''(x) > 0 \rightarrow$ minima

$f''(x) < 0 \rightarrow$ maxima

$f(x) = x^2$



$f'(x) = 2x$

$f''(x) = 2$

$\Theta \Rightarrow \quad x^2 - x + 2$

$f'(x) = 2x - 1 \Rightarrow f''(x) = 2$

$2x - 1 = 0$

$\boxed{x = 1/2}$

$\left(\frac{1}{2}\right)^2 - \left(\frac{1}{2}\right) + 2 \Rightarrow \frac{7}{4}$

$\Theta \Rightarrow \quad p(x) = 41 - 72x - 18x^2$

Max profit

$p'(x) \Rightarrow 0 - 72 - 36x = 0$

$-72 = 36x$

$x = -2$

$p''(x) \Rightarrow -36 \Rightarrow$ maxima

$\Rightarrow p(x) = 41 - 72(-2) - 18(-2)^2$

$\Rightarrow 113$

$\Rightarrow$ $h(x) = f(g(x))$ $\qquad$ f & g $\rightarrow$ differentiable

$g(-1) = 2$

$g'(-1) = 3$

$f'(2) = -4$

$h'(-1) = ?$

$h'(x) = f'(g(x)) \cdot g'(x)$

$h'(-1) = f'(g(-1)) \cdot g'(-1)$

$\Rightarrow f'(2) \cdot 3$

$\Rightarrow -4 * 3$

$\Rightarrow -12$

$\Rightarrow$ $y = x^2 + 7$

$(3, 7)$

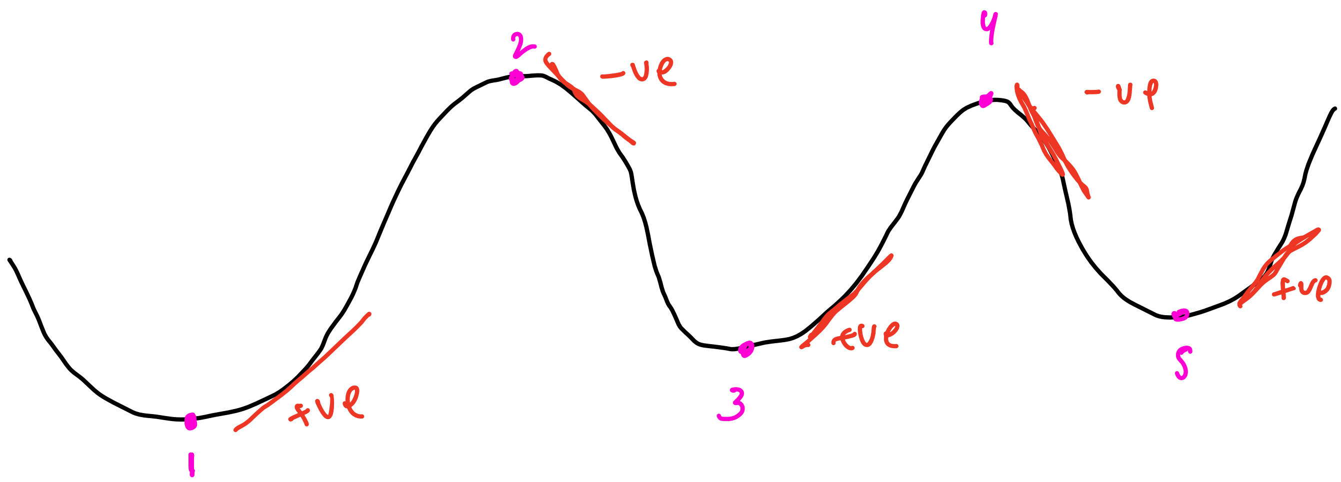
$(x, x^2 + 7)$

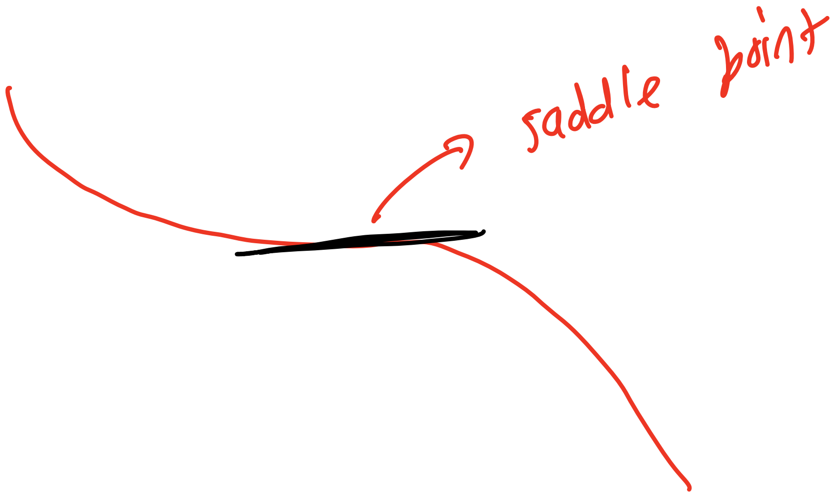
$(3, 7)$

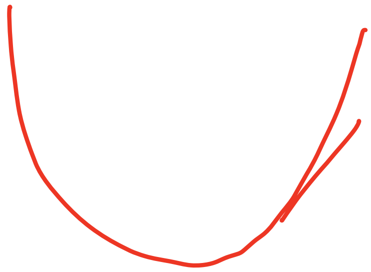
$\Rightarrow \sqrt{(x-3)^2 + (x^2 + 7 - 7)^2}$

$\Rightarrow \sqrt{(x-3)^2 + x^4} \rightarrow f^2(x)$

$\Rightarrow \quad f(x) \Rightarrow (x-3)^2 + x^4 \Rightarrow \sqrt{5}$

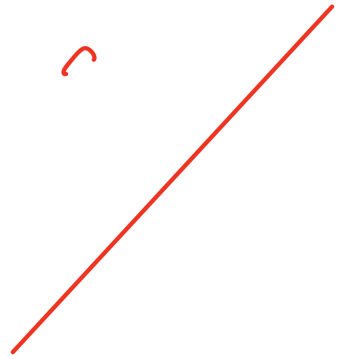






x^2

$f(x)$



$f'(x)$

$f''(x)$

$f'(x) = 2x$

$f''(x) = 2$