

# Neural Networks

ECE 4200

# Plan

- Neural Networks
- Back propagation
- Multi-layer perceptron
- Training Neural Networks
  
- PyTorch: Tool we will use

# Resources

- Mitchell: Old
  - Derivation of back propagation
- Fei-Fei Li's class on CNN for visual recognition

Link:

<http://vision.stanford.edu/teaching/cs231n/2017/syllabus.html>

# Neural Networks - History

40's, 70's, 90's,

2006 – Now

What is new ... ?

Computational advances!

# The Brain Connection

100B Neurons in human brain

Each connected to 10K others

Neuron switching time:  $10^{-3}$  seconds

Computer switching time:  $10^{-10}$  seconds

**Brain works faster than these can explain, in a serial fashion**

Brain is massively parallel

We have very little idea how brain really works - **Sabuncu**

# Artificial Neural Networks

Densely interconnected set of **simple units**

## Pros:

Best known performance in various tasks, eg, Image processing, speech

Very little knowledge is needed about how they work!

## Cons:

Large training sets

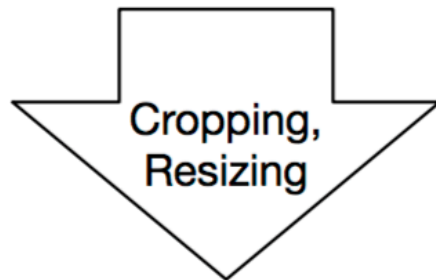
Slow training

We do not understand **how they work!**

**Do we want to know?? Adversarial examples**

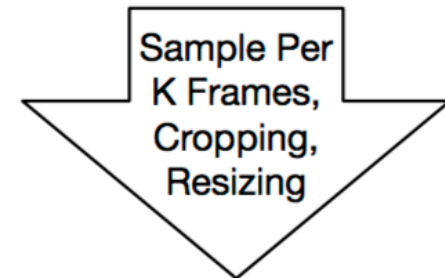
# Possible Failures and challenges

Physical road signs with adversarial perturbation under different conditions



Stop Sign → Speed Limit Sign

Video sequences taken under different driving speeds



Stop Sign → Speed Limit Sign

# Problems and directions

Self driving cars ...

**Understanding the system is VITAL**

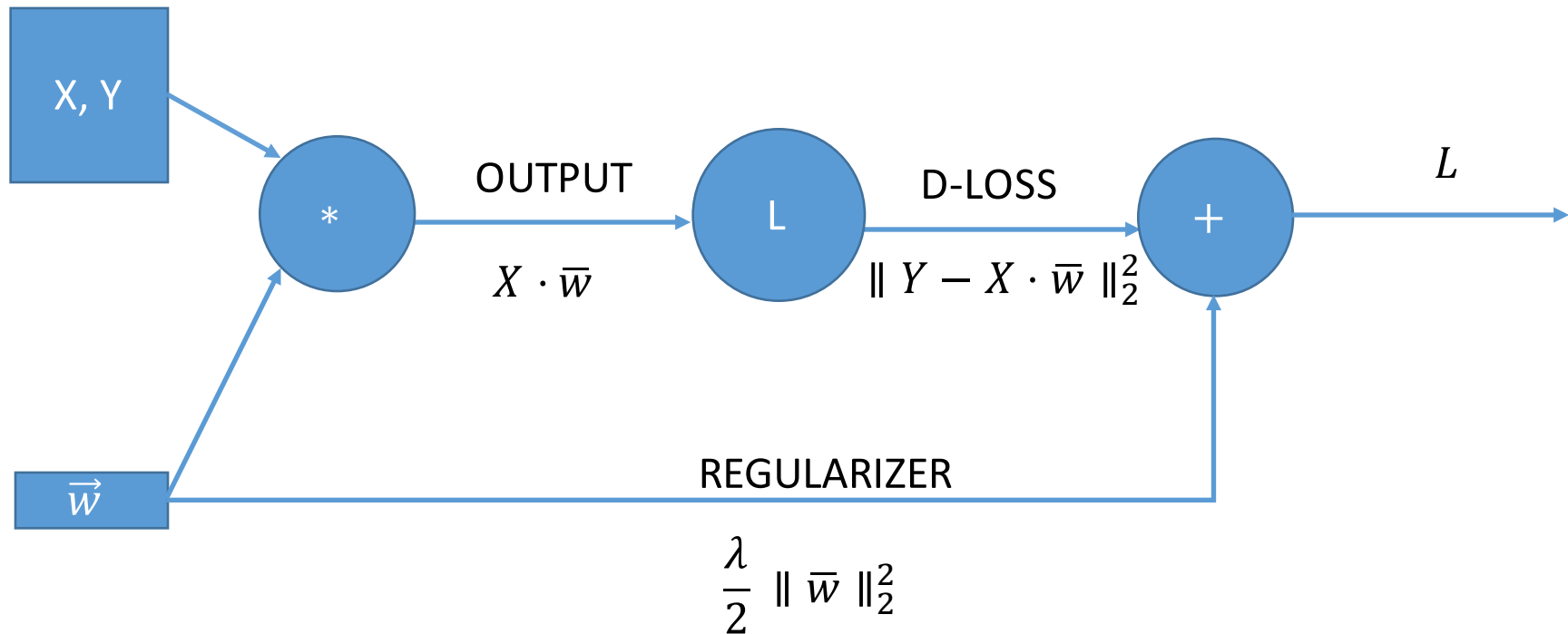
One very active area: Generative Adversarial Networks

**Take human image, perturb a little -> make a cat!!**



# Computational Graph

Consider a classic problem, **regression**.

