Introduction to Neural Networks

Inspiration from Nature

Birds inspired humans to build airplanes. The tiny hooks on burrs sticking to a dog's fur led to the invention of **Velcro**. And just like that, nature has always been humanity's greatest engineer.

So, when it came to making machines that could **think, learn, and solve problems**, where did we look?

To the **human brain**.

That's how **neural networks** were born — machines inspired by **neurons** in our brains, built to recognize patterns, make decisions, and even learn from experience.

What is AI, ML, and DL?

Before we dive into neural networks, let's untangle these buzzwords.

Term	Stands for	Think of it as...
AI	Artificial Intelligence	The big umbrella: making machines "smart"
ML	Machine Learning	A subset of AI: machines that learn from data
DL	Deep Learning	A type of ML: uses neural networks

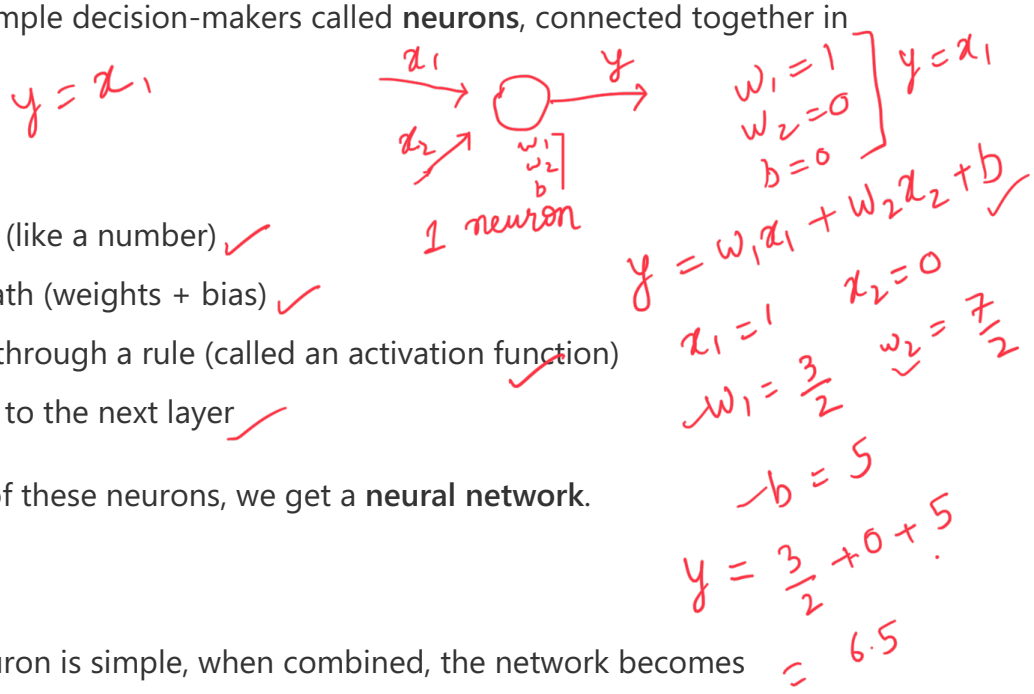
Let's simplify:

- **AI** is the dream: "Can we make machines intelligent?"
- **ML** is the method: "Let's give machines data and let them learn."
- **DL** is the tool: "Let's use neural networks that learn in layers — like the brain."

So, when we talk about **neural networks**, we're entering the world of **deep learning**, which is a part of **machine learning**, which itself is a part of **AI**.

So, What Are Neural Networks?

Imagine a bunch of simple decision-makers called **neurons**, connected together in layers.



Each neuron:

- Takes some input (like a number)
- Applies a little math (weights + bias)
- Passes the result through a rule (called an activation function)
- Sends the output to the next layer

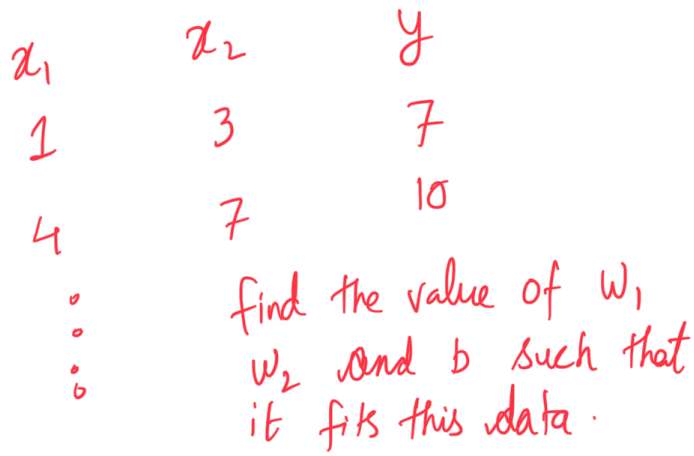
By connecting many of these neurons, we get a **neural network**.

