



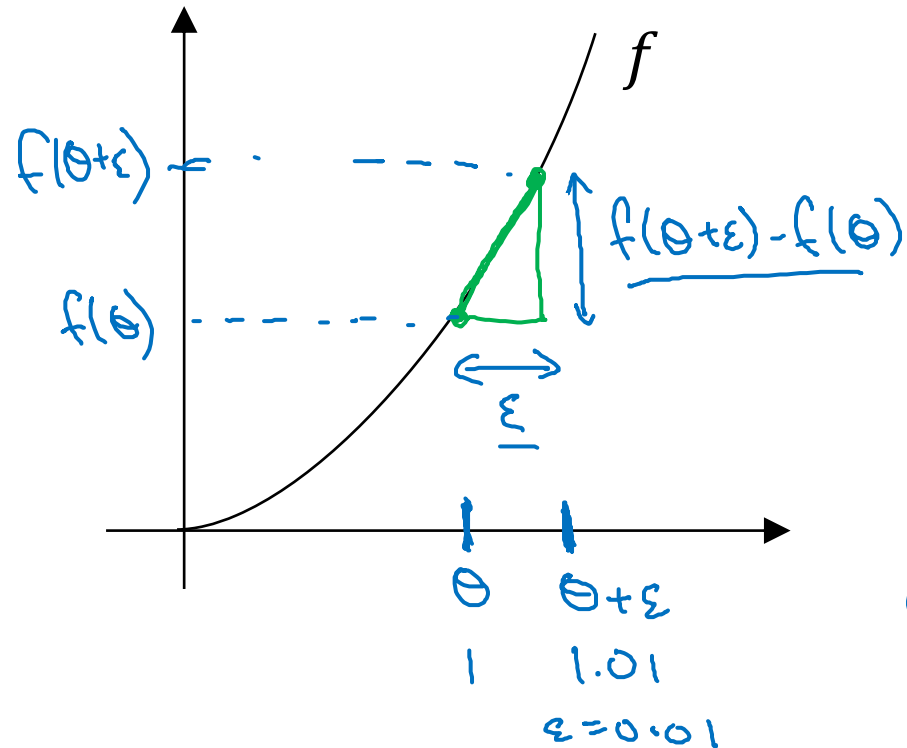
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Setting up your optimization problem

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 $\theta = 1$

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

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

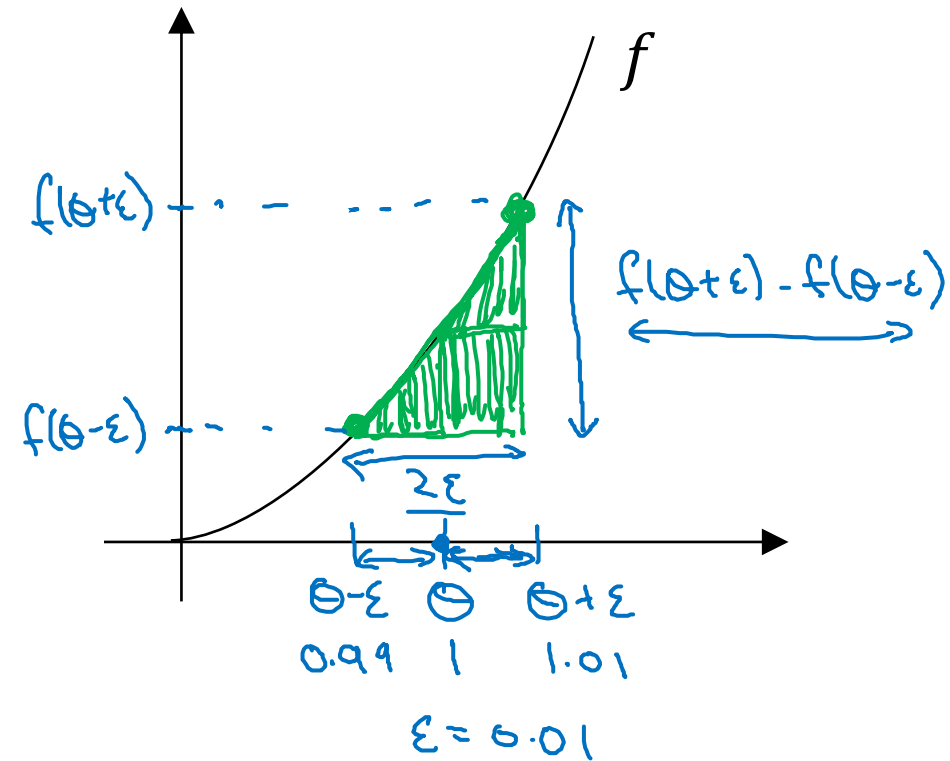
Annotations for the calculation above:

- $1.01^3 = 1.030301$
- $1.030301 - 1 = 0.0301$
- $0.0301 / 0.01 = 3.0301$
- $3.0301 \approx 3$

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

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)

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