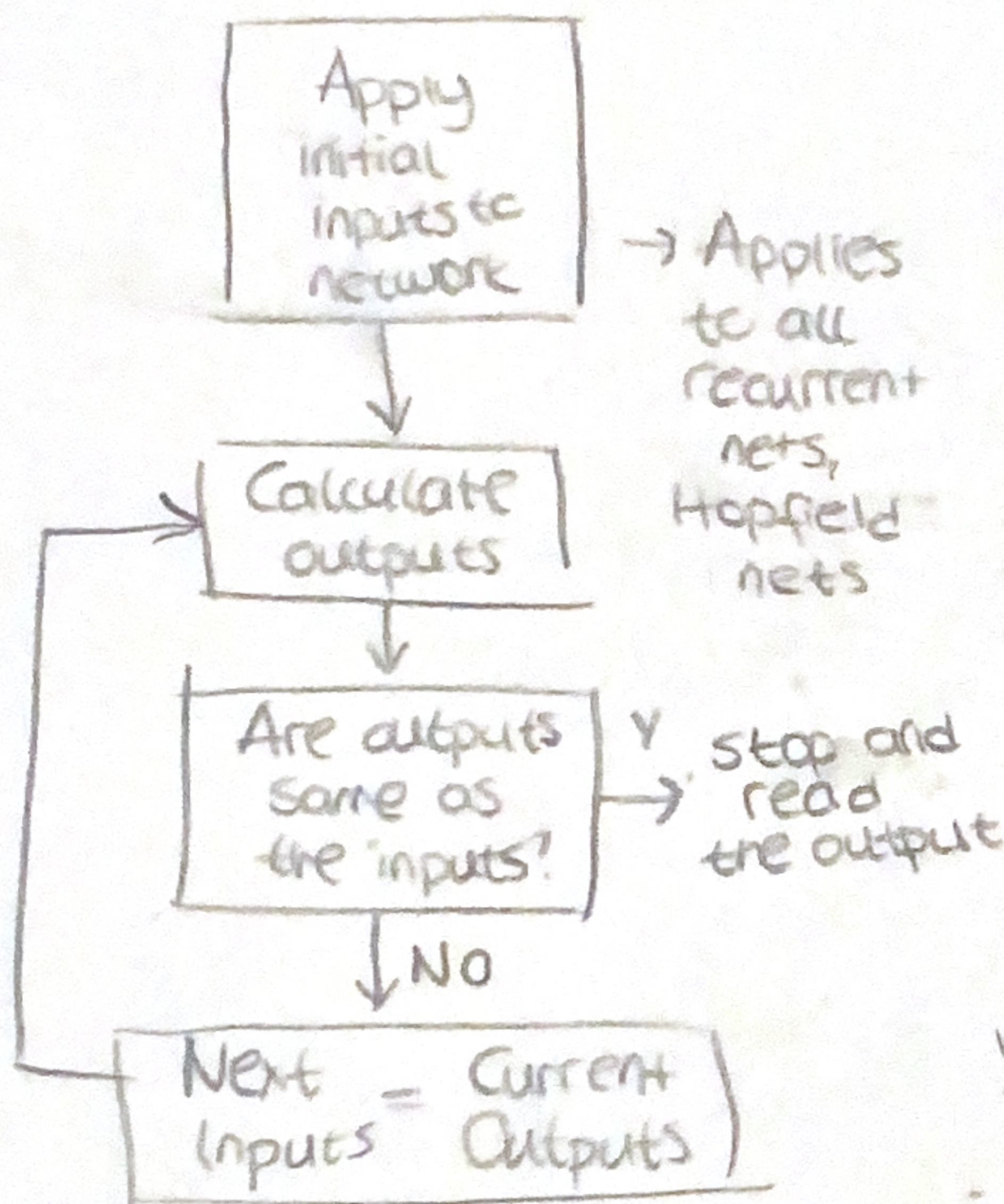