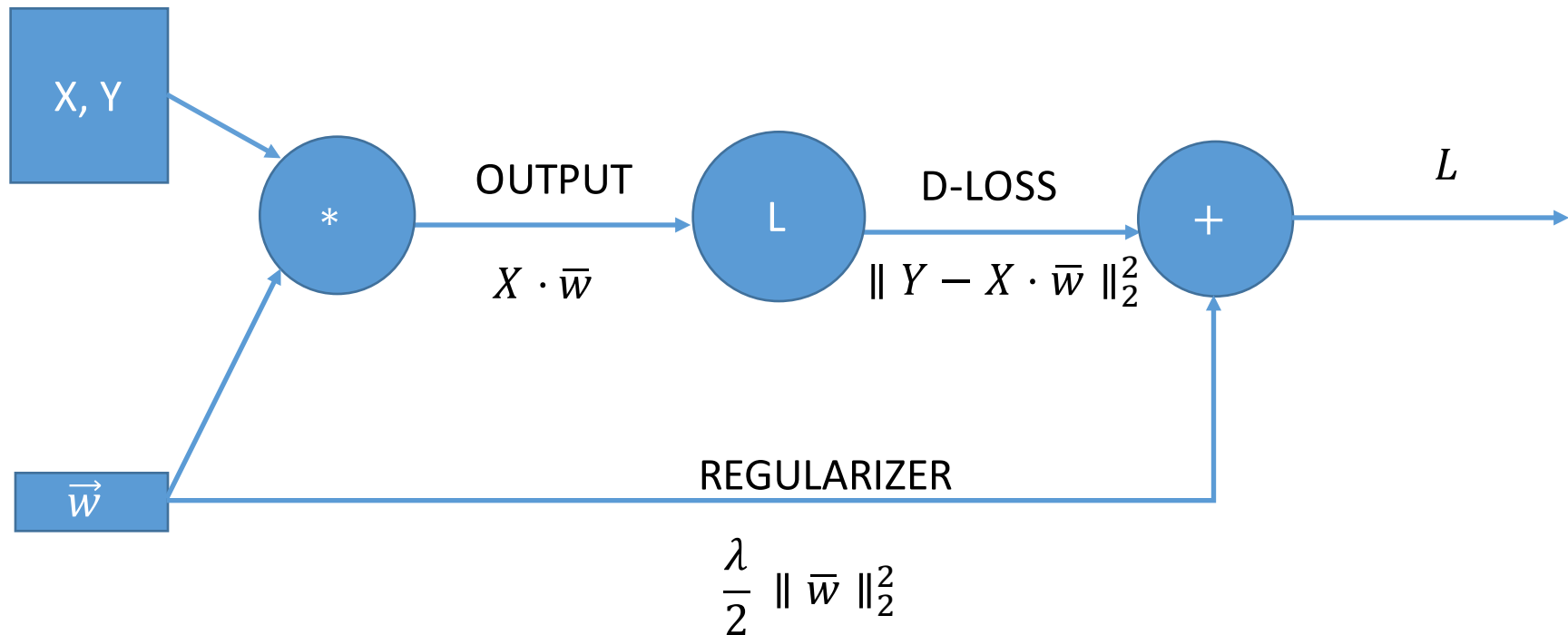


# Computational Graph

We want to do **gradient descent**

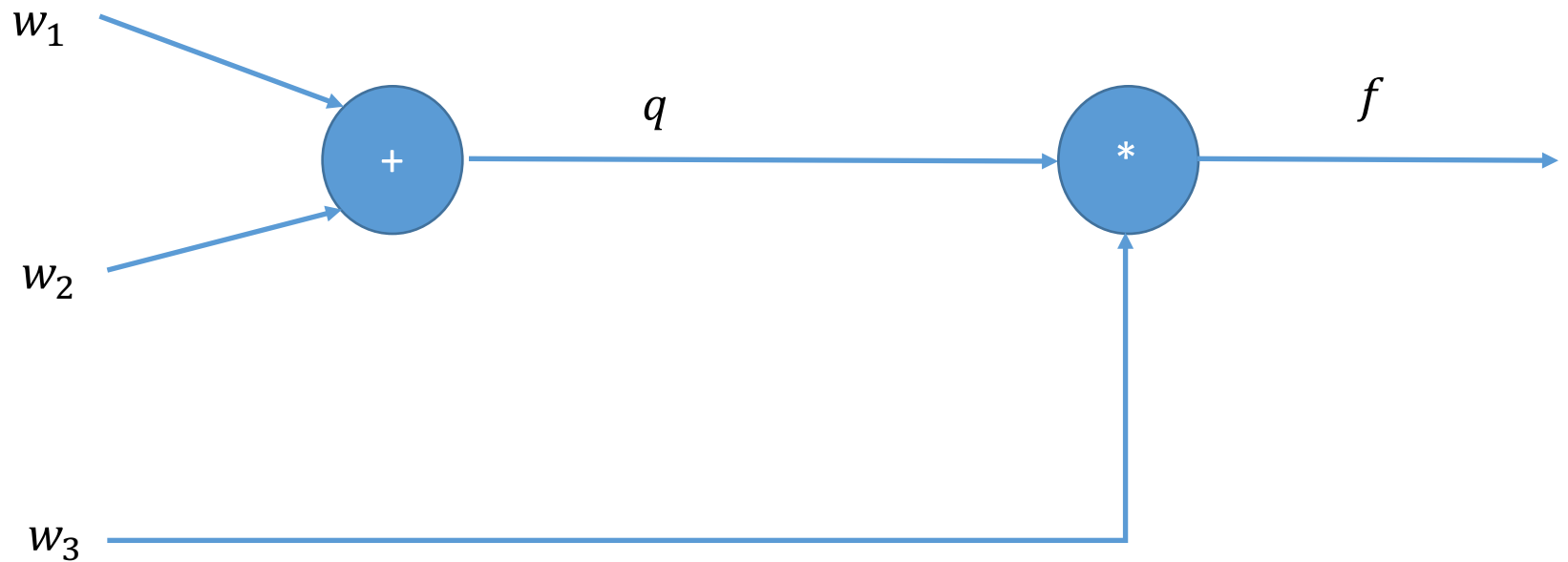
Functions, and networks will be **super-complicated**

