Day-91, Feb 29, 2025 (Falgun 17, 2081 BS)

1) Vectors and Linear Transformations (Machine Learning Motivation)
2) Vectors and their properties
3) Vector Operations, Multiplying a Matrix by a vector
4) The dot Product & Geometric Dot Product
5) Matrices as Linear transformations and Linear transformations as matrices, Matrix Multiplication
6) Identity Matrix, Matrix Inverse, Condition for Matrices to be Inverse?
7) Neural Networks and Matrices.

Linear Regression

Linear Model.

$$W \cdot X + b = \hat{y}$$

feature 1	feature 2	...	feature n		target

$$
\begin{array}{ccccccccccc}
w_1 x_1^{(1)} & + & w_2 x_2^{(1)} & + & \cdots & + & w_n x_n^{(1)} & + & b & = & y^{(1)} \\
w_1 x_1^{(2)} & + & w_2 x_2^{(2)} & + & \cdots & + & w_n x_n^{(2)} & + & b & = & y^{(2)} \\
\vdots & & \vdots & & \vdots & & \vdots & & \vdots & & \vdots \\
w_1 x_1^{(m)} & + & w_2 x_2^{(m)} & + & \cdots & + & w_n x_n^{(m)} & + & b & = & y^{(m)}
\end{array}
$$

System of Linear Equations

As a reminder, the way that
worked was that you have

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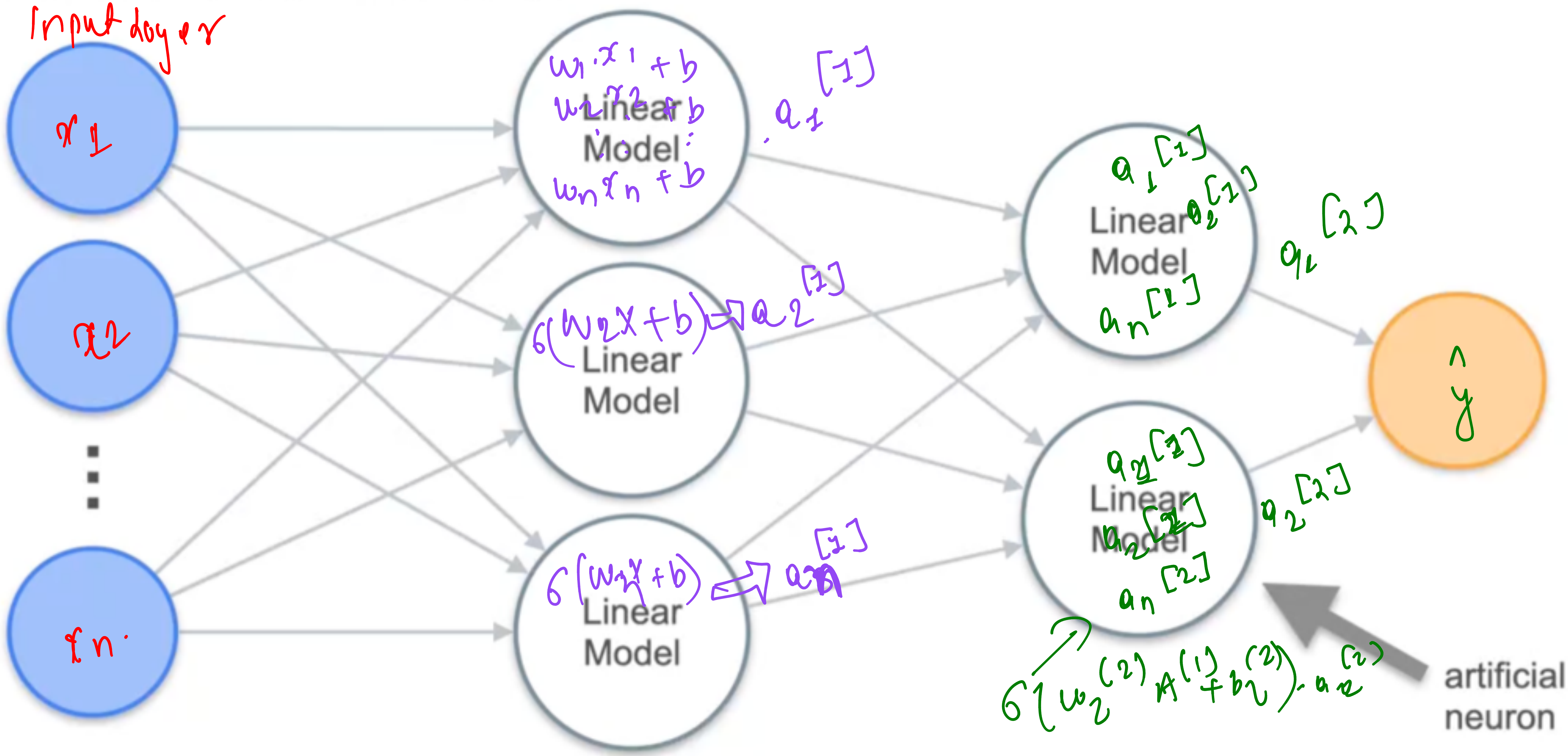
They are just linear Models stacked and backed by Activation functions (σ)

The Neural Network



so-called artificial neurons,

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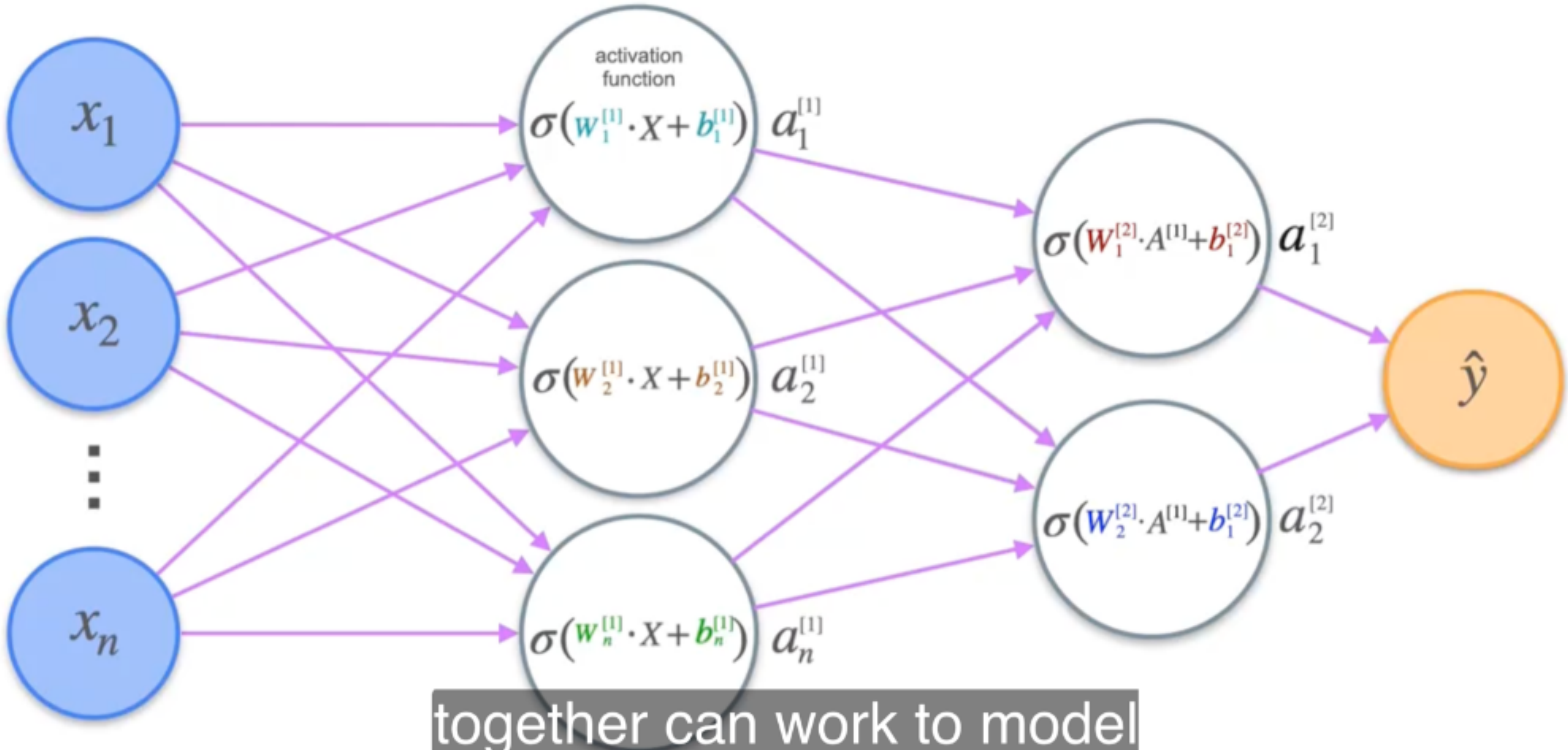
$\vec{a}$ vectors → Matrices, tensors

The Neural Network



together can work to model
highly nonlinear systems.