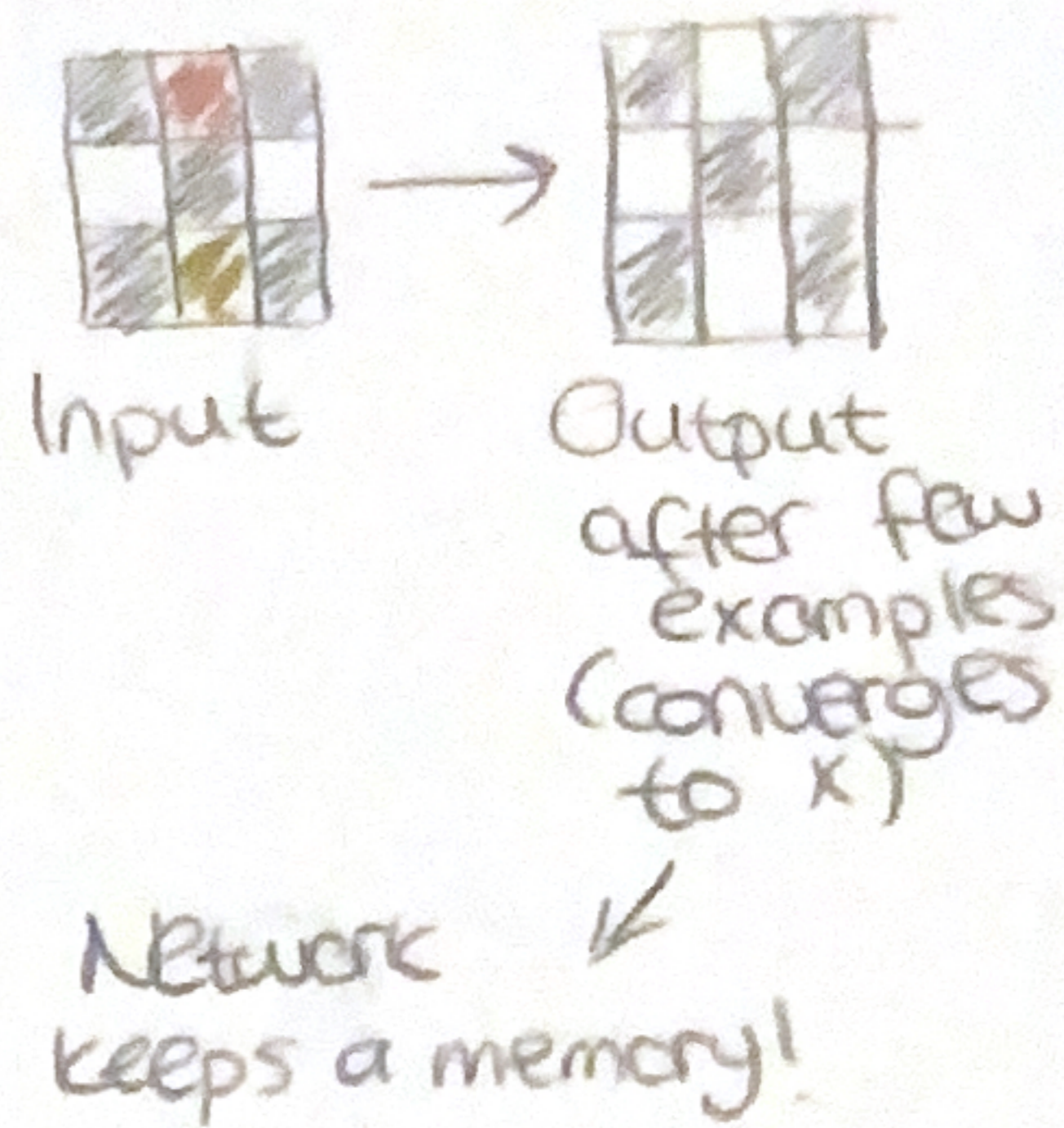
