



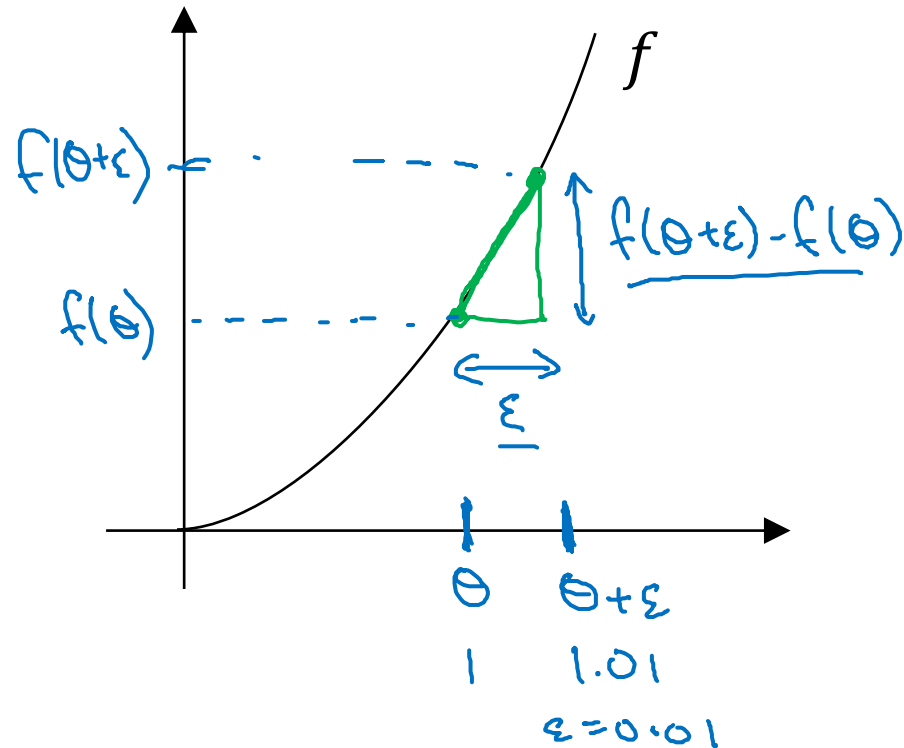
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Setting up your optimization problem

Numerical approximation of gradients

Checking your derivative computation

I $f(\theta) = \theta^3$
 $\theta \in \mathbb{R}.$



$$g(\theta) = \frac{d}{d\theta} f(\theta) = f'(\theta)$$

$g(\theta) = 3\theta^2$

$g(\theta) = 3 \cdot (1)^2 = 3$
 when $\theta = 1$

$$\frac{f(\theta + \epsilon) - f(\theta)}{\epsilon} \approx g(\theta)$$

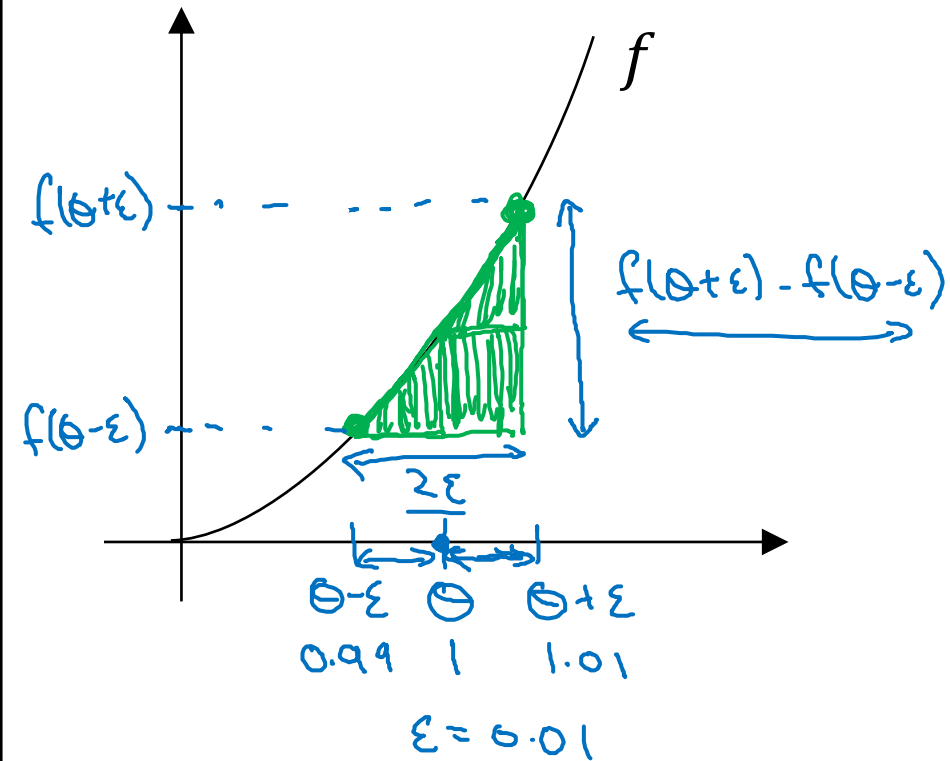
$$\frac{(1.01)^3 - 1^3}{0.01} = 3.0301 \approx 3$$

Arrows indicate the mapping from the terms in the equation above to the terms in the equation below.

$\theta = 1$
 $\theta + \epsilon = 1.01$
 $\epsilon = 0.01$

Checking your derivative computation

$$\underline{f(\theta) = \theta^3}$$



$$\left[\frac{f(\theta + \epsilon) - f(\theta - \epsilon)}{2\epsilon} \approx \underline{g(\theta)} \right]$$

$$\frac{(1.01)^3 - (0.99)^3}{2(0.01)} = 3.0001 \approx 3$$

$$g(\theta) = 3\theta^2 = 3$$

approx error: 0.0001

(prev slide: 3.0301. error: 0.03)

$$\left\{ \begin{array}{l} f'(\theta) = \lim_{\epsilon \rightarrow 0} \frac{f(\theta + \epsilon) - f(\theta - \epsilon)}{2\epsilon} \quad \begin{array}{l} O(\epsilon^2) \\ 0.01 \\ \underline{0.0001} \end{array} \quad \left| \quad \begin{array}{l} \frac{f(\theta + \epsilon) - f(\theta)}{\epsilon} \quad \text{error: } O(\epsilon) \\ \uparrow \quad \uparrow \\ \quad 0.01 \end{array} \end{array} \right.$$