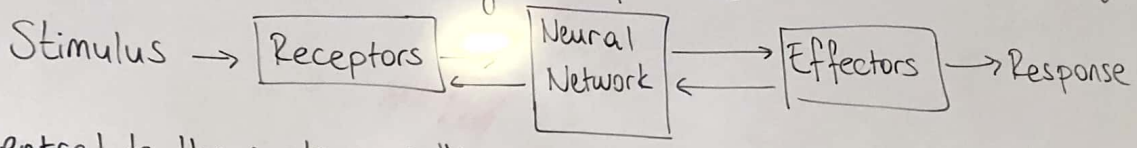
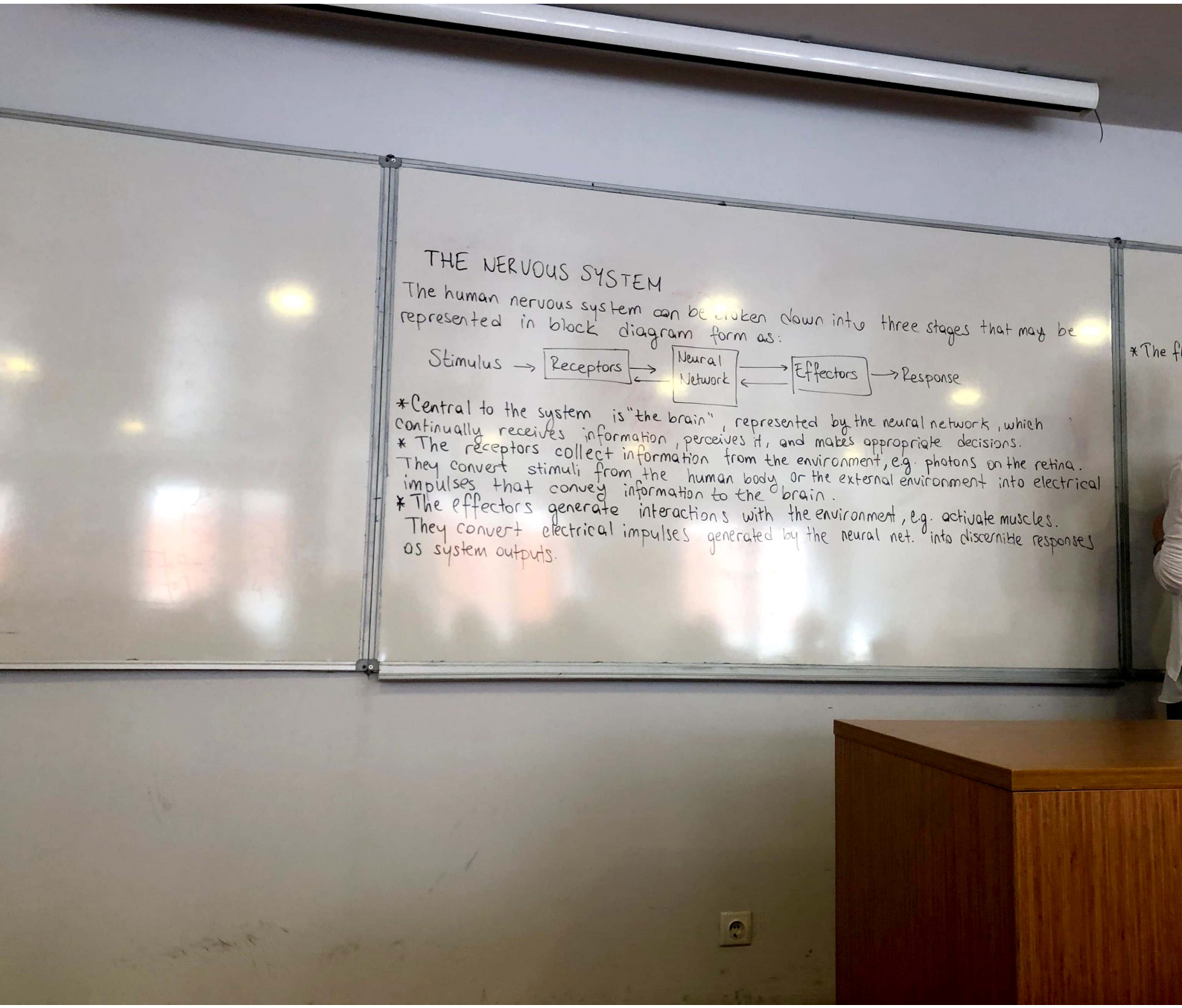
THE NERVOUS SYSTEM

