# 50.039 - Theory and Practice of Deep Learning
# Week 9 Homework

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## Task 1

### Figure 1

1. $$\frac{\partial E}{\partial n_4} = \frac{\partial E}{\partial n_6} \cdot \frac{\partial n_6}{\partial n_4}$$

2. $$\frac{\partial E}{\partial w_{2,5}} = \frac{\partial E}{\partial n_7} \cdot \frac{\partial n_7}{\partial n_5} \cdot \frac{\partial n_5}{\partial w_{2,5}}$$

3. $$\frac{\partial E}{\partial (v_{1,1})_d} = \frac{\partial E}{\partial n_6} \cdot \frac{\partial n_1}{\partial (v_{1,1})_d} \cdot \left[ \frac{\partial n_6}{\partial n_3} \cdot \frac{\partial n_3}{\partial n_1} + \frac{\partial n_6}{\partial n_4} \cdot \frac{\partial n_4}{\partial n_1} \right]$$

4. $$\frac{\partial E}{\partial (x_2)_d} = \frac{\partial n_2}{\partial (x_2)_d} \cdot \left[ \frac{\partial E}{\partial n_6} \cdot \frac{\partial n_6}{\partial n_4} \cdot \frac{\partial n_4}{\partial n_2} + \frac{\partial E}{\partial n_7} \cdot \frac{\partial n_7}{\partial n_5} \cdot \frac{\partial n_5}{\partial n_2} \right]$$

### Figure 2

1. $$\frac{\partial E}{\partial (v_{2,2})_d} = \frac{\partial E}{\partial n_6} \cdot \frac{\partial n_6}{\partial n_4} \cdot \frac{\partial n_4}{\partial n_2} \cdot \frac{\partial n_2}{\partial (v_{2,2})_d}$$

2. $$\frac{\partial E}{\partial w_{2,4}} = \frac{\partial E}{\partial n_4} \cdot \frac{\partial n_4}{\partial w_{(2,4)}} \cdot \frac{\partial n_5}{\partial w_{2,5}}$$

3. $$\frac{\partial E}{\partial n_1} = \frac{\partial n_3}{\partial n_1} \cdot \left[ \frac{\partial E}{\partial n_6} \cdot \frac{\partial n_6}{\partial n_3} + \frac{\partial E}{\partial n_8} \cdot \frac{\partial n_8}{\partial n_3} \right]$$

## Task 2

Let $C_{i,i+1}$ be the number of connections to a neuron in layer $i+1$. Then the number of terms is

$$N = \prod_{i=1}^{K} C_{i,i+1}$$