



“From Fundamentals to Building  
Your Own Intelligent System”

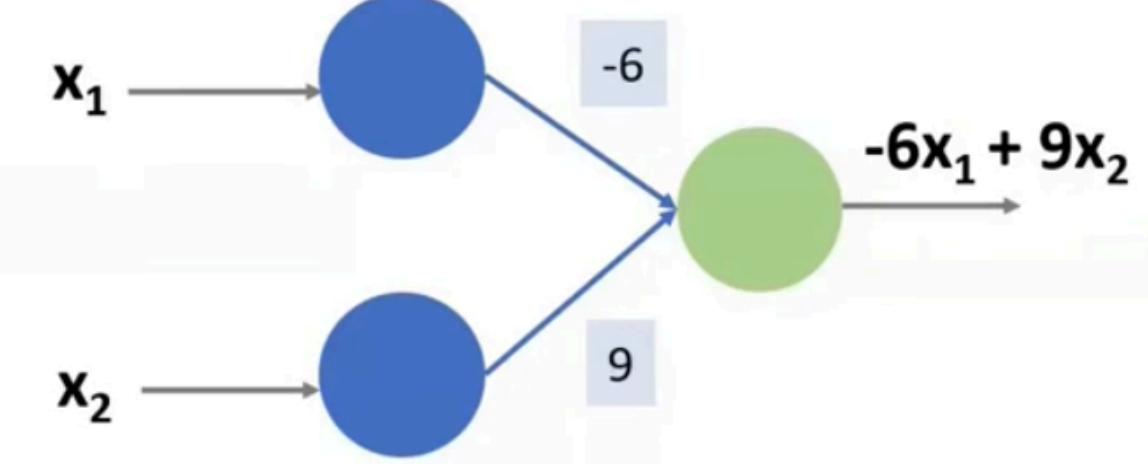
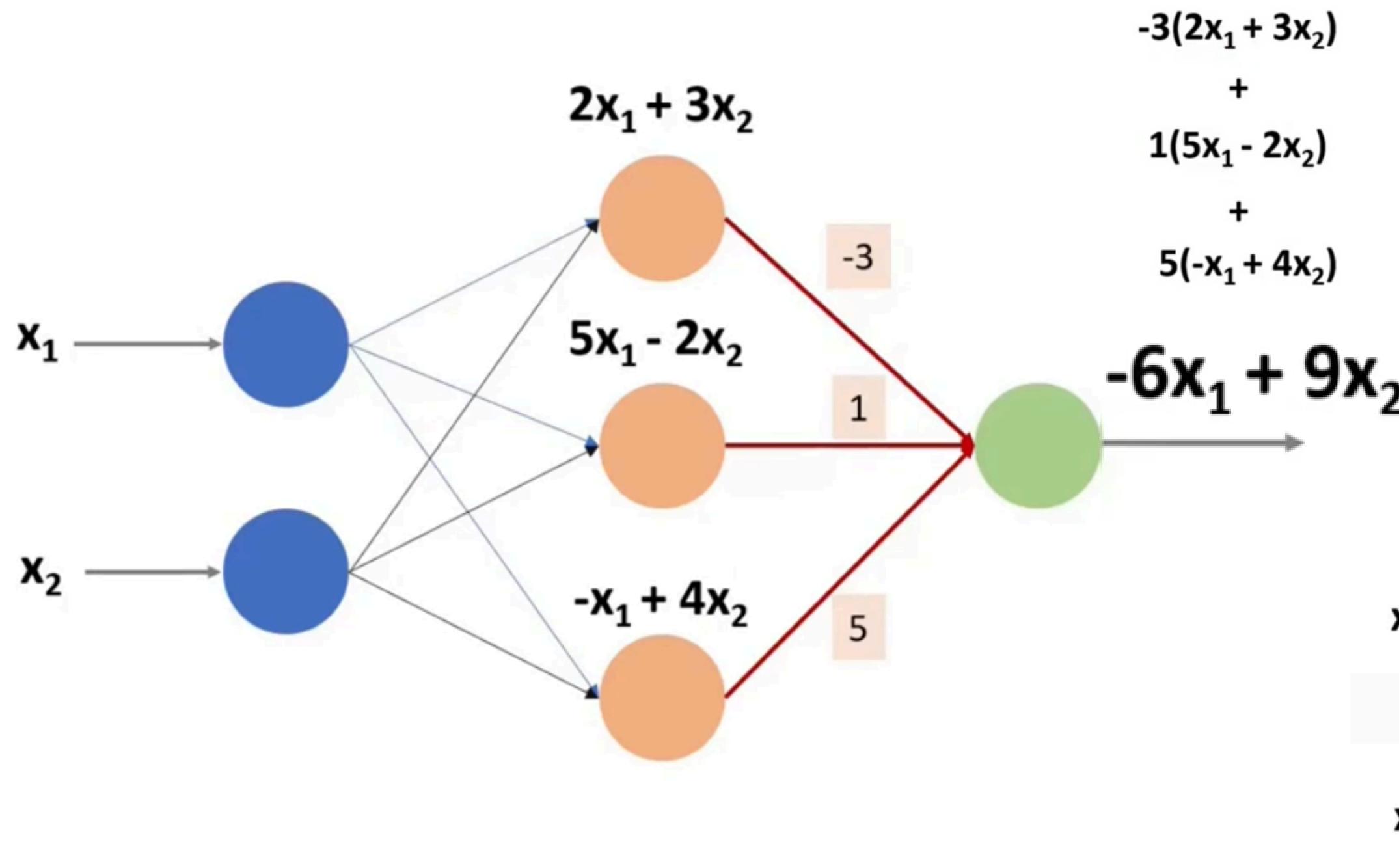
# AI & Machine Learning Bootcamp 2025