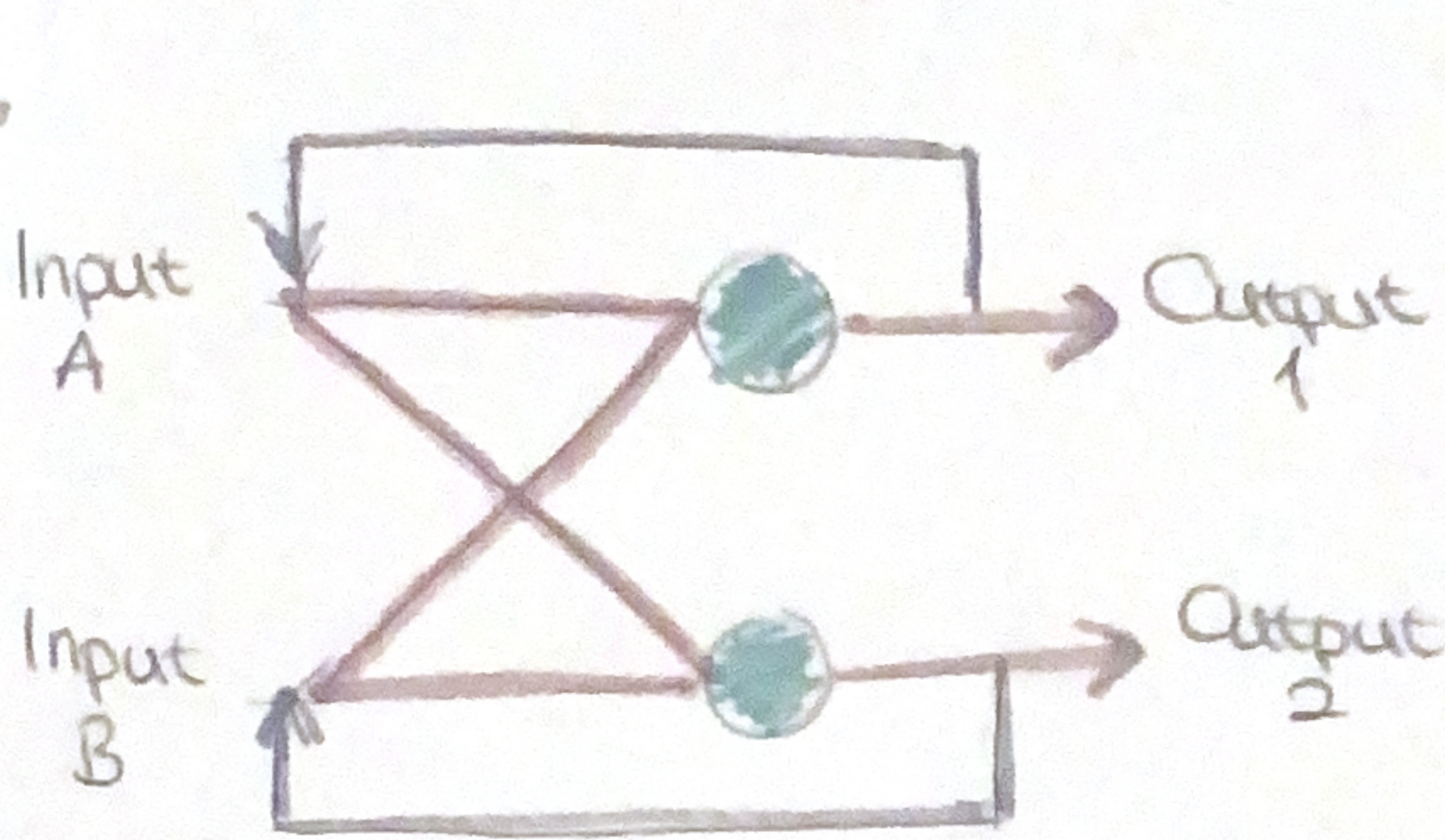