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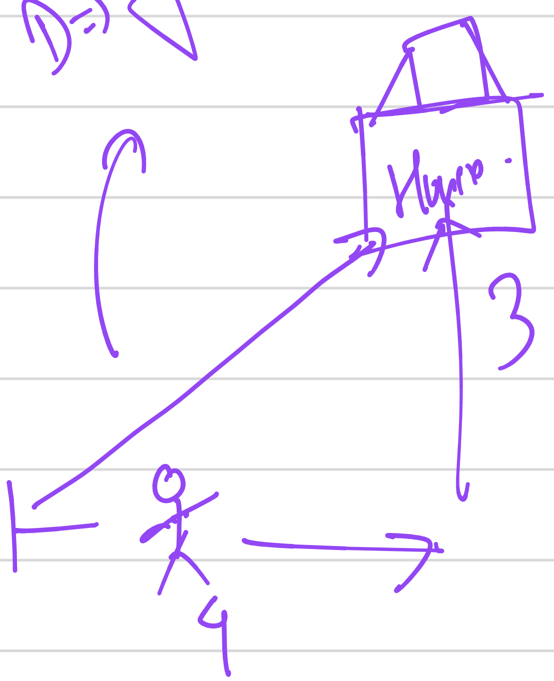
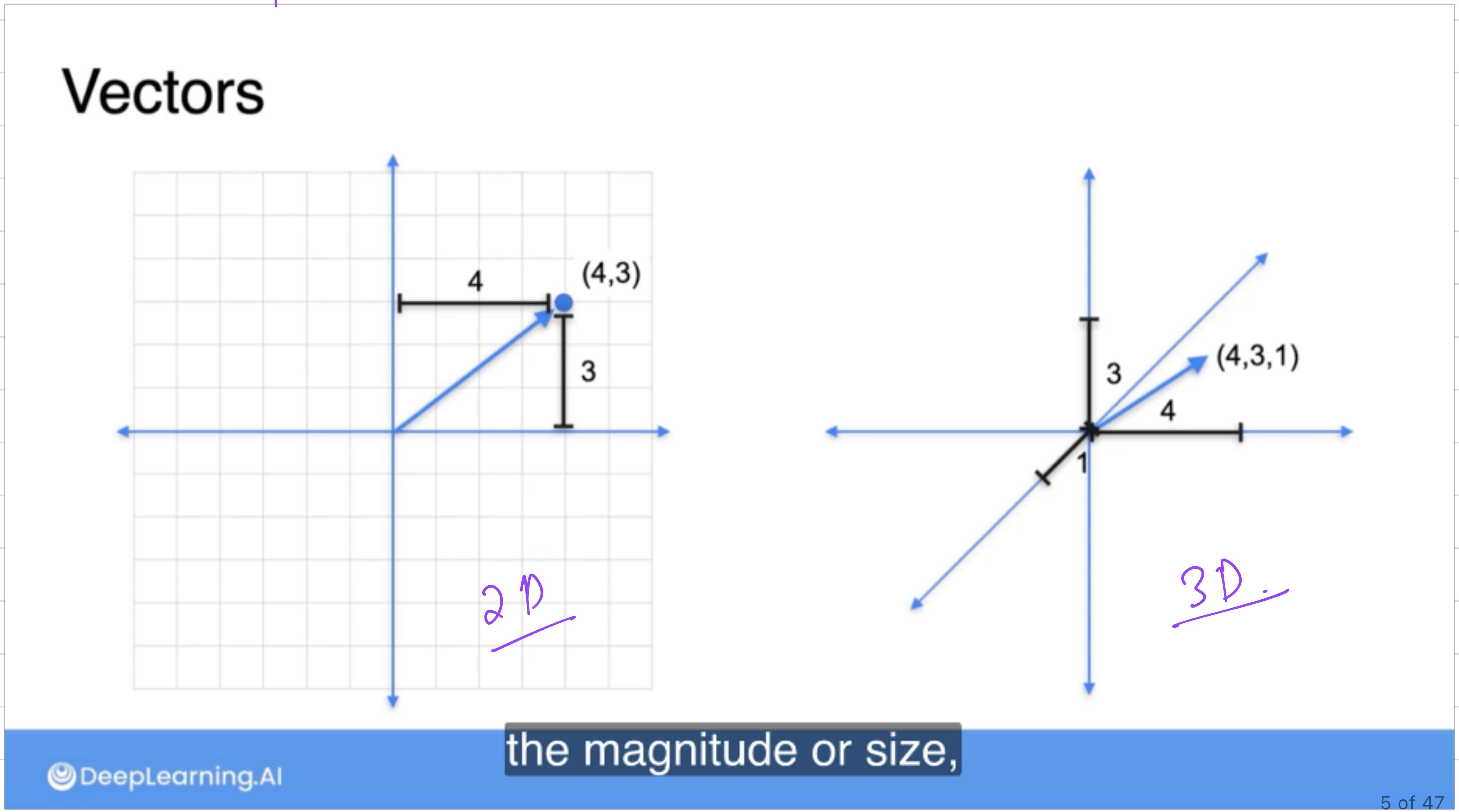
Vectors & their Properties:

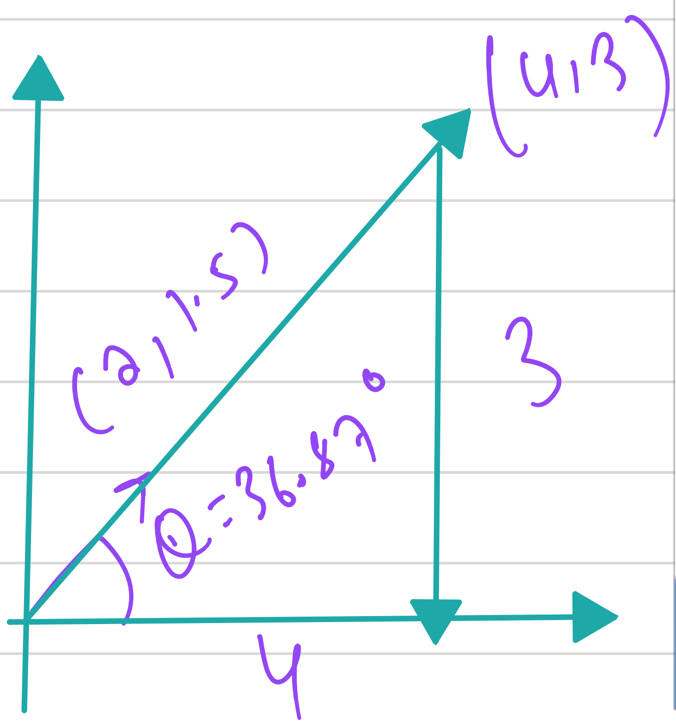
→ Vectors can be seen as arrows in the plane, or in a higher dimensional space.

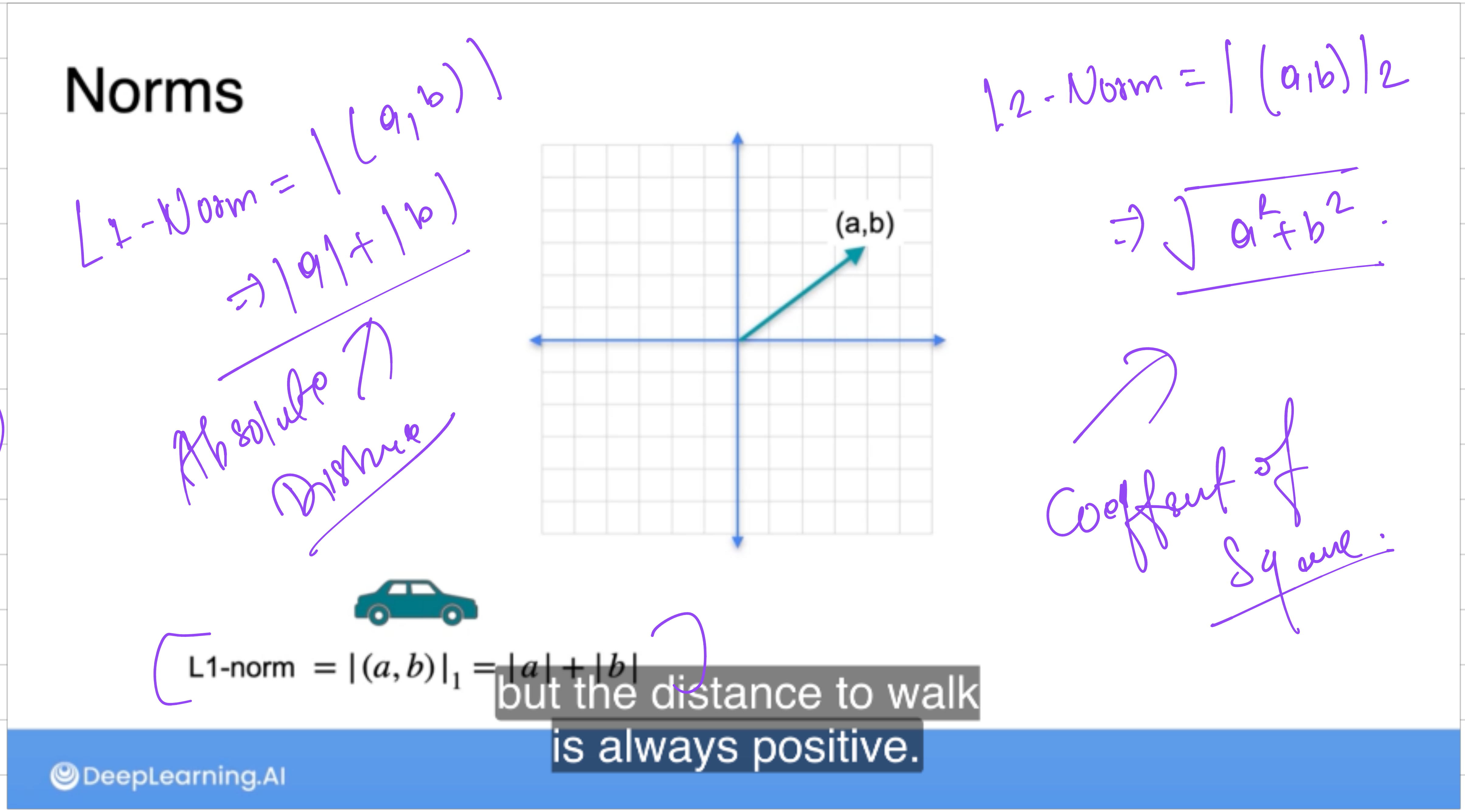
$D \Rightarrow \sqrt{3^2+4^2} \Rightarrow 5$