The human nervous system can be broken down into three stages that may be represented in block diagram form as:



* Central to the system is "the brain", represented by the neural network, which continually receives information, perceives it, and makes appropriate decisions.
* The receptors collect information from the environment, e.g. photons on the retina. They convert stimuli from the human body or the external environment into electrical impulses that convey information to the brain.



nay be

nich

e retina.
o electrical

scles.
e responses

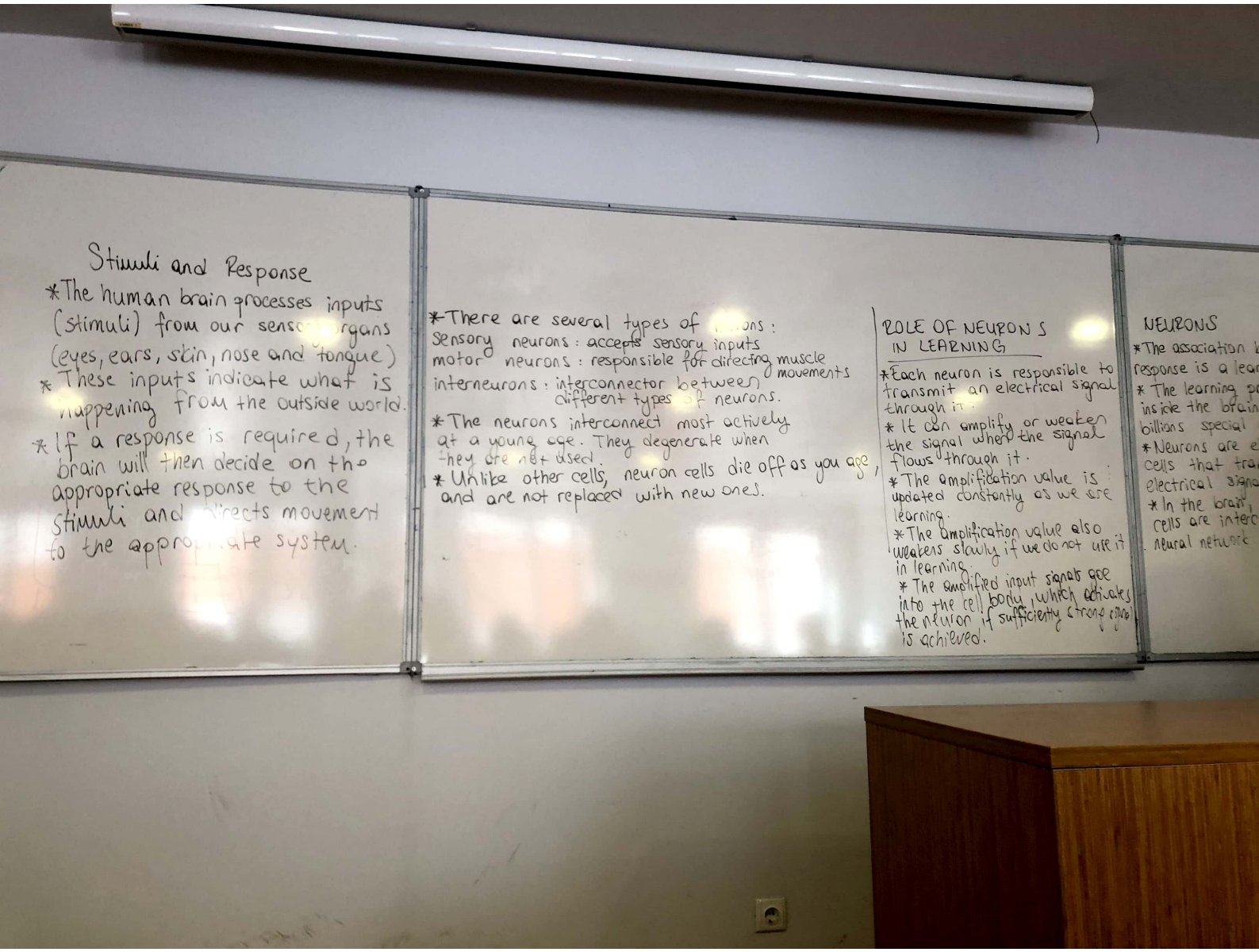
* The flow of information/activation is represented by arrows.
* The arrows pointing from left to right, indicate the forward transmission of information bearing signals through the system.
* The arrows pointing from right to left, signify the presence of feedback in the system.