Dr. Fazlul Hasan Siddiqui & Dr. Sabah Binte Noor

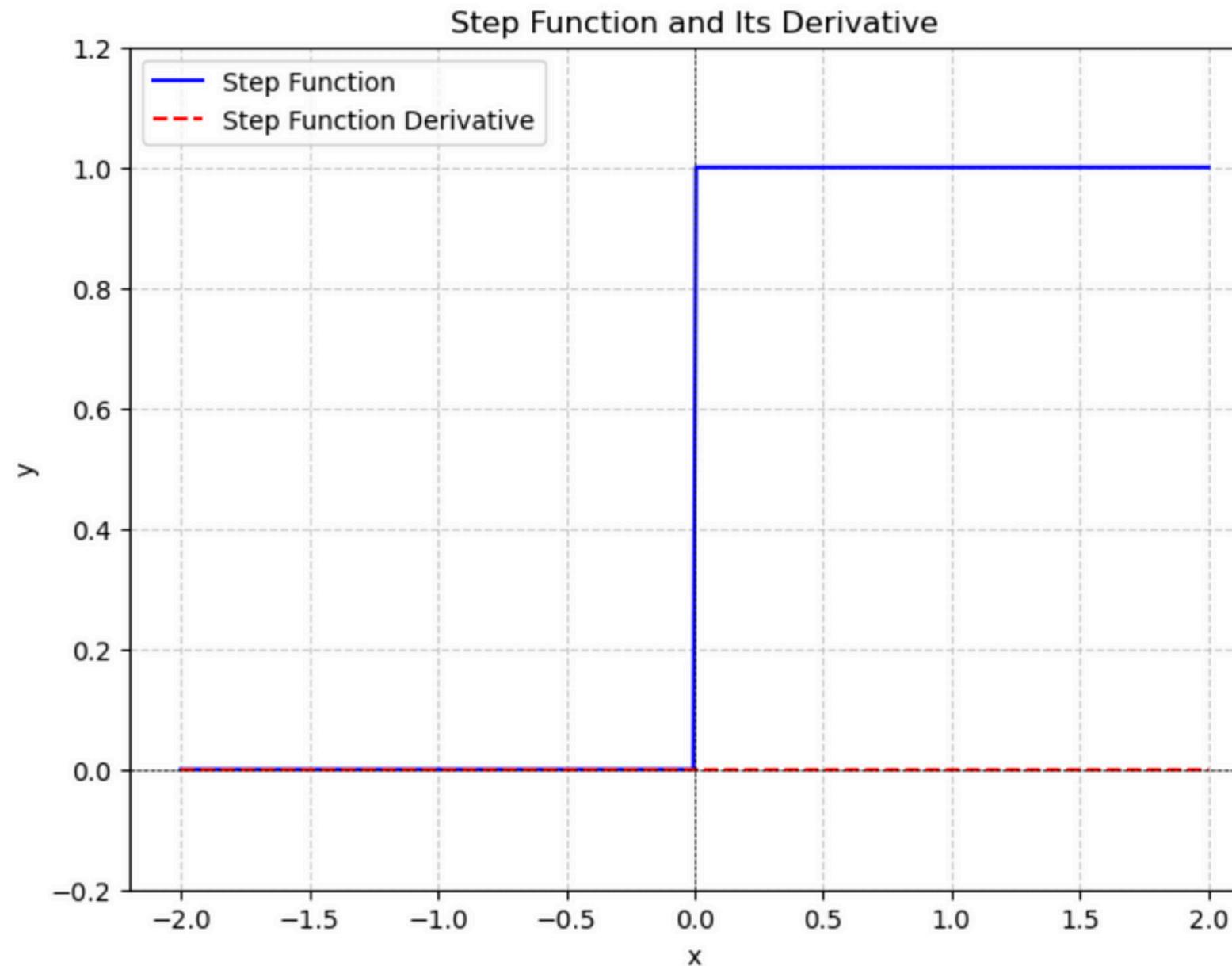
# Activation Functions

# Why

- To add non-linearity



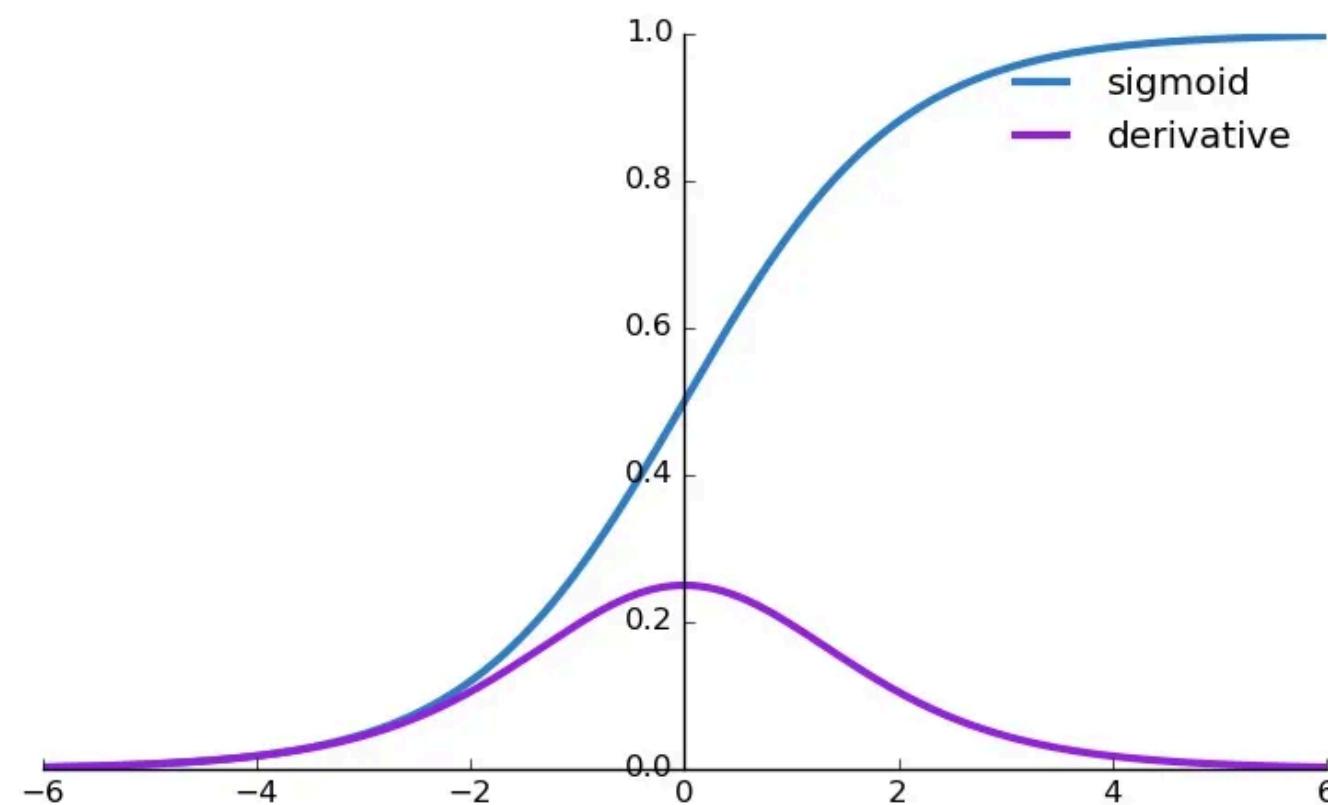
# Step function



$$f(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x \geq 0 \end{cases}$$

- Non-linearity ✓
- Differentiability ✗
- Zero-centeredness ✗
- Computational efficiency ✓