**What we want:**  $\nabla_{\vec{w}} L$



# Backpropagation: via example

$$f(w_1, w_2, w_3) = (w_1 + w_2)w_3$$



What we want:  $\frac{\partial f}{\partial w_1}, \frac{\partial f}{\partial w_2}, \frac{\partial f}{\partial w_3}$

# Backpropagation: via example

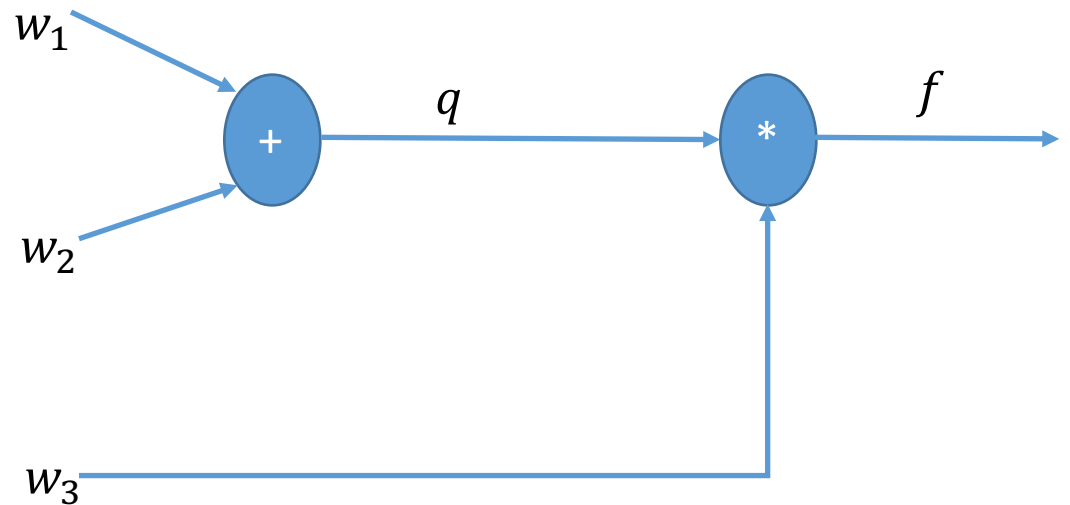
$$f(w_1, w_2, w_3) = (w_1 + w_2)w_3$$

$$w_1 = -2, w_2 = 5, w_3 = -4$$

$$\frac{\partial f}{\partial w_1}, \frac{\partial f}{\partial w_2}, \frac{\partial f}{\partial w_3}$$

$$\frac{\partial f}{\partial w_1} = \frac{\partial f}{\partial q} \frac{\partial q}{\partial w_1}$$

$$\frac{\partial f}{\partial w_2} = \frac{\partial f}{\partial q} \frac{\partial q}{\partial w_2}$$



Propagating the gradients back!

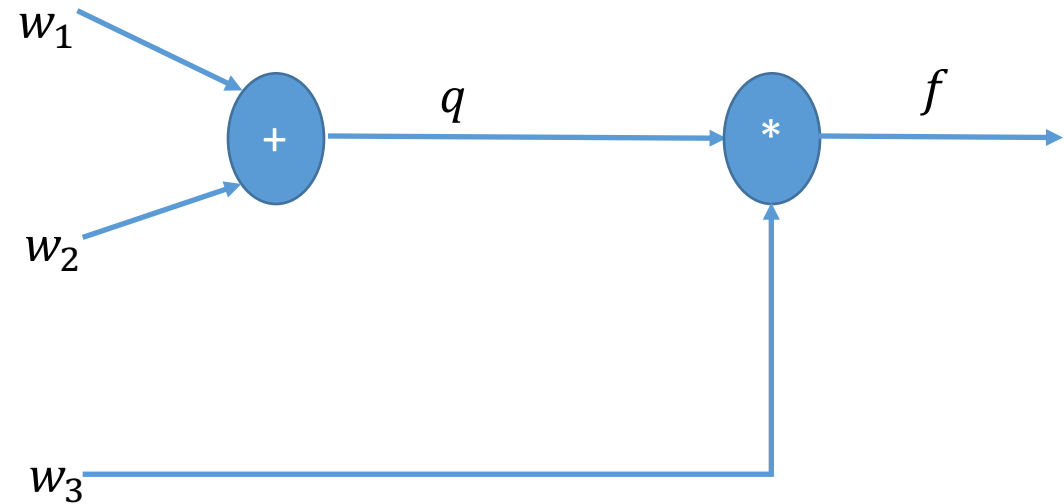
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$$w_1 = -2, w_2 = 5, w_3 = -4$$

$$q = w_1 + w_2, \frac{\partial q}{\partial w_1} = 1, \frac{\partial q}{\partial w_2} = 1$$

$$f = qw_3, \frac{\partial f}{\partial q} = w_3, \frac{\partial f}{\partial w_3} = q$$



