$$\frac{df}{dx}$$

$$f: \mathbb{R} \to \mathbb{R}$$

$$\frac{\partial f}{\partial x} \quad \frac{\partial f}{\partial y}$$

$$f: \mathbb{R}^n \to \mathbb{R}$$

$$f(\vec{x})$$

$$\mathbb{R}^2$$

$$f(x, y)$$

$$\mathbb{R}^3$$

$$f(x, y, z)$$

$$\frac{\partial f}{\partial \vec{x}_i}$$

$$\nabla f_x(x) = \left[\frac{\partial f(x)}{\partial x_i} \; \cdots \; \frac{\partial f(x)}{\partial x_n} \right]$$

$$f : \mathbb{R}^n \to \mathbb{R}$$

$$\nabla f : \mathbb{R}^n \to \mathbb{R}^n$$

$$\frac{\partial f}{\partial x_i} : \mathbb{R}^n \to \mathbb{R}$$

$$f : \mathbb{R}^n \to \mathbb{R}^m$$

$$f' \qquad \frac{d}{dx}$$

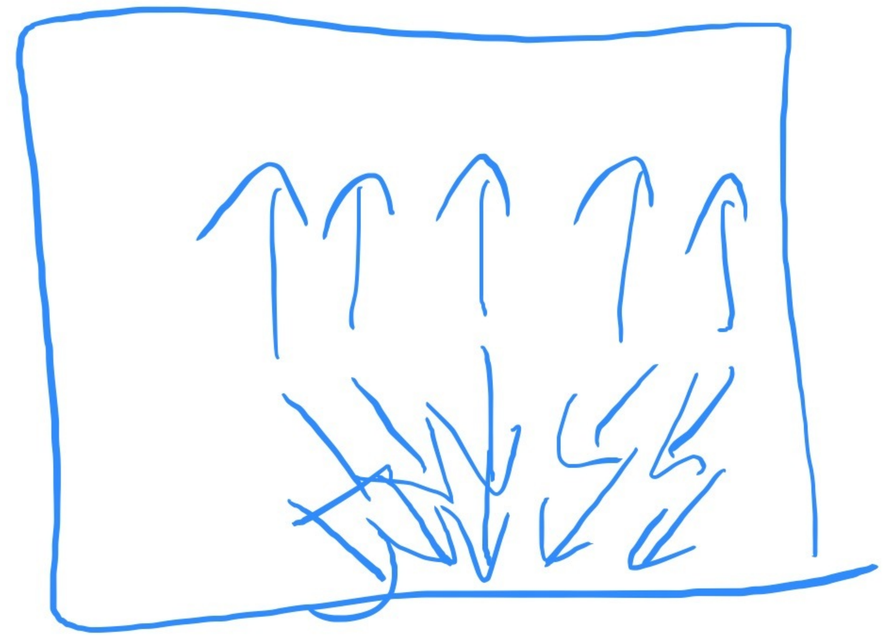
$$J_{m \times n} \qquad \nabla \qquad g$$

$$J_{ij} = \frac{\partial (f(\vec{x}))_i}{\partial x_j}$$

$$\frac{d}{dx} = \mathcal{D} : (\mathbb{R} \to \mathbb{R}) \to (\mathbb{R} \to \mathbb{R})$$

$$\nabla : (\mathbb{R}^n \to \mathbb{R}) \to (\mathbb{R}^n \to \mathbb{R}^n)$$

$$J : (\mathbb{R}^n \to \mathbb{R}^m) \to (\mathbb{R}^n \to \mathbb{R}^{m \times n})$$



$f(x)$ $\quad f' : \mathbb{R} \to \mathbb{R}$

$\frac{d^2 f}{dx^2} : \mathbb{R} \to \mathbb{R}$

$\frac{d^2}{dx^2} : (\mathbb{R} \to \mathbb{R}) \to (\mathbb{R} \to \mathbb{R})$

$$f : \mathbb{R}^n \to \mathbb{R}$$

$$\frac{\partial f(x,y)}{\partial x} \qquad \frac{\partial f(x,y)}{\partial y}$$

$$\frac{\partial^2 f(\vec{x})}{\partial x_i \partial x_j} = \frac{\partial^2 f(\vec{x})}{\partial x_j \partial x_i}$$

$$H_{n \times n} \qquad H_{ij} = \frac{\partial^2 f}{\partial x_i \partial x_j}$$