Where to use L2 or L1 ?





L1-Norm = |(a,b)|

$\Rightarrow |a| + |b|$

Absolute Distance

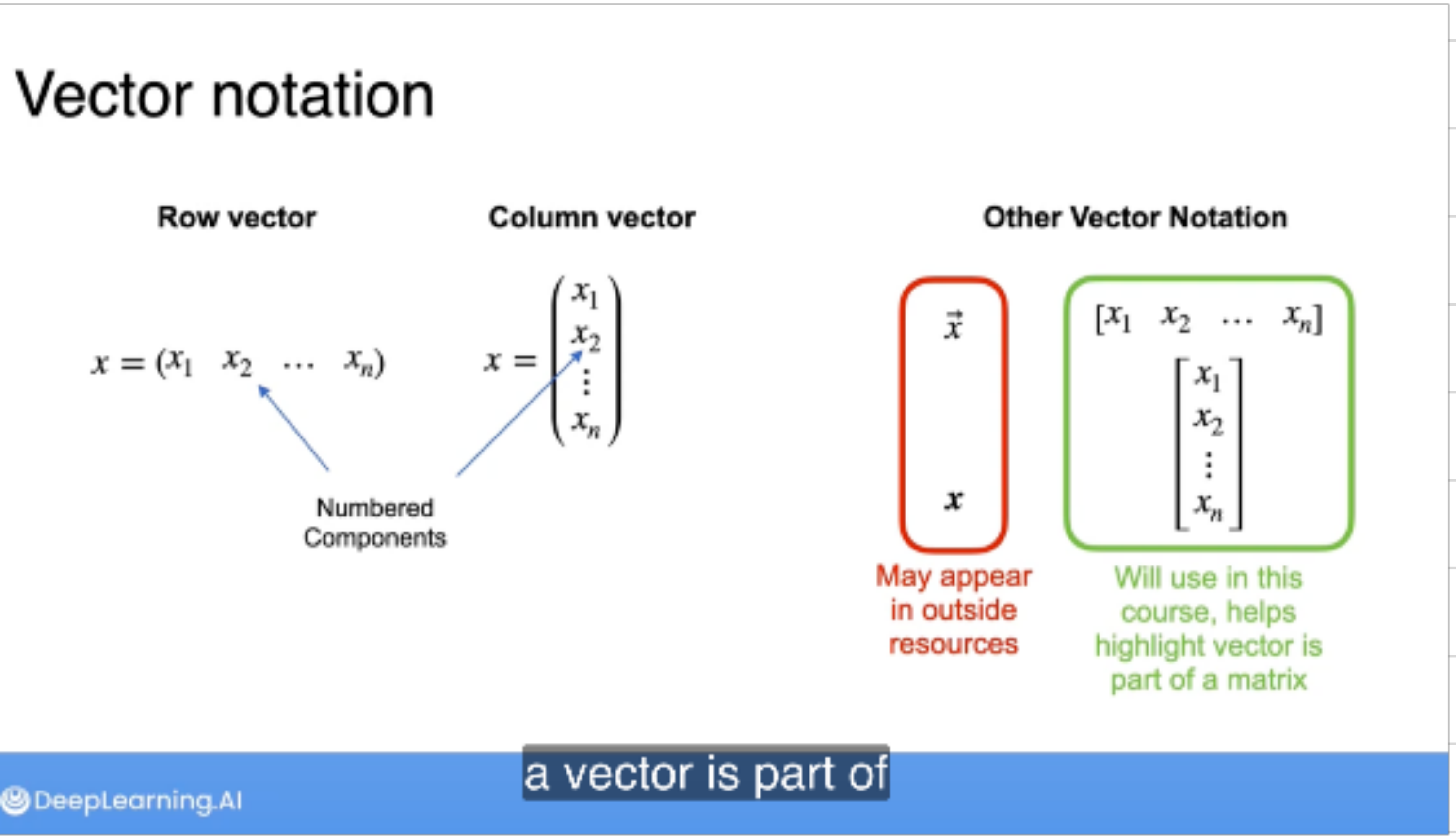
L2-Norm = $|(a,b)|_2$

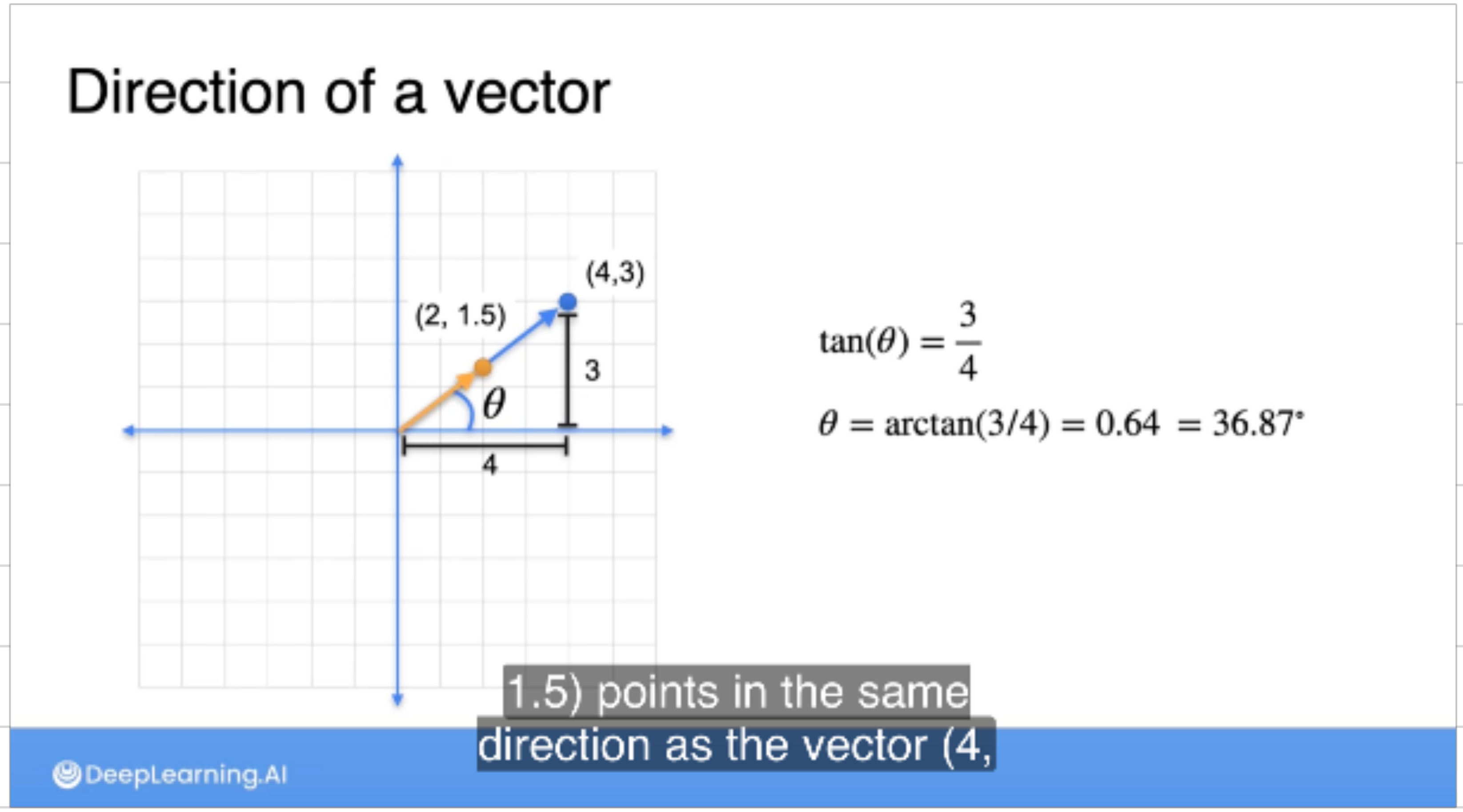
$\Rightarrow \sqrt{a^2+b^2}$.