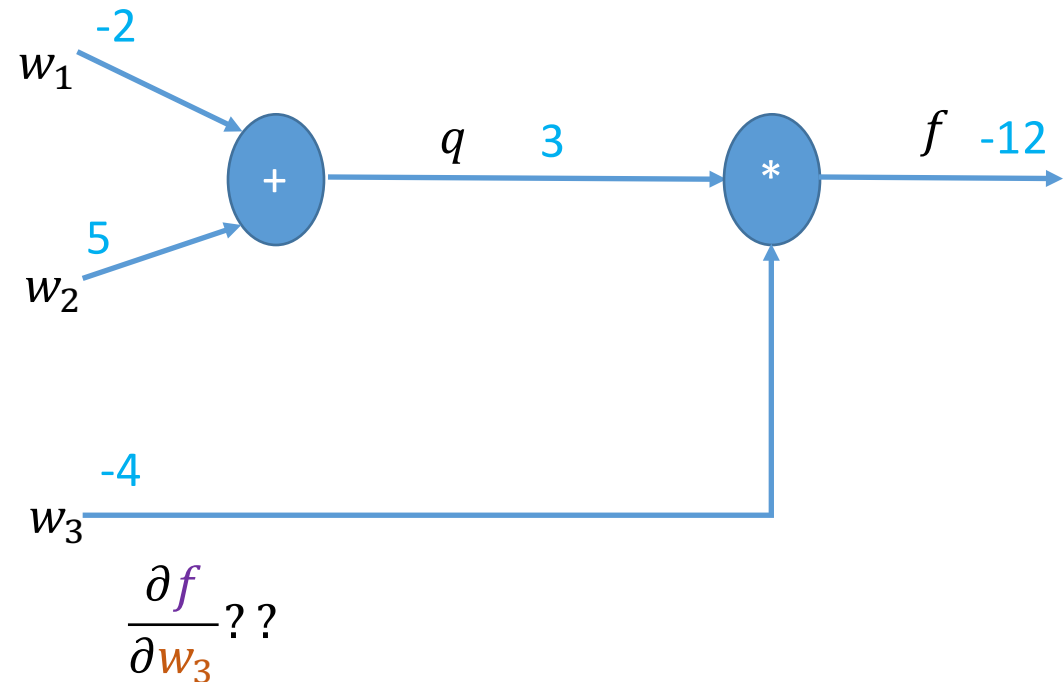
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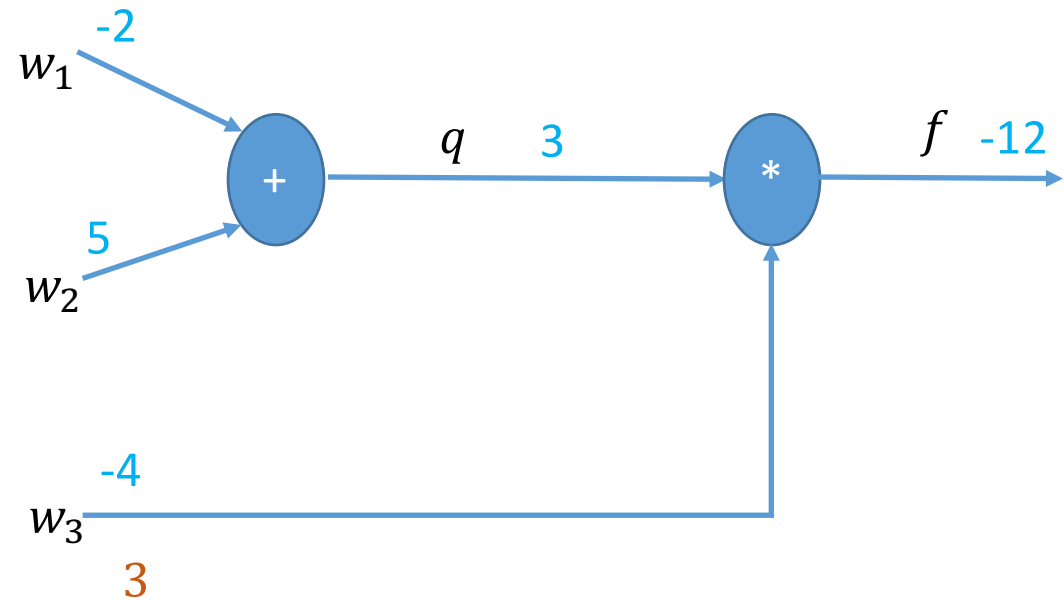
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