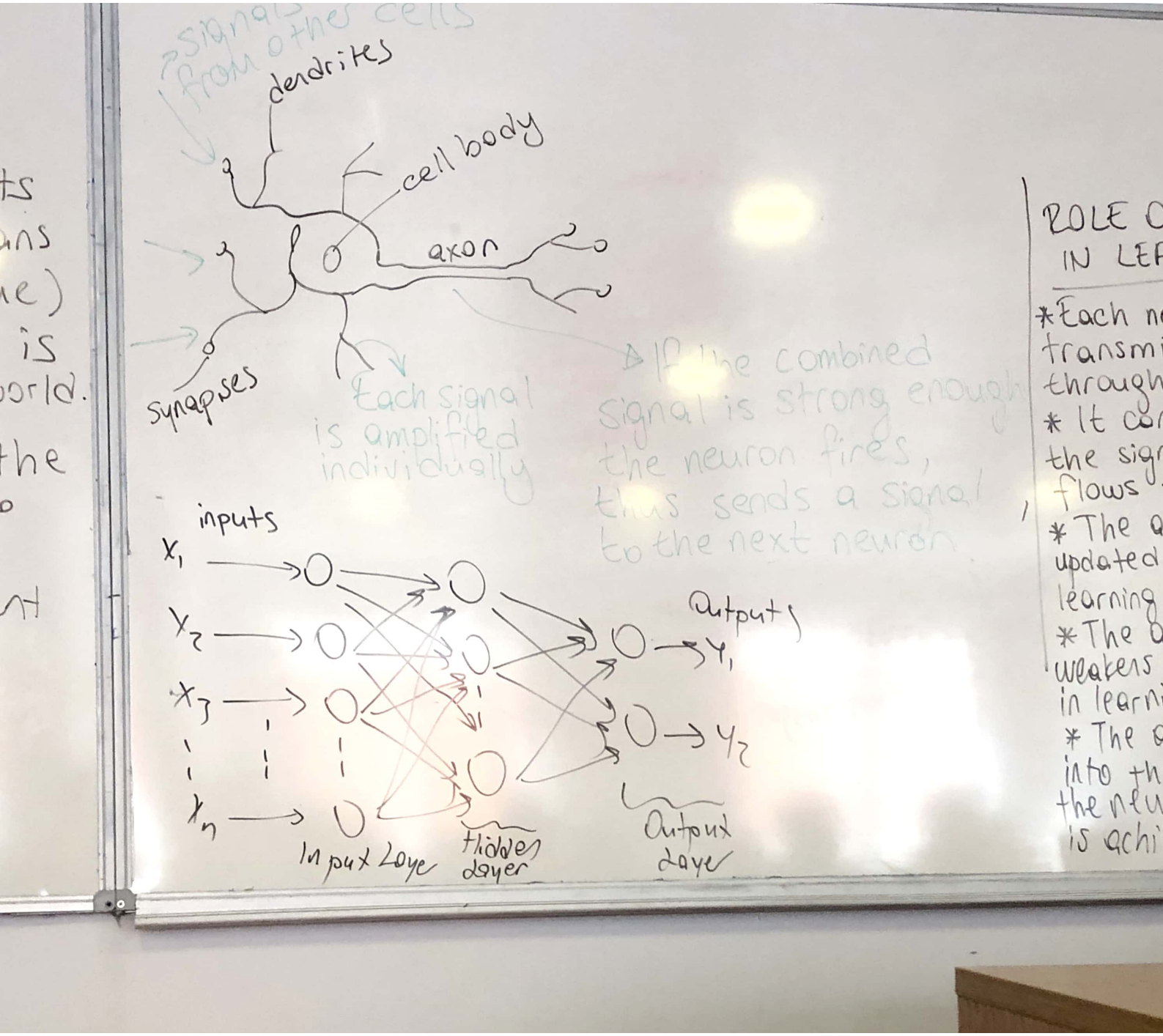
Stimuli and Response

* The human brain processes inputs (stimuli) from our sensory organs (eyes, ears, skin, nose and tongue)
* These inputs indicate what is happening from the outside world.
* If a response is required, the brain will then decide on the appropriate response to the stimuli and directs movement to the appropriate system.

NEURONS