Coefficient of Square.

1) Co-ordinates can help to deduce the Vector direction too [$\tan(\theta) = 3/4$]

2) Smaller or Larger depends upon the Vector Norms.





$$x = (x_1 \; x_2 \; \cdots \; x_n)$$

$$\|x\|_1 = |x_1| + |x_2| + \cdots + |x_n|$$

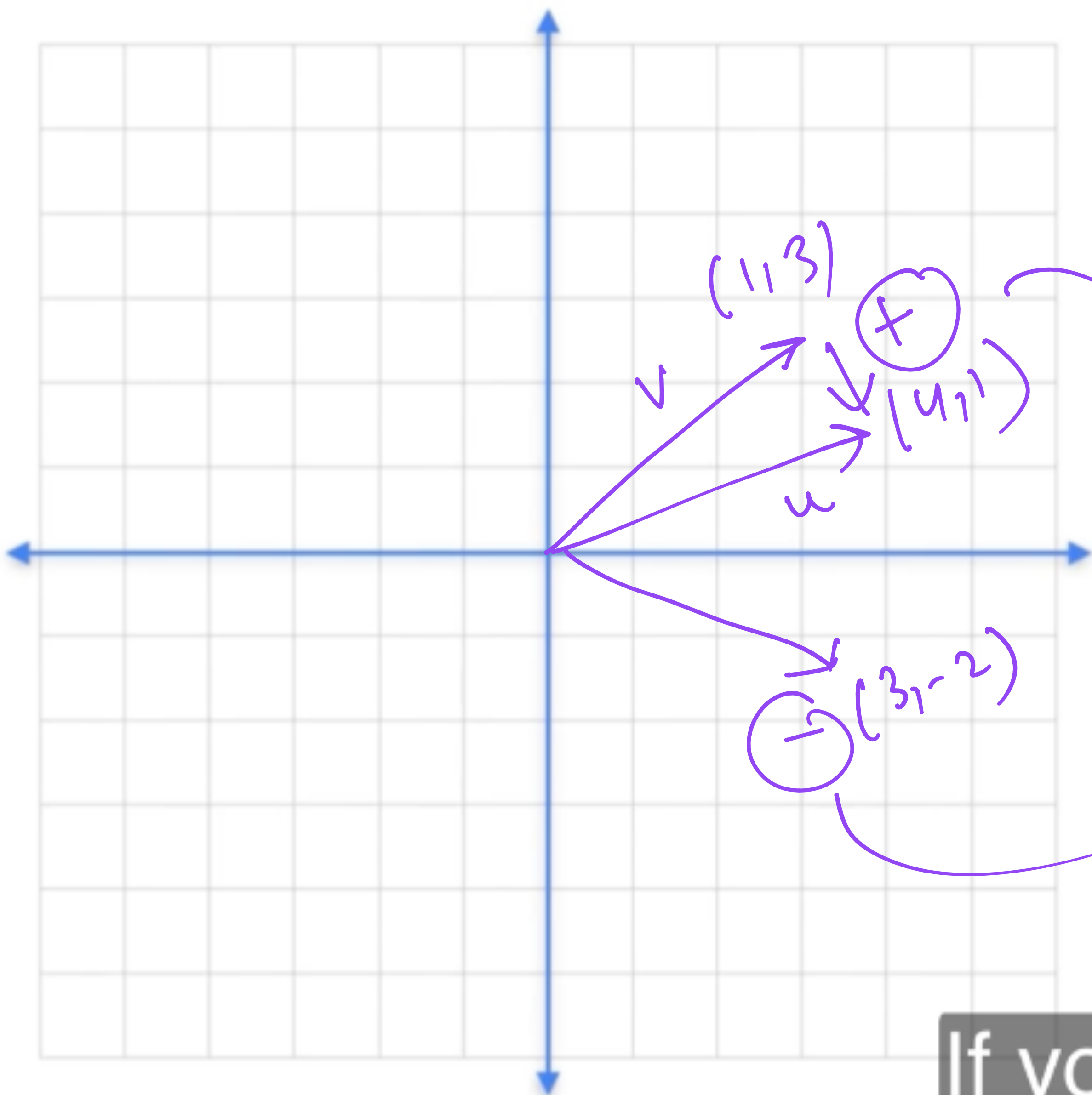
L1 Norm.

L2 norm.

Common Practice to use.

$$\|x\|_2 = \sqrt{x_1^2 + x_2^2 + \cdots + x_n^2}$$

Sum of vectors



Sum and Difference

element-wise operation ⊙.

$$(u+v) = (4+1, 1+3) = (5,4).$$

$$(u-v) = (4-1, 1-3) = (3,-2)$$

If you'd like to add two vectors,

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General definition: sum and difference

Same no. of components

$$x = (x_1 \quad x_2 \quad \cdots \quad x_n) \qquad y = (y_1 \quad y_2 \quad \cdots \quad y_n)$$

Sum

$$x + y = (x_1 + y_1 \quad x_2 + y_2 \quad \cdots \quad x_n + y_n)$$

Sum component by component

$$x - y = (x_1 - y_1,\ x_2 - y_2 \ \cdots\ x_n - y_n)$$

Subtract component by component

Note: Same number of components.

the sum component by component.

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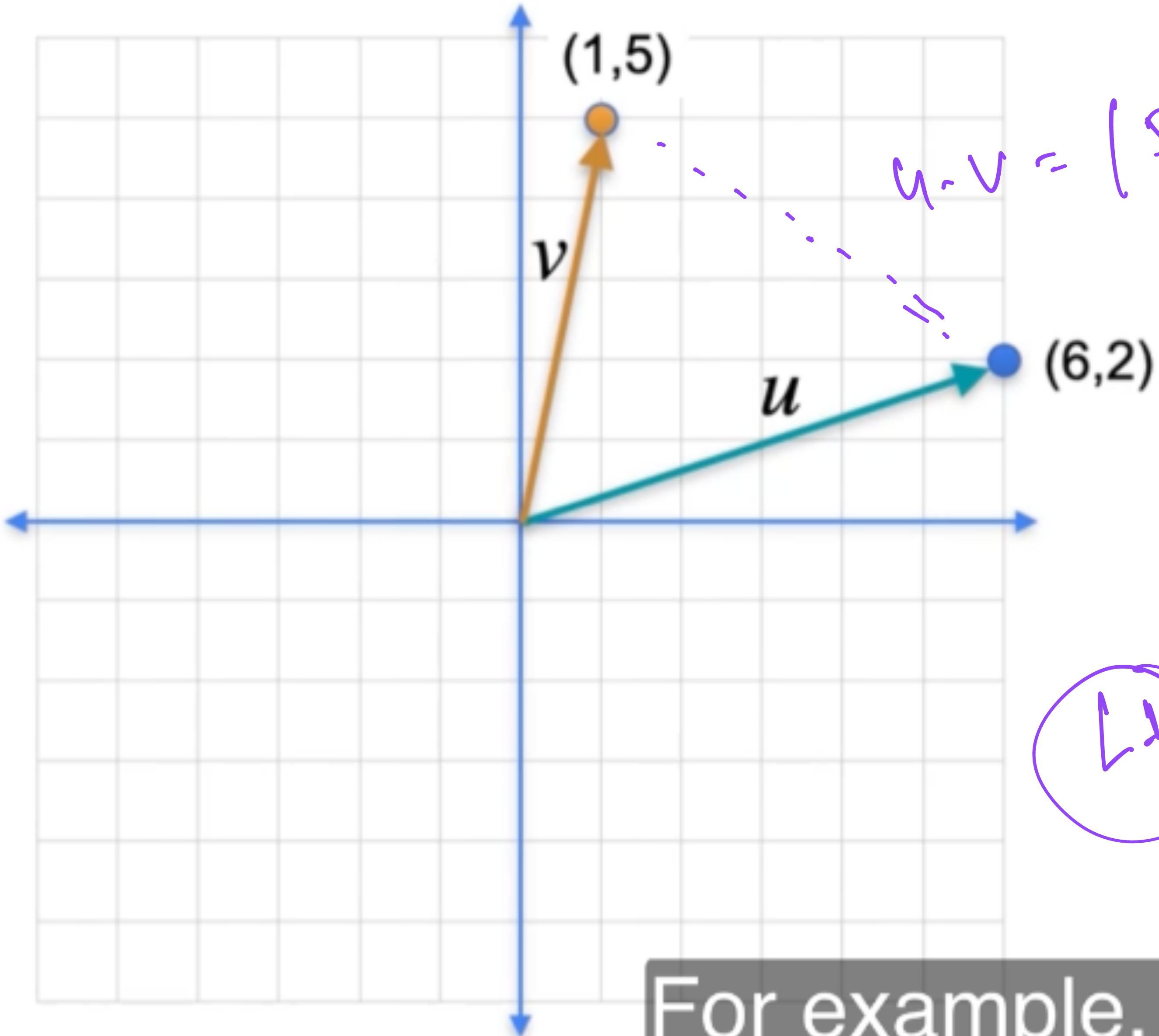
Distances

(How far apart 2 vectors are?) use L1 Distance.