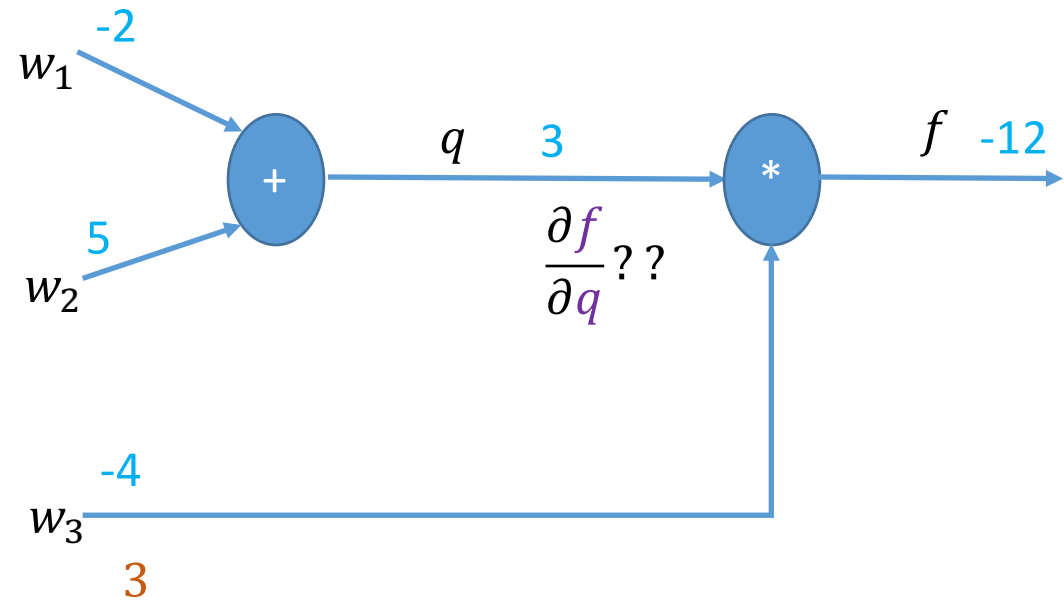
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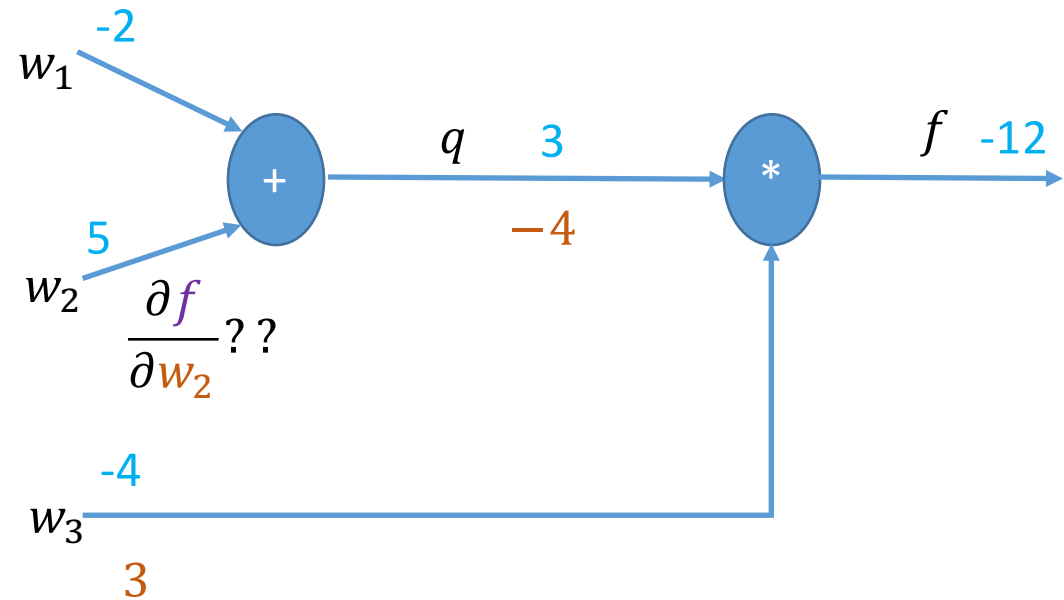
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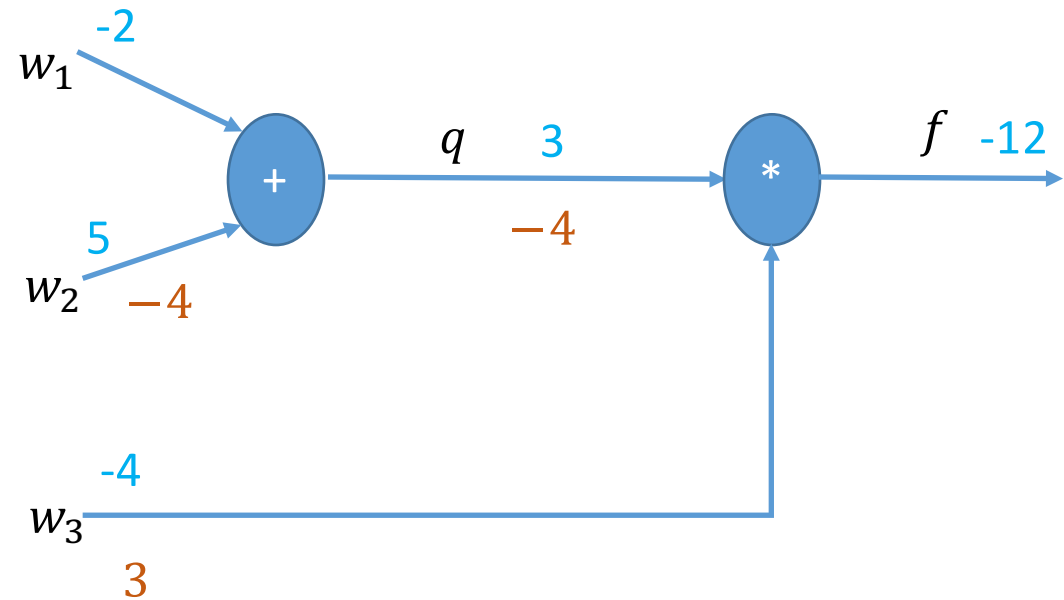