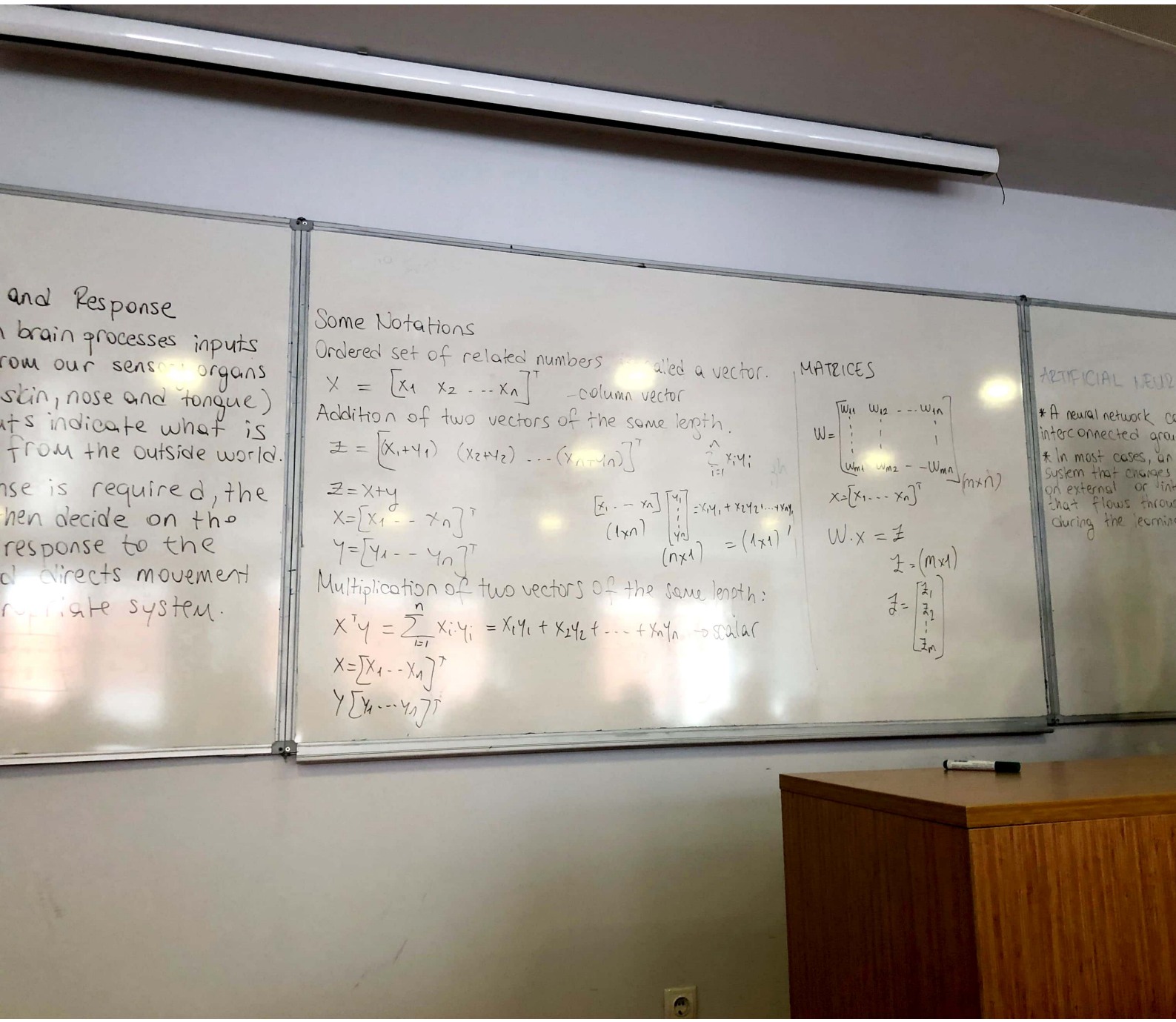
* The association between stimuli and response is a learned process.
* The learning process takes place inside the brain, where there are billions special cells called neurons.
* Neurons are electrically excitable cells that transmit information by electrical signaling.
* In the brain, billions of the neuron cells are interconnected to form a neural network.

