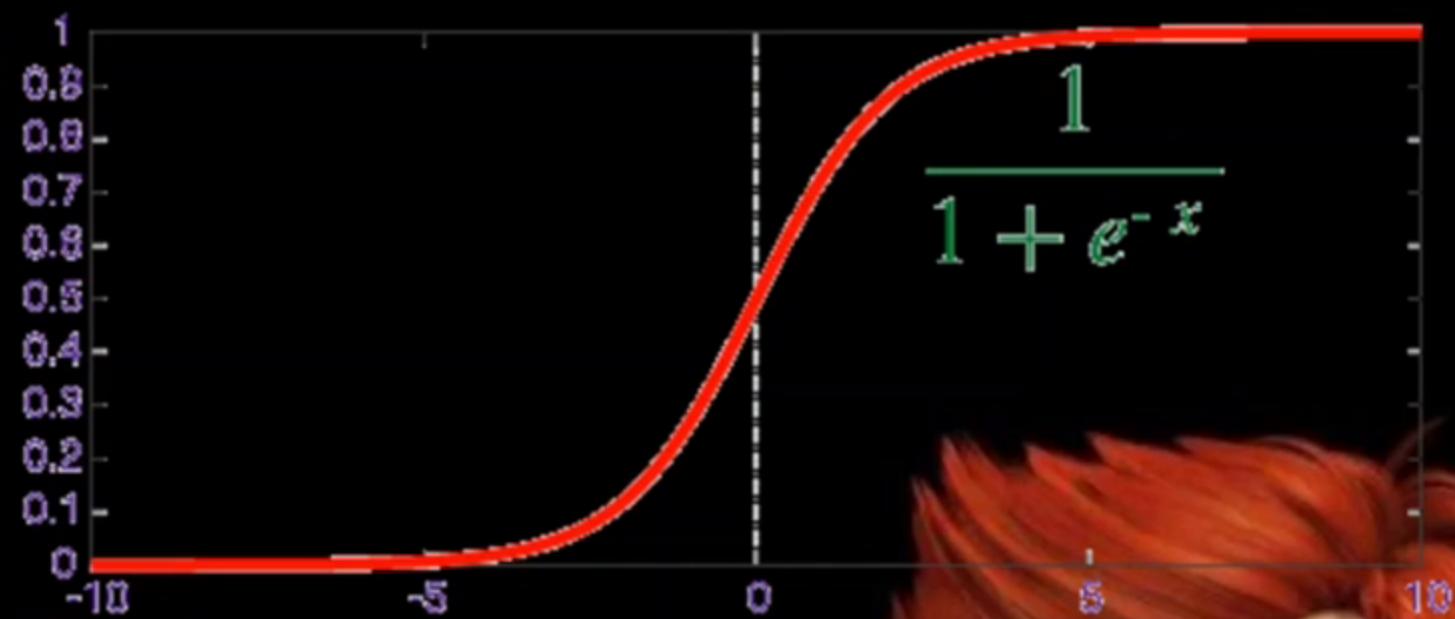


ACTIVATION  
FUNCTIONS

# SIGMOID ACTIVATION



# MACHINE LEARNING

UPPPERE

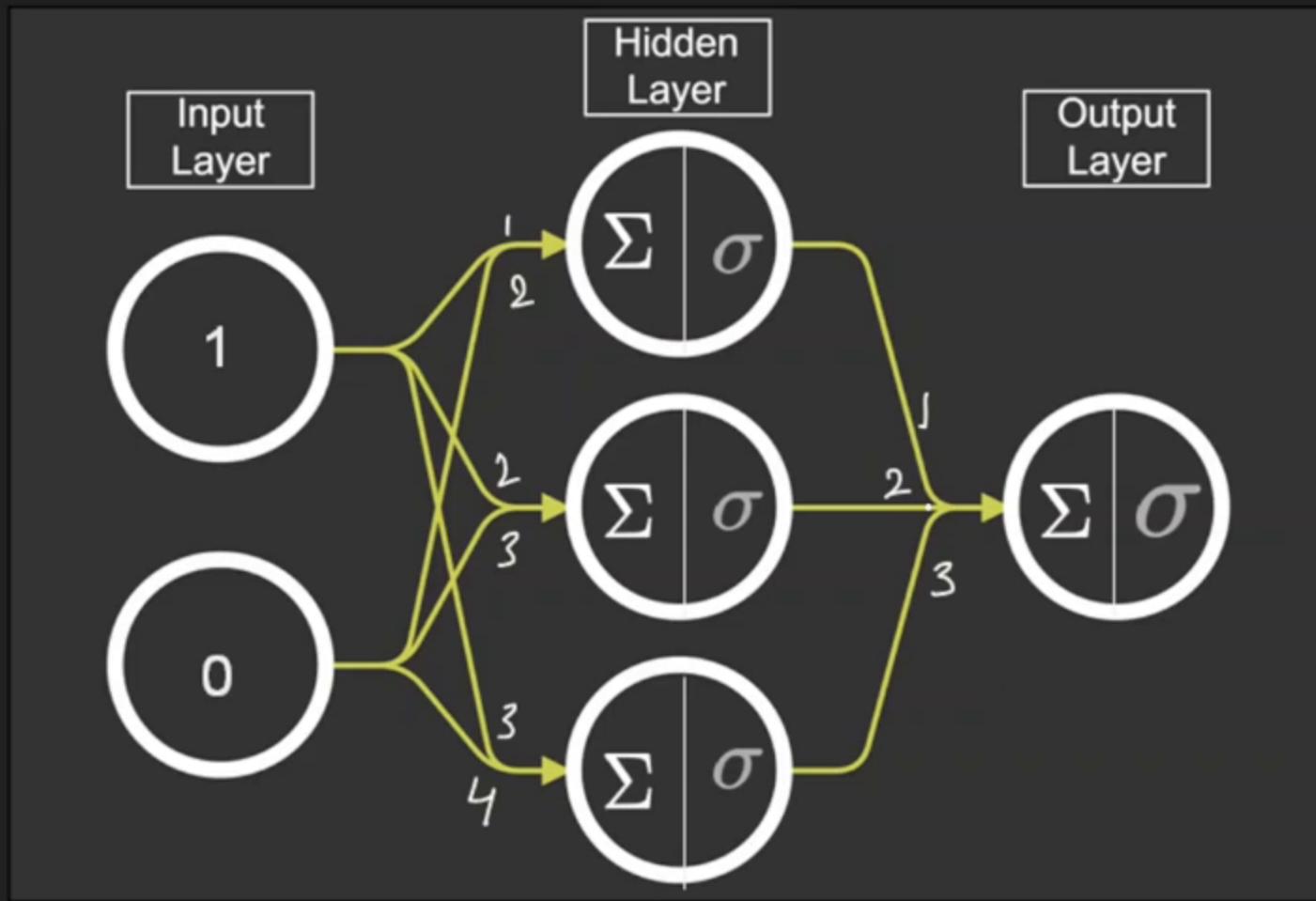
# Sigmoid Function

ML For Nerds

# Sigmoid Function

ML For Nerds

# Binary Classification

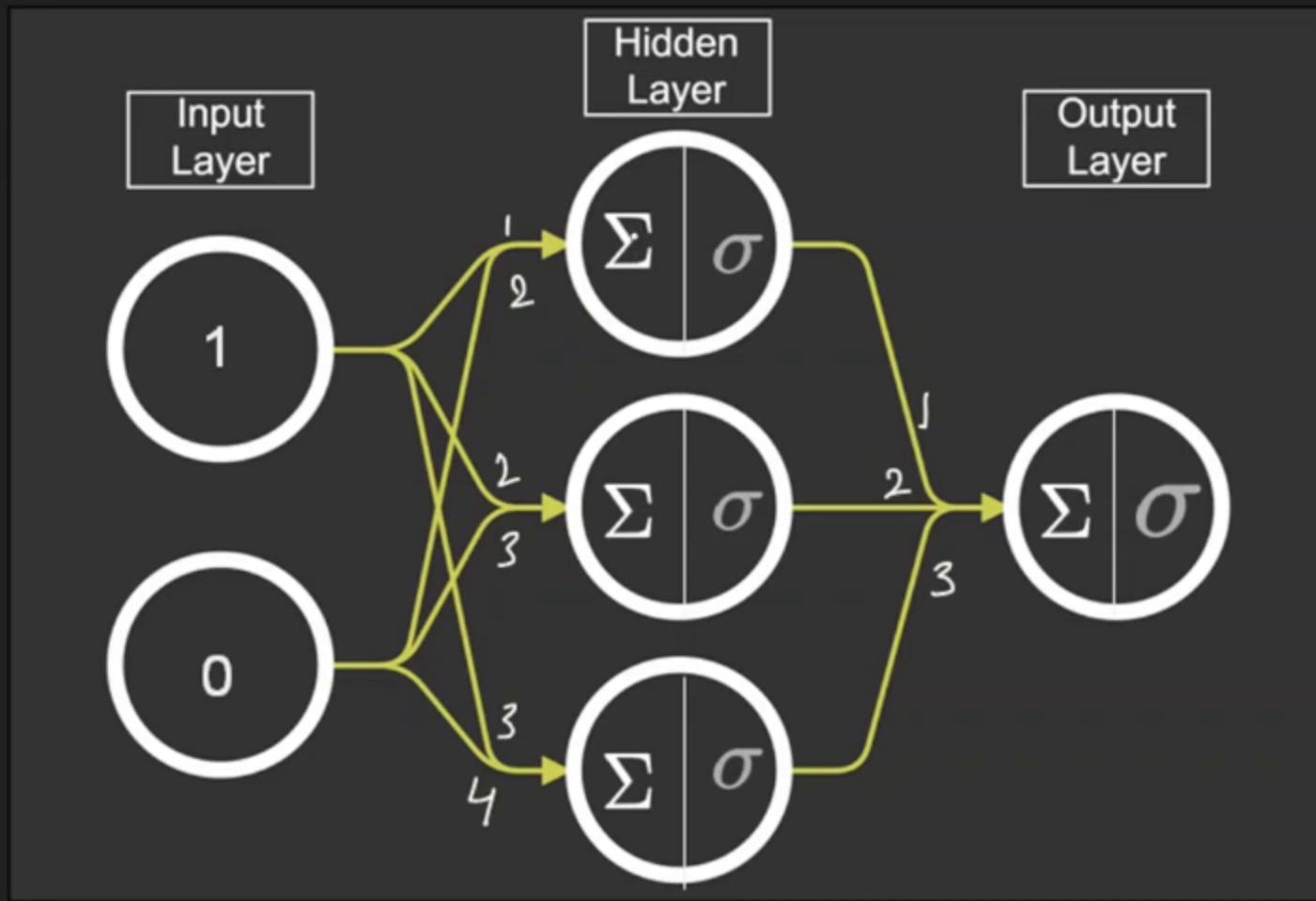


Inputs: [1,0]

Weights-1: [[1,2],  
[2,3],  
[3,4]]

Weights-2: [1,2,3]

# Binary Classification

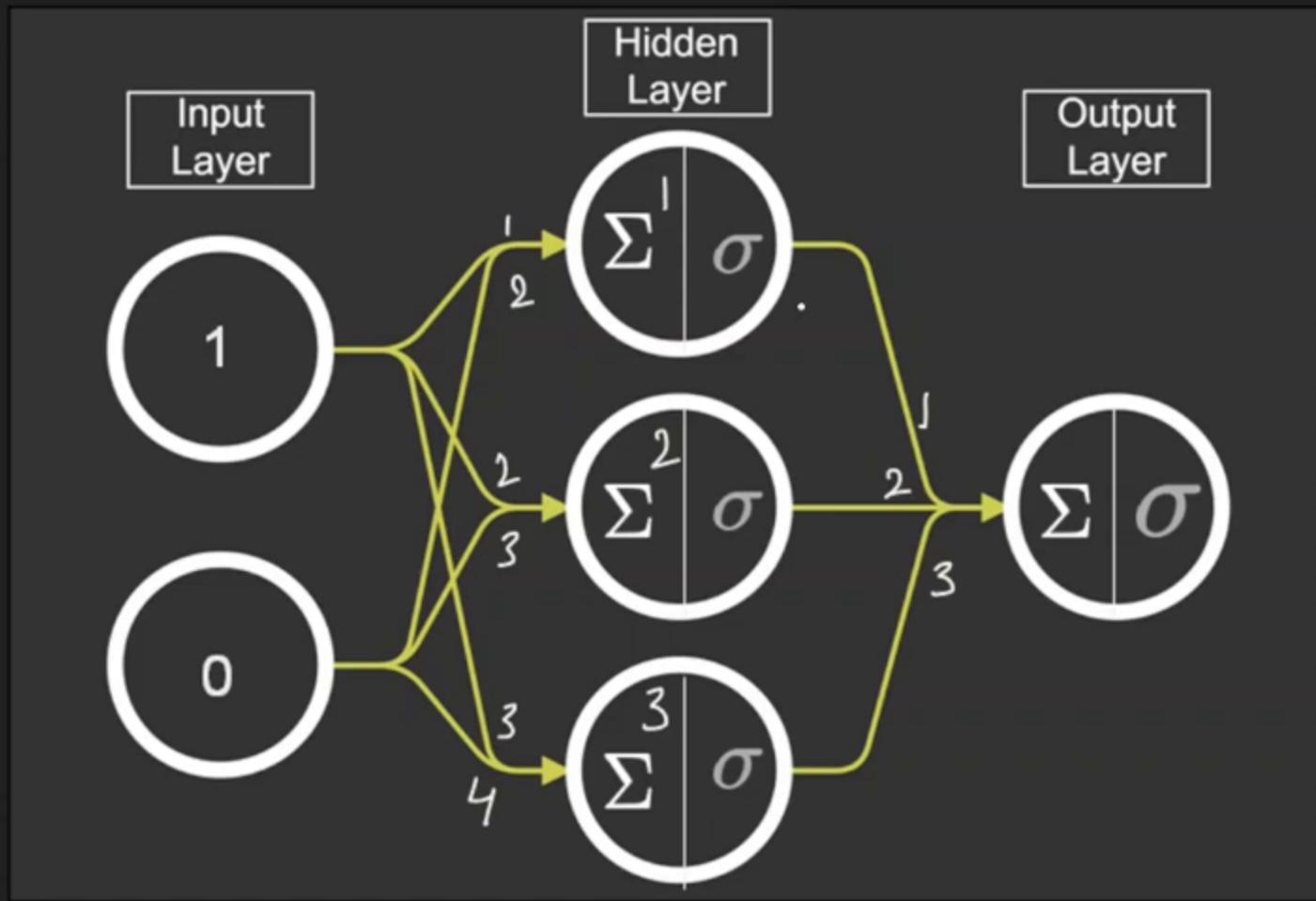


Inputs: [1,0]

Weights-1: [[1,2],  
[2,3],  
[3,4]]

Weights-2: [1,2,3]

# Binary Classification

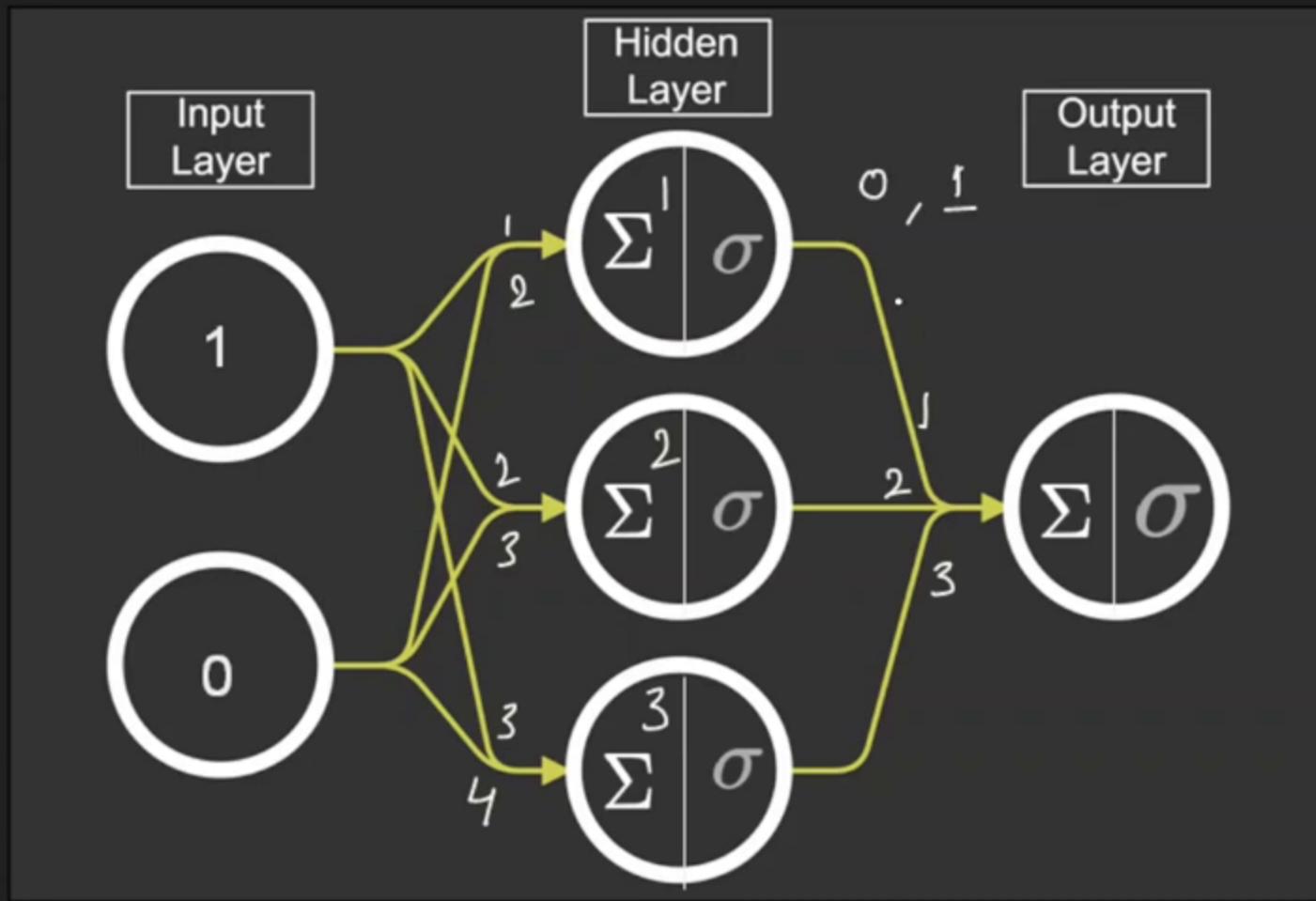


Inputs: [1,0]

Weights-1: [[1,2],  
[2,3],  
[3,4]]

Weights-2: [1,2,3]

# Binary Classification

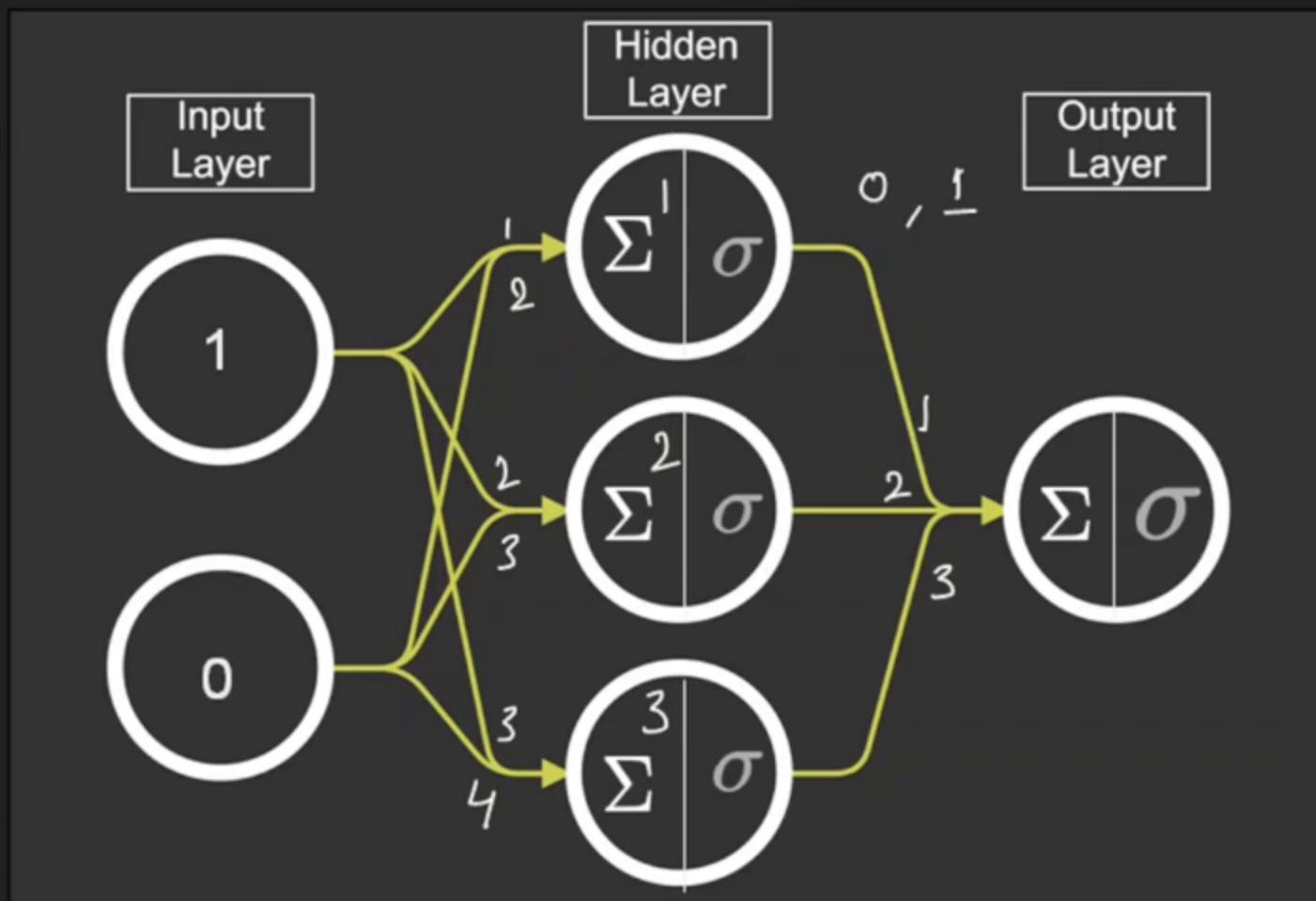


Inputs: [1,0]

Weights-1: [[1,2],  
[2,3],  
[3,4]]

Weights-2: [1,2,3]

