# AI5031: Machine learning, exercise sheet 2

## 1 1D derivatives

Compute the derivative $h'(x)$. Always give rule and decomposition!!
**a)** $h(x) = \sin(\sin(x))$
**b)** $h(x) = 2\sin(x) + 5\cos(x)$
**c)** $h(x) = \alpha\sin(x) + \beta\cos(x)$
**d)** $h(x) = \ln(\sin(\cos(5.2)))$
**e)** $h(x) = \exp(x)\ln(x)$
**f)** $h(x) = x\cos(x)$
**g)** $h(x) = e^{\cos(x)}$

## 2 Preparations (on paper)

Compute the following derivatives!
**a)** $\frac{\partial}{\partial x_3}\sum_{i=1}^{5} x_i$
**b)** $\frac{\partial}{\partial x_6}\sum_{i=1}^{5} x_i$
**c)** $\frac{\partial}{\partial x_3}\sum_{i=1}^{5}(2x_i - 5)^2$
**d)** $\frac{\partial}{\partial x_3}\sum_{i=1}^{5}(x_i^2 - 5x_i)^2$
**e)** $\frac{\partial}{\partial x_3}\cos(x_3)x_3$
**f)** $\frac{\partial}{\partial x_3}\cos(x_3)x_4$
**g)** $\frac{\partial}{\partial x_3}\cos(\exp(x_3))$

## 3 Vector-vector chain rule 1

Given the function $\vec{g}(\vec{x})$ with $g_i(\vec{x}) = x_i^2$, and $f(\vec{x}) = \sum_i \log x_i$: compute the partial derivative $\frac{\partial f(g(\vec{x}))}{\partial x_1}$!

## 4 Vector-vector chain rule 2

We can chain the functions $\vec{y} = \vec{f}(\vec{w})$ with $f_i(\vec{w}) = w_i^3$, and $\tilde{\mathcal{L}}(\vec{y}) = \sum_i y_i$ as $\mathcal{L}(\vec{w}) \equiv \tilde{\mathcal{L}}(\vec{f}(\vec{w}))$. Compute the partial derivative $\frac{\partial \mathcal{L}}{\partial w_1}$! What does this remind you of?

## 5 Gradient descent on paper

Consider the function $f(\vec{x}) = x_1^2 + 2x_2^2$. Assuming a starting point of $\vec{x}(0) = [1, 3]$ and a step size of $\epsilon = 0.1$: perform 2 steps of gradient descent, that is, compute the values of $\vec{x}(1)$, $\vec{x}(2)$ by iteration. Verify that the value of $f$ is decreasing!