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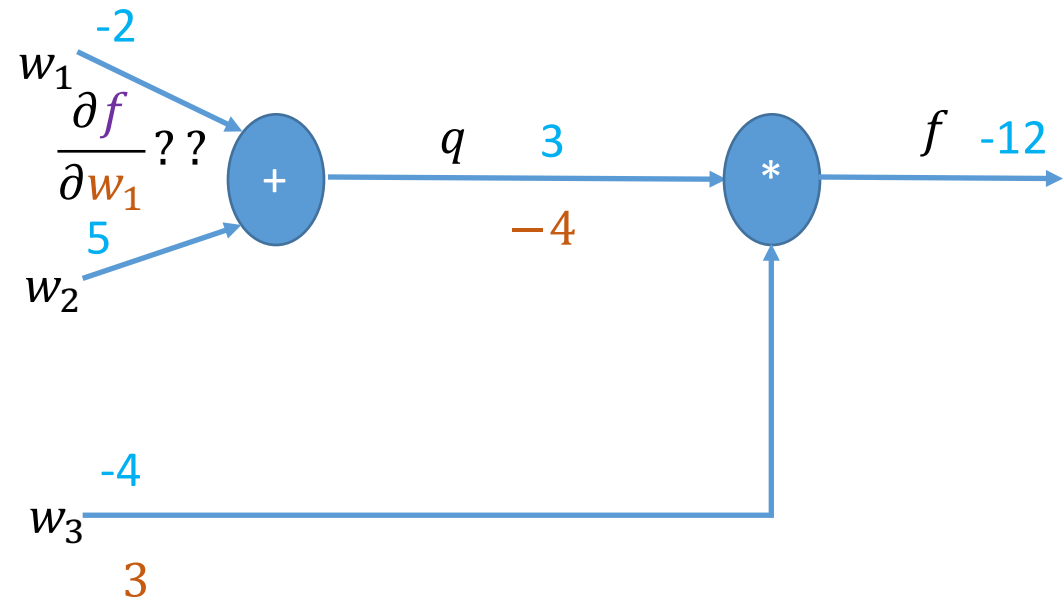
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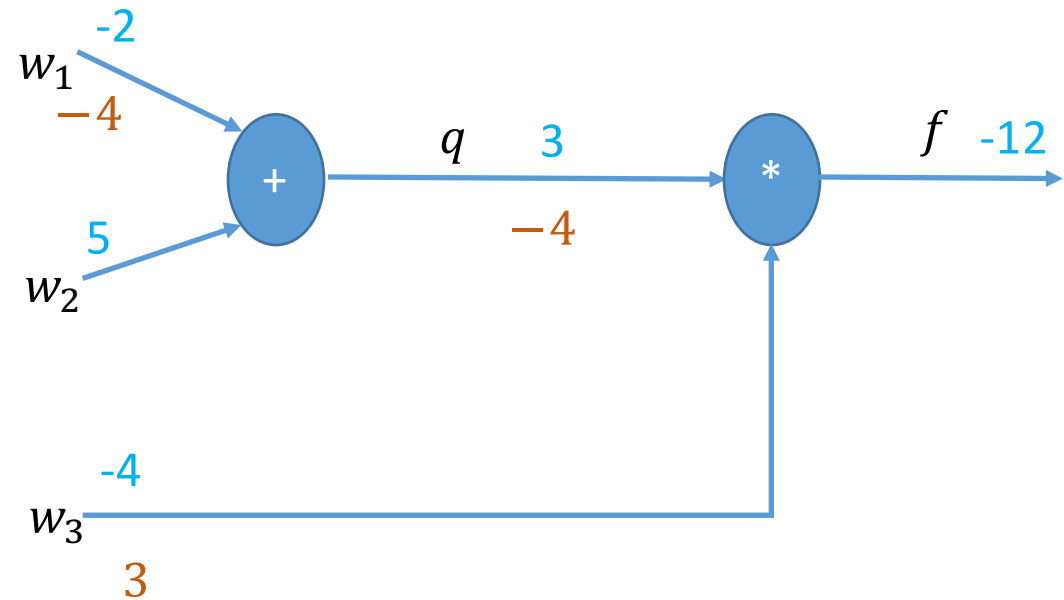