# Binary Classification



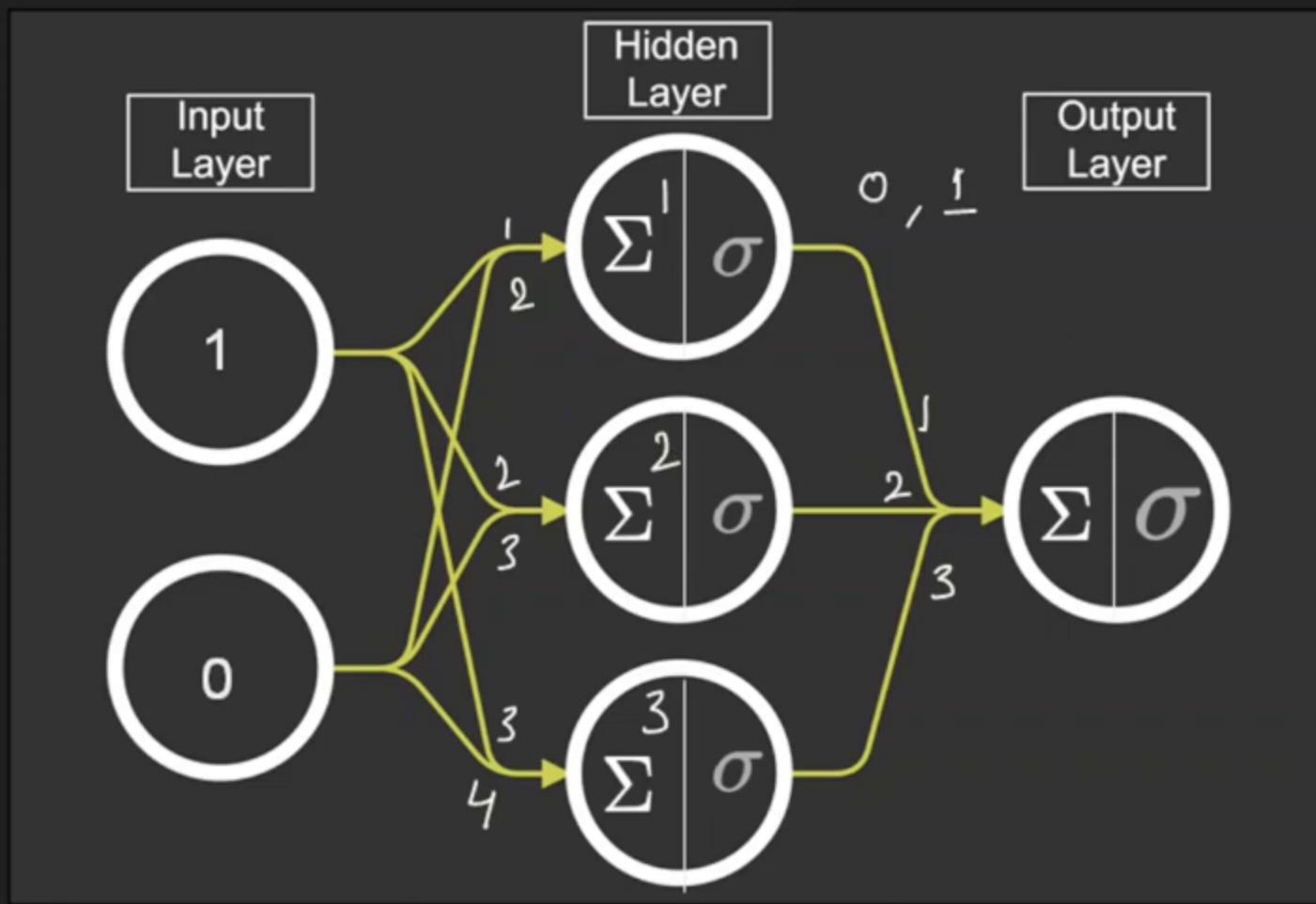
Inputs: [1,0]

Weights-1: [[1,2],  
[2,3],  
[3,4]]

Weights-2: [1,2,3]

[0, .1]

# Binary Classification



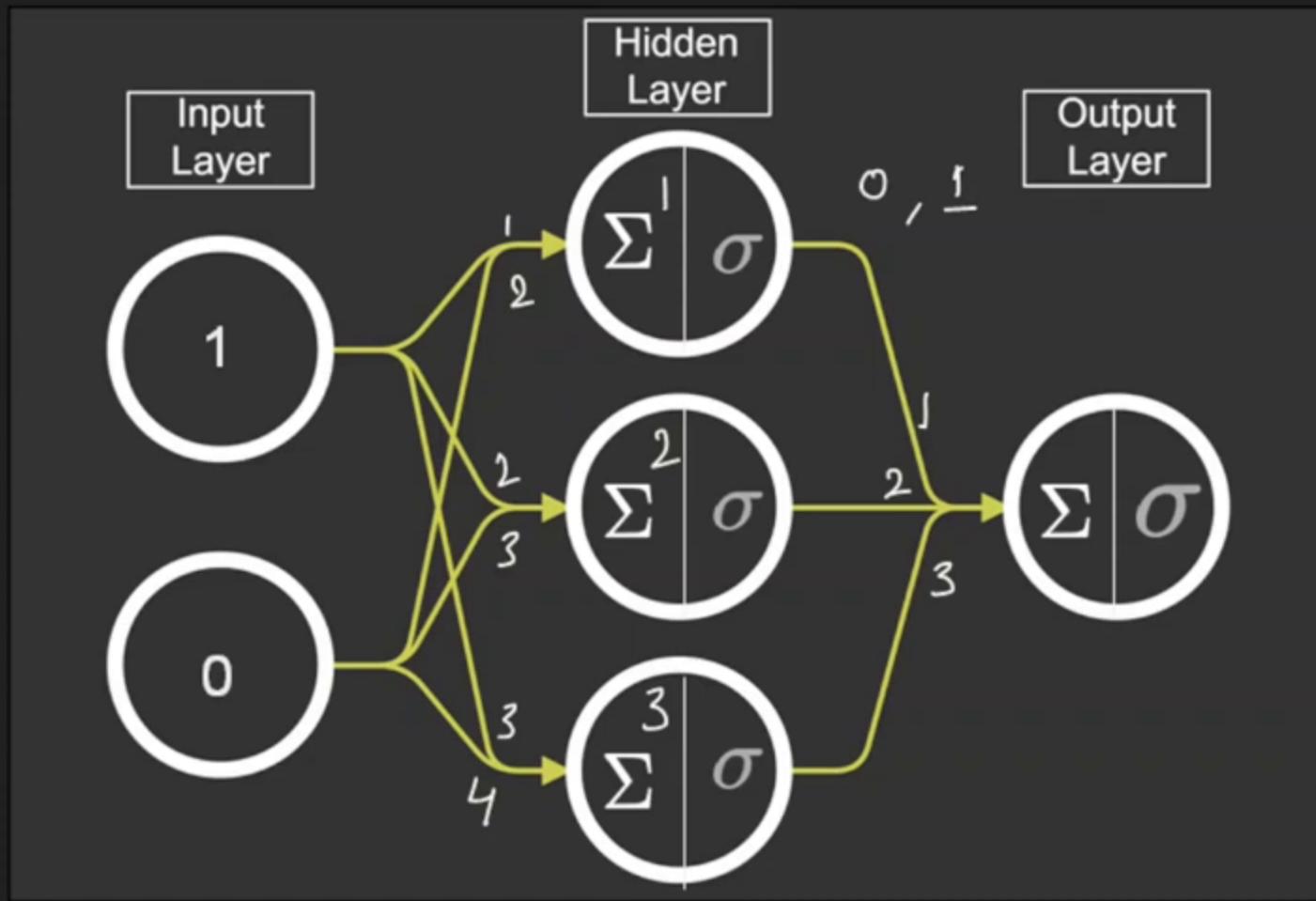
Inputs: [1,0]

Weights-1: [[1,2],  
[2,3],  
[3,4]]

Weights-2: [1,2,3]

[0, 1]

# Binary Classification



Inputs: [1,0]

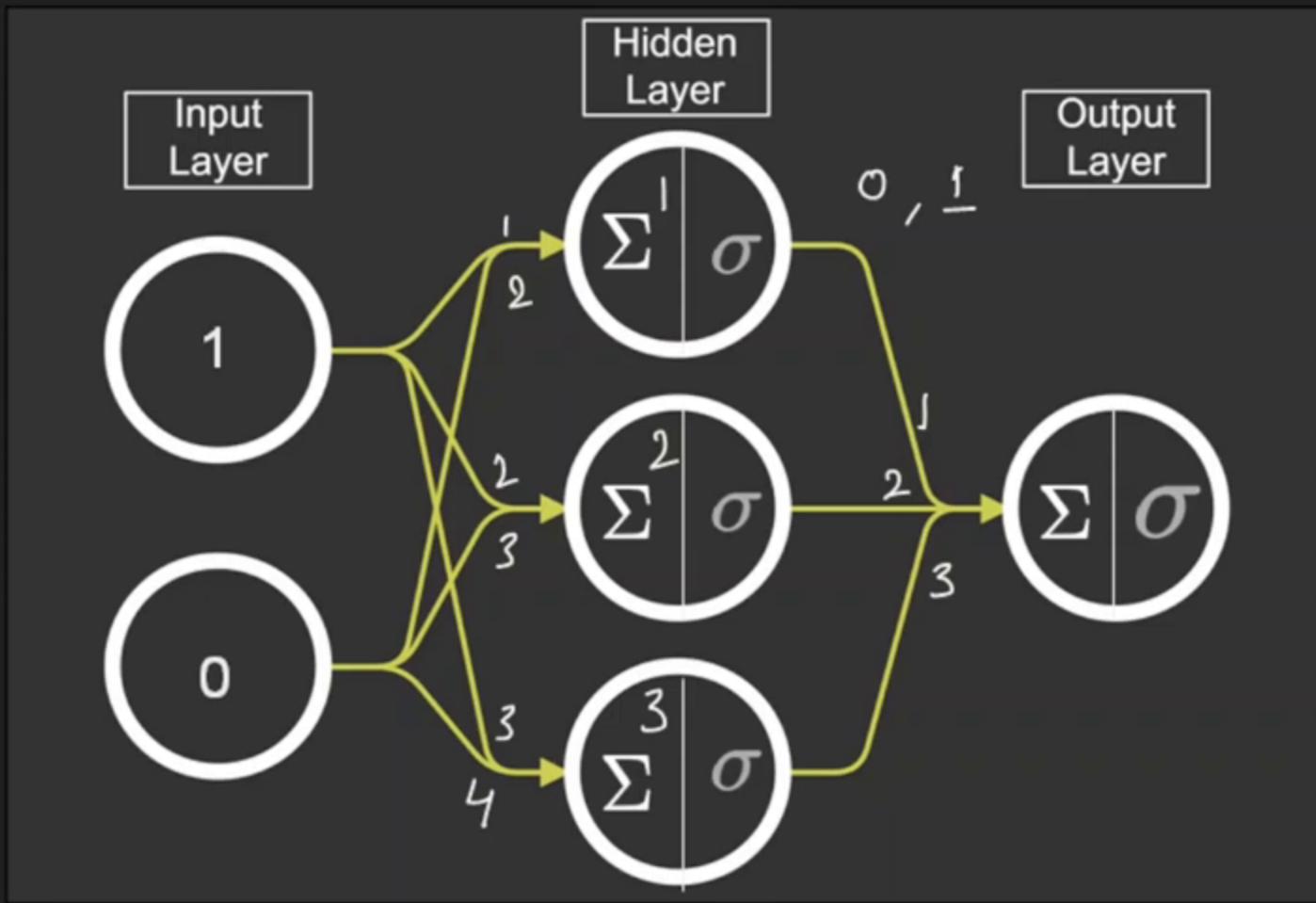
Weights-1: [[1,2],  
[2,3],  
[3,4]]

Weights-2: [1,2,3]

$$\begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$-\sigma \rightarrow \sigma \rightarrow 0, 1$$

# Binary Classification



Inputs: [1,0]

Weights-1: [[1,2],  
[2,3],  
[3,4]]

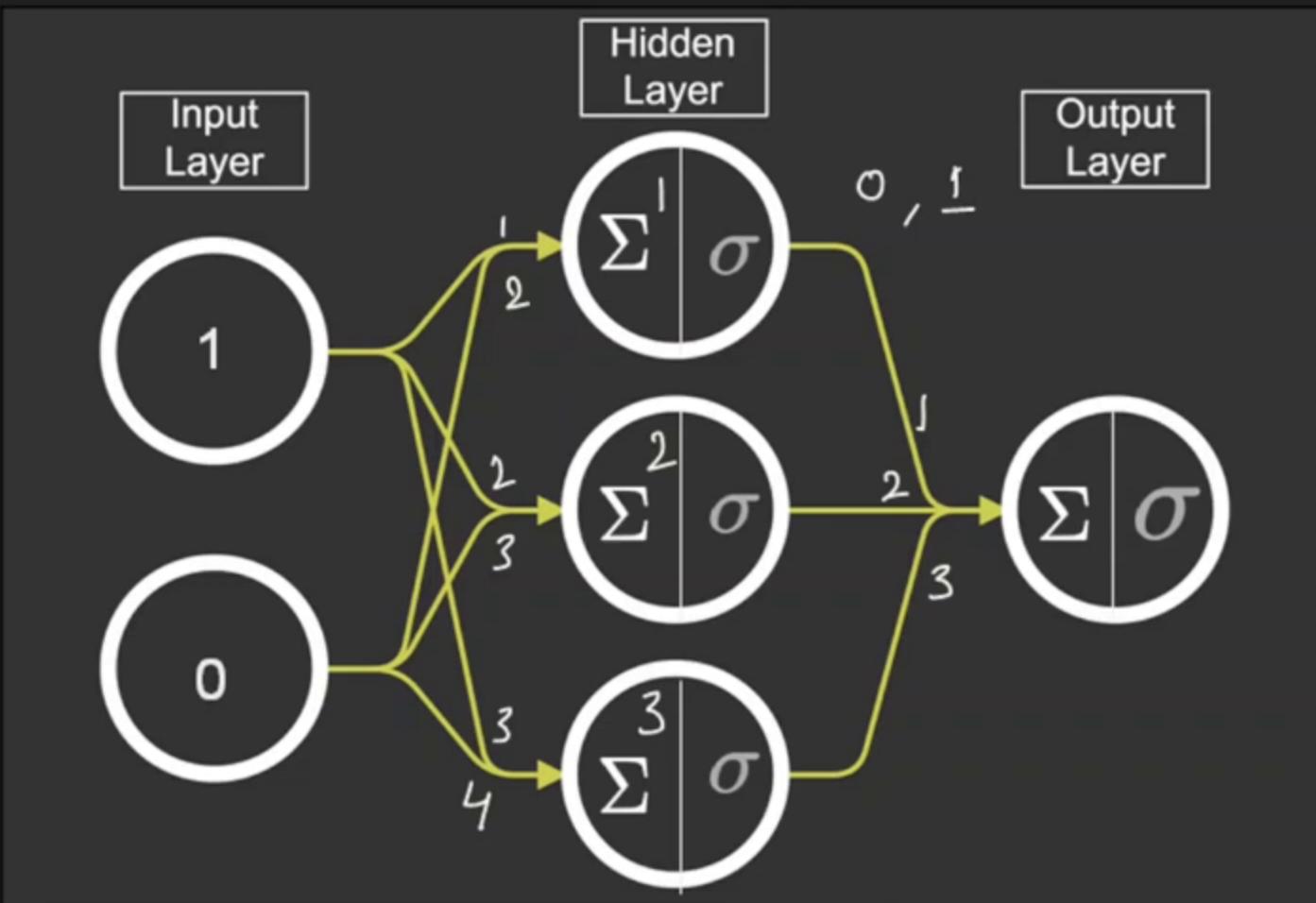
Weights-2: [1,2,3]

$$[0, 1] \downarrow$$

$$-\infty \rightarrow \sigma \rightarrow 0, 1$$

$$-\underline{\infty} \rightarrow \sigma \rightarrow [0, 1] \downarrow$$

# Binary Classification



Inputs: [1,0]

Weights-1: [[1,2],  
[2,3],  
[3,4]]

Weights-2: [1,2,3]

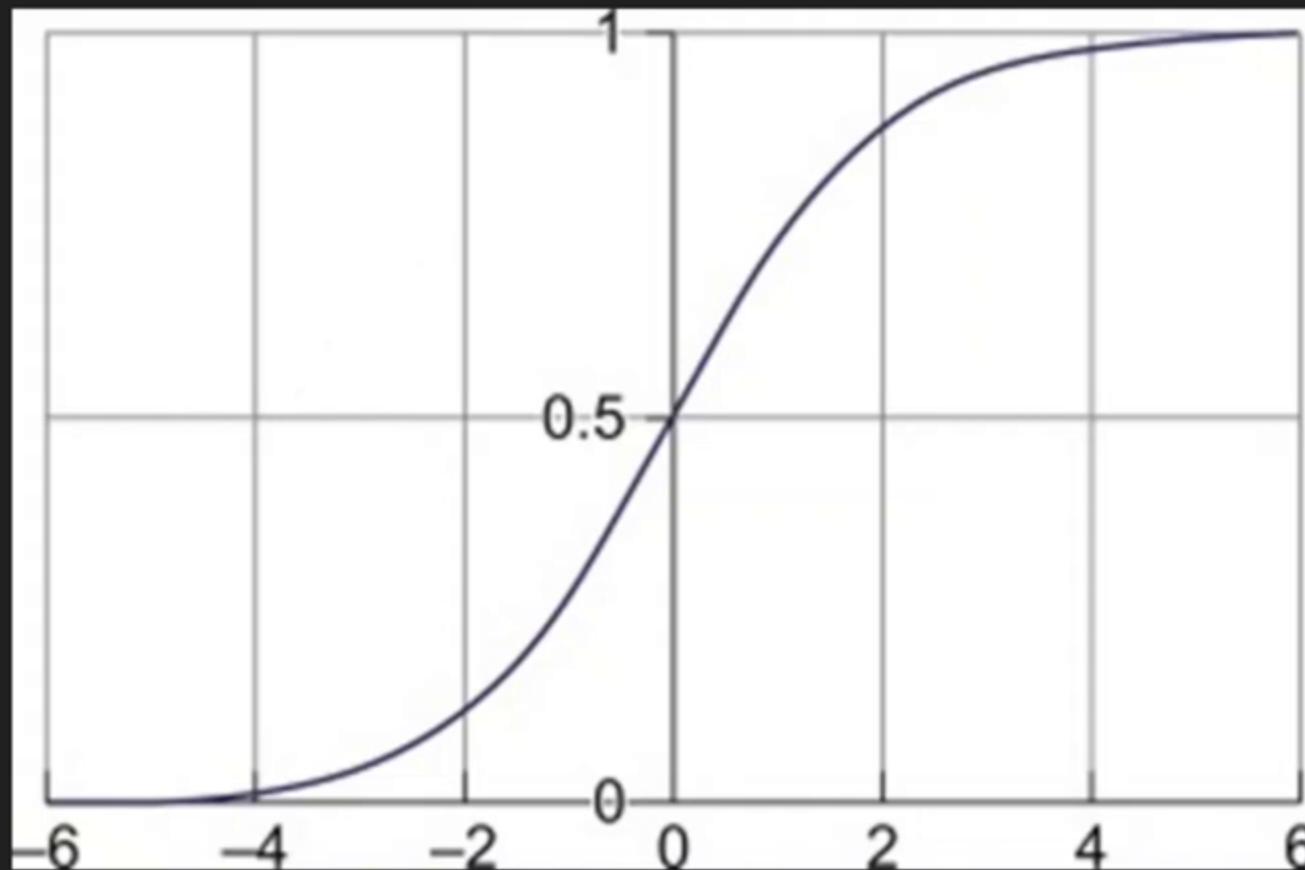
$$[0, 1]$$

$-\infty \rightarrow \infty \rightarrow 0, 1$

$\underline{-\infty \rightarrow \infty} \rightarrow [0, 1]$   
Range

Definition:

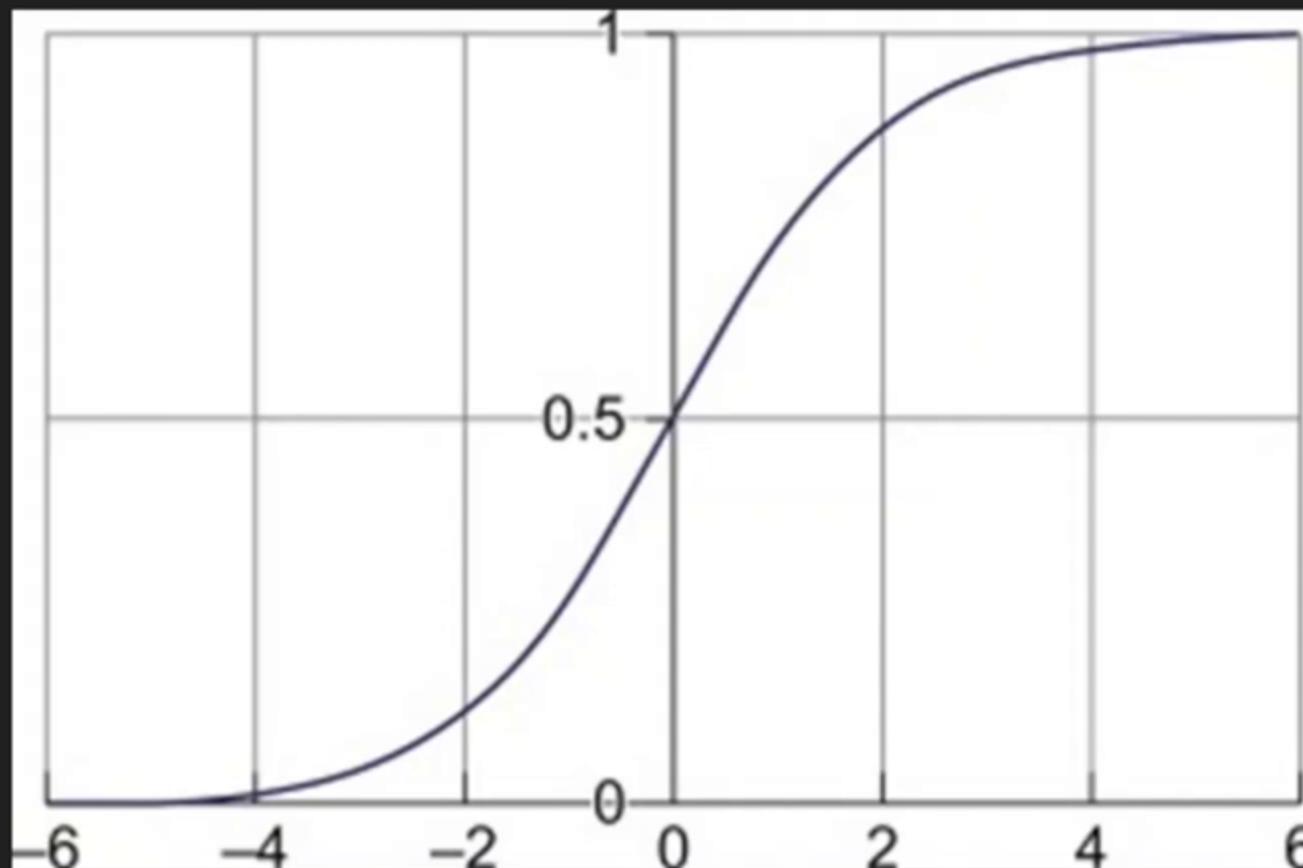
$$S(x) = \frac{1}{1 + e^{-x}}$$



Definition:

$$S(x) = \frac{1}{1 + e^{-x}}$$

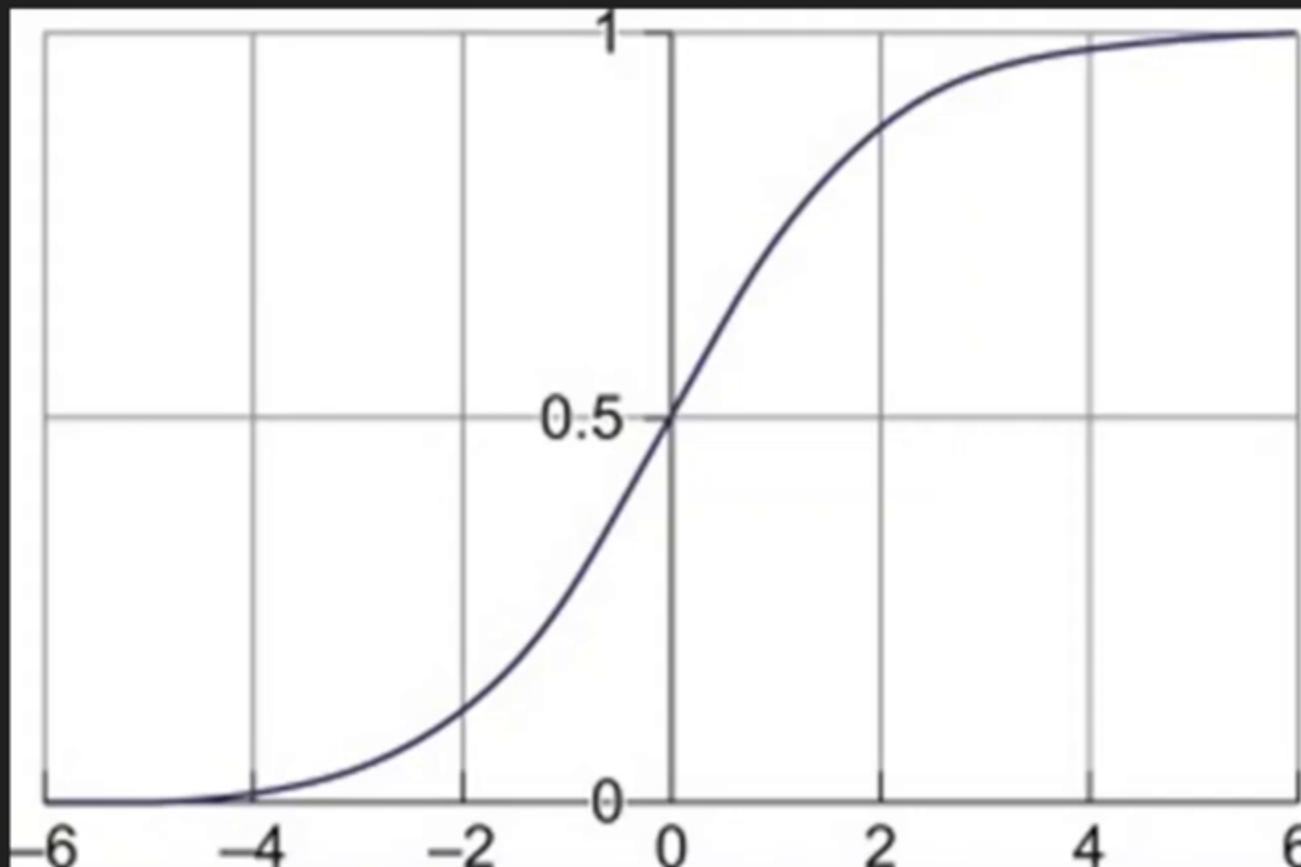
$\rightarrow -\infty$   $\rightarrow 0$   
 $x \nearrow$   $\searrow$