$u - v = (5, -3)$

L1 $\Rightarrow (u-v)$

$\Rightarrow (5, -3)$

L2 use L2

$|u-v|_2 \Rightarrow \sqrt{5^2 + 3^2}$

$\Rightarrow 5.83$

L1

$|u-v|_1 \Rightarrow |5| + |-3|$

$\Rightarrow 8$

For example, how different is the vector 1,

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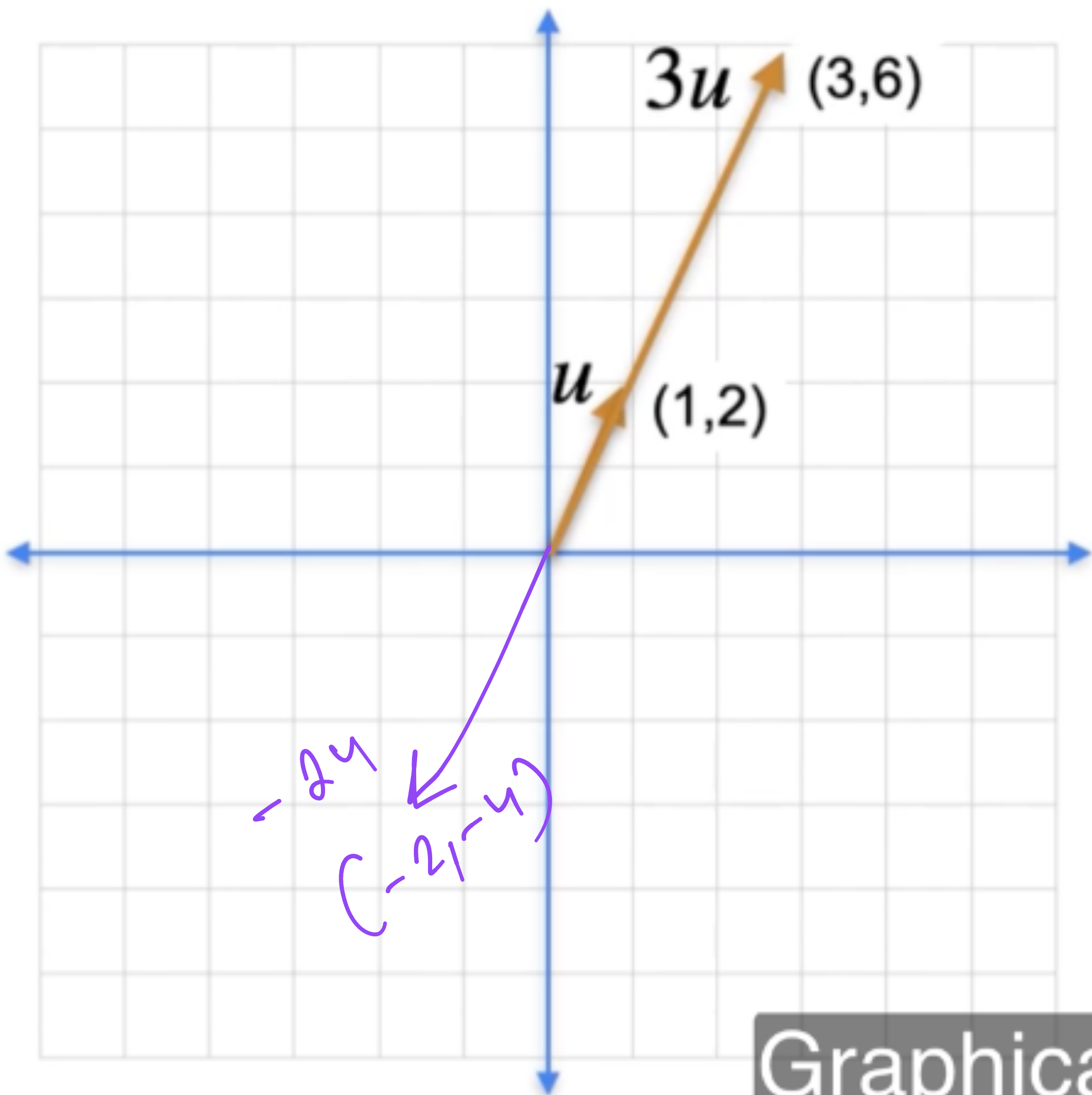
Multiplying a vector by a scalar (+ve).



$$u = (1,2)$$
$$\lambda = 3$$
$$\lambda u = (3,6)$$

$x = (x_1, x_2 \ldots x_n)$

$\lambda x = (\lambda x_1, \lambda x_2 \ldots \lambda x_n)$

Multiplication by a scalar

$u = (1,2)$ $-ve$?

$\lambda = -2$

$\lambda(u) = (-2,-4)$

Graphically means you
stretch the vector 1,

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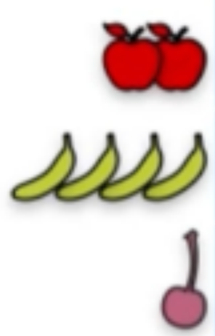
Dot Product → Express linear equation using Matrices and Vectors

A shortcut for linear operations

Quantities	Prices	Total price
2 apples	apples: $3	
4 bananas	bananas: $5	
1 cherry	cherries: $2	



$$\begin{bmatrix} 2 \\ 4 \\ 1 \end{bmatrix} \rightarrow \$ \begin{bmatrix} 3 \\ 5 \\ 2 \end{bmatrix} \rightarrow \begin{matrix} 2 \times 3 = 6 \\ 4 \times 5 = 20 \\ 1 \times 2 = 2 \end{matrix}$$

$6 + 20 + 2 = 28$

$[2 \cdot 3 + 4 \cdot 5 + 1 \cdot 2 = \$28]$

2, 4, and 1.

The dot product

$$\begin{bmatrix} 2 & 4 & 1 \end{bmatrix} \cdot \begin{bmatrix} 3 \\ 5 \\ 2 \end{bmatrix} = 28$$

$$2 \cdot 3 + 4 \cdot 5 + 1 \cdot 2 = 28$$

Connection between Dot product and Norm?

$$\begin{bmatrix} 3 & 4 \end{bmatrix} \begin{bmatrix} 3 \\ 4 \end{bmatrix} \Rightarrow$$

$$3 \cdot 3 + 4 \cdot 4 \Rightarrow 25$$

and then forget about the fruits and get the dot product.

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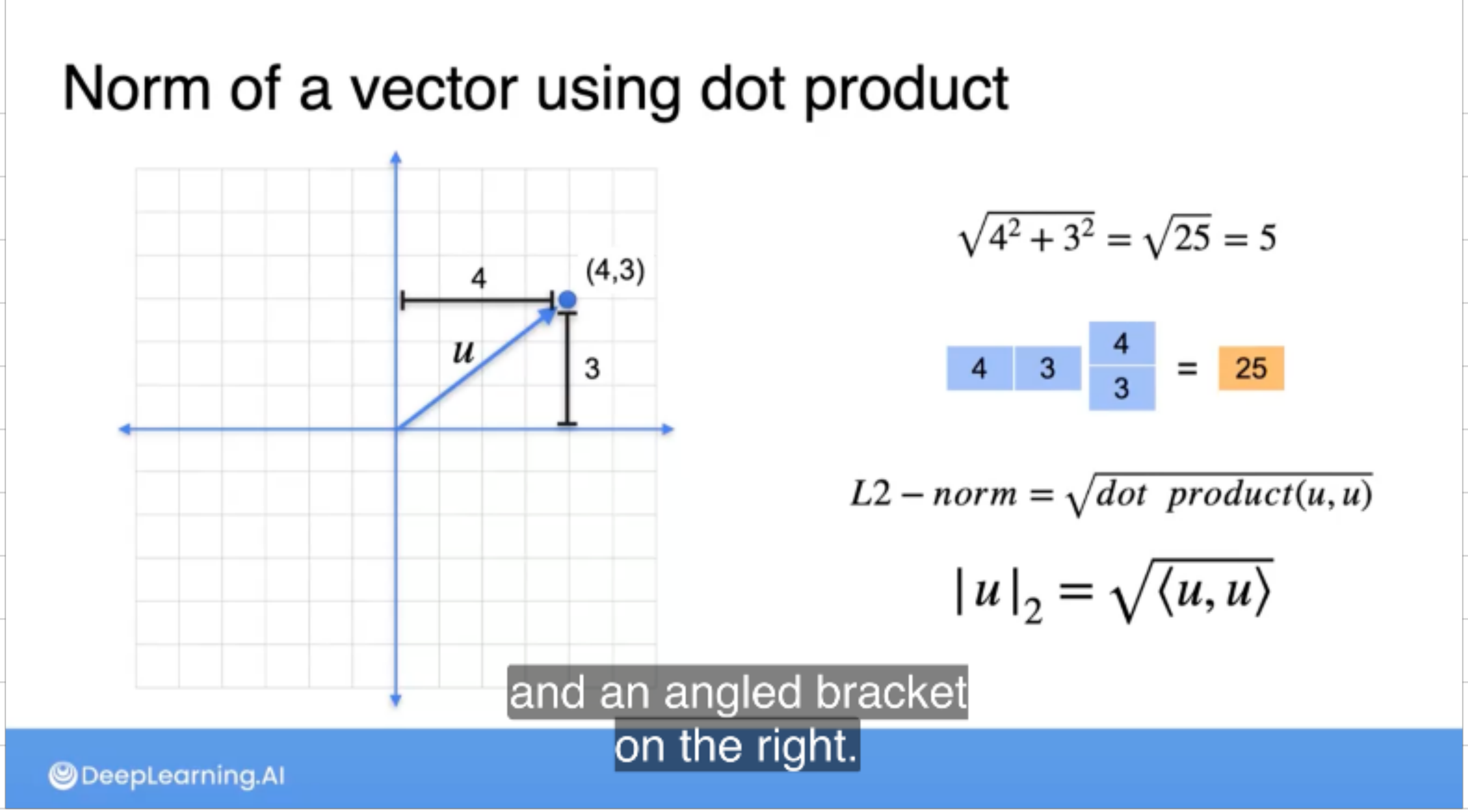
Vector Transpose.