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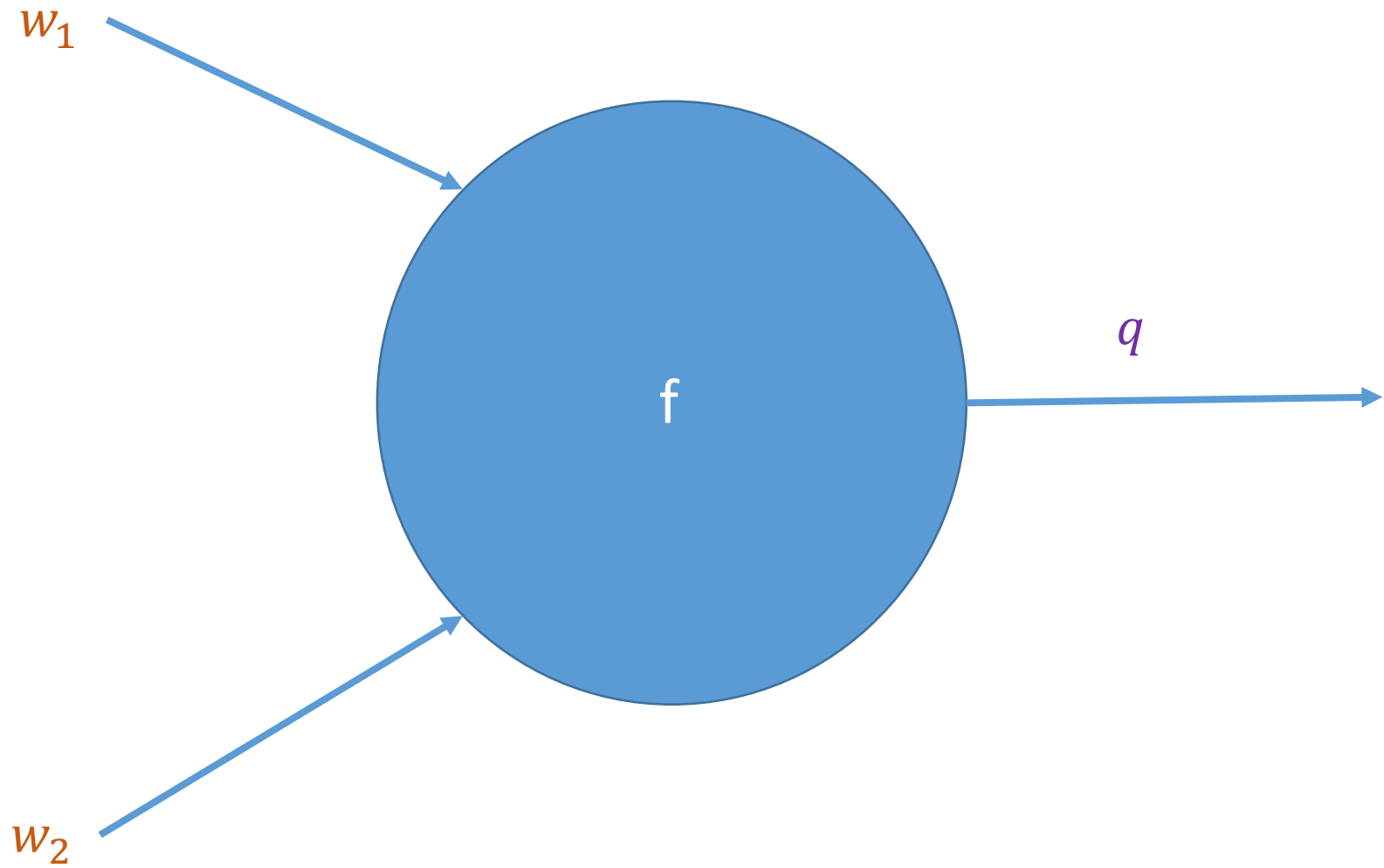
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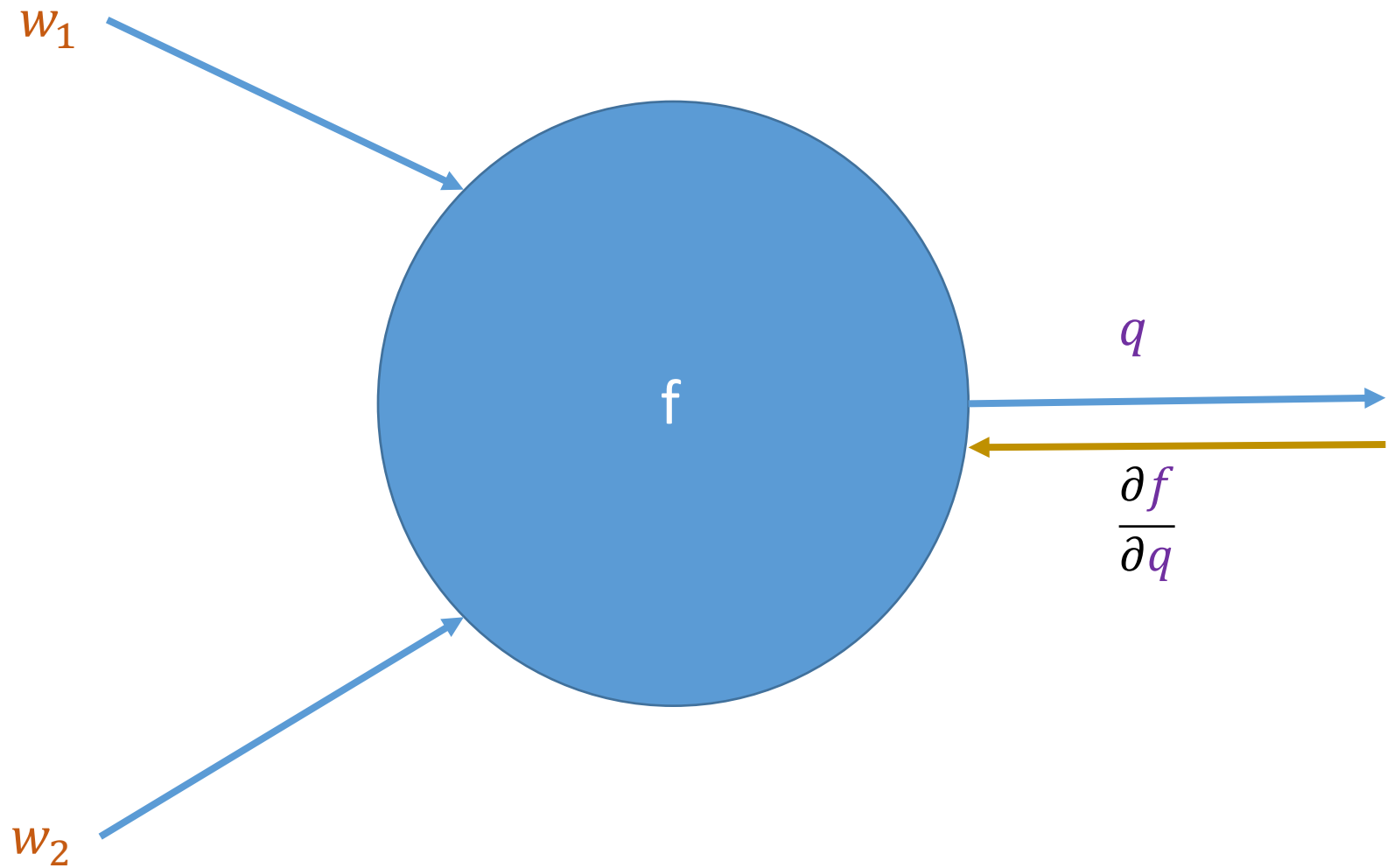