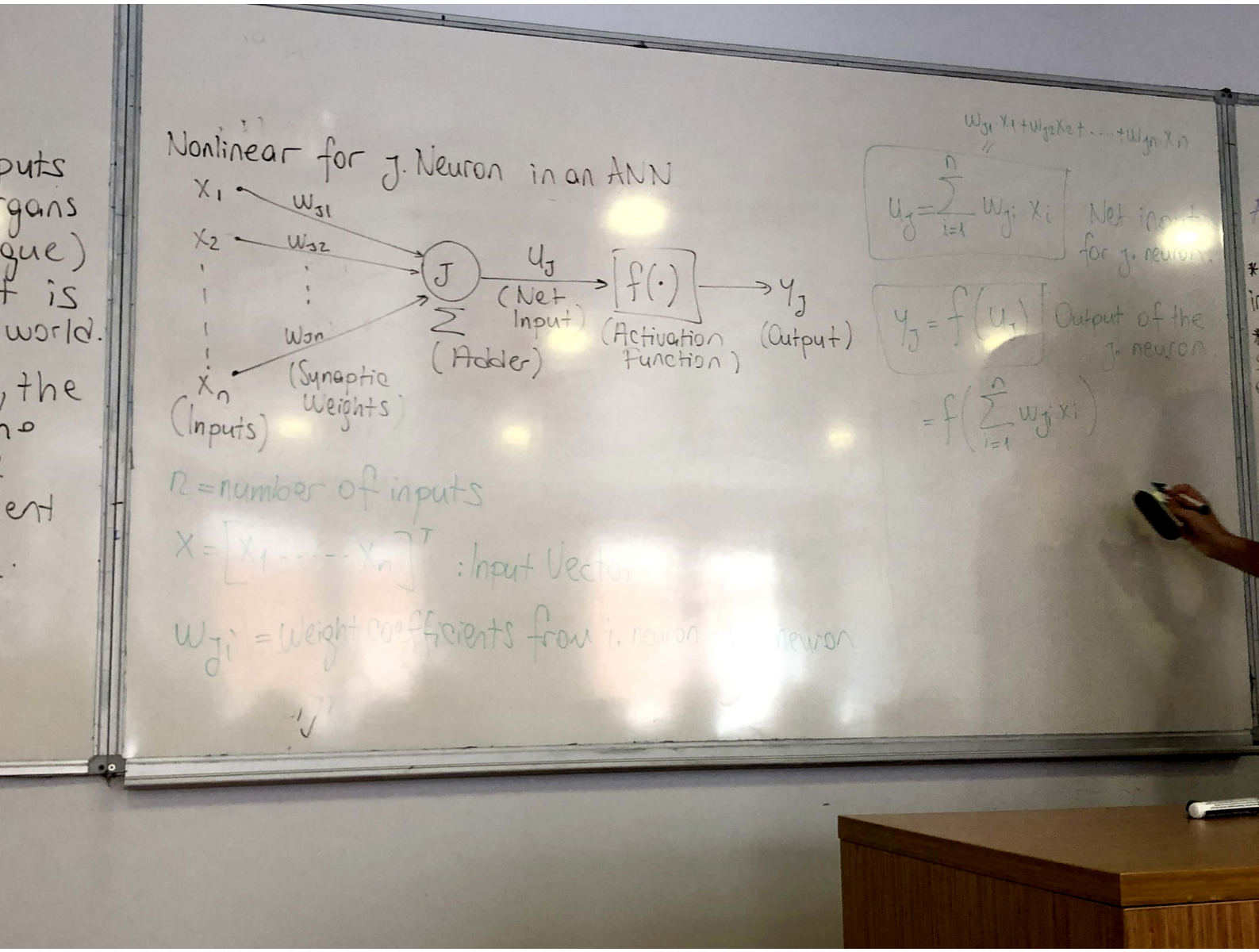


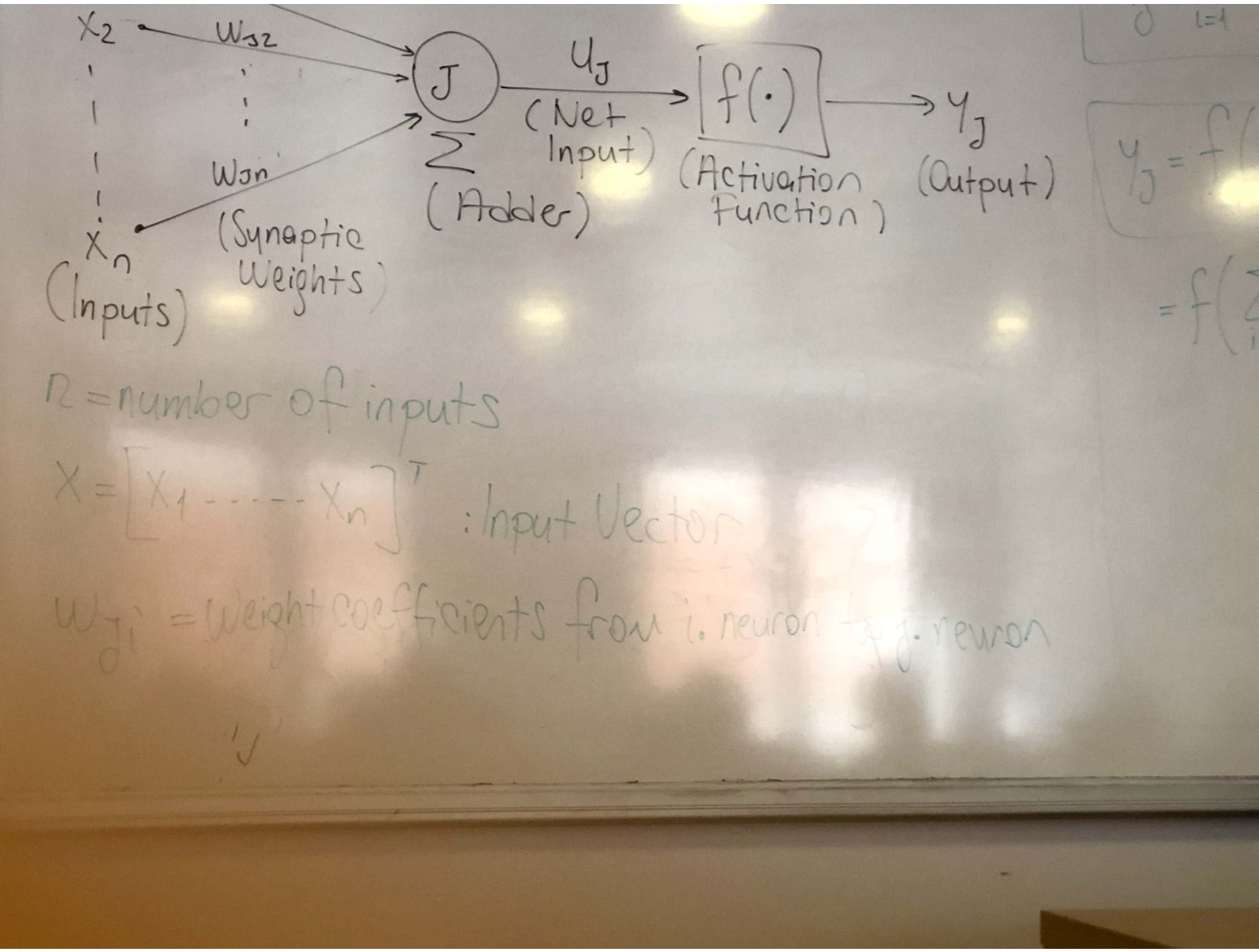