# Recurrent Neural Network



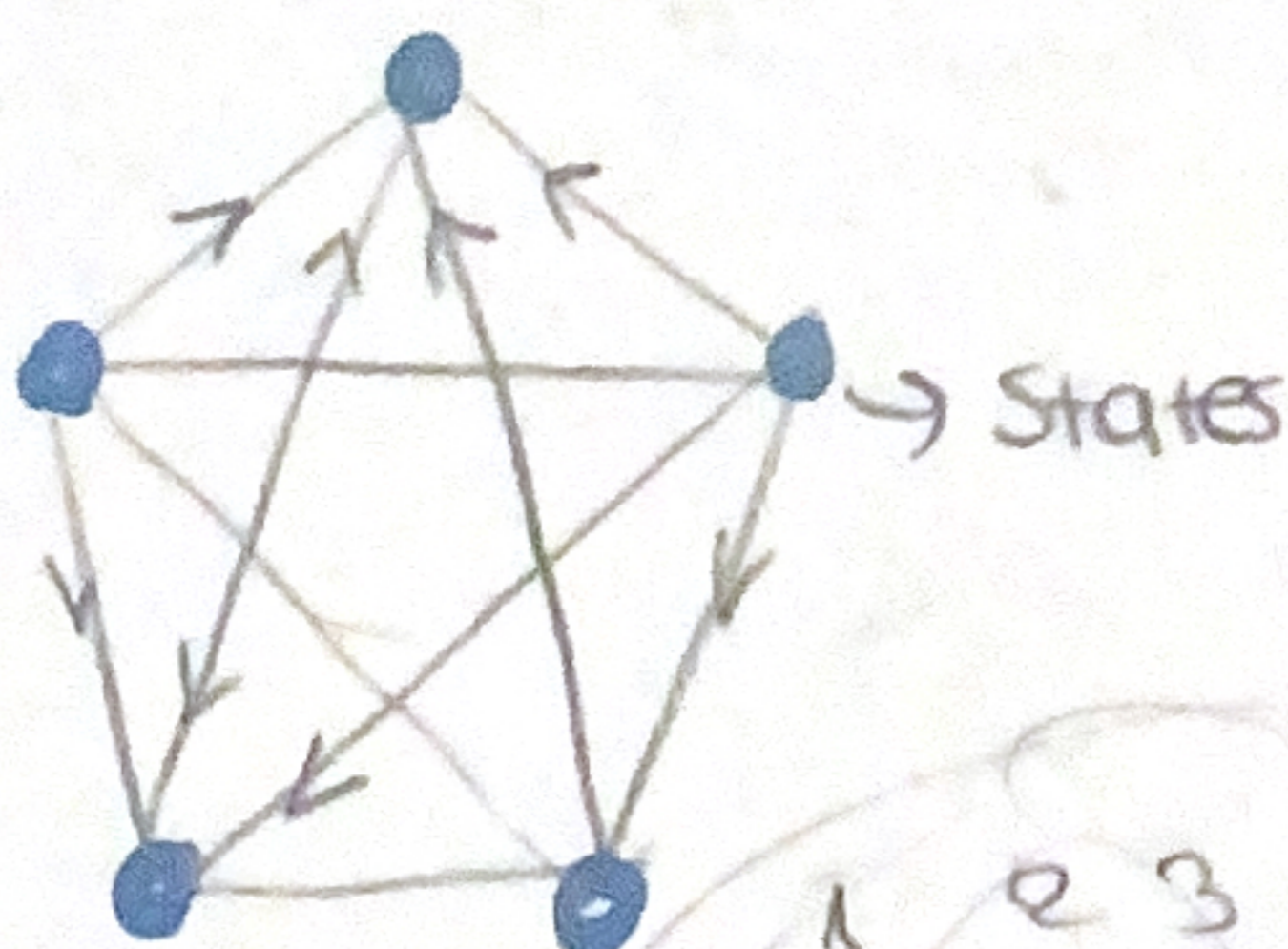
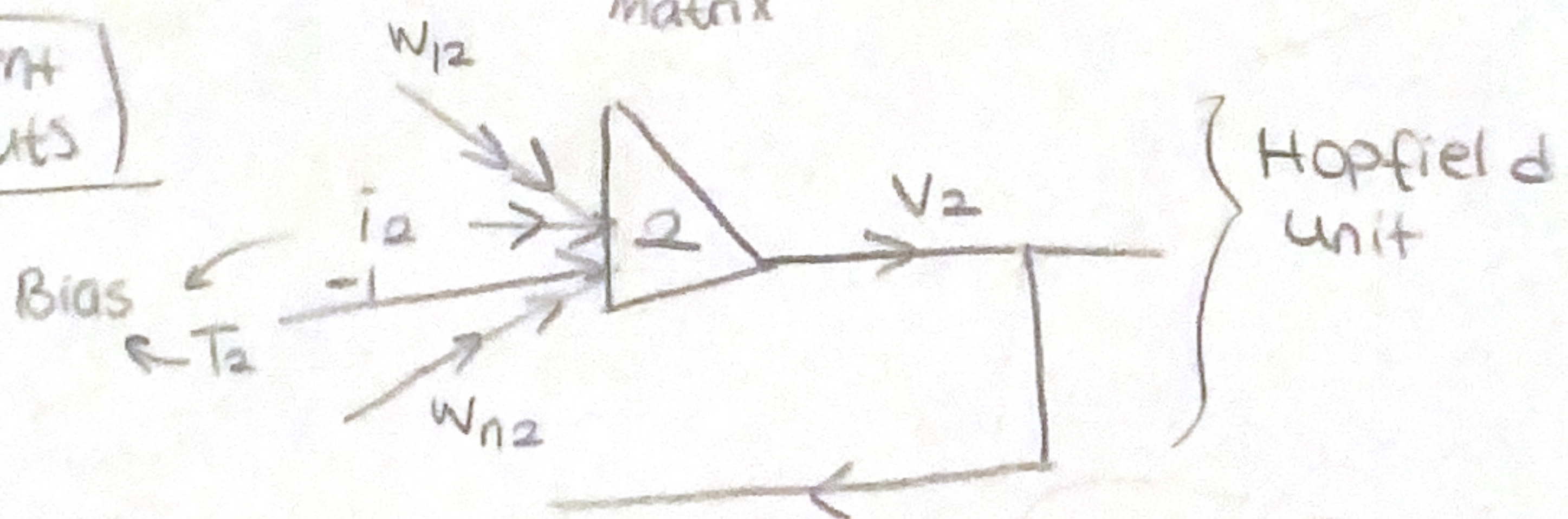
## Hopfield Networks