$$\begin{bmatrix}2\\4\\1\end{bmatrix} \begin{bmatrix}3\\5\\2\end{bmatrix} \Rightarrow 28$$

$$(2.3 + 4.5 + 1.2) \Rightarrow 28$$

Transpose T

$$\begin{bmatrix}2 & 4 & 1\end{bmatrix} \begin{bmatrix}3\\5\\2\end{bmatrix} \Rightarrow 28$$



Convert columns to Rows.

$$\begin{bmatrix}5\\6\\7\end{bmatrix}^T \Rightarrow \begin{bmatrix}5 & 6 & 7\end{bmatrix}$$

$$\begin{bmatrix}2 & 6\\3 & 8\\5 & 9\end{bmatrix}^T \Rightarrow \begin{bmatrix}2 & 3 & 5\\6 & 8 & 9\end{bmatrix}$$

Columns $\rightarrow$ Rows OR Rows $\rightarrow$ Column.

General definition: dot product

Same number of components

$x = (x_1 \quad x_2 \quad \dots \quad x_n)$ $\qquad$ $y = (y_1 \quad y_2 \quad \dots \quad y_n)$

$$x \cdot y = (x_1 \times y_1) + (x_2 \times y_2) + \dots + (x_n \times y_n)$$

$\langle x, y \rangle$ is another notation for the dot product

$x \cdot y^T = (x_1 \; x_2 \; \dots \; x_n) \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}$ → Column Vector in the Right.

Row Vector in the Left

another notation for the dot product.

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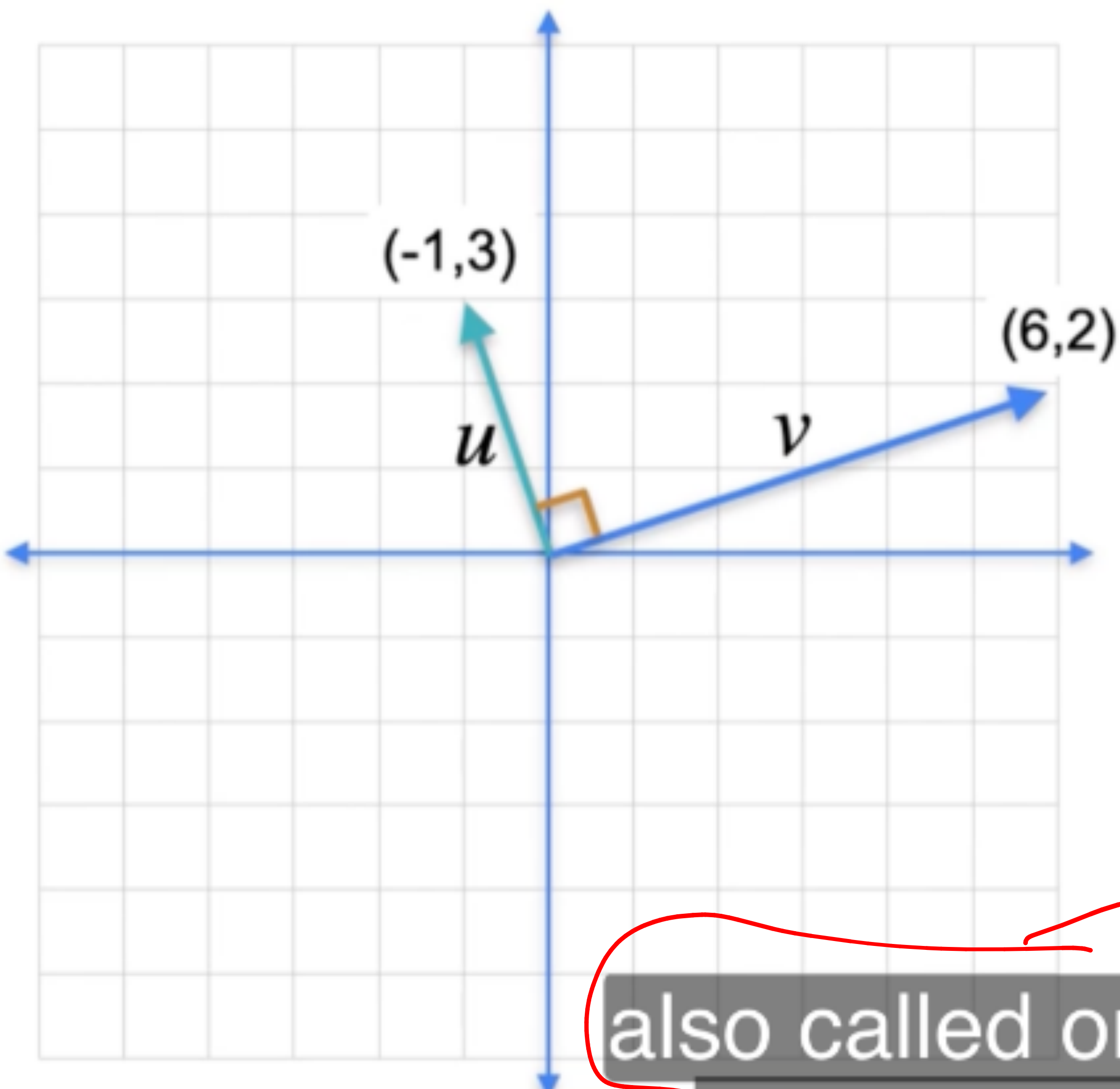
Geometric Dot Product | Angle between two vector is very Import |

Orthogonal vectors have dot product 0



$u \rightarrow$ unidirection

$\langle u, v \rangle = |u|^2$

$$\begin{bmatrix} 6 & 2 \end{bmatrix} \begin{bmatrix} -1 \\ 3 \end{bmatrix} \Rightarrow \begin{bmatrix} 0 \end{bmatrix}$$

$\langle u, v \rangle = 0$

the dot product between two $\perp$ or orthogonal vectors is always '0'.

also called orthogonal vectors,
with entries -1, 3 and 6, 2.

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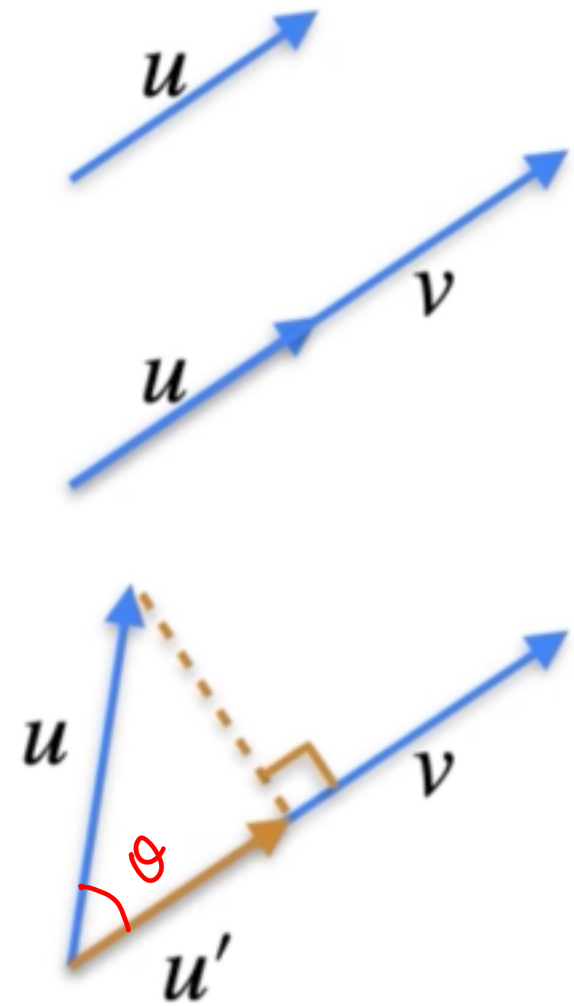
The dot product



$$\langle u, u\rangle = |u|^2 = |u| \cdot |u|$$

$$\langle u, v\rangle = |u| \cdot |v|$$

$$\langle u, v\rangle = |u'| \cdot |v|$$

$$\Rightarrow |u| \cdot |v| \cdot \cos\theta$$

v is the product of the magnitude
of u prime and the magnitude of v.

