Scalar Derivatives

Rule	$f(x)$	$\frac{d}{dx}f(x)$	Example
Constant	c	0	$\frac{d}{dx}99 = 0$
Multiply by Constant	cf	$c\frac{df}{dx}$	$\frac{d}{dx}3x = 3$
Power Rule	x^n	nx^{n-1}	$\frac{d}{dx}x^3 = 3x^2$
Chain Rule	$f(g(x))$	$\frac{df(u)}{du}\frac{du}{dx}$, where $u = g(x)$	$\frac{d}{dx}\ln(x^2) = \frac{1}{x^2}2x = \frac{1}{x}$

Partial Derivatives

$$f(x_1, x_2) = 3{x_1}^2(2x_2 + 7)$$

then $\frac{\partial}{\partial x_1}f(x_1, x_2) = 6x_1(2x_2 + 7)$ and $\frac{\partial}{\partial x_2}f(x_1, x_2) = 6{x_1}^2$

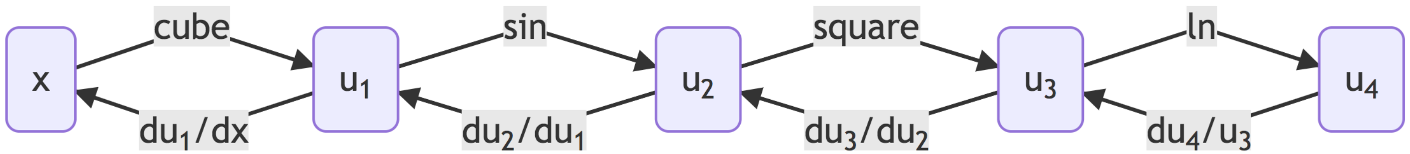
Derivatives and Computation Graph

Apply Chain Rule with Intermediate functions

$$
\begin{aligned}
& & u_1 &= cube(x) &&= x^3 \\
& & u_2 &= sin(x) &&= \sin(u_1) \\
& & u_3 &= square(x) &&= {u_2}^2 \\
y &= & u_4 &= ln(x) &&= \ln(u_3)
\end{aligned}
$$

$$\frac{dy}{dx} = \frac{du_4}{dx} = \frac{du_4}{du_3}\frac{du_3}{du_2}\frac{du_2}{du_1}\frac{du_1}{dx}$$

When the input ***x* flows in a single direction** to the end to produce $\boldsymbol{y}$, we can simply ***"flow" backwards in derivatives of the chain of operations*** to differential.



Dot Product

$$\begin{bmatrix} a & b \end{bmatrix} \bullet \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} ax + by \end{bmatrix}$$

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \bullet \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} ax + by \\ cx + dy \end{bmatrix}$$

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \bullet \begin{bmatrix} w & x \\ y & z \end{bmatrix} = \begin{bmatrix} aw + by & ax + bz \\ cw + dy & cx + dz \end{bmatrix}$$