- Weight matrix is symmetrical  
 $W_{ij} = W_{ji}$
- Output  $v_i = -1$  if  $net_i < 0$   
 $v_i = 1$  if  $net_i \geq 0$

Activation function used is the sign function.

$$net_i = w_i \cdot v + i_i - T_i$$

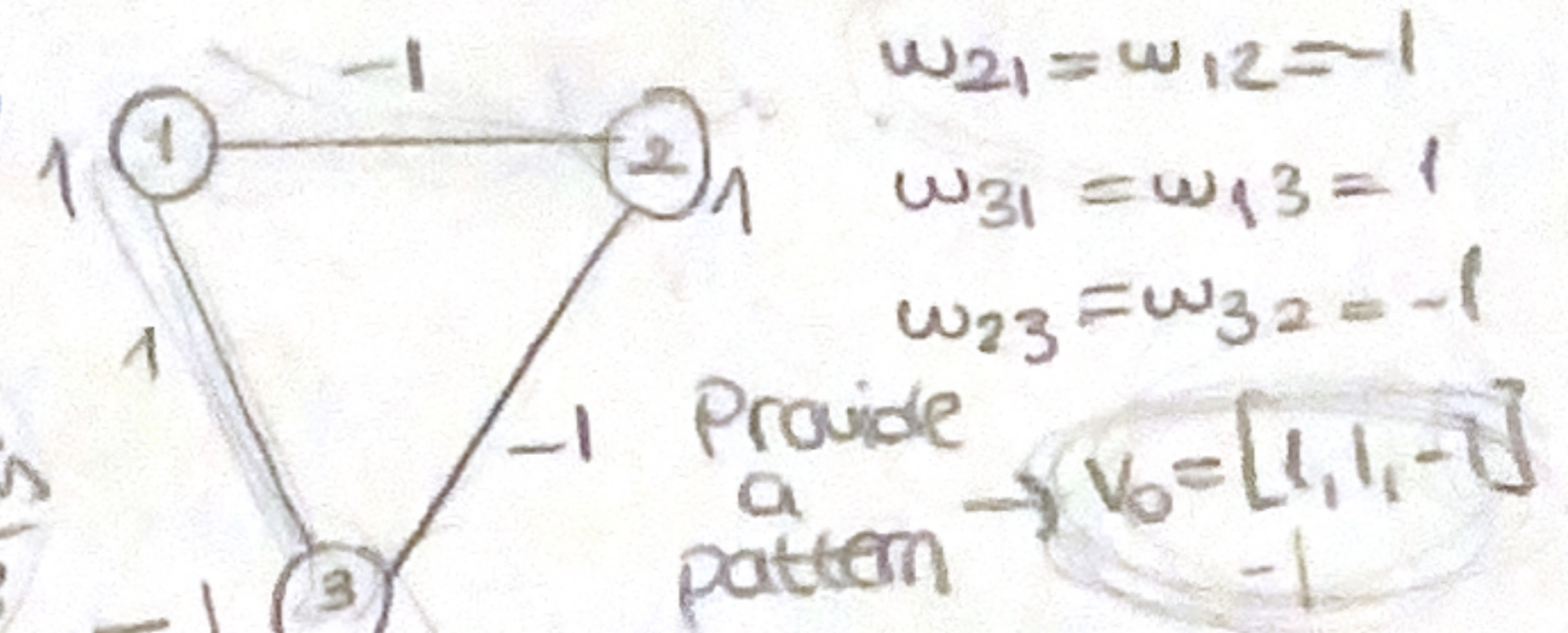
$w_i$  (weight matrix)       $v$  (output matrix)       $T_i$  (Bias inputs)



$$w_i = \begin{bmatrix} 1 & 2 & 3 \\ 0 & -1 & 1 \\ -1 & 0 & -1 \\ 1 & -1 & 0 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$

HPL  
 $W_{12} \cdot v_{12} + W_{13} \cdot v_{13}$

ex 11



Calculate  $net_1$

$$net_1 = 1 * (-1) + (-1) * 1 = -2$$

$$net_2 = 1 * (-1) + (-1) * (-1) = 0$$

$$net_3 = 1 * 1 + 1 * (-1) = 0$$

$$v_i = [-1, 1, 1]$$

$$w_{21} = w_{12} = -1$$

$$w_{31} = w_{13} = 1$$

$$w_{23} = w_{32} = -1$$

Provide a pattern →  $v_0 = [1, 1, -1]$