Definition:

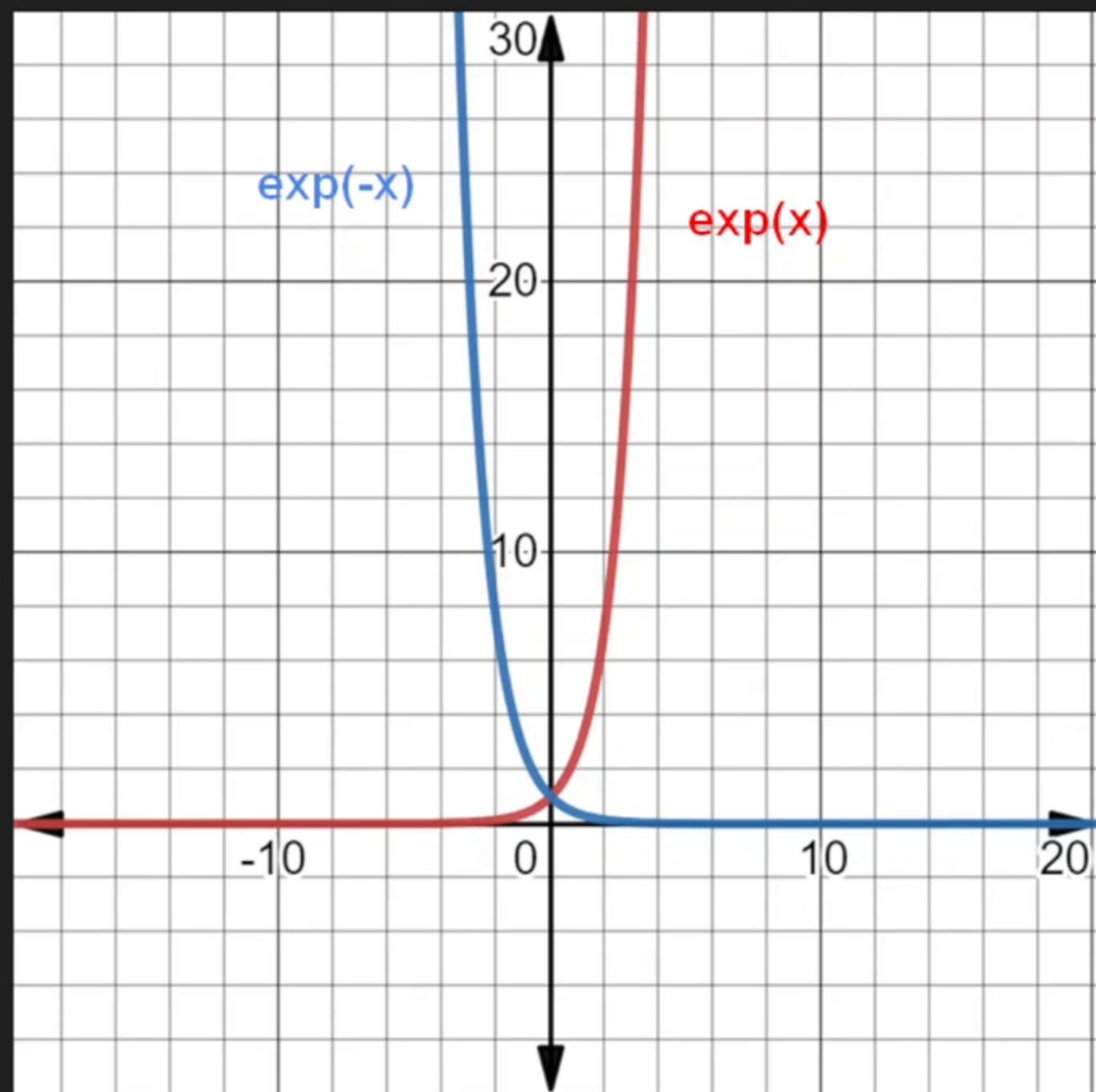
$$S(x) = \frac{1}{1 + e^{-x}}$$

$\rightarrow -\infty$   
 $x \rightarrow 0$   
 $\rightarrow \infty$



$$e^{-x} \rightarrow$$

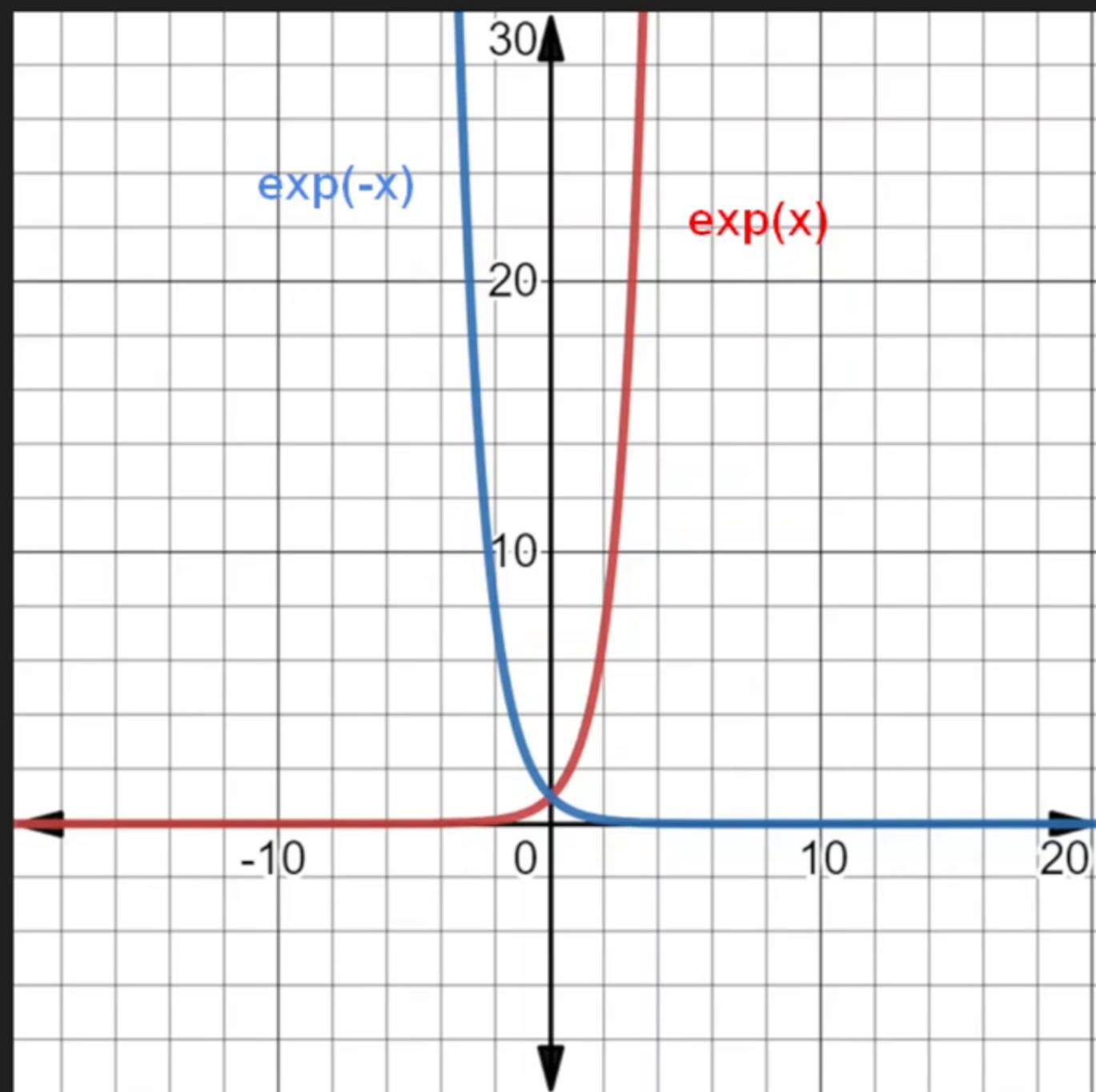
Limits



$$e^{-x} \rightarrow$$

Limits

$$x \rightarrow -\infty \Rightarrow e^{-x} \rightarrow \infty$$



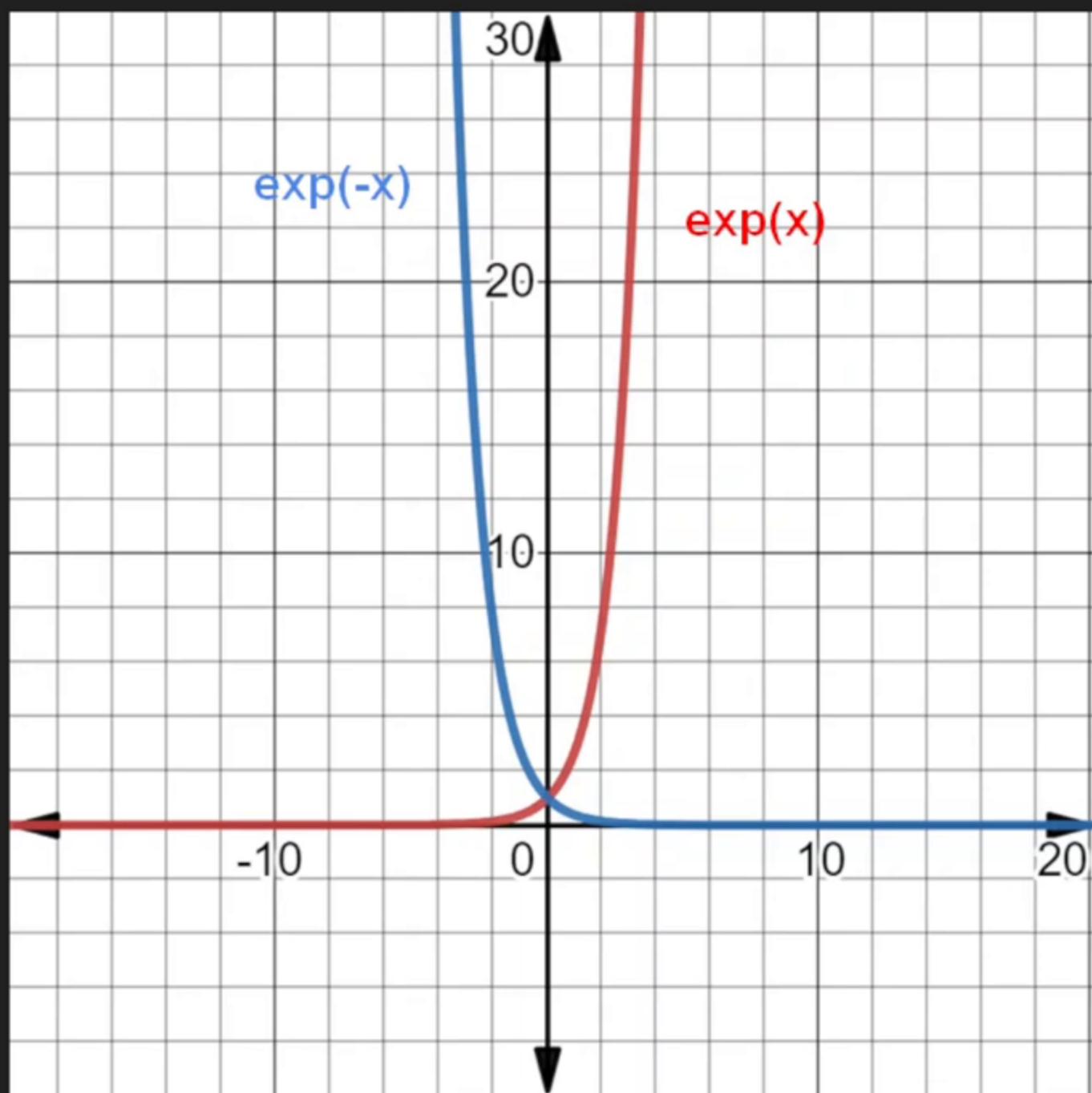
$$e^{-x} \rightarrow$$

Limits

$$x \rightarrow -\infty \Rightarrow e^{-x} \rightarrow \infty$$

$$x \rightarrow 0 \Rightarrow e^{-x} = 1$$

$$x \rightarrow \infty$$



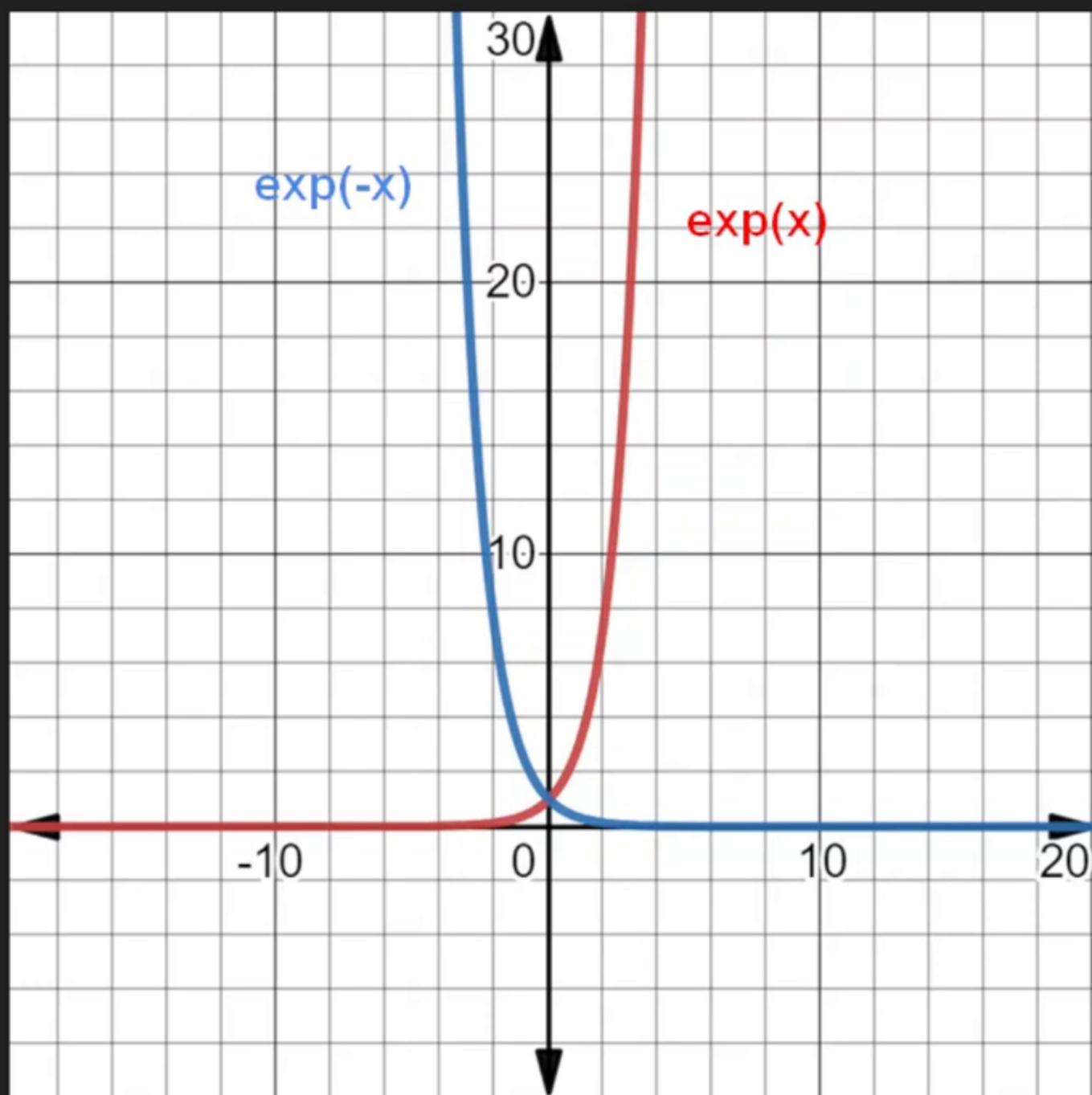
$$e^{-x} \rightarrow$$

Limits

$$x \rightarrow -\infty \Rightarrow e^{-x} \rightarrow \infty$$

$$x \rightarrow 0 \Rightarrow e^{-x} = 1$$

$$x \rightarrow +\infty \Rightarrow e^{-x} \rightarrow 0$$



$$\text{Sigmoid} \rightarrow \frac{1}{1+e^{-x}}$$

$$\text{Sigmoid} \rightarrow \frac{1}{1+e^{-x}}$$

$$\frac{x}{e^x} \int_{-\infty}^{\infty} \int_1^1$$

$$\text{Sigmoid} \rightarrow \frac{1}{1+e^{-x}}$$

$$\begin{array}{c|ccc|c} x & -\infty & 0 & \infty \\ \hline e^{-x} & \infty & 1 & 0 \end{array}$$

$$x = -b$$

$$\text{Sigmoid} \rightarrow \frac{1}{1+e^{-x}}$$

$x$	$-\infty$	$0$	$\infty$
$e^x$	$\infty$	1	0

$$x = -\infty \rightarrow \frac{1}{1+\infty} \rightarrow 0.$$

$$\text{Sigmoid} \rightarrow \frac{1}{1+e^{-x}}$$

$x$	$-\infty$	$0$	$\infty$
$e^x$	$\infty$	1	0

$$x = -\infty \rightarrow \frac{1}{1+\infty} \rightarrow 0$$

$$x = 0 \rightarrow \frac{1}{1+}$$

$$\text{Sigmoid} \rightarrow \frac{1}{1+e^{-x}}$$

$x$	$-\infty$	$0$	$\infty$
$e^x$	$\infty$	1	0

$$x = -\infty \rightarrow \frac{1}{1+\infty} \rightarrow 0$$

$$x = 0 \rightarrow \frac{1}{1+1} = 0.5$$

$$x = \infty$$

$$\text{Sigmoid} \rightarrow \frac{1}{1+e^{-x}}$$

$x$	$-\infty$	0	$\infty$
$e^x$	$\infty$	1	0

$$x = -\infty \rightarrow \frac{1}{1+\infty} \rightarrow 0$$

$$x = 0 \rightarrow \frac{1}{1+1} = 0.5$$

$$x = +\infty \rightarrow \frac{1}{1+0} = 1.$$

$$\text{Sigmoid} \rightarrow \frac{1}{1+e^{-x}}$$

$x$	$-\infty$	$0$	$\infty$
$e^{-x}$	$\infty$	$1$	$0$

$$x = -\infty \rightarrow \frac{1}{1+\infty} \rightarrow 0$$

$$x = 0 \rightarrow \frac{1}{1+1} = 0.5 \quad x \rightarrow -\infty \quad 0 \quad +\infty$$

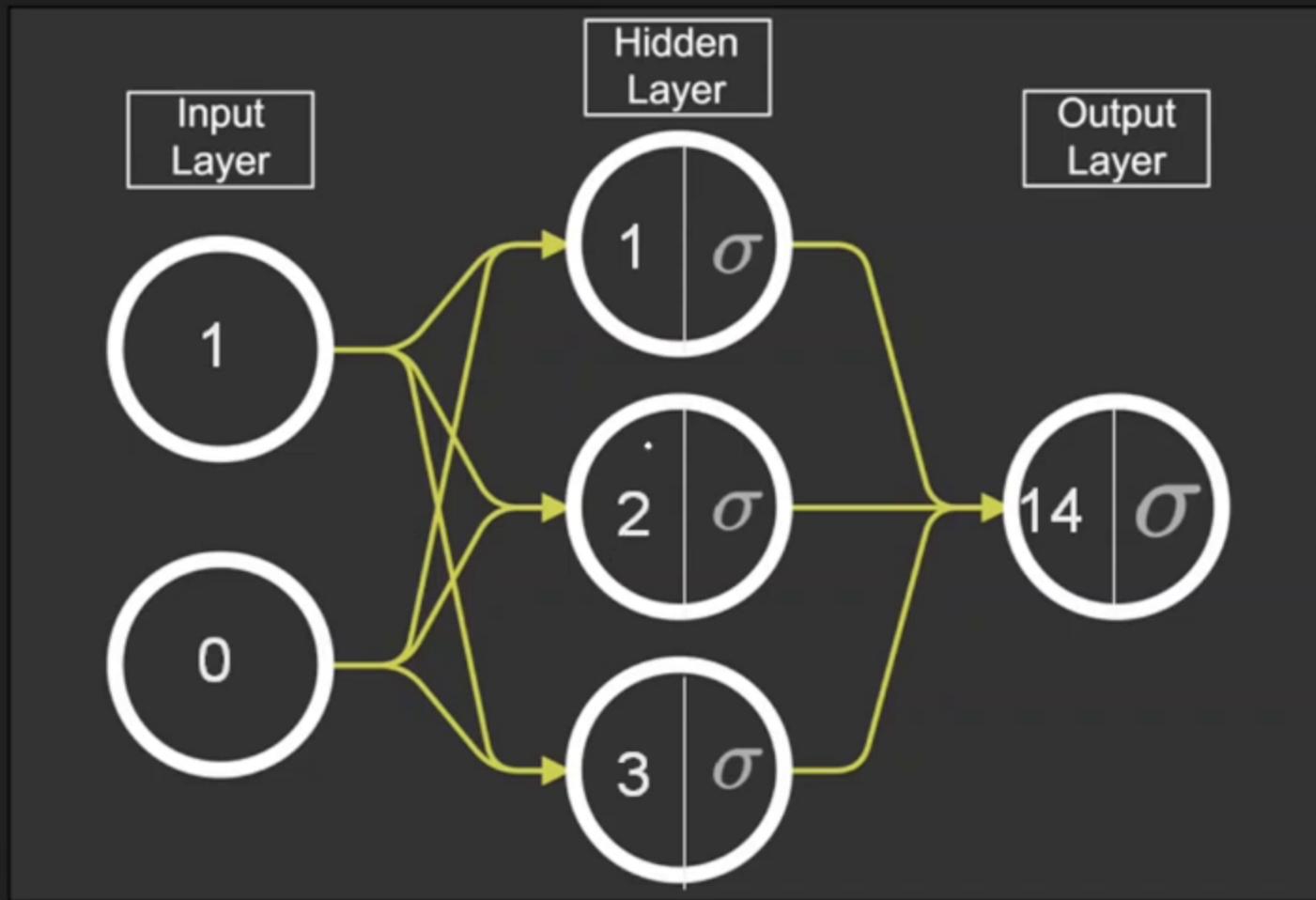
Sigmoid.