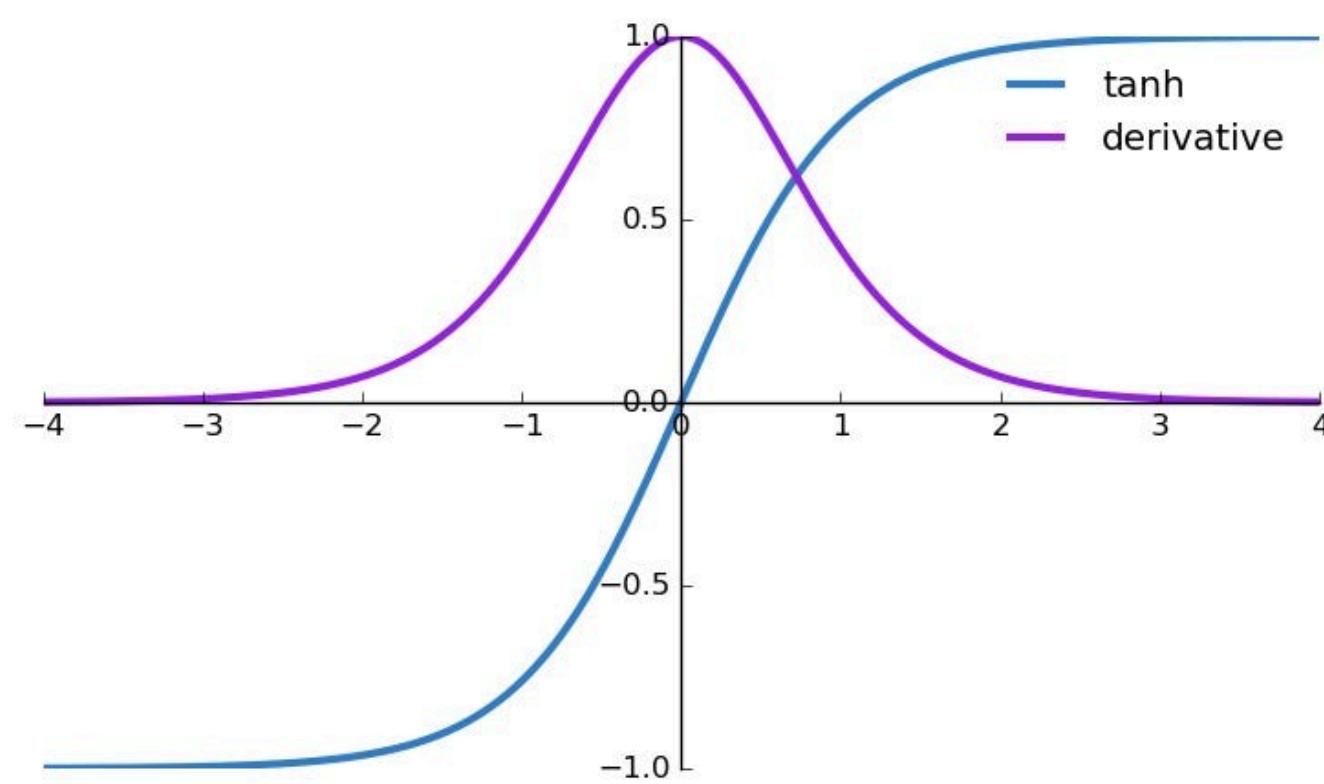
# Sigmoid (Logistic)



$$f(x) = \frac{1}{1 + e^{-x}}$$

- Non-linearity ✓
- Differentiability ✓
- Zero-centeredness ✗
- Computational efficiency !

