Neurons are the basic units of the nervous system, they underlie everything that the nervous system is able to do.
The proprieties of the neuron allow action potentials, we will talk about the process of action potentials. Are you familiar with it?

Neurons are the basic unit and allows communication within the system, and it all happened via electrical signals.
Electrical signals transmitted to one neuron to the next.

Here you have a stereotypical image of a neuron.
It has “Dentrites” (collectelectrical signals and bring it towards the cell body,
the cell body (also called Soma).
And its the sum of all the activity that comes from these dendrites that will then trigger the generation of an action potential (here at the base).
And then the action potential will propagated along the axon all the way to the the axon terminals where you have these synapses. Here neurotransmitters are released then trigger another electrical signal in an adjacent neuron. (on the dendrites of the adjacent neuron)

Before going to the Action potential:
We have the so called “Graded Potentials”: electrical signals that can be of various intensities. So I
have the inputs arriving to the neuron that sums together and if the sum of these graded potentials exceeds a certain point, they are able to trigger an action potential.

Now let’s refresh the idea of the action potential or “Spikes”
We can call them a rapid change in the polarity of the membrane potential.

First what is the membrane potential?
Cells have a membrane,
(DRAWING OF THE CELL) extracellular space, intracellular space

Differential distribution of ions on either side of the membrane creates a membrane potential
What it means is that the sum of all the ions you have in the external space is different from the sum of all the ions in the internal space.
So if you add up all the ions on the external space and subtract it from the ions in the internal space, you end up with a situation where the ext space is more positively charged than the internal space. This difference creates a gradient and a potential difference which (when the neuron is not doing much) is at -70mV.

There are channels in the membrane that allows ions to pass in and out the cell as they need to.

In the outside one of the main ions that is there SODIUM, in the internal part POTASSIUM. Almost equal amount.

For the action potential you have the first part which is an influx of sodium ions, sodium ions coming into the cell and with it bringing a positive charge, so that now the inside is

more positively charged than the outside but shortly after that you have an efflux of K+ , potassium ions leave the cell and take with it their positive charge.
So then what happens is that the inside becomes negative again, and this is that rapid flip in the polarity, we mentioned.

GRAPH to represent the action potential
time, amplitude in mV

When the neuron is not doing much we have -70, when the graded potentials exceed a certain point, when we reach a threshold we have the action potential. This happens at -55 mV
When you reach -55 there is stereotypical response, all the way about +30mV
and then return to the resting membrane potential.

Some stimulus come in, it didn't' reach the threshold so it comes down again, then more inputs are coming the membrane increase.. More stimulus come in and built on each other and when we reach that threshold you get the action potential:
Influx of sodium, efflux of potassium, fall below resting potential and then return to our resting membrane potential.
And this is action potential.

How can we model this? Simply with LIF neuron!

What is a LIF neuron?
It is a neuron model, a simplified versions of a neuron which capture its behavior.
Very simplified model on the RIGHT,
doesn't model any physical aspect of the neuron in terms of morphology, but it does model very interesting things.

LIF stands for leaky integrate and fire. It models the membrane potential voltage, it has a leack term and it can spikes.
Let's talk about the membrane equation,
the LFF models voltage in time and this is represented by this equation called "membrane equation".

Let's understand it in blocks:
Left side: time evolution of our membrane potential (the voltage of the neuron). So the time evolution of V(t) is given by the right side of this equation, namely the synaptic input and the leak term.
Synaptic input: input to the neuron
Leak term is a a mechanism that makes the V(t) go to a rest value if no further input arrives. Otherwise if the neuron receive some synaptic input and was at a certain voltage level without the leak term, it would stay there. But this way it just goes down to the rest value.

So now let's code it and understand the role of each variable!