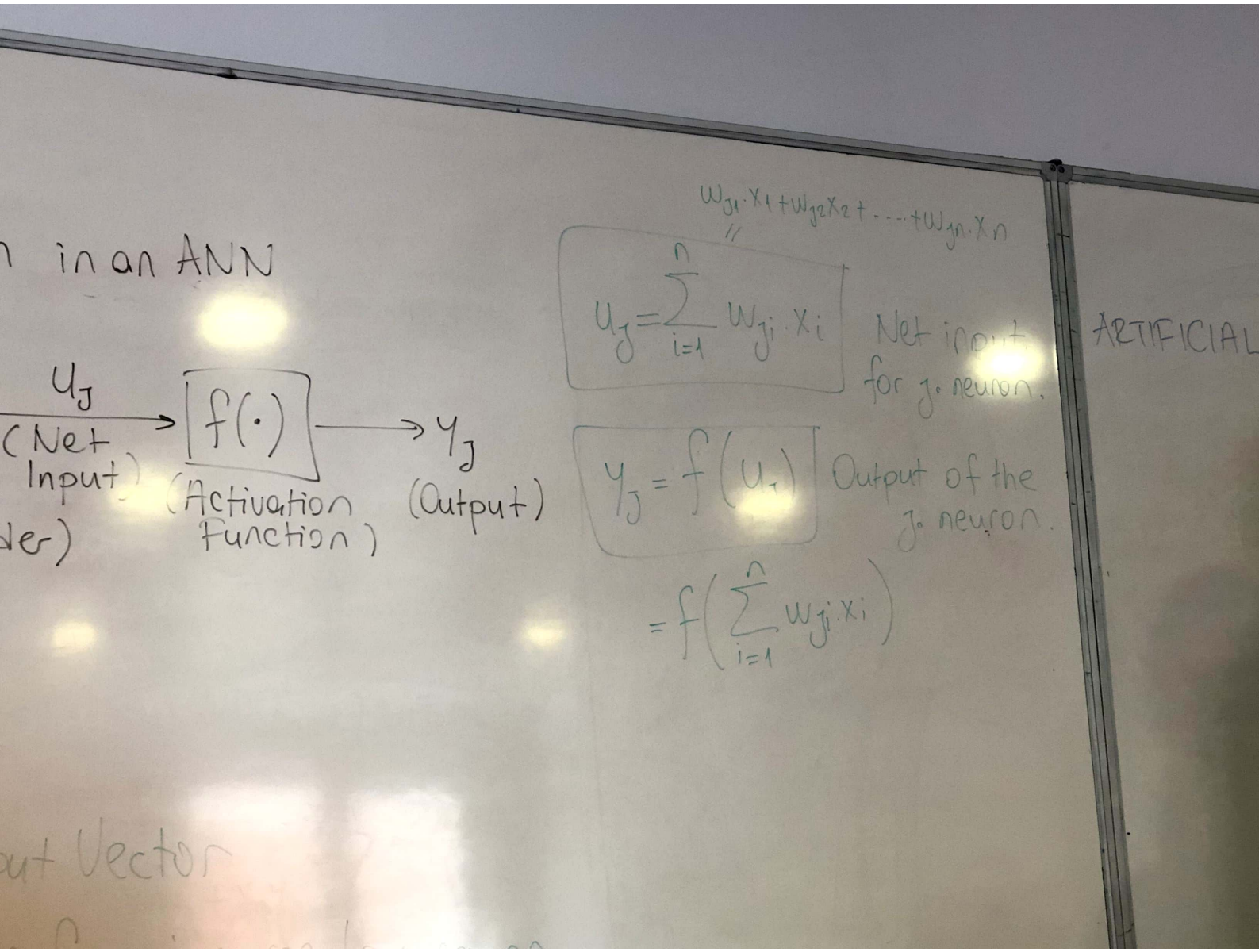
ARTIFICIAL NEURAL NETWORK

* A neural network consists of an interconnected group of artificial neurons.
* In most cases, an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase.

