**What are Spiking Neural Networks?**

Spiking Neural Networks are a class of [*artificial neural networks*](https://www.geeksforgeeks.org/artificial-neural-networks-and-its-applications/)that mimic the behaviour of biological neurons more closely than traditional neural networks. In SNNs, neurons communicate by sending discrete spikes, which represent changes in voltage across a neuron's membrane.

SNNs operate on discrete events called "spikes."

**Key Concepts in Spiking Neural Networks**

**1. Neurons and Spikes**

In SNNs, each neuron emits spikes based on its membrane potential

When the membrane potential reaches a certain threshold, the neuron "fires" and emits a spike.

**2. Temporal Coding**

SNNs use temporal coding, where the timing of spikes carries information.

information is represented by the frequency of neuron firing

**3. Synaptic Weights and Plasticity**

Connections between neurons in SNNs are governed by synaptic weights, which determine the influence of one neuron's spike on another.

Synaptic plasticity, often governed by rules such as Spike-Timing-Dependent Plasticity (STDP), allows these weights to change based on the timing of spikes, enabling learning.

**Mechanisms of Spiking Neural Networks**

**1. Membrane Potential and Firing Threshold**

Each neuron has a membrane potential that integrates incoming spikes. When the potential crosses a threshold, the neuron fires a spike and the potential resets.

**2. Synaptic Integration**

**3. Learning Rules**

* **Spike-Timing-Dependent Plasticity (STDP)**: The strength of synapses is adjusted based on the relative timing of spikes. If a presynaptic neuron fires shortly before a postsynaptic neuron, the connection is strengthened (LTP). If the order is reversed, the connection is weakened (LTD).

**4. Neuron Models**

* **Leaky Integrate-and-Fire (LIF)**: A simple model where the membrane potential decays over time unless it's boosted by incoming spikes.
* **Hodgkin-Huxley Model**: A more complex and biologically realistic model that describes the ionic mechanisms underlying the initiation and propagation of action potentials.

**Implementation of Spiking Neural Network**

**Step 1: Define Neuron and Synapse Classes**

* The LIFNeuron class models the behaviour of a leaky integrate-and-fire neuron.
* The Synapse class represents the connection between neurons with an associated weight.

**Step 2: Define the STDP Learning Rule**

* The stdp function adjusts the synaptic weights based on the timing difference between the pre- and post-synaptic spikes.

**Step 3: Initialize Simulation Parameters and Network**

* Set the number of time steps and the sizes of input, hidden, and output layers.
* Initialize neurons and synapses with their parameters and random weights.

**Step 4: Define the Spike Train Pattern to Detect**

**Step 5: Simulation Loop**

* Run the simulation for the defined number of time steps.
* Update neurons and synapses at each time step.
* Apply the STDP learning rule to adjust synaptic weights.
* Check if the pattern is detected.