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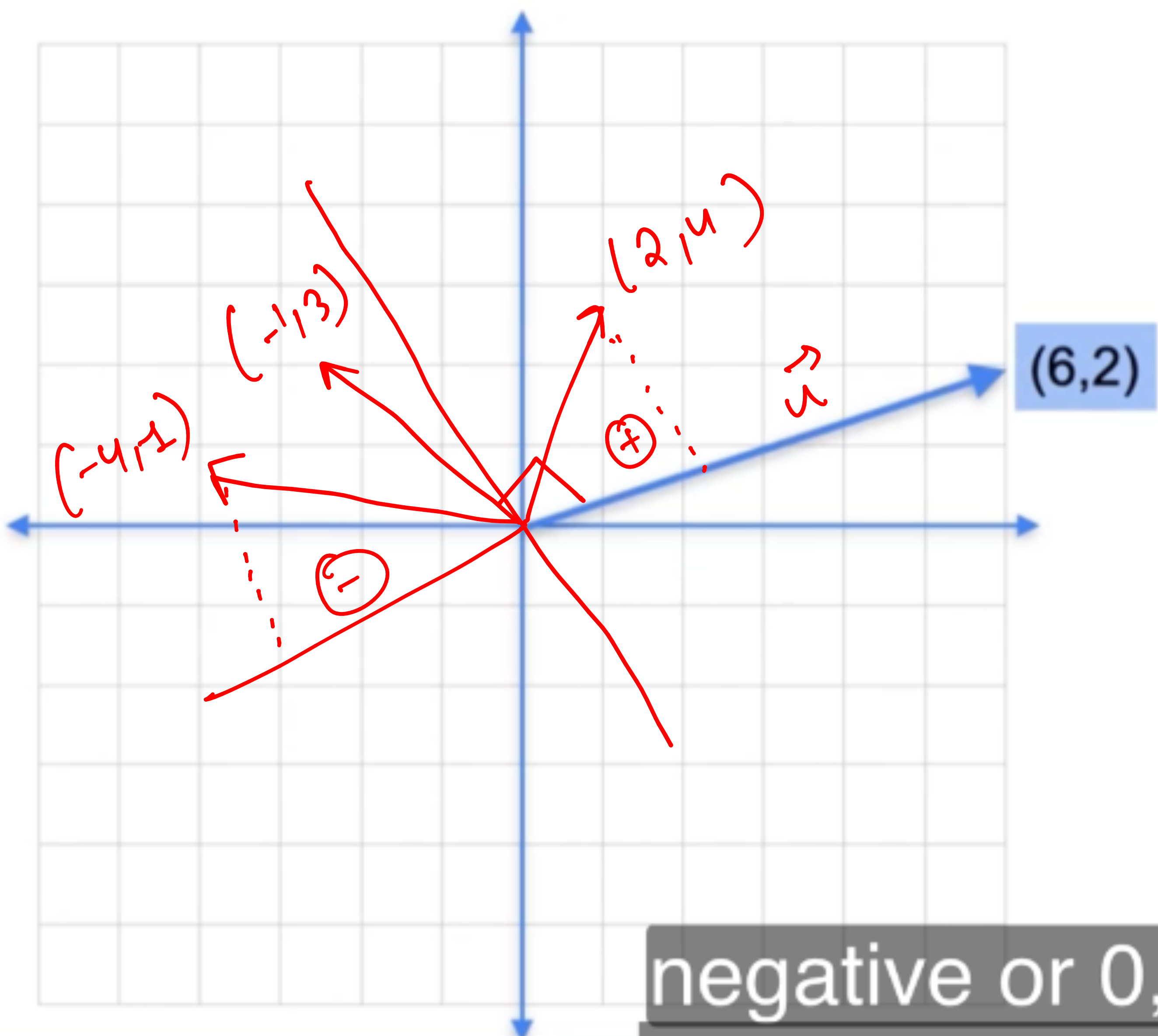
Geometric dot product



$$\begin{bmatrix} 6 & 2 \end{bmatrix} \begin{bmatrix} -4 \\ 1 \end{bmatrix} \Rightarrow -22 \quad (-ve)$$

$$\begin{bmatrix} 6, & 2 \end{bmatrix} \begin{bmatrix} -4 \\ 3 \end{bmatrix} \Rightarrow [0]$$

$$\begin{bmatrix} 6, & 2 \end{bmatrix} \begin{bmatrix} 2 \\ 4 \end{bmatrix} \Rightarrow 20 \quad (+ve)$$

negative or 0, for example,
take a look at a vector 6, 2.

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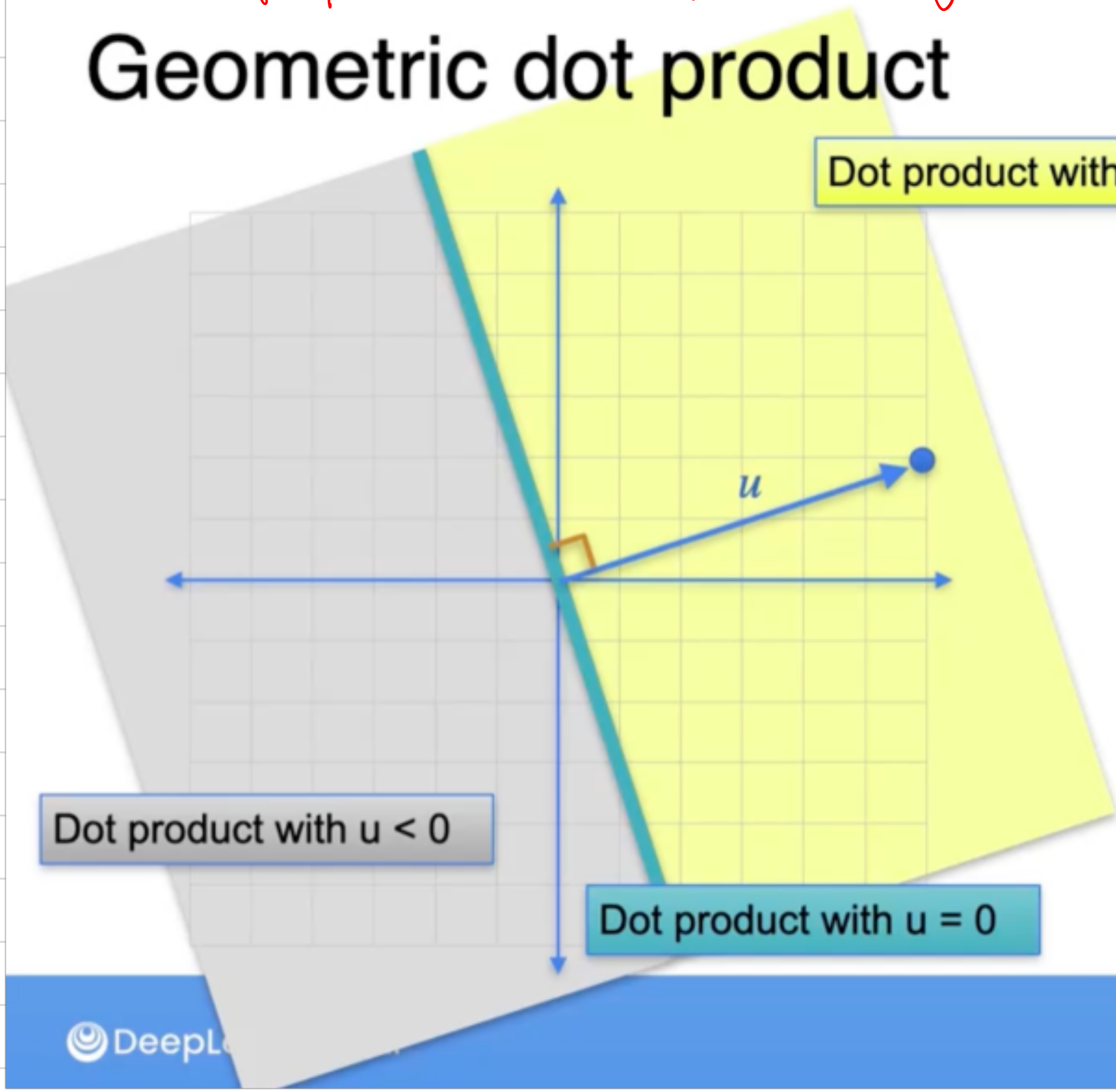
Glimpse of Classification for ML ??