$$x = +\infty \rightarrow \frac{1}{1+0} = 1$$



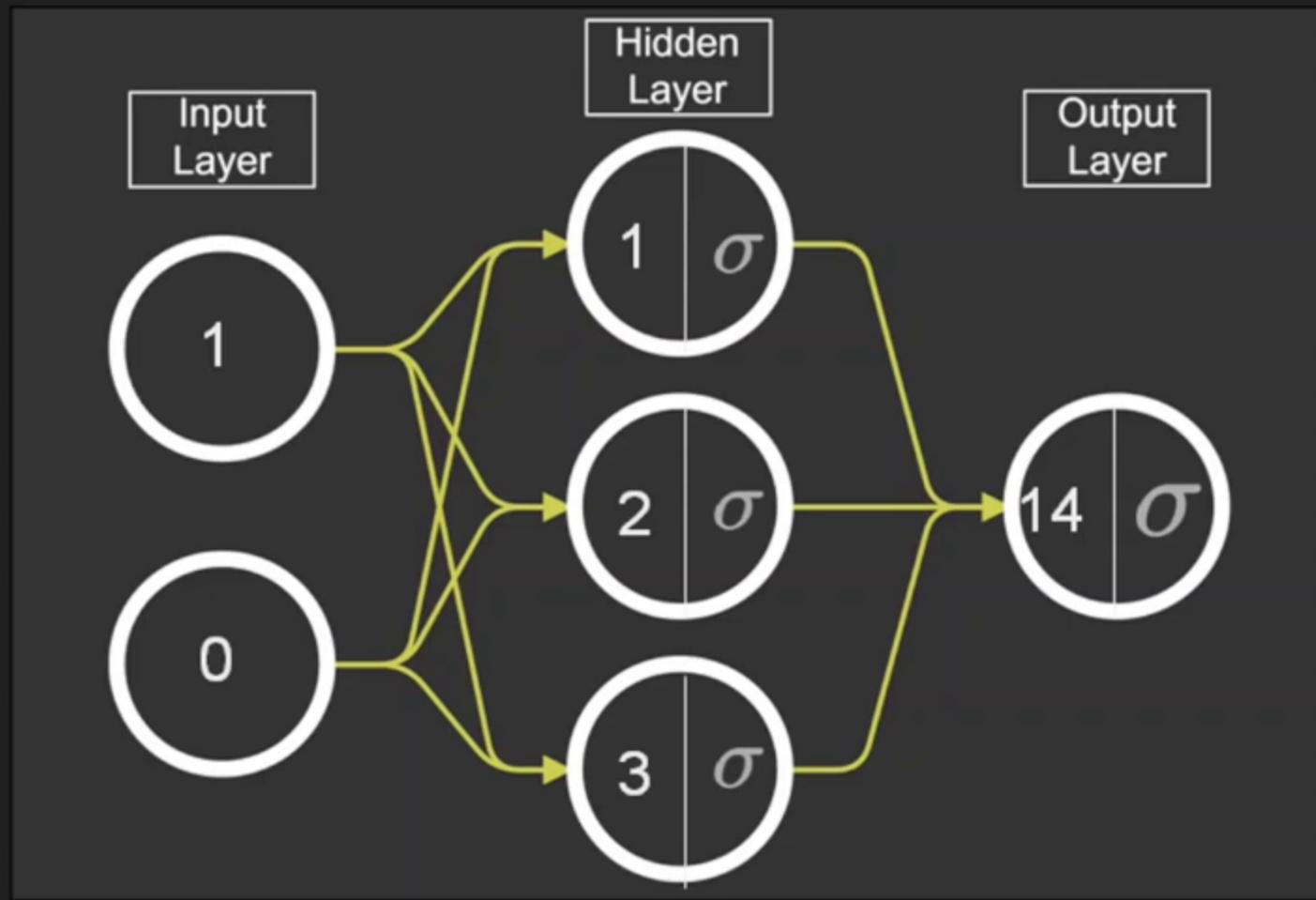


# Binary Classification



$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



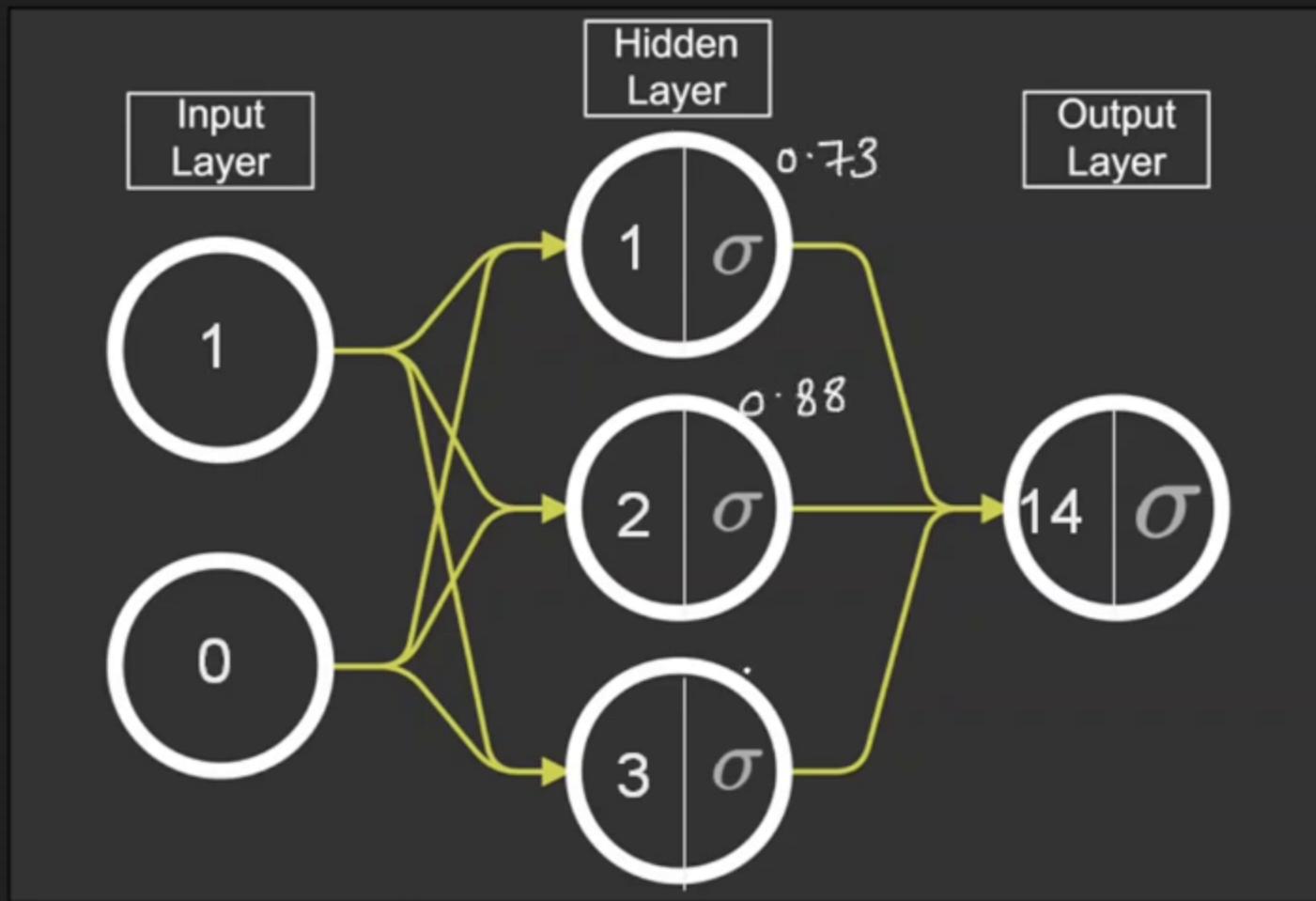
$\text{sig}(1)$  .

$\text{sig}(2)$

$\text{sig}(3)$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



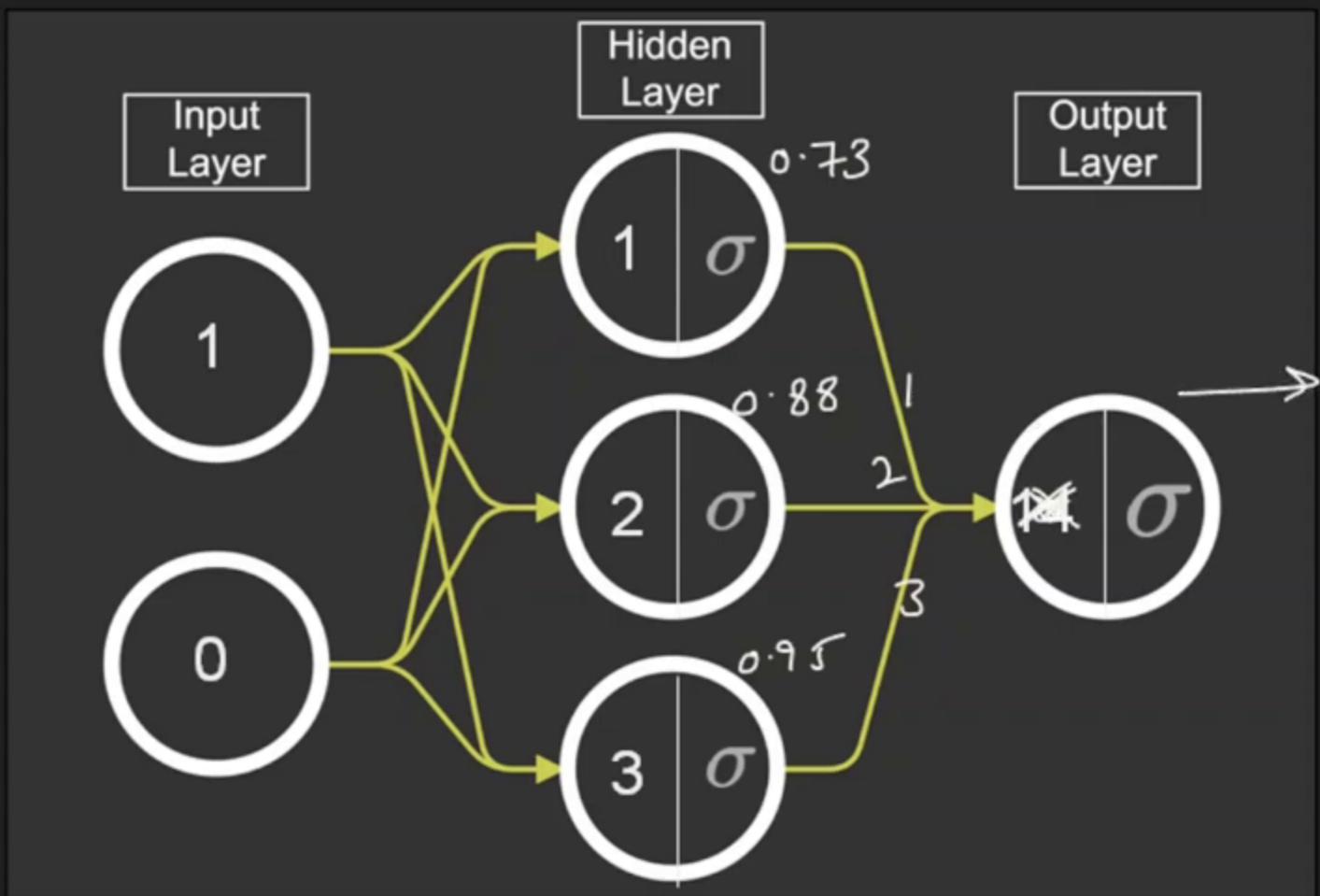
$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

$$\text{sig}(3) \rightarrow 0.95$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



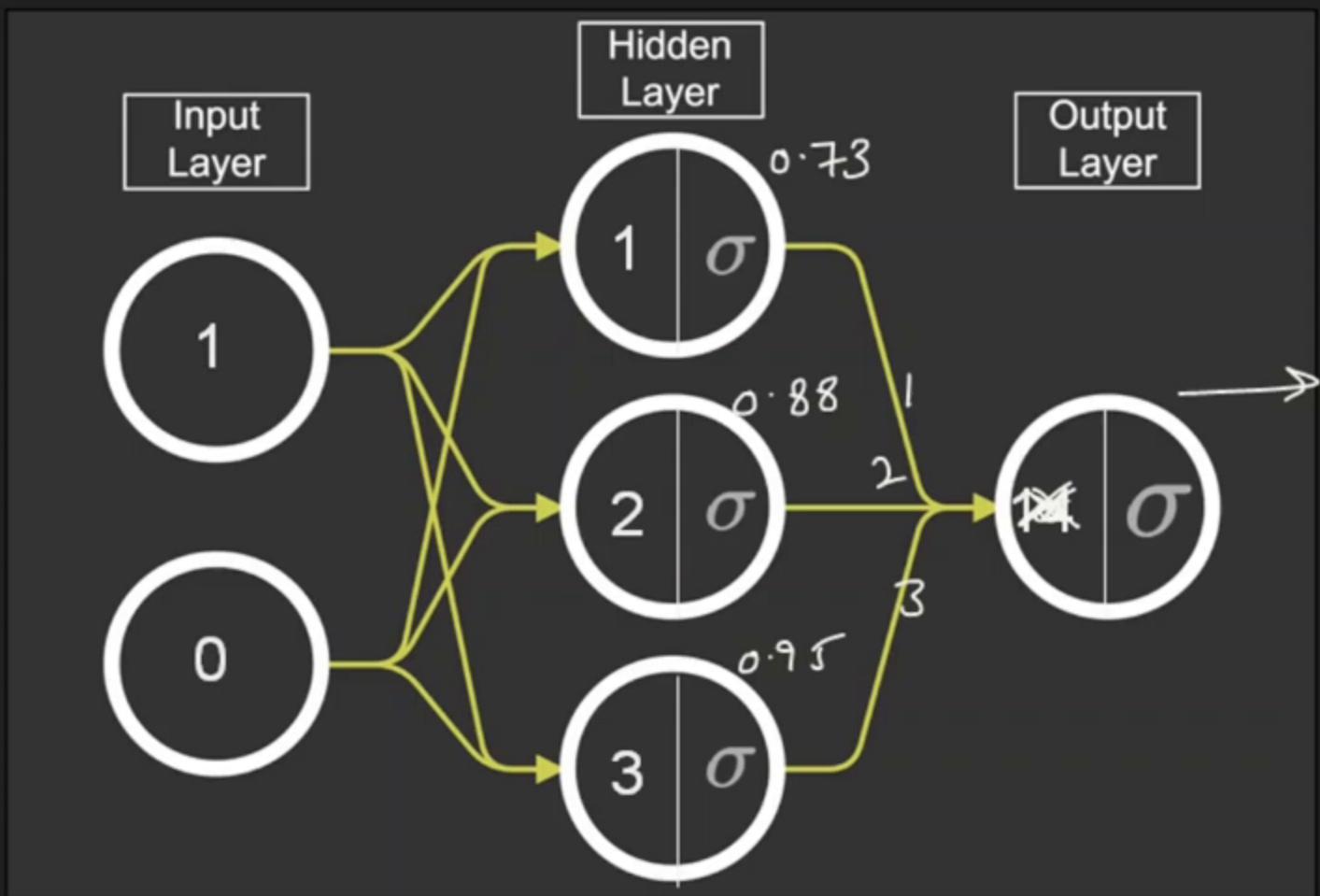
$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

$$\text{sig}(3) \rightarrow 0.95$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

$$\text{sig}(3) \rightarrow 0.95$$

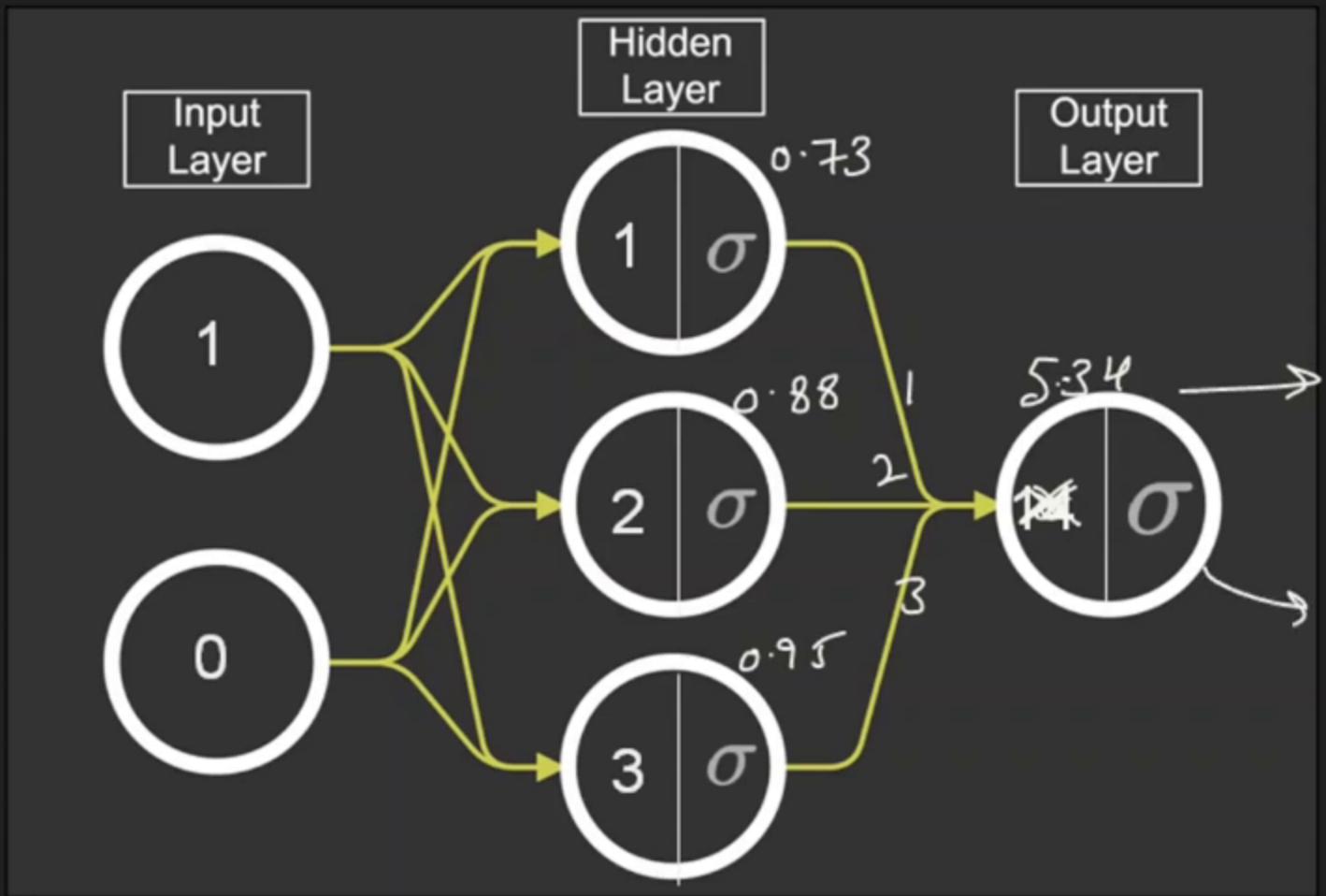
$$1 \times 0.73 + 2 \times 0.88$$

$$+ 3 \times 0.95$$

=

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

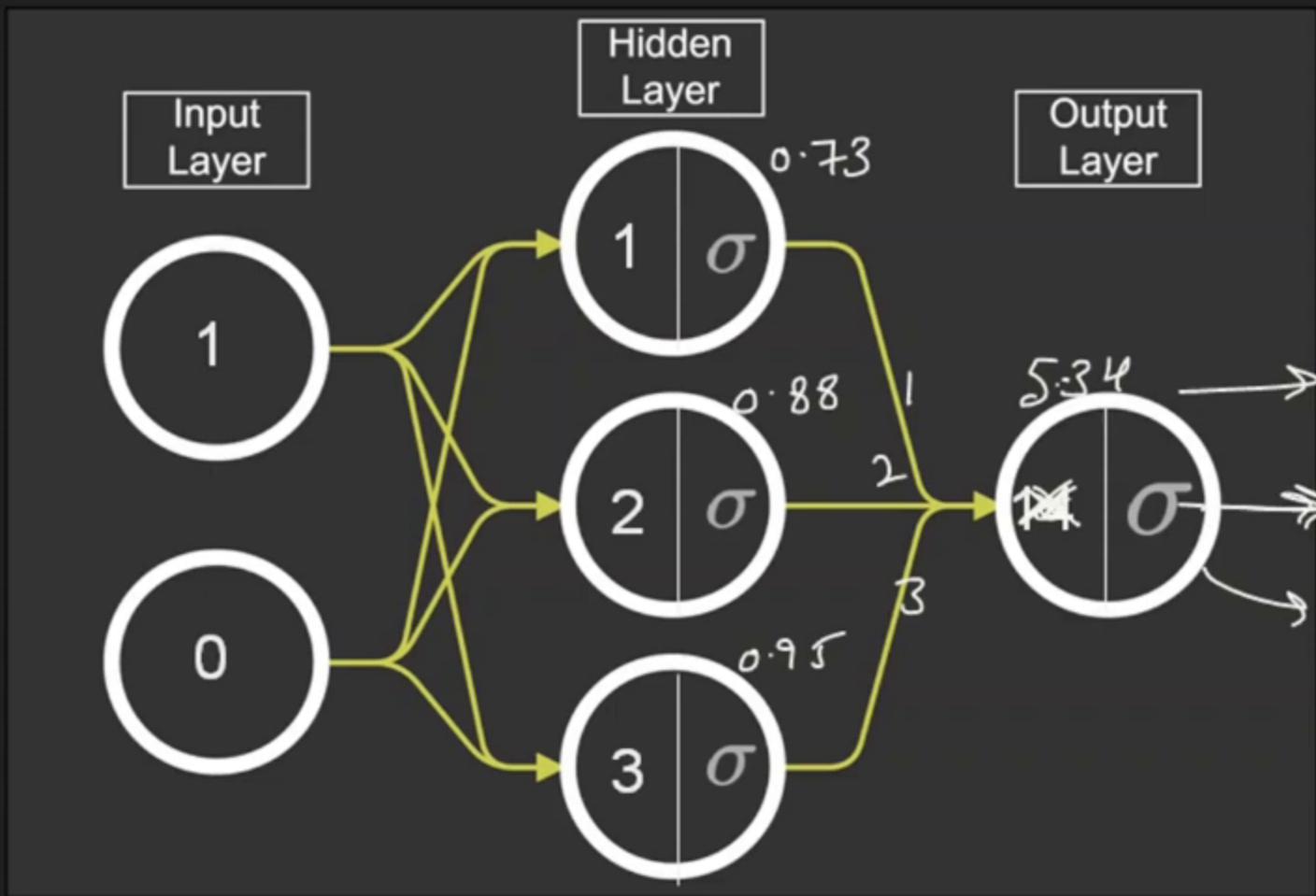
$$\text{sig}(3) \rightarrow 0.95$$

$$\begin{aligned} & 1 \times 0.73 + 2 \times 0.88 \\ & + 3 \times 0.95 \\ \Rightarrow & \underline{5.34} \end{aligned}$$