And what's amazing?

Even though each neuron is simple, when combined, the network becomes powerful — like how a bunch of ants can build a complex colony.

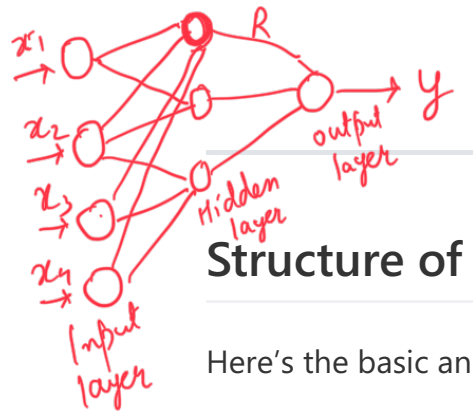
Why Are Neural Networks Useful?

Because they can **learn patterns**, even when we don't fully understand the patterns ourselves.



Examples:

- Recognize cats in photos
- Convert speech to text
- Translate languages
- Predict stock prices
- Generate art
- Power AI like ChatGPT



$R = \sigma(x_1 w_1 + x_2 w_2 + x_3 w_3 + x_4 w_4 + b_1)$

Activation f_n → Sigmoid, Relu, Step function.

Structure of a Neural Network

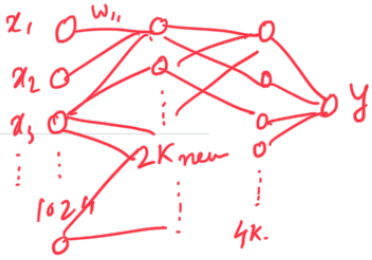
Here's the basic anatomy of a neural network:

```
Input Layer        →      Hidden Layers        →      Output Layer
  (Data)                  (Neurons doing math)          (Prediction)
```

Each **layer** is just a bunch of neurons working together. The more hidden layers, the **"deeper"** the network. Hence: **Deep Learning**.

$y = x_1$

Wait — Why Not Use Simple Code Instead?



Good question.

Sometimes, a simple formula or rule is enough (like `area = length × width`).

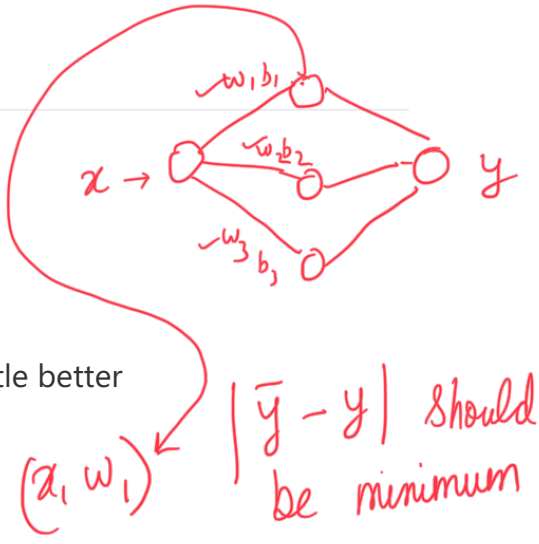
But what about:

$y = f(x)$ → very complex function.

- Recognizing handwritten digits?
- Understanding language?
- Diagnosing diseases from X-rays?

There are **no easy formulas** for these. Neural networks **learn the formula by themselves** from lots of examples.

How Do Neural Networks Learn?



Let's say the network tries to predict `y = x² + x`.

1. It starts with **random guesses** (bad predictions)
2. It checks how wrong it is (loss)
3. It adjusts the internal settings (weights) to be a little better
4. Repeat, repeat, repeat...

Over time, the network **figures out the relationship** between x and y.

This process is called **training** — and it's where the magic happens.

Are They Really Like the Brain?

Kind of — but **very simplified**.

- A biological brain neuron connects to 1000s of others
- It processes chemicals, spikes, timings
- It adapts and rewires itself

A neural network is a **mathematical model** — inspired by the brain, but way simpler. Still, the results are powerful.

Summary

Concept	Meaning
AI	Making machines act smart
ML	Letting machines learn from data
DL	Using multi-layered neural networks to learn complex stuff
Neural Network	A network of artificial neurons that learns from data