Time step mechanics(dt)

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1. What is dt?

dt = time step

It is small amount of time the simulation moves forward in each update.

Examples:

- dt = 1 ms → neuron updates every 0.001 seconds
- dt = 0.5 ms → updates even more frequently
- dt = 5 ms → slower update, less detail

Simple idea:

dt = "how fast the clock ticks" inside the simulation

2. Why do neurons update every millisecond?

→ Because real biological neuron fire & change voltage at millisecond precision. To capture this, simulations also use very small dt values.

$\boxed{\text{Brain works fast → Simulation must also update fast.}}$

3. Continuous vs Discrete Simulation

Real neuron:

- Voltage changes smoothly every moment (continuous time)

Computer Simulation:

- Computer cannot update continuously
- So it updates in small jumps (discreate time)

Example:

Continuous = smooth flow

Discrete = step by step

Simulation mimics real behavior by using very small steps (dt).

4. Why smaller dt = smoother voltage curves?

Because the neuron updates more often

- More updates = small changes each time → smooth line
- Fewer updates = big jumps → rough / jagged line

Like drawing a curve with:

- 100 dots → smooth
- 10 dots → zig-zag

Smaller dt = more detail = more accurate simulation

5. What happens at each dt step? (Simulation loop)

At each dt interval the neuron checks:

1. Input coming in?
2. Add input → voltage increases (integration)
3. Leak some voltage (decay)
4. If voltage > threshold → fire spike
5. Reset voltage
6. Move to next dt

This Repeats Like:

t = 0
t = dt
t = 2*dt
t = 3*dt
...

Simulation loop = time moves in small jumps.

* Short

- dt = "frame" of the brain movie
- smaller dt = more frames → smoother
- neurons change quickly → use ms-level dt
- Computer uses discrete steps
- each dt = update the neuron once.