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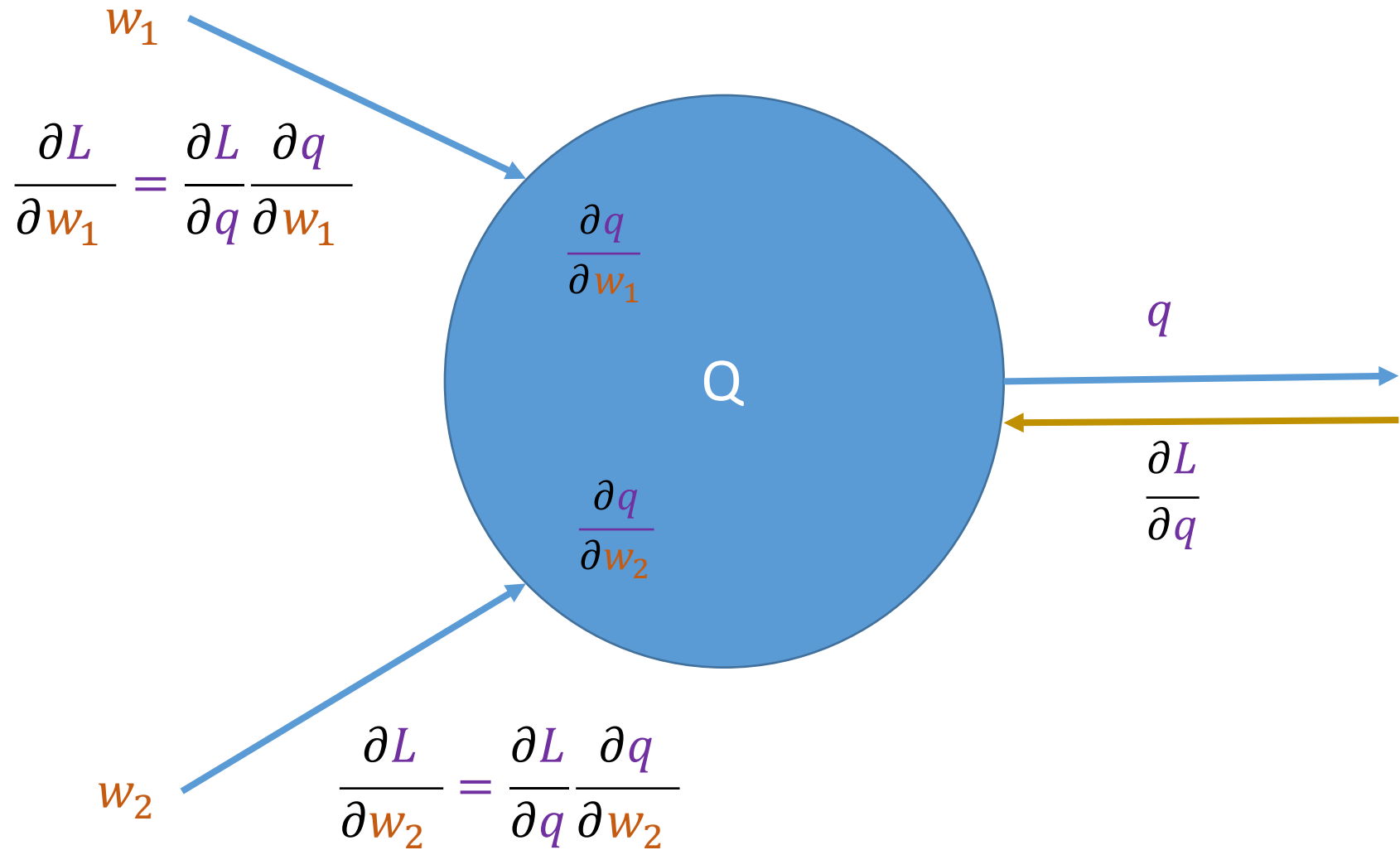
# One Node



# One Node



# One Node



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