Si

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

$$\text{sig}(3) \rightarrow 0.95$$

$$1 \times 0.73 + 2 \times 0.88$$

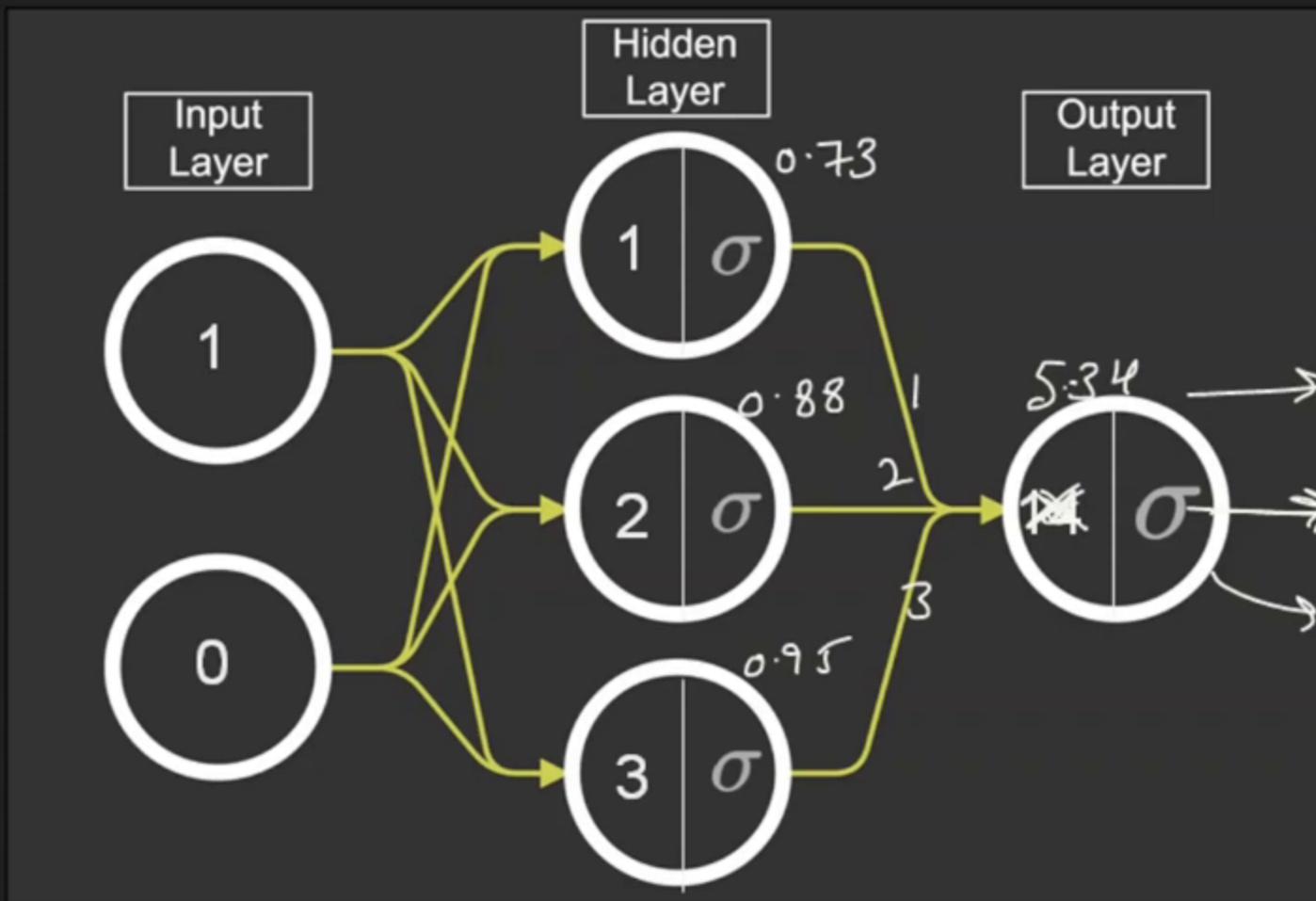
$$+ 3 \times 0.95$$

$$\Rightarrow 0.9 \cdot \underline{\underline{5.34}}$$

$$\text{sig}(5.34) \rightarrow 0.99$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

$$\text{sig}(3) \rightarrow 0.95$$

$$1 \times 0.73 + 2 \times 0.88$$

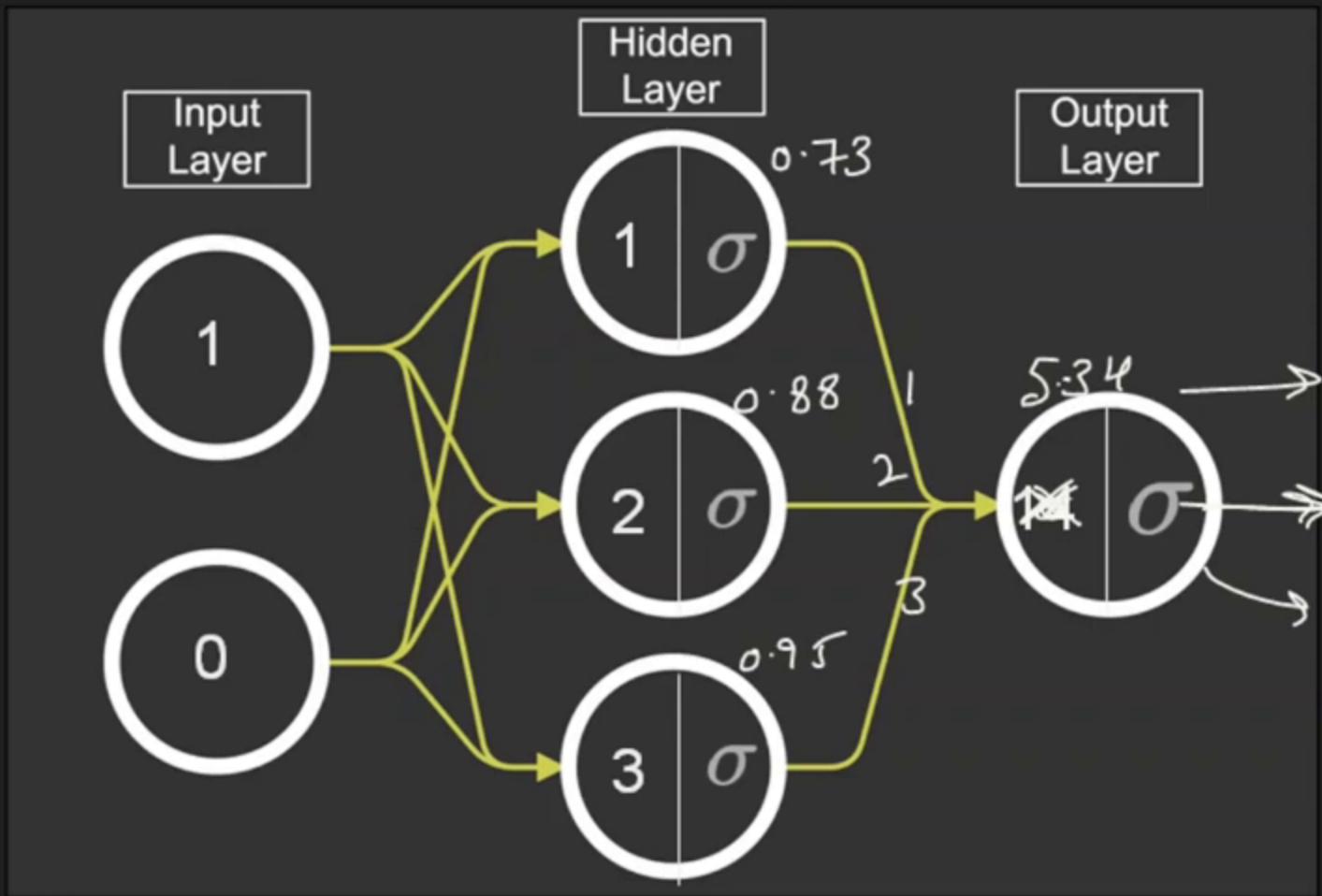
$$+ 3 \times 0.95$$

$$\underline{5.34}$$

$$\text{sig}(5.4) \rightarrow 0.99$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

$$\text{sig}(3) \rightarrow 0.95$$

$$1 \times 0.73 + 2 \times 0.88$$

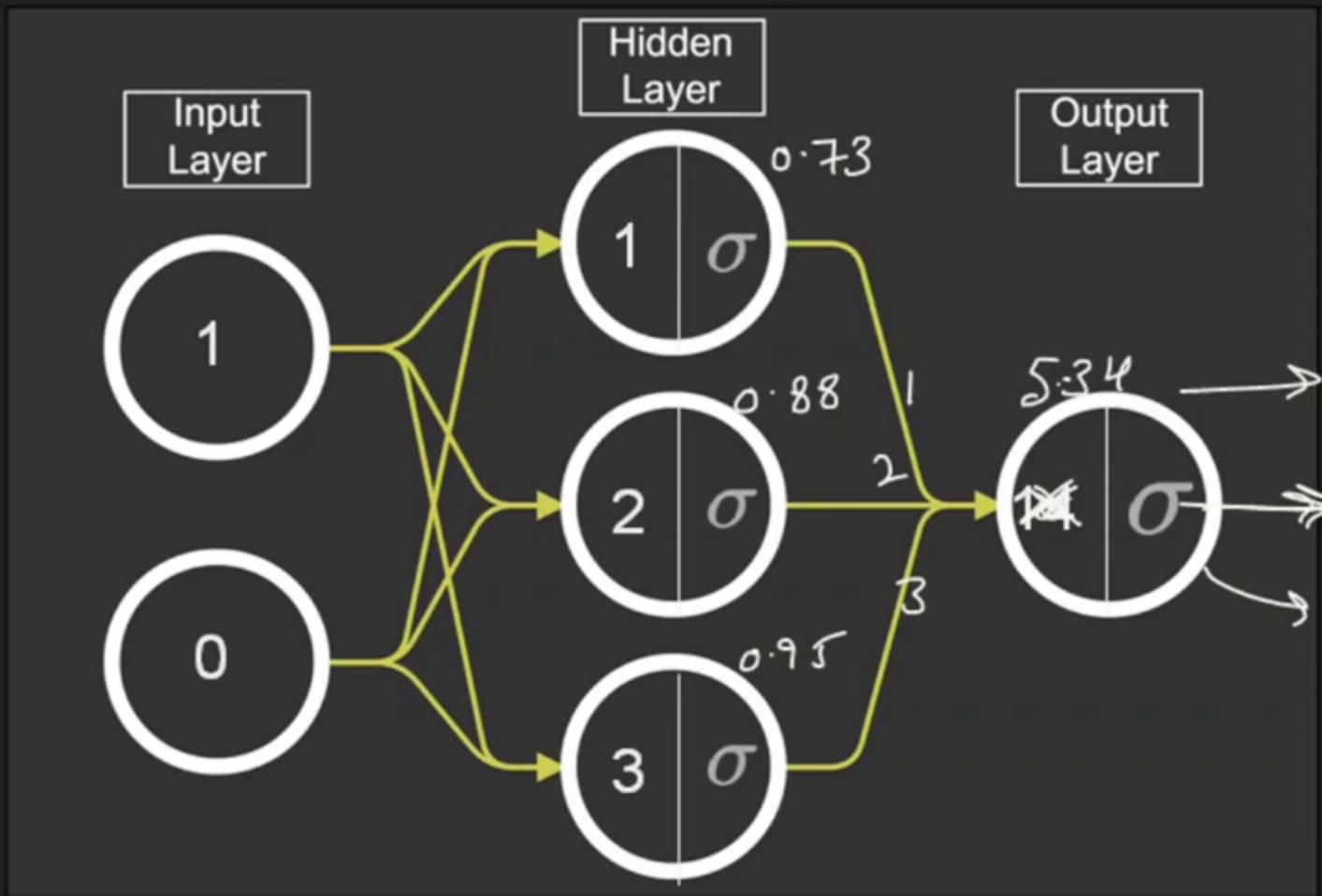
$$+ 3 \times 0.95$$

$$\underline{5.34}$$

$$\text{sig}(5.4) \rightarrow 0.99$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

$$\text{sig}(3) \rightarrow 0.95$$

$$1 \times 0.73 + 2 \times 0.88$$

$$+ 3 \times 0.95$$

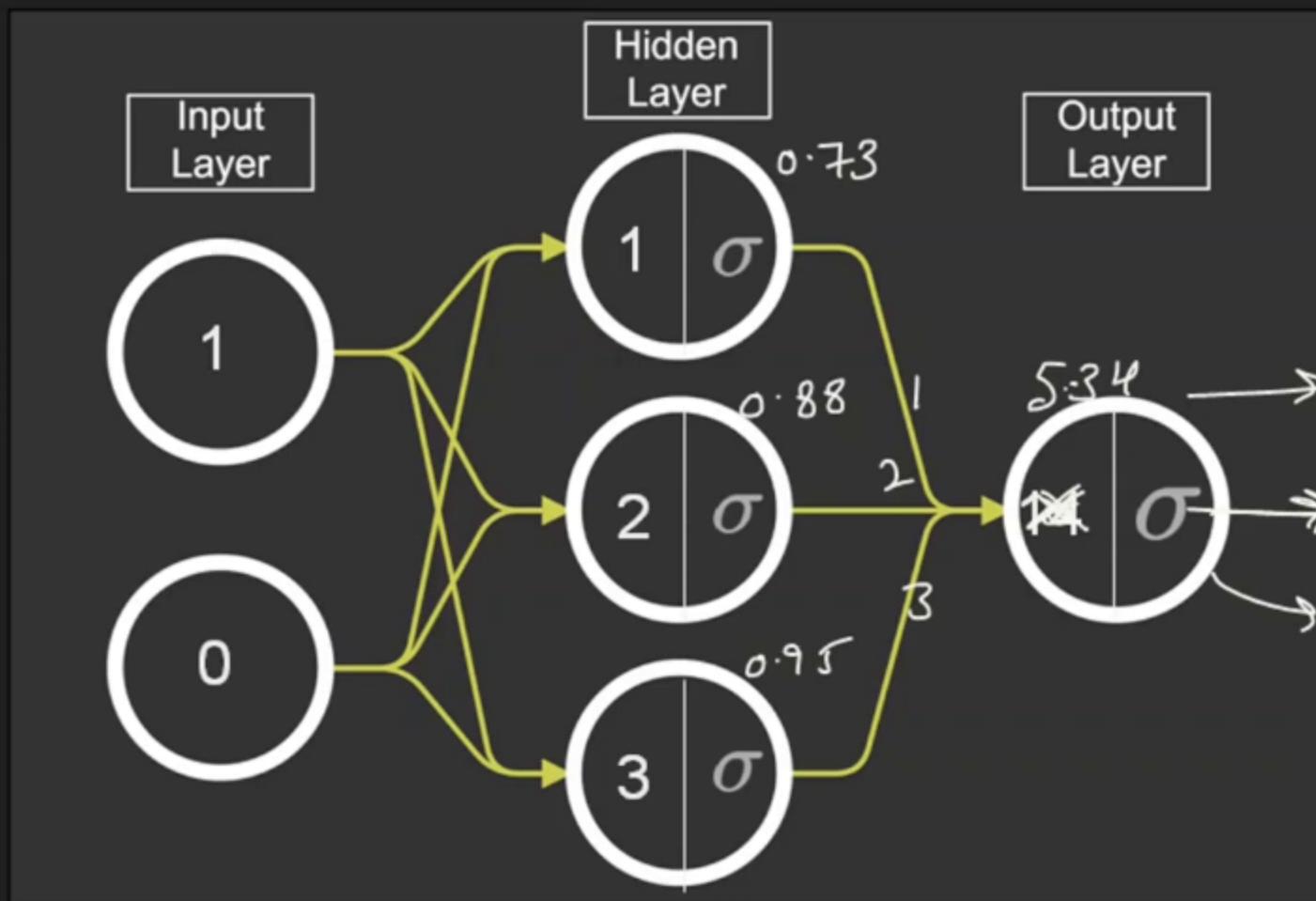
$$\Rightarrow 5.34$$

$$\text{sig}(5.4) \rightarrow 0.99$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification

$$\begin{aligned}x=1 &\rightarrow 1 \\x=2 &\rightarrow 2\end{aligned}$$



$$\text{sig}(1) \rightarrow 0.73$$

$$\text{sig}(2) \rightarrow 0.88$$

$$\text{sig}(3) \rightarrow 0.95$$

$$1 \times 0.73 + 2 \times 0.88$$

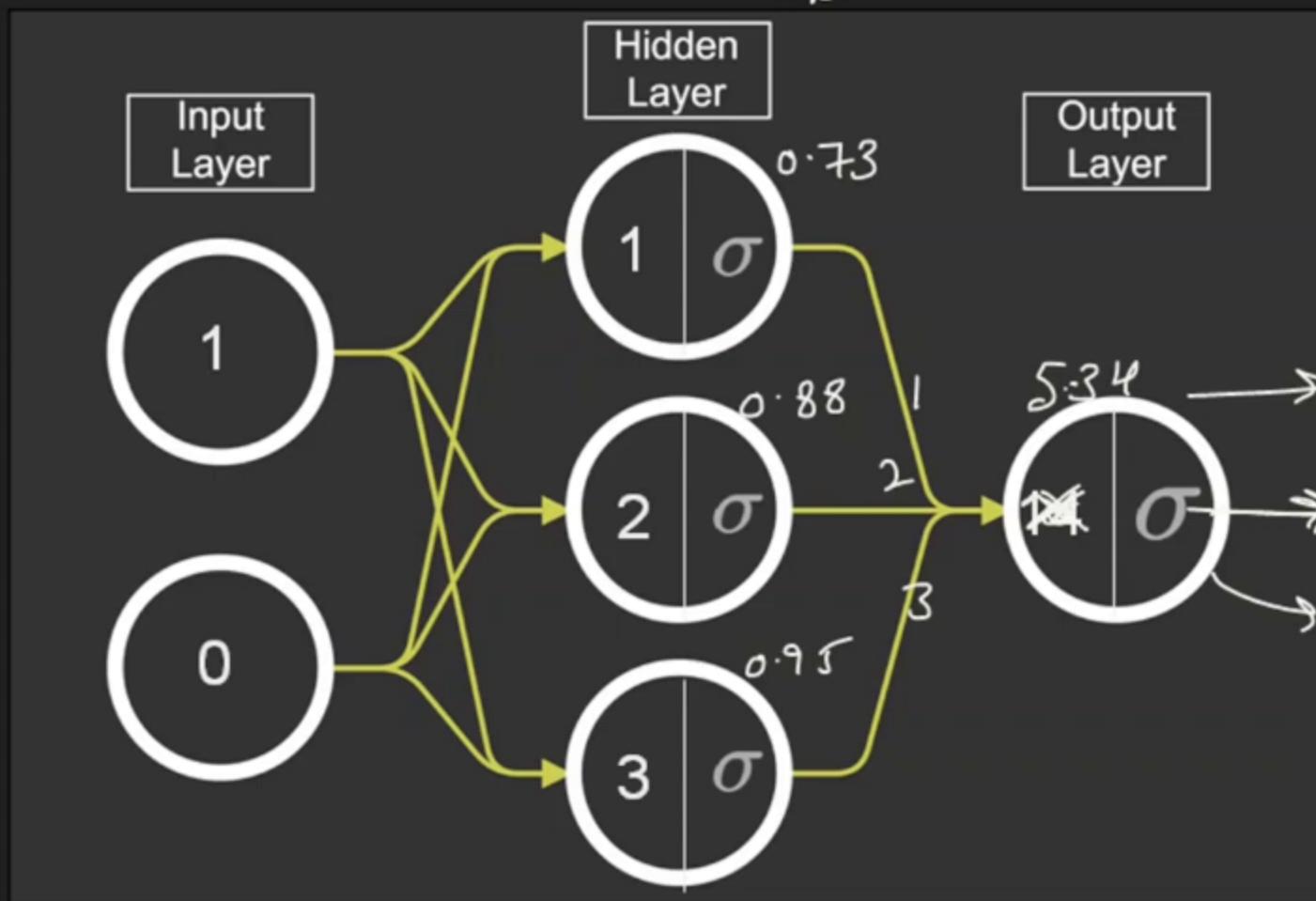
$$+ 3 \times 0.95$$

$$0.99$$

$$\text{Sig}(5.4) \rightarrow 0.99$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



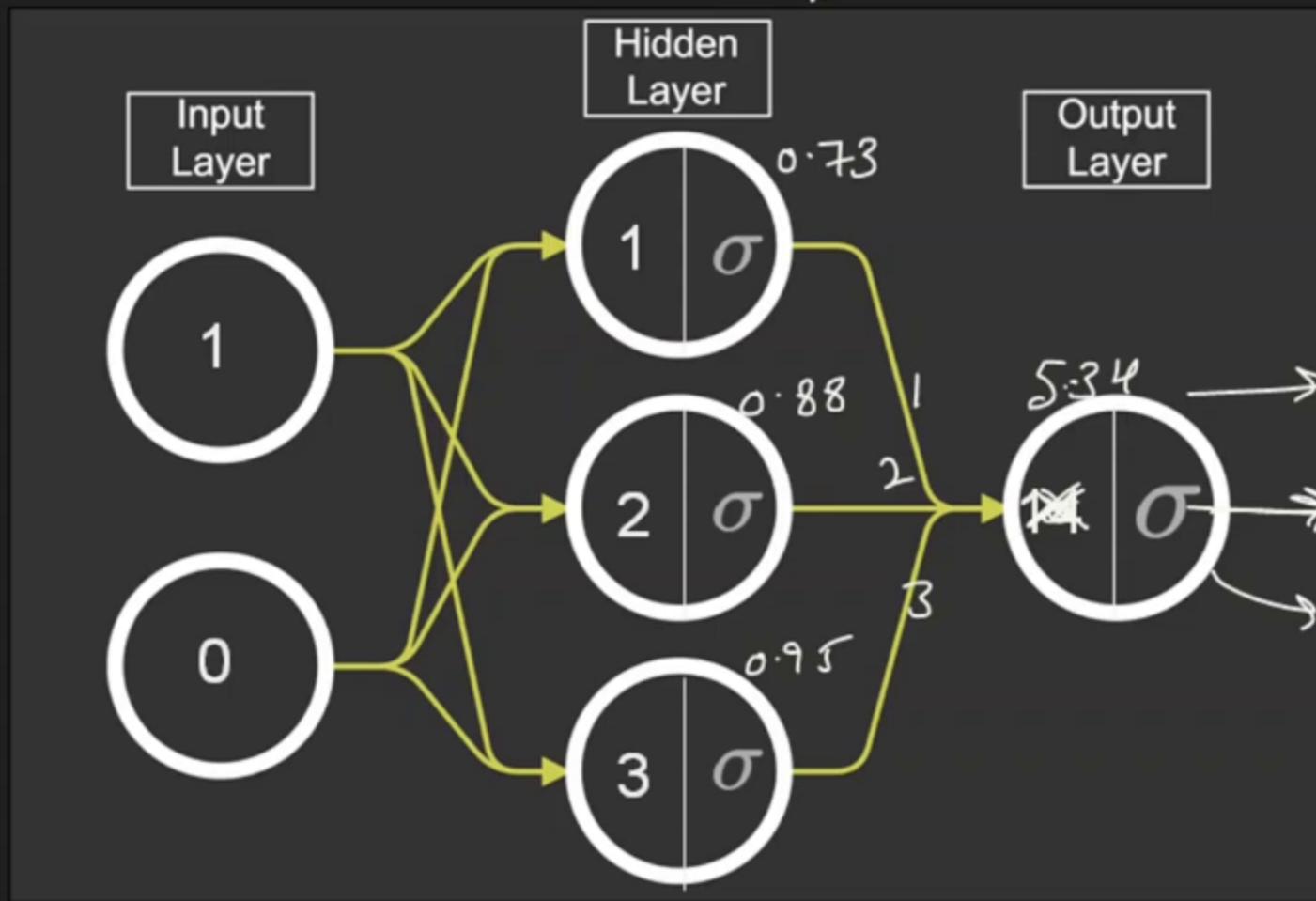
$$\begin{aligned}x=1 &\rightarrow 1 \\x=2 &\rightarrow 1 \\x=3 &\rightarrow 1\end{aligned}\left.\right\} \text{Step}$$

$$\begin{aligned}\text{sig}(1) &\rightarrow 0.73 \\ \text{sig}(2) &\rightarrow 0.88 \\ \text{sig}(3) &\rightarrow 0.95\end{aligned}\left.\right\} \rightarrow$$

$$\begin{aligned}1 \times 0.73 + 2 \times 0.88 \\+ 3 \times 0.95 \\ \text{sig}(5.34) \rightarrow 0.99\end{aligned}$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification



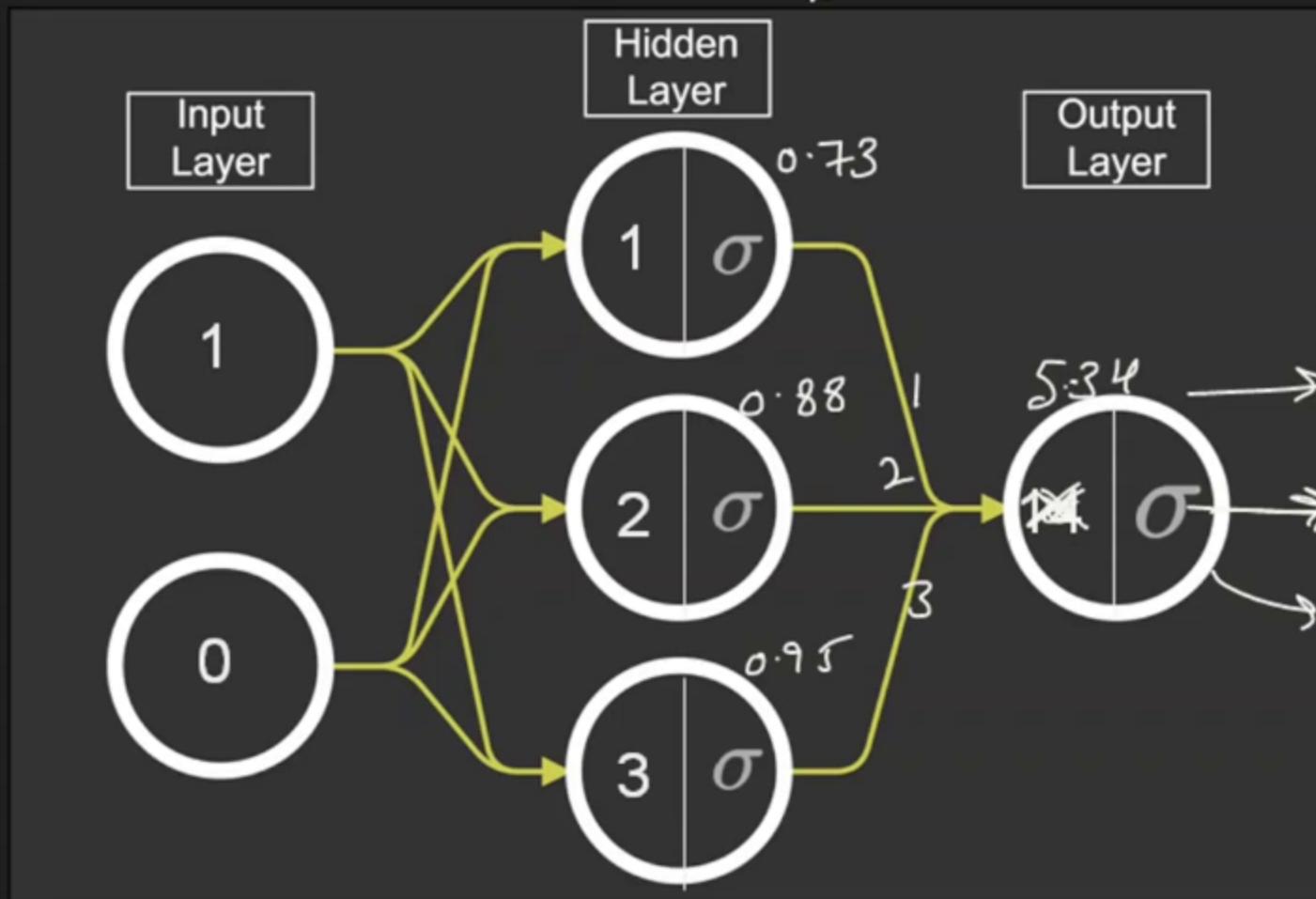
$$\begin{aligned}x=1 &\rightarrow 1 \\x=2 &\rightarrow 1 \\x=3 &\rightarrow 1\end{aligned}\left.\right\} \text{Step}$$

$$\begin{aligned}\text{sig}(1) &\rightarrow 0.73 \\ \text{sig}(2) &\rightarrow 0.88 \\ \text{sig}(3) &\rightarrow 0.95\end{aligned}\left.\right\} \rightarrow$$

$$\begin{aligned}1 \times 0.73 + 2 \times 0.88 \\+ 3 \times 0.95 \\ \text{Sig}(5.4) \rightarrow 0.99\end{aligned}$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification

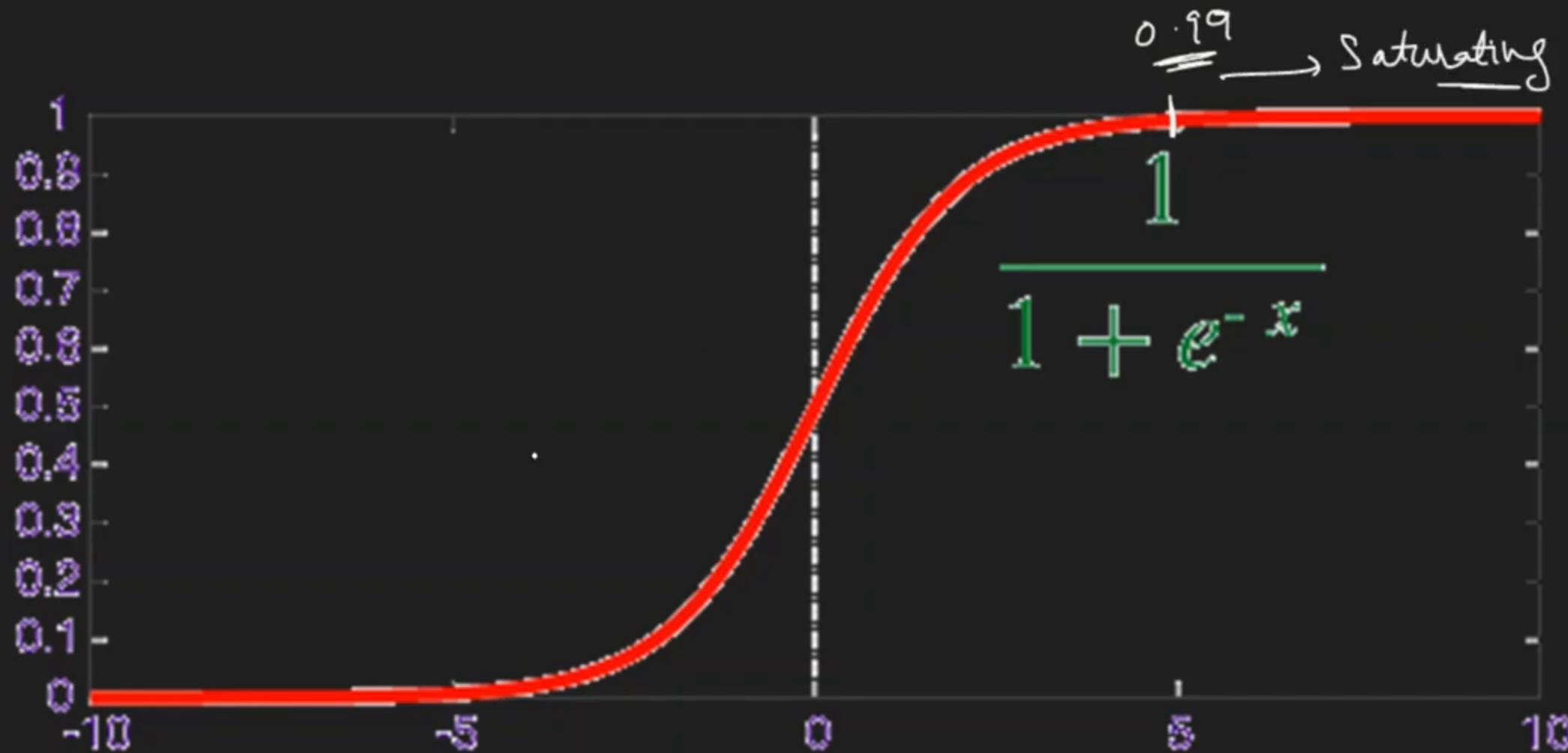


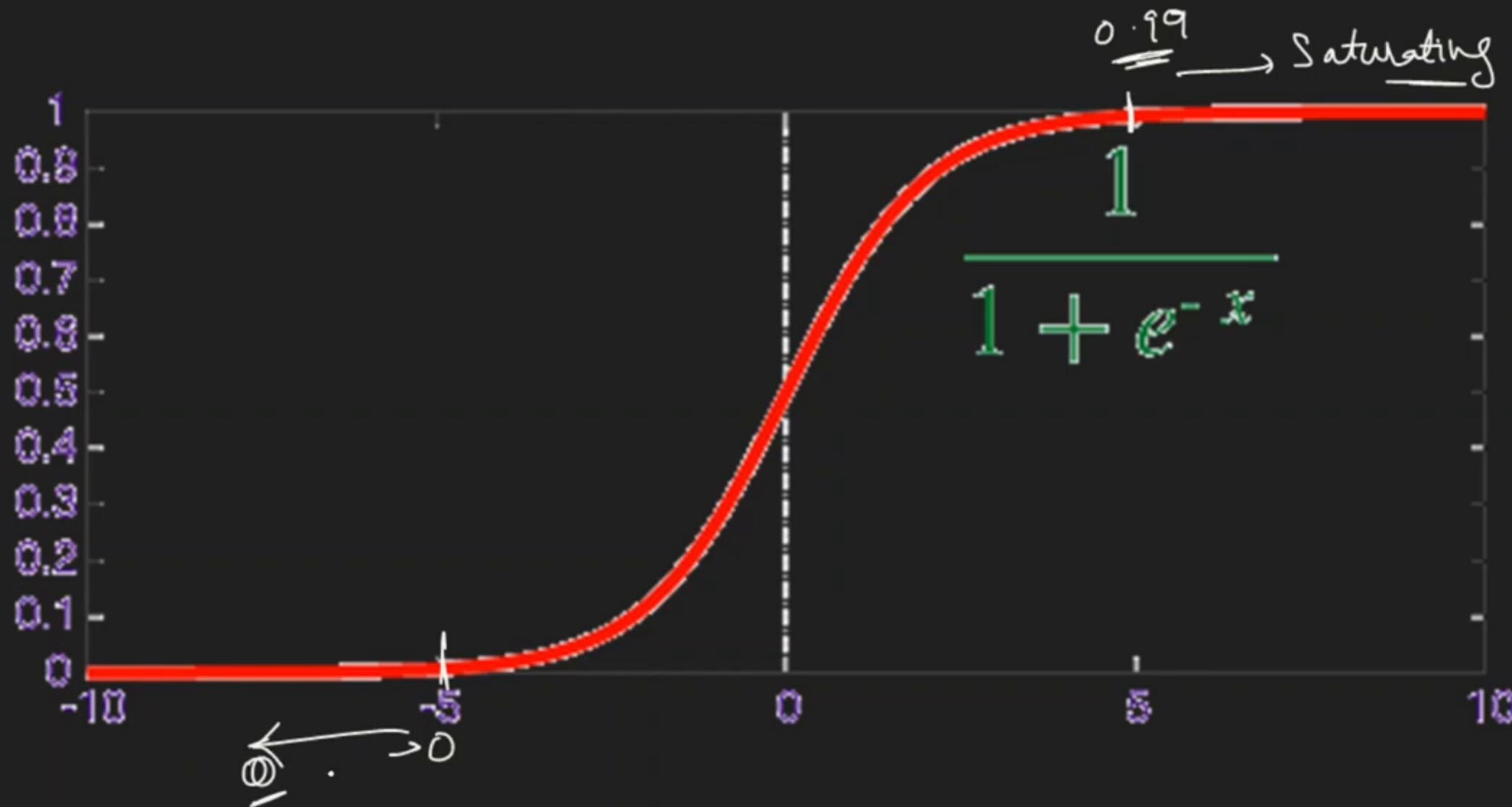
$$\begin{aligned} x=1 &\rightarrow 1 \\ x=2 &\rightarrow 1 \\ x=3 &\rightarrow 1 \end{aligned} \quad \left. \begin{array}{l} \downarrow \\ \downarrow \\ \downarrow \end{array} \right\} \text{Step}$$

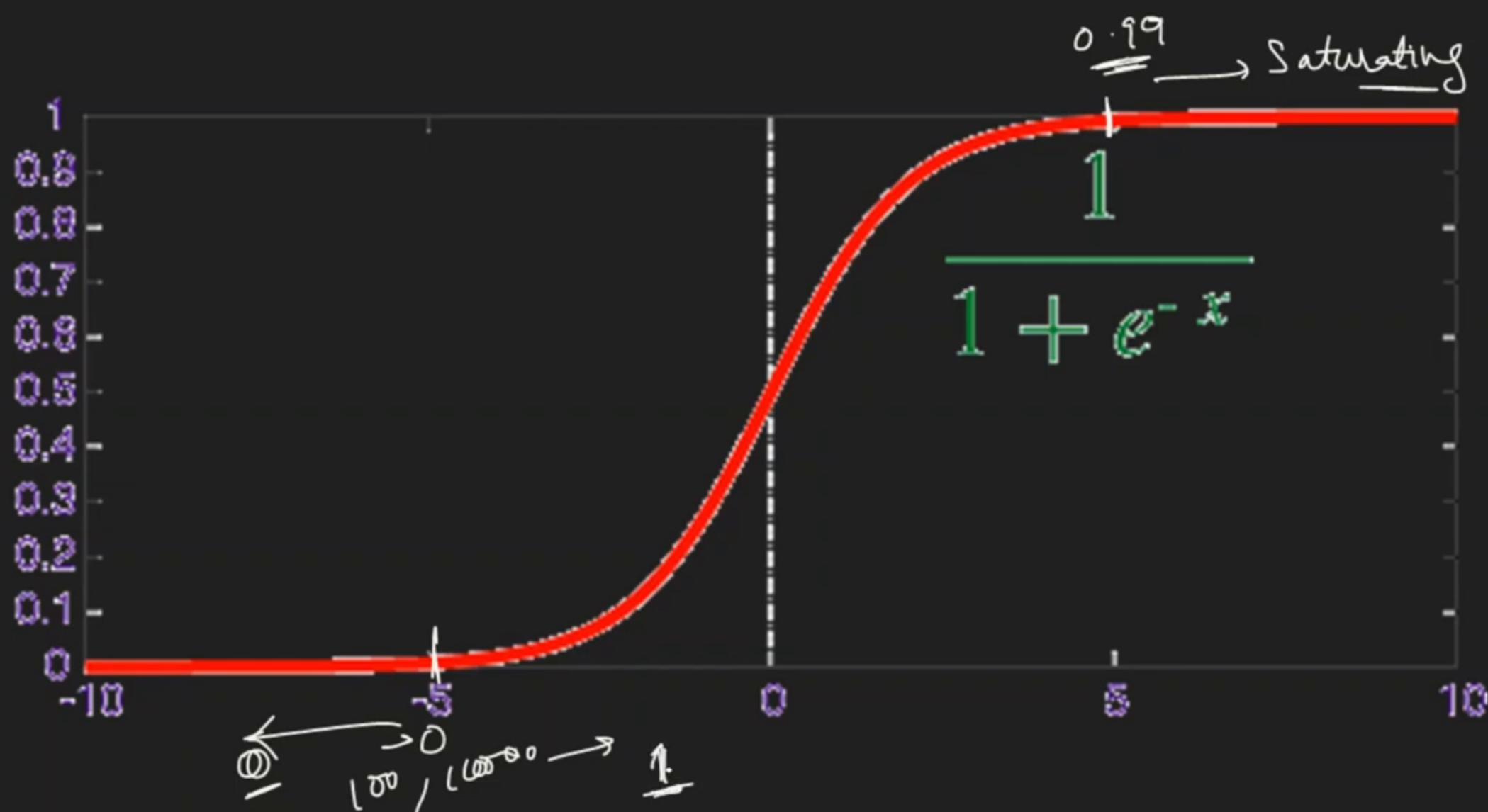
$$\begin{aligned} \text{sig}(1) &\rightarrow 0.73 \\ \text{sig}(2) &\rightarrow 0.88 \\ \text{sig}(3) &\rightarrow 0.95 \end{aligned} \quad \left. \begin{array}{l} \downarrow \\ \downarrow \\ \downarrow \end{array} \right\} \rightarrow$$

$$\begin{aligned} 1 \times 0.73 + 2 \times 0.88 \\ + 3 \times 0.95 &\Rightarrow 5.34 \\ \text{sig}(5.4) &\rightarrow 0.99 \end{aligned}$$