$$\nabla^2 f$$

$$\nabla^2 : (\mathbb{R}^n \to \mathbb{R}) \to (\mathbb{R}^n \to \mathbb{R}^{n \times 1})$$

$$y = f(x)$$

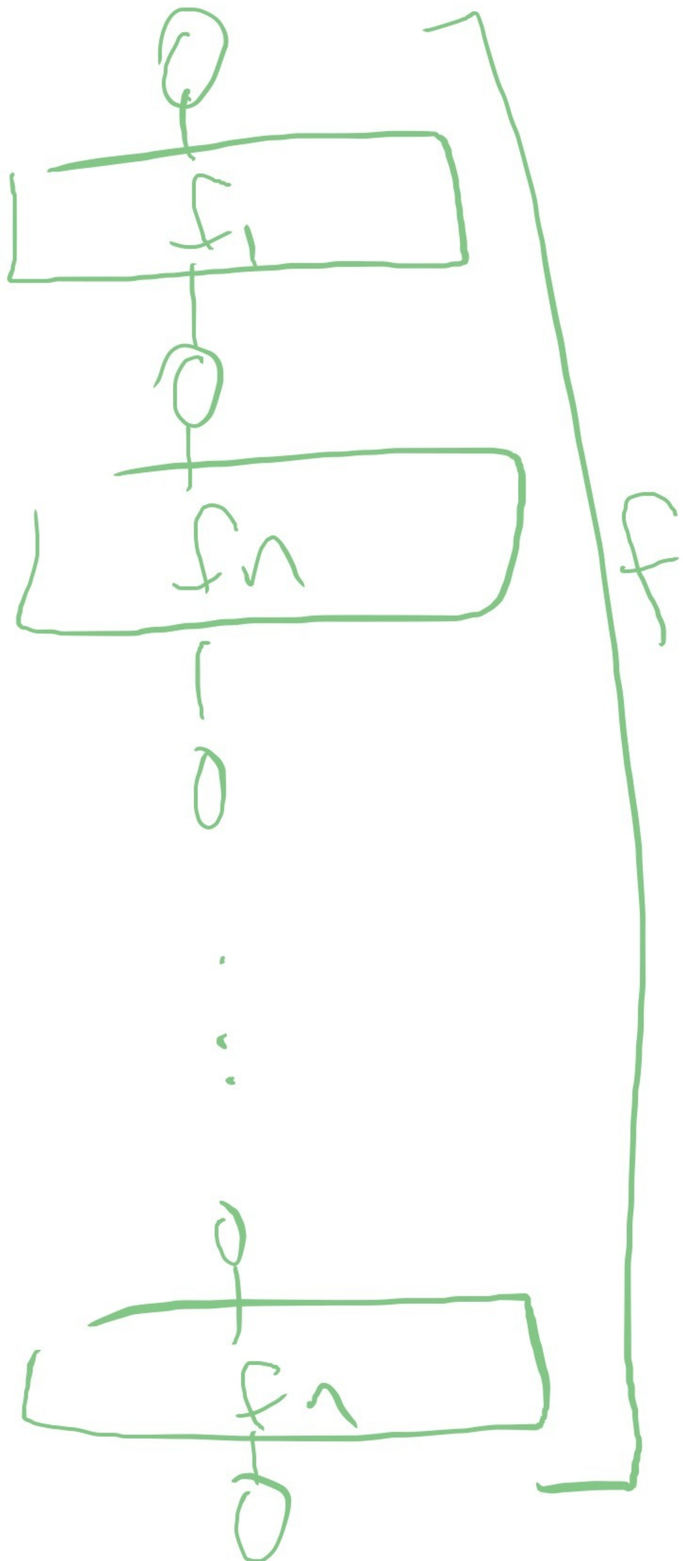
$$z = g(y)$$

$$z = g(f(x)) = h(x)$$

$$h = g \circ f$$

$$\frac{dz}{dy} \times \frac{dy}{dx} = \frac{dz}{dx}$$

$$\mathcal{D}(h) = \mathcal{D}(g) \circ \mathcal{D}(f)$$



$$f = f_n \circ \cdots \circ f_1$$

$$f_n(\cdots f_n(f_2(f_1(\square))))$$

$$f = f_n \circ \cdots \circ f_1$$

$$f' = f_n'(x_{n-1}) \; f_2'(x) \; f_1'(x_0)$$

$$J = J_n \times \cdots \times J_1$$