Izhikevich's spiking neuron model:

$$\dot{v}_i = 0.04 v_i^2 + 5 v_i + 140 - u_i + I_i + \xi_i$$

ξ_i: noise

$$\dot{u}_i = a(b v_i - u_i)$$

For non-I nodes	For I-nodes
$a = 0.02$	$a = 0.1$
$b = 0.2$	$b = 0.2$
$c = -65$	$c = -65$
$d = 8$	$d = 2$

if $v_i \geq 30$

$v_i \to c$

$u_i \to u_i + d$

$$I_i(t) = G_i^{Exc}(t)\left(V_E - V_i(t)\right) - G_i^{inh}(t)\left(V_i(t) - V_I\right)$$

$V_E = 0$

$V_I = -80$

$$\frac{dG_i^{exc}}{dt} = -\frac{G_i^{exc}}{\tau_{exc}} + \beta \sum_{j=1, W_{ij}>0}^{N} W_{ij} \sum_k \delta(t - t_{j,k})$$

$\tau_{exc} = 5$

$$\frac{dG_i^{inh}}{dt} = -\frac{G_i}{\tau_{inh}} + \beta \sum_{j=1, W_{ij}<0}^{N} |W_{ij}| \sum_k \delta(t - t_{j,k})$$

$\tau_{inh} = 6$

$$\Rightarrow G_i^{exc} = \beta \sum_{j=1, W_{ij}>0} W_{ij} \sum_k e^{-\frac{(t - t_{j,k})}{\tau_{exc}}} \theta(t - t_{j,k})$$

θ: Heaviside step function

$$G_i^{inh} = \beta \sum_{j=1, W_{ij}<0} |W_{ij}| \sum_k e^{-\frac{(t - t_{j,k})}{\tau_{inh}}} \theta(t - t_{j,k})$$

(inhibitory)

I nodes: nodes i such that $W_{ji} < 0 \quad \forall j$

non-I nodes: nodes i such that $W_{ji} > 0 \quad \forall j$ excitatory or E-nodes

$W_{ji} = 0 \quad \forall j$ nodes with no detectable outgoing links

Convention:

W_{ij} gives the coupling strength (synaptic weight) of the link from node j to node i