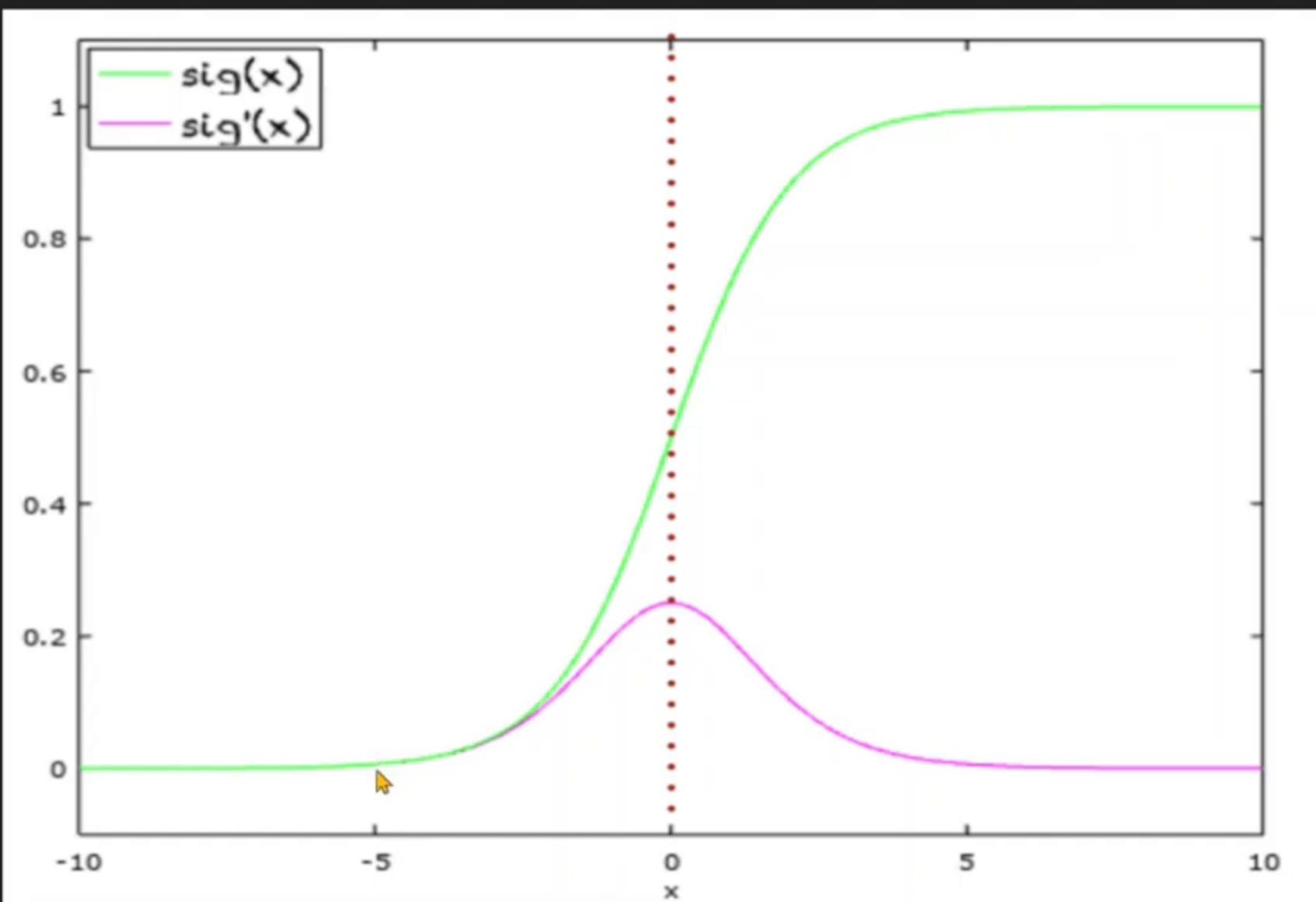
$$S(x) = \frac{1}{1 + e^{-x}}$$



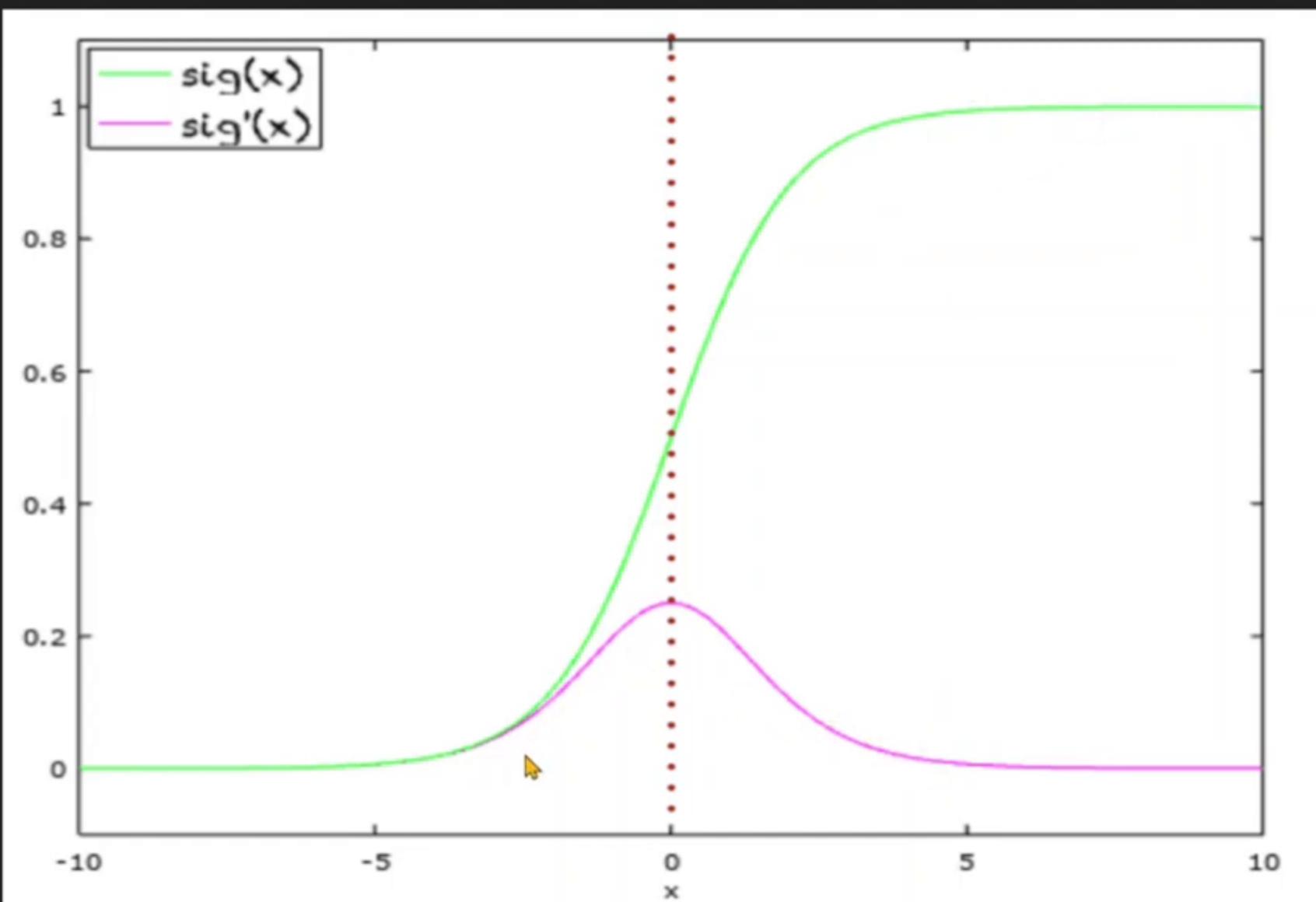




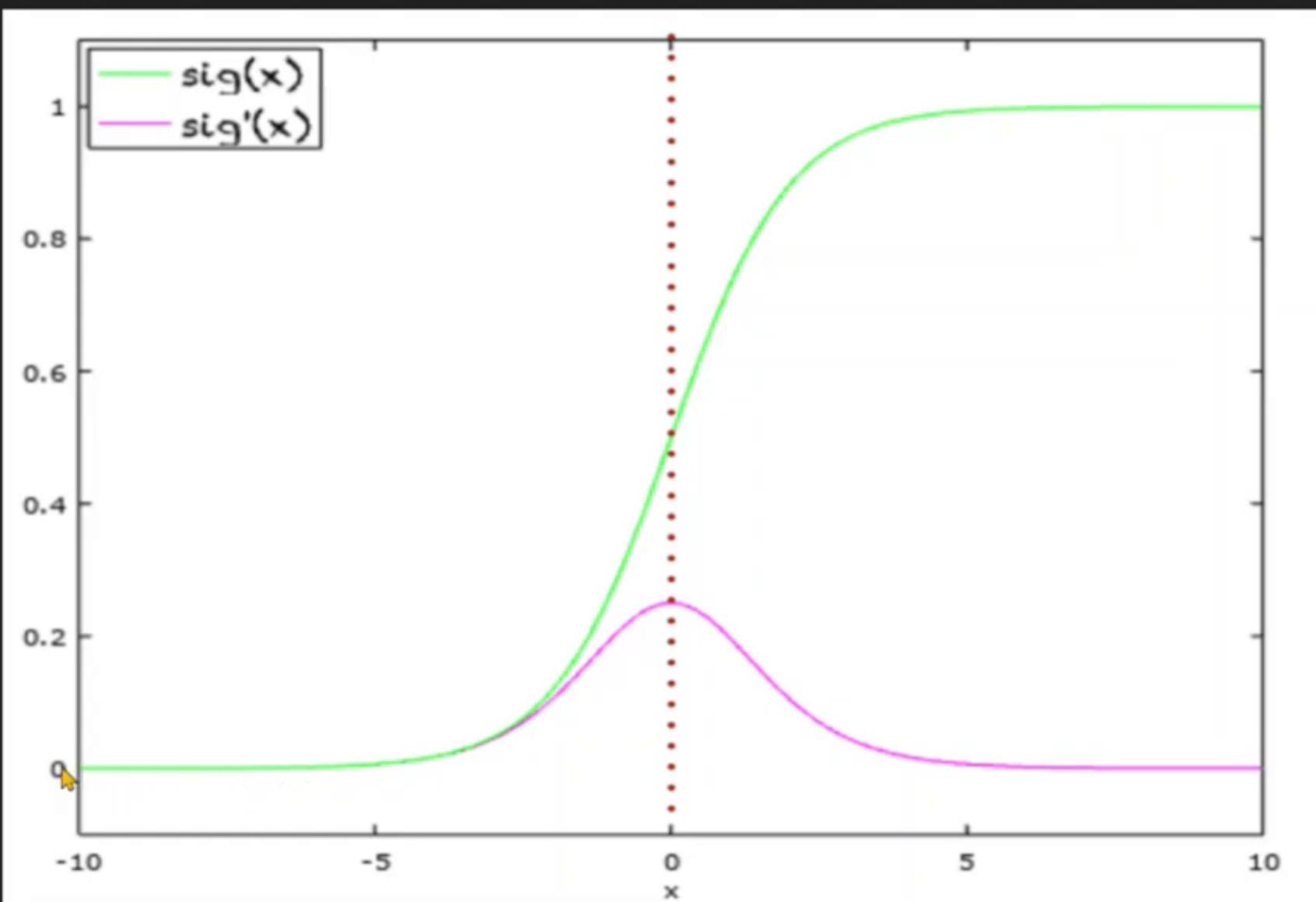
# Derivative



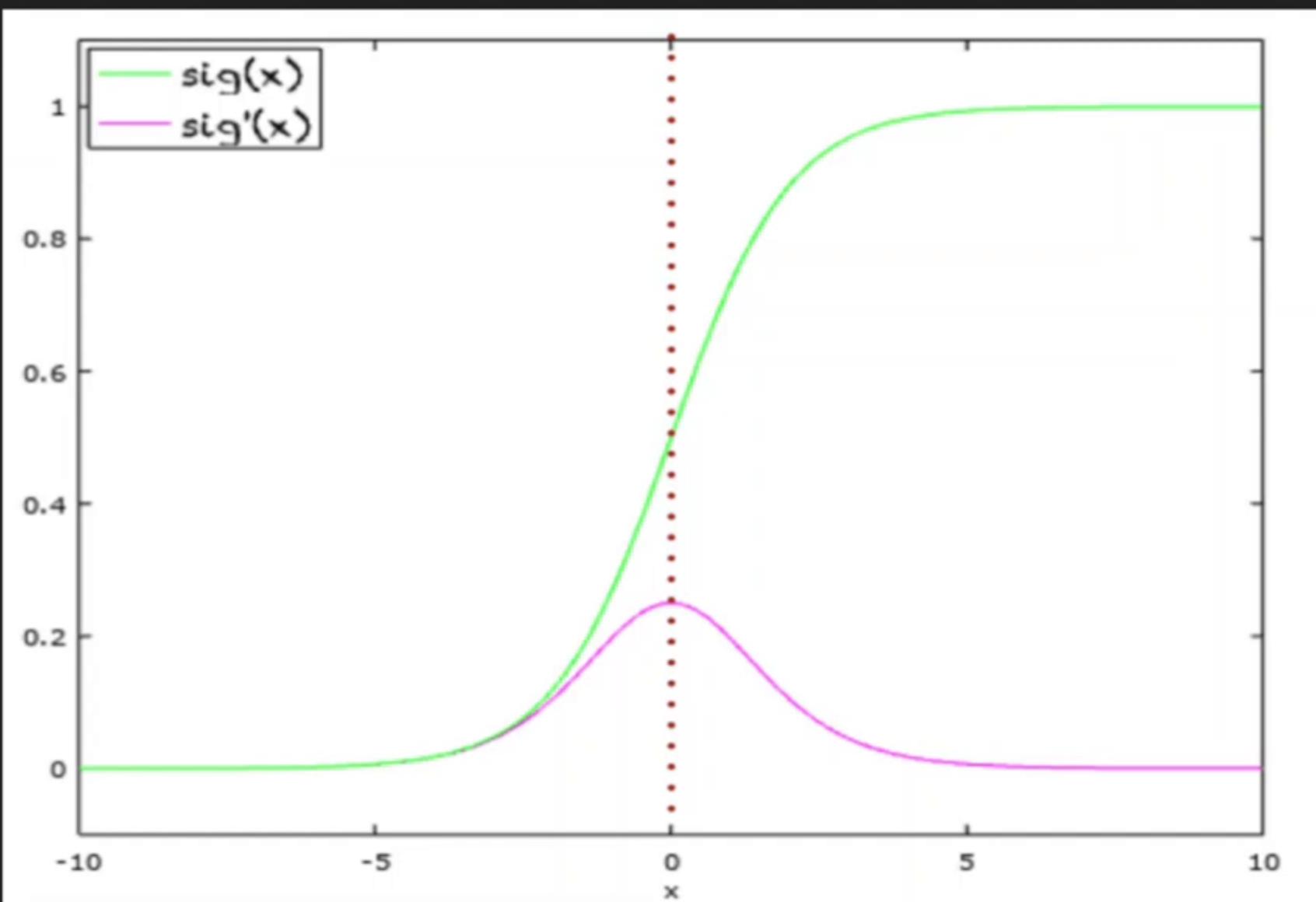
# Derivative



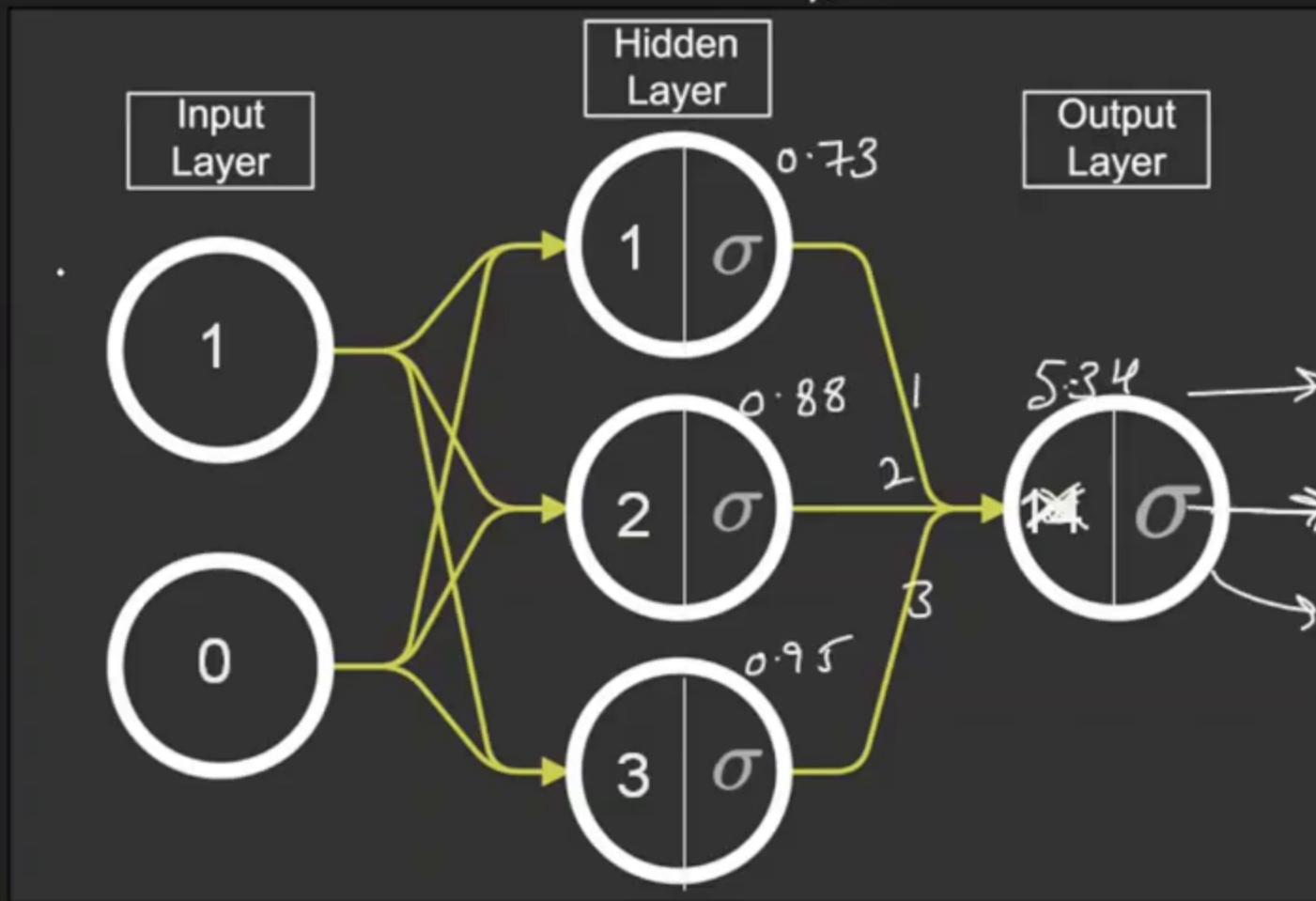
# Derivative



# Derivative



# Binary Classification



$$\begin{aligned}x=1 &\rightarrow 1 \\x=2 &\rightarrow 1 \\x=3 &\rightarrow 1\end{aligned}\left.\right\} \text{Step}$$

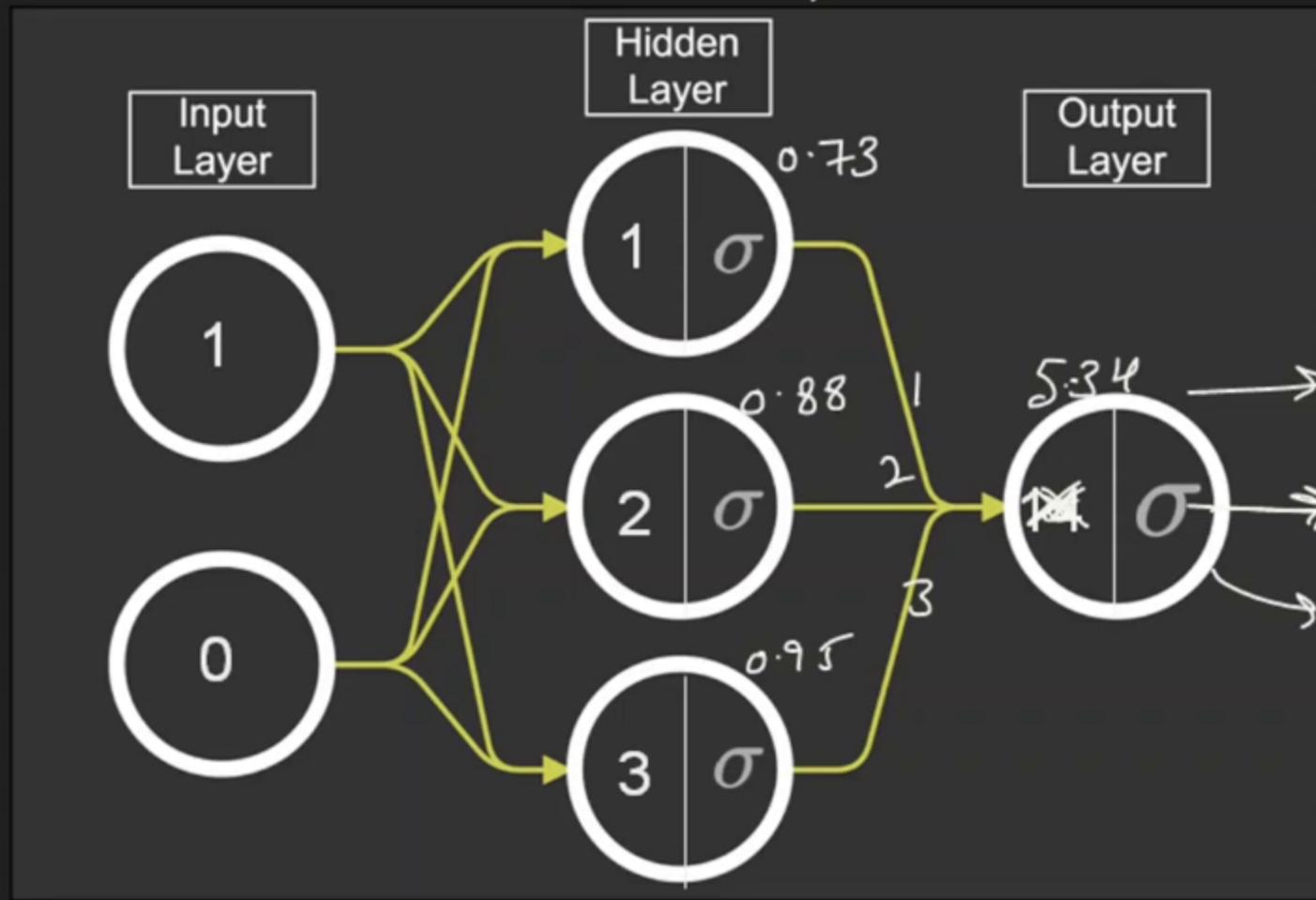
$$\begin{aligned}\text{sig}(1) &\rightarrow 0.73 \\ \text{sig}(2) &\rightarrow 0.88 \\ \text{sig}(3) &\rightarrow 0.95\end{aligned}\left.\right\} \rightarrow$$

$$\begin{aligned}1 \times 0.73 + 2 \times 0.88 \\+ 3 \times 0.95 &\Rightarrow 5.34 \\ \text{Sig}(5.4) &\rightarrow 0.99\end{aligned}$$

$$S(x) = \frac{1}{1 + e^{-x}}$$

# Binary Classification

-5 to 5  
100  
100



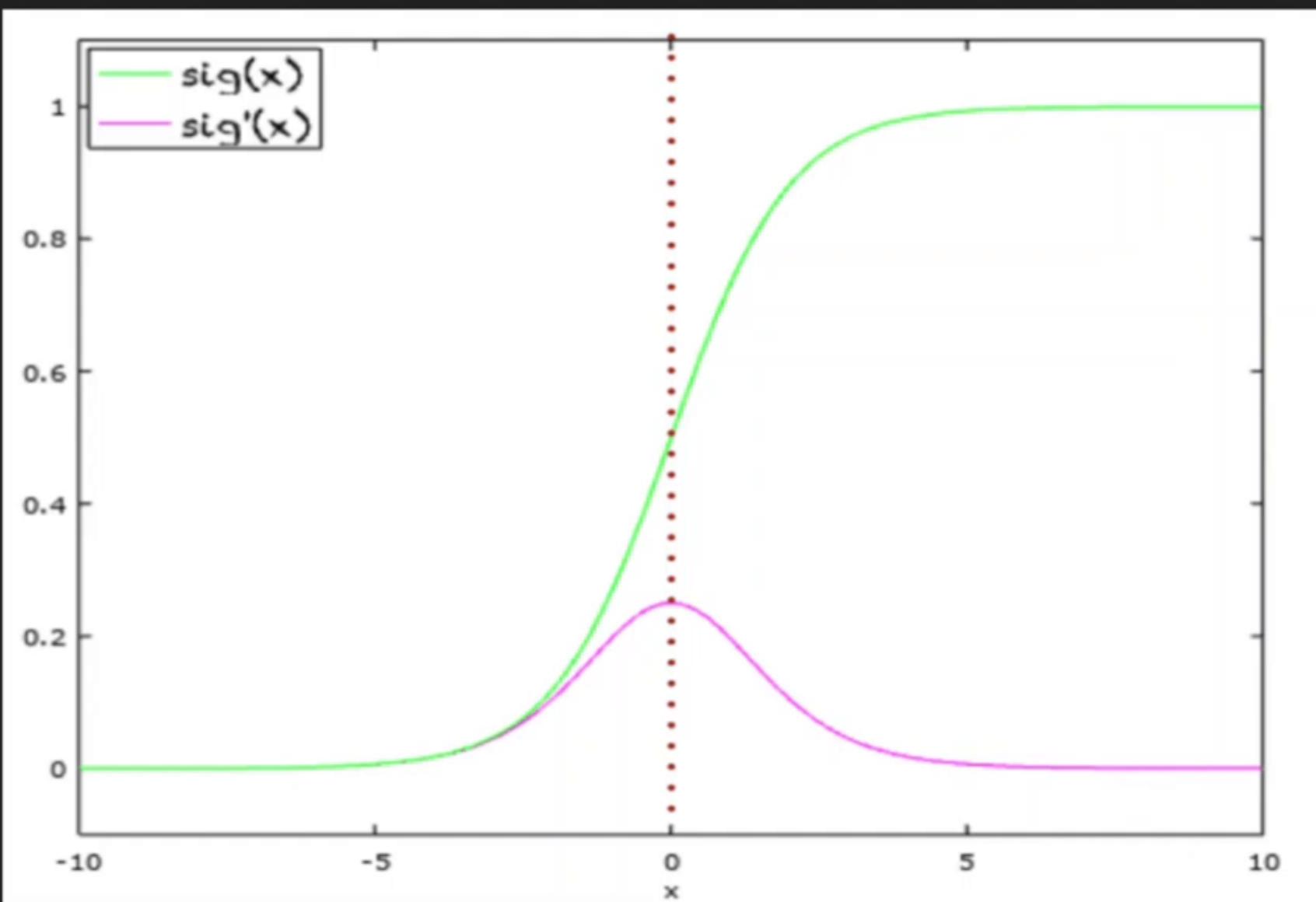
$$\begin{aligned}x=1 &\rightarrow 1 \\x=2 &\rightarrow 1 \\x=3 &\rightarrow 1\end{aligned}\left.\right\} \text{Step}$$

$$\begin{aligned}\text{sig}(1) &\rightarrow 0.73 \\ \text{sig}(2) &\rightarrow 0.88 \\ \text{sig}(3) &\rightarrow 0.95\end{aligned}\left.\right\} \rightarrow$$

$$\begin{aligned}1 \times 0.73 + 2 \times 0.88 + 3 \times 0.95 &= 5.34 \\ \text{sig}(5.34) &\rightarrow 0.99\end{aligned}$$