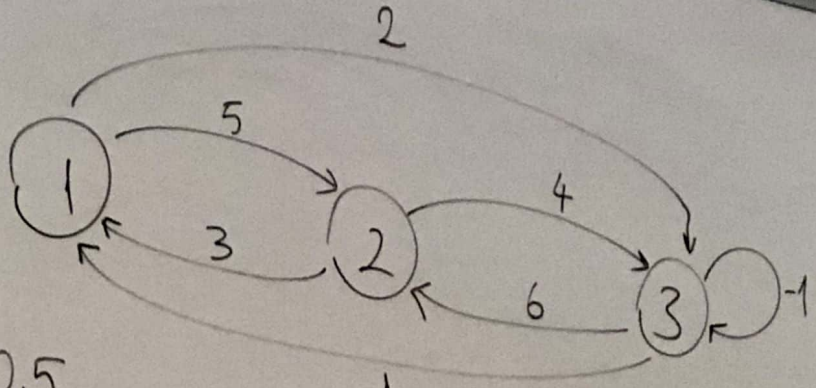








Ex.



$x_1 = 0,5$

$x_2 = 1$

$x_3 = 0,7$

$f(\cdot) = \text{sgn}(\cdot)$

$n = 3$

(1) $u_1 = \sum_{i=1}^{3} w_{1i} \cdot x_i = w_{11} \cdot x_1 + w_{12} x_2 + w_{13} x_3$

$= 0 \cdot x_1 + 3 \cdot x_2 + x_3$

$u_2 = \sum_{i=1}^{3} w_{2i} \cdot x_i = w_{21} \cdot x_1 + w_{22} x_2 + w_{23} \cdot x_3$

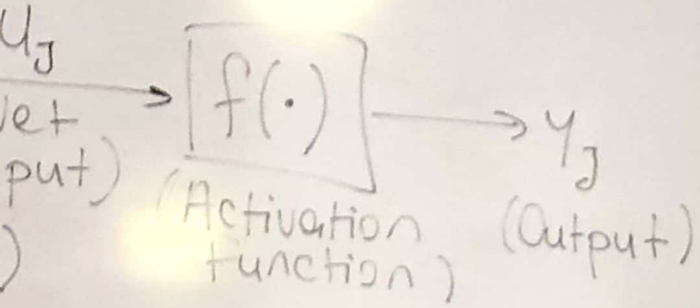
$= 5x_1 + 0 \cdot x_2 + 6x_3$

$$W = \begin{bmatrix} w_{11} & w_{12} & w_{13} \\ w_{21} & w_{22} & w_{23} \\ w_{31} & w_{32} & w_{33} \end{bmatrix} = \begin{bmatrix} 0 & 3 & 1 \\ 5 & 0 & 6 \\ 2 & 4 & -1 \end{bmatrix}$$

$u_3 = \sum_{i=1}^{3} w_{3i} \cdot x_i = w_{31} x_1 + w_{32} x_2 + w_{33} x_3$

$= 2x_1 + 4x_2 + (-1)x_3$

in an ANN



$y_1 = f(u_1) = \text{sgn}(u_1) = 1$

$y_2 = f(u_2) = \text{sgn}(u_2)$

$y_3 = f(u_3) = \text{sgn}(u_3)$

$u = W \cdot x$

$u = (3\times3) \cdot (3\times1) = (3\times1)$

$$\begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix} = \begin{bmatrix} 0 & 3 & 1 \\ 5 & 0 & 6 \\ 2 & 4 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 3x_2 + x_3 \\ 5x_1 + 6x_3 \\ 2x_1 + 4x_2 - x_3 \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \text{sgn}(u)$$

Ex.

$x_1 =$
$x_2 =$
$x_3 =$
$f(\cdot)$
$n =$
$W =$

Vector

row i. neuron