☐ Derivation of the parabola derivative

 $h = \lim_{h \to 0} \frac{2ch + h^2}{h}$ $= \lim_{h \to 0} \frac{2ch + h^2}{h}$ $= \lim_{h \to 0} \frac{h(2c + h)}{h}$ $= \lim_{h \to 0} 2c + h$ = 2c

Derive on the board.

Derivate of a parabola:

$$\lim_{h \to 0} \frac{(x+h)^2 - x^2}{h} = \lim_{h \to 0} \frac{x^2 + 2xh + h^2 - x^2}{h}$$

$$= \lim_{h \to 0} \frac{2xh + h^2}{h}$$

$$= \lim_{h \to 0} \frac{h(2x+h)}{h}$$

$$= \lim_{h \to 0} 2x + h$$

$$= 2x$$
(10)
(11)

The derivative

☐The derivate of a polynomial

What is the derivative of the function $f(x)=x^a?$ $\frac{\mathrm{d}f(x)}{\mathrm{d}x}=\mathrm{d}x^{a-1}$

Derivate of a polynomial $f(x) = x^n$ [DFO20]:

$$\frac{df(x)}{dx} = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h} = \lim_{h \to 0} \frac{(x+h)^n - x^n}{h}$$
(15)

$$= \lim_{h \to 0} \frac{\sum_{i=0}^{n} \binom{n}{i} x^{n-1} h^{i} - x^{n}}{h}$$
 (16)

$$= \lim_{h \to 0} \frac{\sum_{i=1}^{n} \binom{n}{i} x^{n-1} h^{i}}{h} \tag{17}$$

$$= \lim_{h \to 0} \sum_{i=1}^{n} \binom{n}{i} x^{n-1} h^{i-1} \tag{18}$$

$$= \lim_{h \to 0} {n \choose 1} x^{n-1} + \sum_{i=1}^{n} i = 2n \binom{n}{i} x^{n-i} h^{i-1}$$
 (19)

$$=\frac{n!}{1!(n-1)!}x^{n-1}=nx^{n-1}. (20)$$

└─The gradient

- Gradients point in the steepest ascent direction.
- To find the gradient, we must compute the partial derivate with respect to every input.
- A vector collects all derivates.

The gradient of the Rosenbrock function

Recall the Rosenbrock function: $f(x,y) = (a-x)^2 + b(y-x^2)^2$ $\nabla f(x,y) = \begin{pmatrix} -2a + 2x - 4byx + 4bx^3 \\ 2bx - 2bx^2 \end{pmatrix}$

The gradient of the Rosenbrock function

On the board, derive:

$$f(x,y) = (a-x)^2 + b(y-x^2)^2$$
 (54)

$$= a^{2} - 2ax + x^{2} + b(y^{2} - 2yx^{2} + x^{4})$$
 (55)

$$= a^2 - 2ax + x^2 + by^2 - 2byx^2 + bx^4$$
 (56)

$$\Rightarrow \frac{\partial f(x,y)}{\partial x} = -2a + 2x - 4byx + 4bx^3 \tag{57}$$

$$\Rightarrow \frac{\partial f(x,y)}{\partial y} = 2by - 2bx^2 \tag{58}$$

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