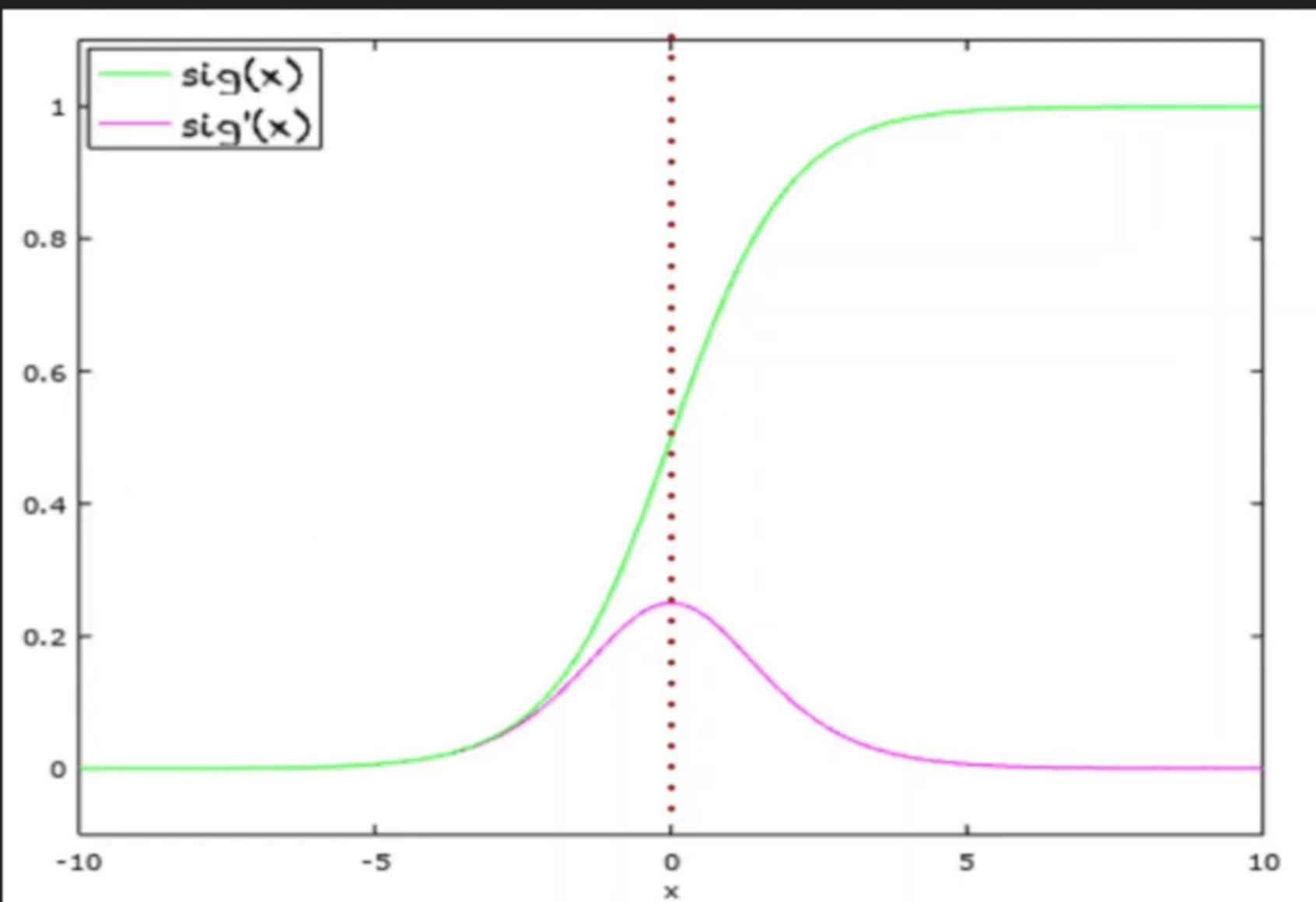
$$S(x) = \frac{1}{1 + e^{-x}}$$

# Derivative



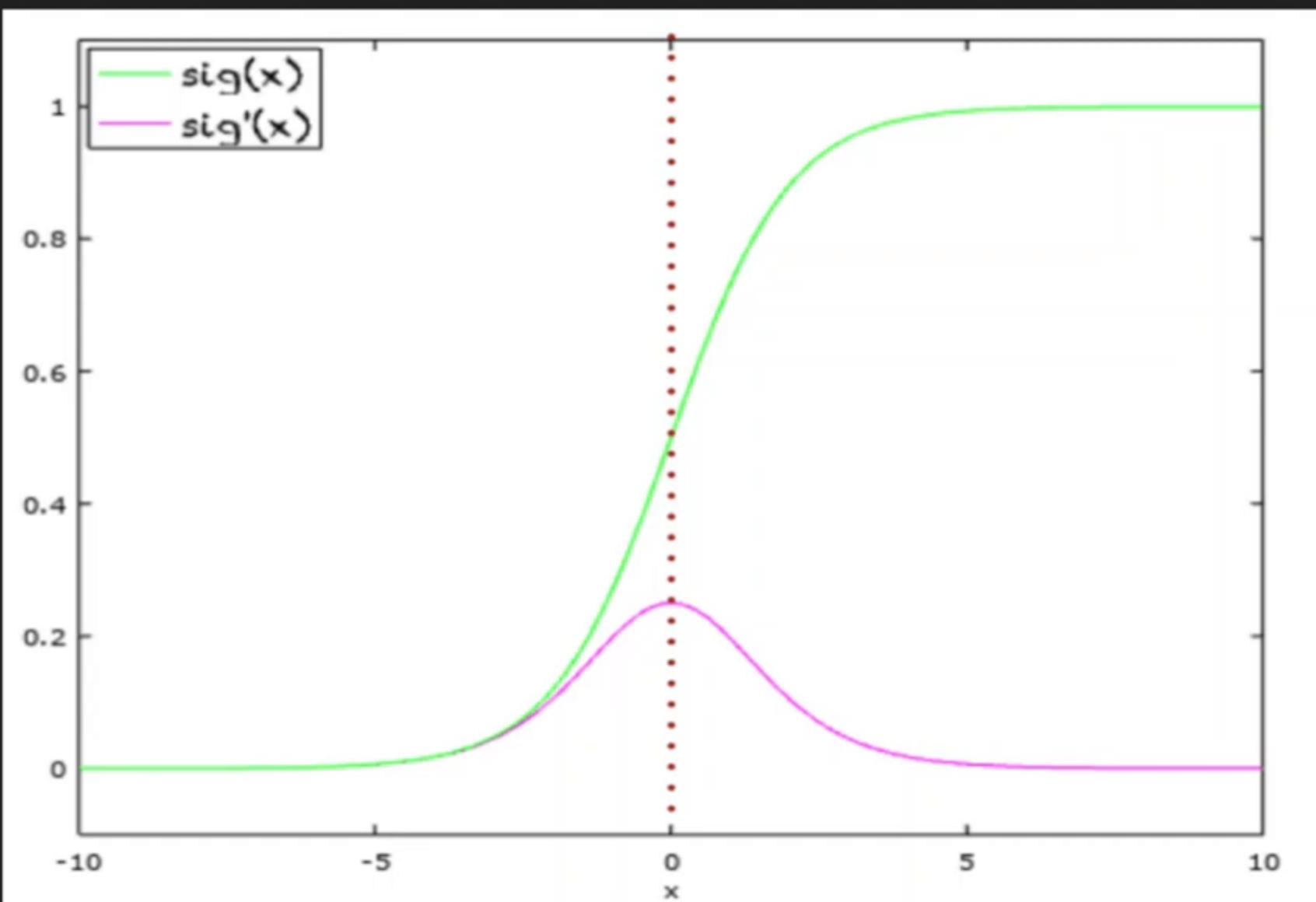
# Derivative

Scallop ~



# Derivative

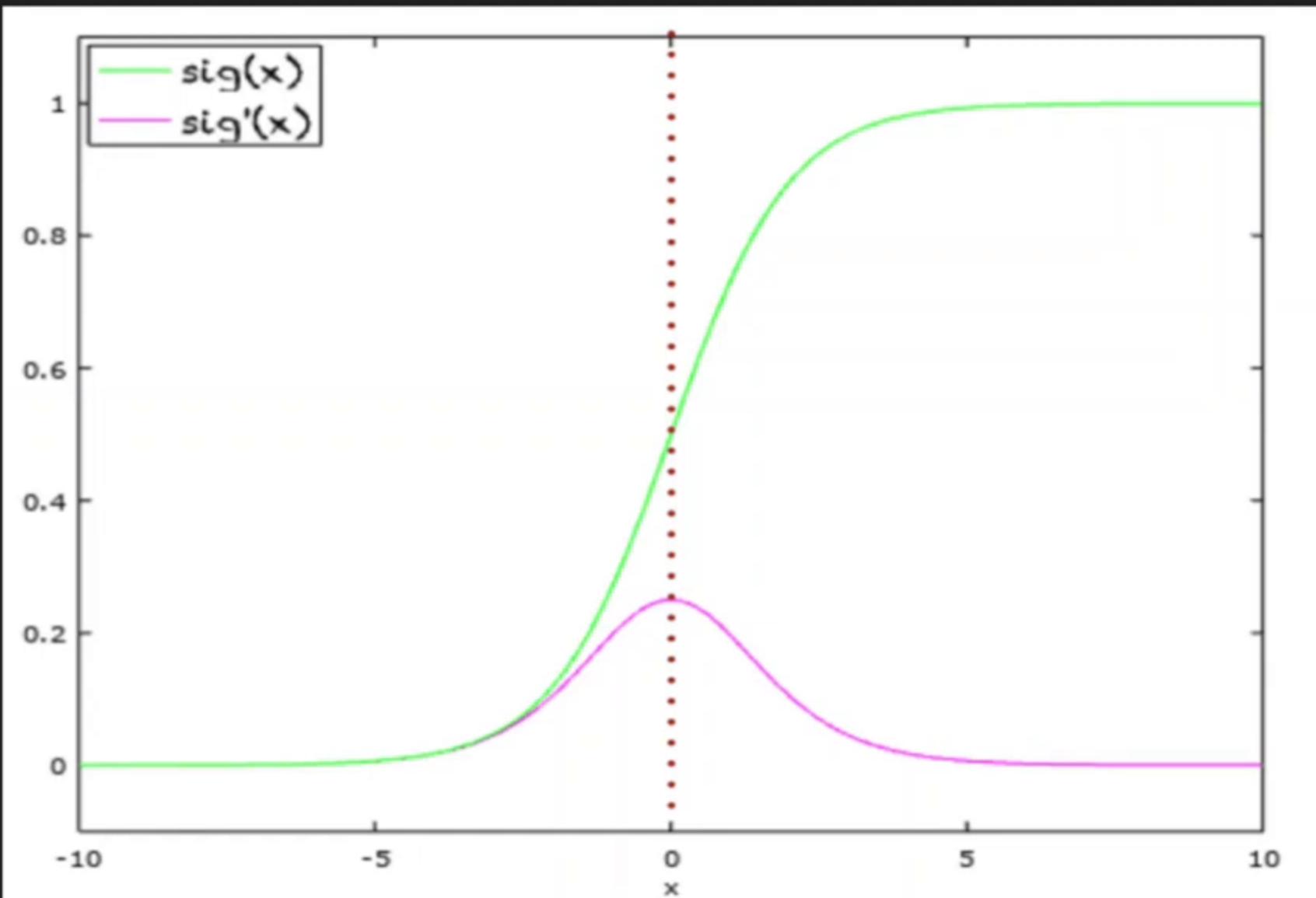
Scallop ~



# Derivative

Seaborg

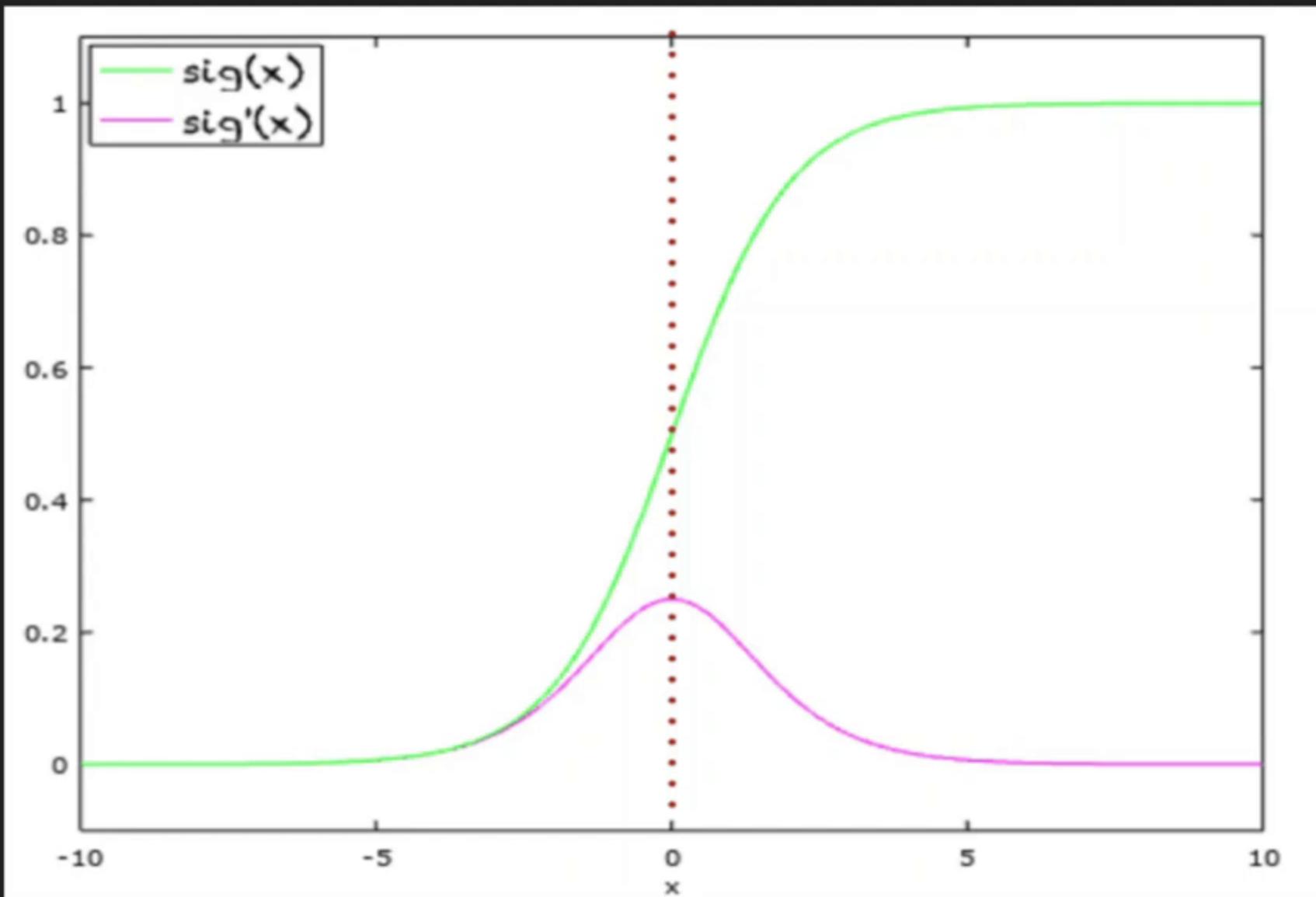
Vanishing  
Gradient



# Derivative

~~Seaborn~~

Vanishing  
Gradient



# Drawbacks

- Vanishing Gradient
- Not-zero centered



# Drawbacks

- Vanishing Gradient
- Not-zero centered

$$\nabla(x) \rightarrow \underbrace{(0, 1)}_{\rightarrow 0(x)} - \cancel{x}$$



# Drawbacks

- Vanishing Gradient
- Not-zero centered

$$\nabla(x) \rightarrow \underbrace{(0, 1)}_{\rightarrow 0(x)} - \cancel{x}$$

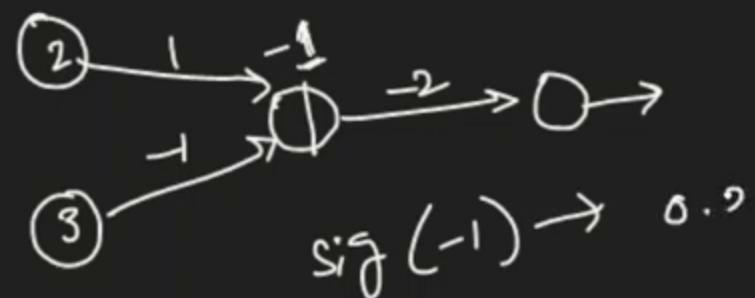


# Drawbacks

- Vanishing Gradient
- Not-zero centered



$$\nabla(x) \rightarrow \begin{pmatrix} 0 \\ 1 \end{pmatrix} \rightarrow \overline{\nabla(x)} \rightarrow \cancel{x}$$

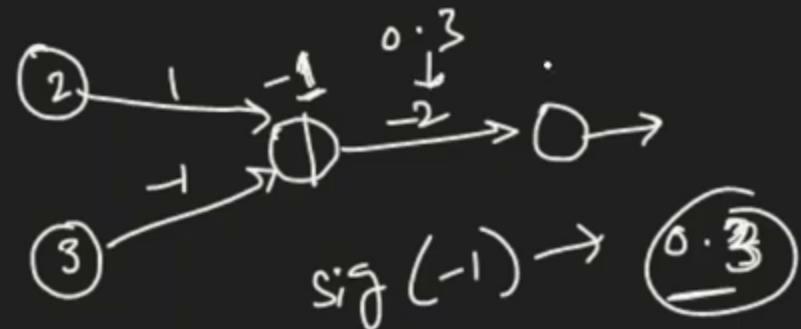


# Drawbacks

- Vanishing Gradient
- Not-zero centered



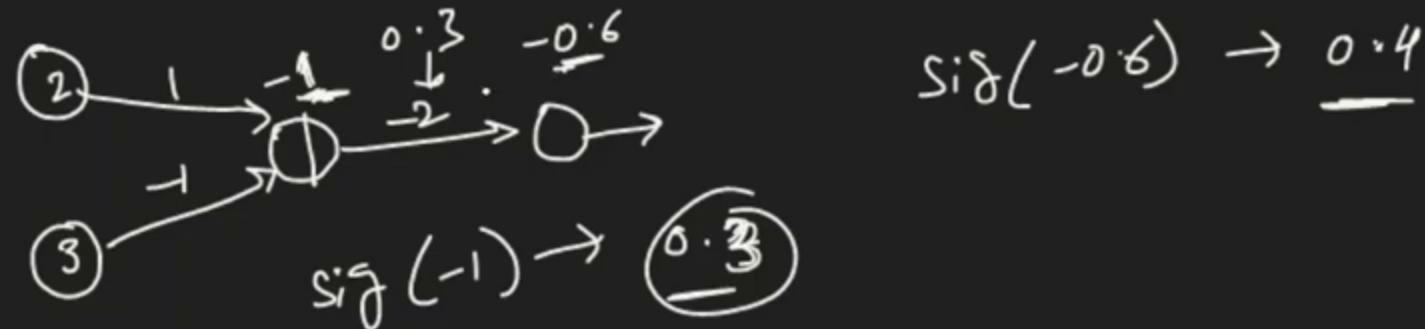
$$\nabla(x) \rightarrow \begin{pmatrix} 0 \\ 1 \end{pmatrix} \rightarrow \overline{\nabla(x)} \rightarrow \cancel{e}$$



# Drawbacks

- Vanishing Gradient
- Not-zero centered

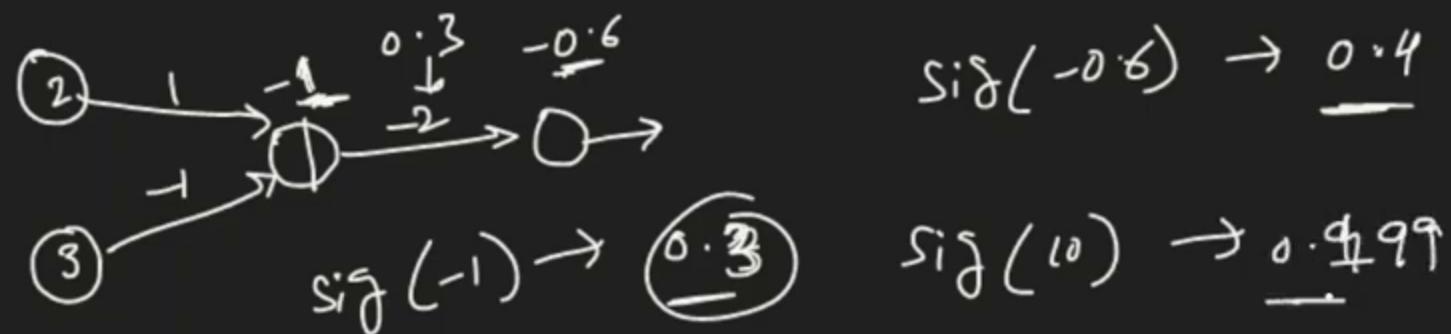
$$\nabla(x) \rightarrow \underbrace{[0, 1]}_{\rightarrow 0(x)} - \cancel{x}$$



# Drawbacks

- Vanishing Gradient
- Not-zero centered

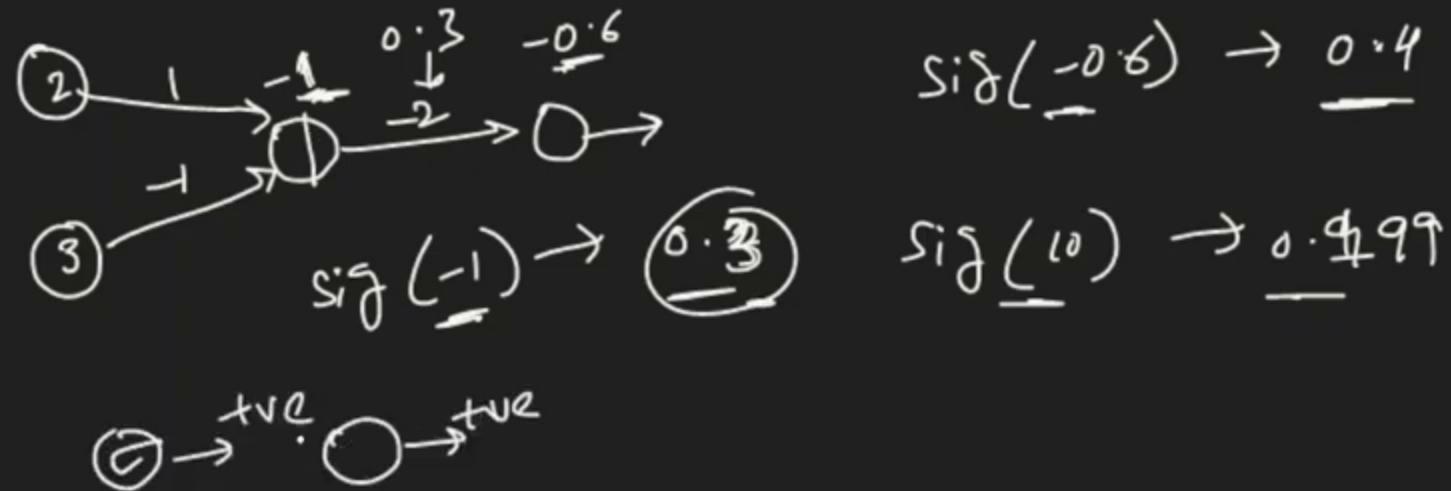
$$\nabla(x) \rightarrow \underbrace{(0, 1)}_{\rightarrow \overline{0}(x)} \quad \cancel{\times}$$



# Drawbacks

- Vanishing Gradient
- Not-zero centered

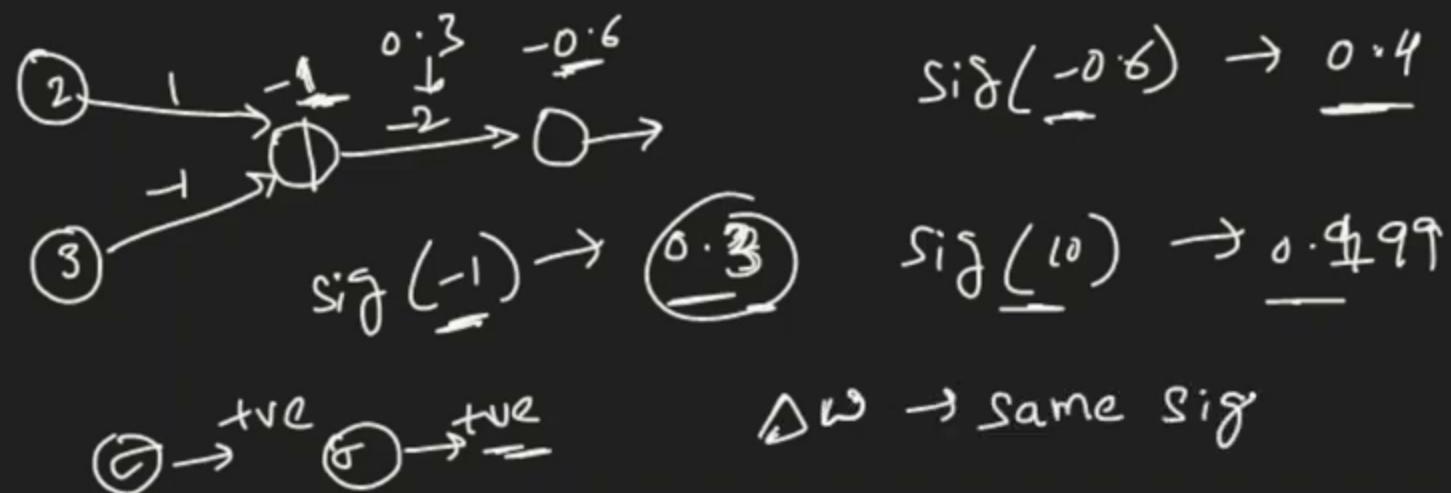
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# Drawbacks

- Vanishing Gradient
- Not-zero centered

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# Drawbacks

- Vanishing Gradient
- Not-zero centered

$\nabla(x) \rightarrow \underline{(0, 1)}$   
 $\rightarrow \nabla(x) \rightarrow \cancel{e}$

$\begin{array}{ccccc} 2 & \xrightarrow{1} & -1 & \xrightarrow{0.3} & -0.6 \\ & & \downarrow & & \\ & & 0 & \xrightarrow{-2} & 0 \\ 3 & \xrightarrow{-1} & 0 & \xrightarrow{\text{sig}(-1)} & 0.3 \\ & & & \text{sig}(0) & \rightarrow 0.99 \end{array}$

$\text{tve}$        $\text{tve}$        $\Delta w \rightarrow \text{same sign}$   
long time.

## Python code

```
import numpy as np  
def sigmoid_function(x):  
    z = (1/(1 + np.exp(-x)))  
    return z
```

$$f'(x) = \text{sigmoid}(x) * (1 - \text{sigmoid}(x))$$

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```
[ ] [2.21815519 3.09669206 4.26920281 5.32628791]  
[2.42056403 3.43944131 4.54612269 5.74895199]  
[2.42581862 3.51955335 4.58970735 5.88371524]  
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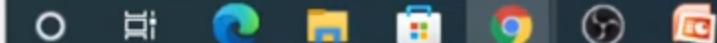
✓ [14] import matplotlib.pyplot as plt  
0s import numpy as np

✓ [17] x=np.arange(-6,6,0.01)  
# Plotting  
fig, ax = plt.subplots(figsize=(9, 5))  
ax.spines['left'].set\_position('center')  
ax.spines['right'].set\_color('none')  
ax.spines['top'].set\_color('none')  
ax.xaxis.set\_ticks\_position('bottom')

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{x}

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ax.yaxis.set\_ticks\_position('left')  
ax.plot(x,sig(x)[0], color="#307EC7", linewidth=3, label="sigmoid")  
ax.plot(x,sig(x)[1], color="#9621E2", linewidth=3, label="derivative")  
ax.legend(loc="upper left", frameon=False)  
fig.show()

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```

{x}

sigmoid derivative

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