# tanh

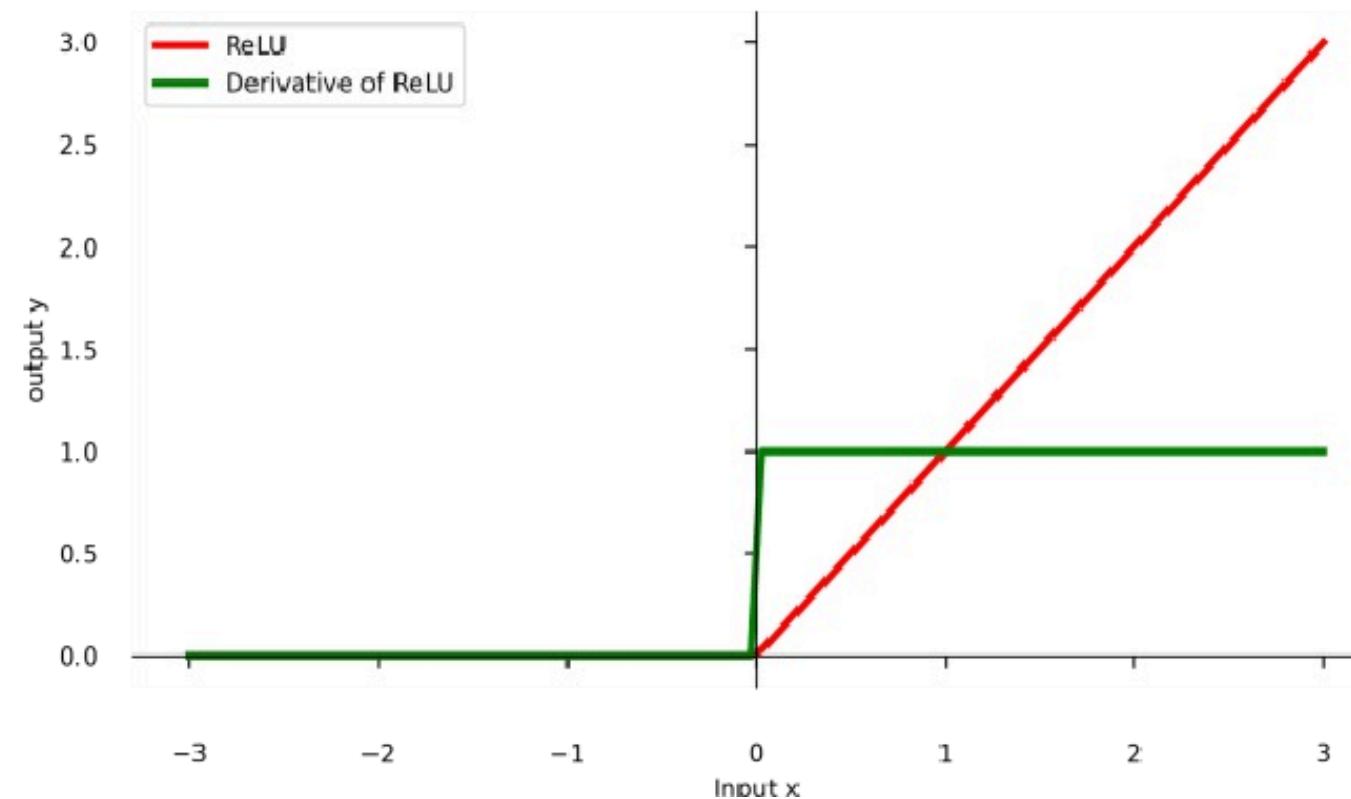


$$f(x) = \tanh(x) = \frac{2}{1 + e^{-2x}} - 1$$

- Non-linearity ✓
- Differentiability ✓
- Zero-centeredness ✓
- Computational efficiency !

# Rectified Linear Unit (ReLU)

$$f(x) = \max(0, x)$$



- Non-linearity ✓
- Differentiability ! (not at 0)
- Zero-centeredness ✗
- Computational efficiency ✓

# Summary

Activation Function	Non-linearity	Differentiability	Zero-centeredness	Computational Efficiency	Saturation Effects
Step	✓	✗	✗	✓	✓
Sigmoid	✓	✓	✗	⚠	✗
Tanh	✓	✓	✓	⚠	✗
ReLU	✓	⚠ (not at 0)	✗	✓	✗

# Cheat Sheet

Problem Type	Last-layer Output Nodes	Hidden-layer activation	Last-layer activation	Loss function
Binary classification	1	RELU (first choice), Tanh (for RNNs)	Sigmoid	Binary Crossentropy
Multi-class, single-label classification	Number of classes		Softmax	Categorical Crossentropy
Multi-class, multi-label classification	Number of classes	RELU (first choice), Tanh (for RNNs)	Sigmoid (one for each class)	Binary Crossentropy
Regression to arbitrary values	1		None	MSE
Regression to values between 0 and 1	1	RELU (first choice), Tanh (for RNNs)	Sigmoid	MSE/Binary Crossentropy