Geometric dot product



1. $\langle u, v \rangle > 0$
2. $\langle u, v \rangle = 0$
3. $\langle u, v \rangle < 0$

Multiplying a Matrix by a Vector

$a+b+c=10$ | $a+2b+c=15$ | $a+b+2c=12$

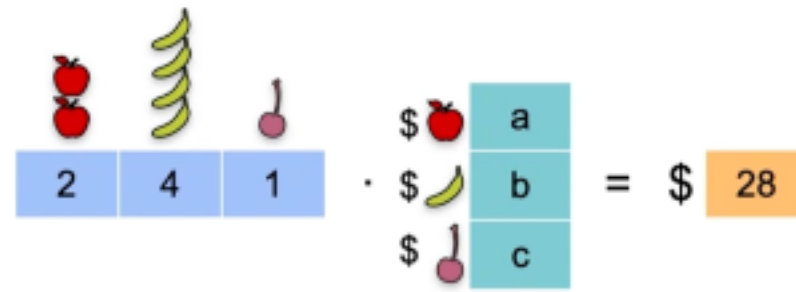
$\begin{bmatrix} 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = 10$

$\begin{bmatrix} 1 & 2 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = 15$

$\begin{bmatrix} 1 & 1 & 2 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = 12$

Equations as dot product

$2a + 4b + c = 28$



An equation with a known variable, such as, for example,

Equations as dot product

System of equations

$a + b + c = 10$

$a + 2b + c = 15$

$a + b + 2c = 12$

Matrix product

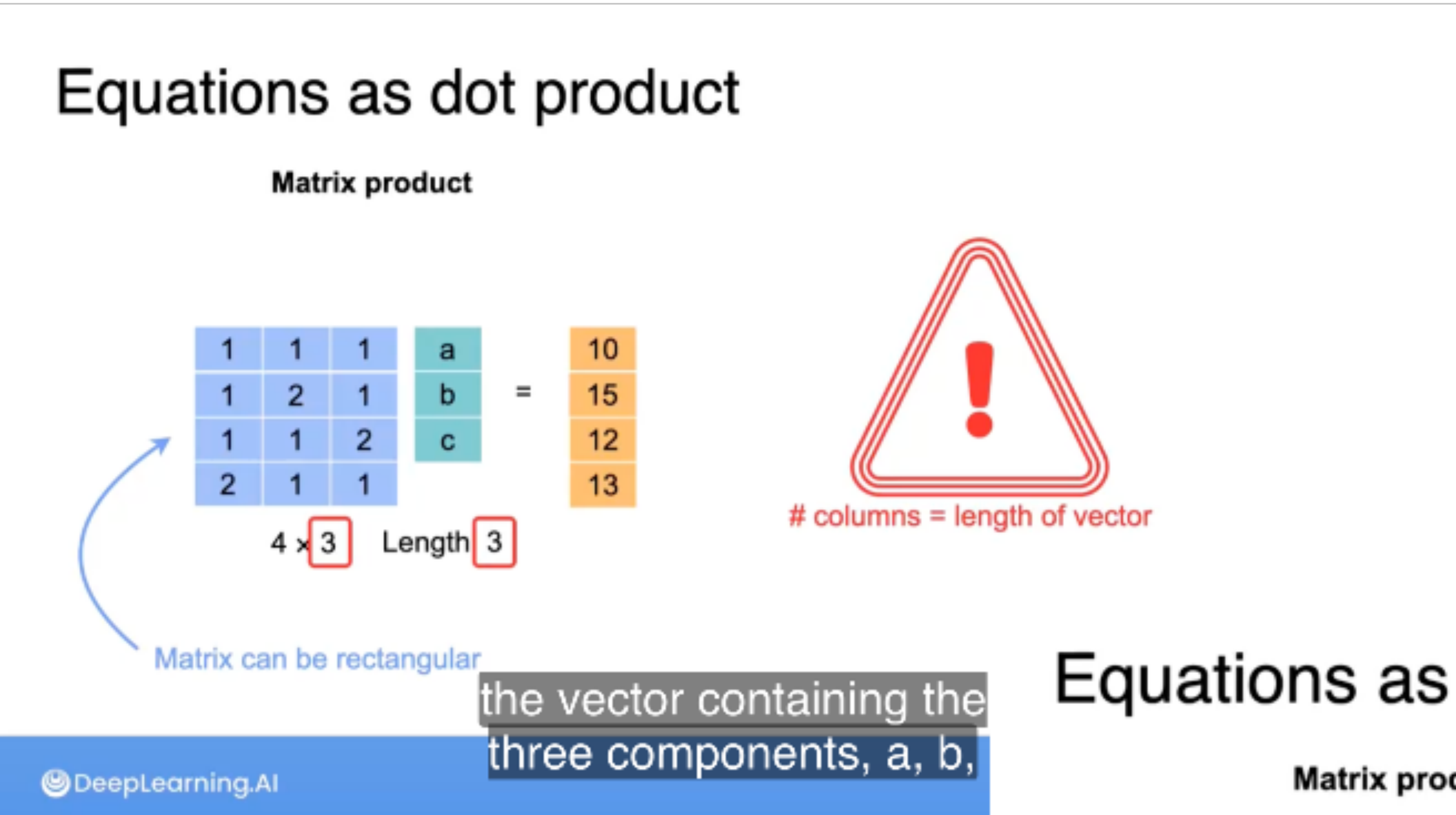
$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 10 \\ 15 \\ 12 \end{bmatrix}$$

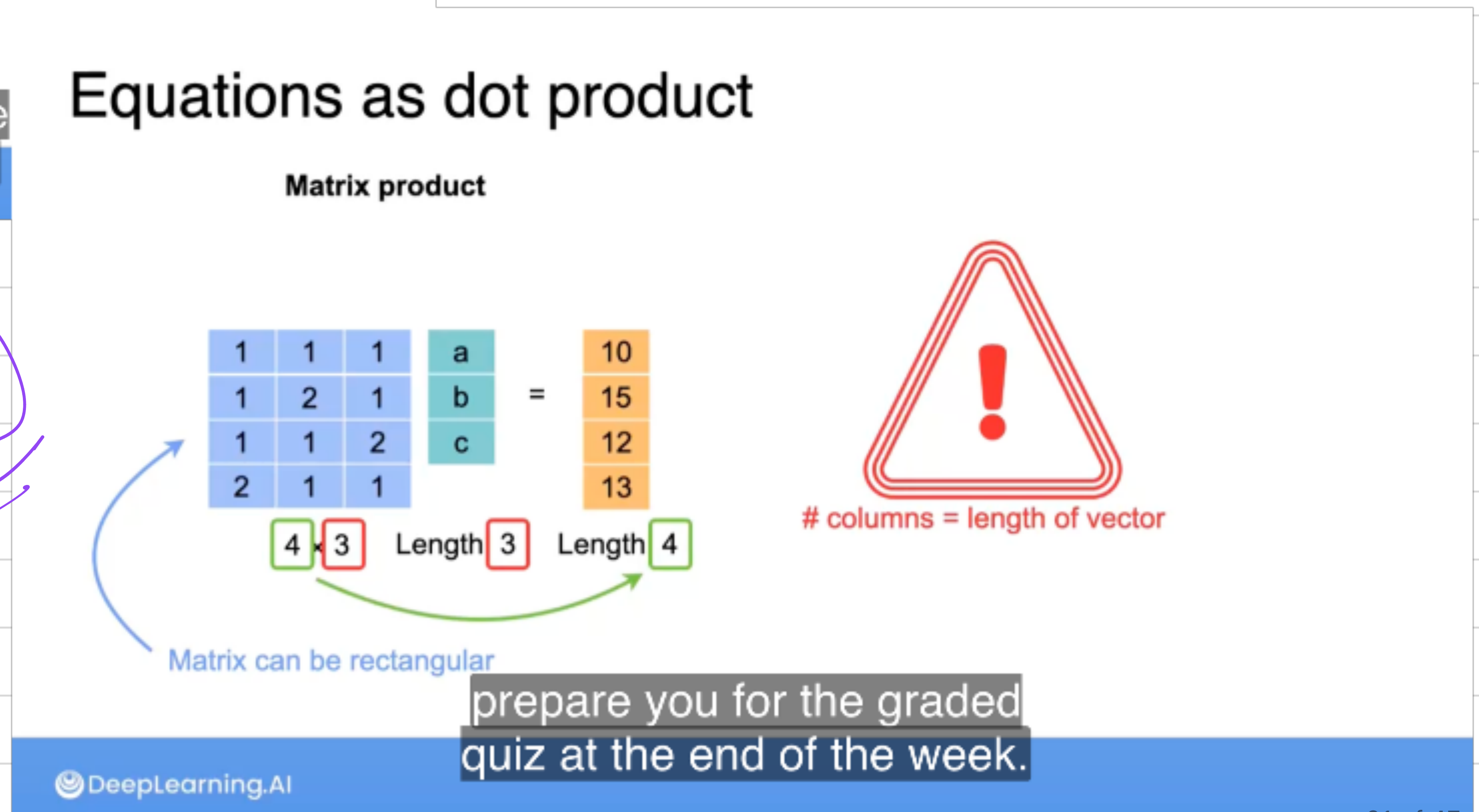
3x3 3

If you have more equations in your system,

columns = length of vector

can be unmatched





4x3 3x3 → 3x3

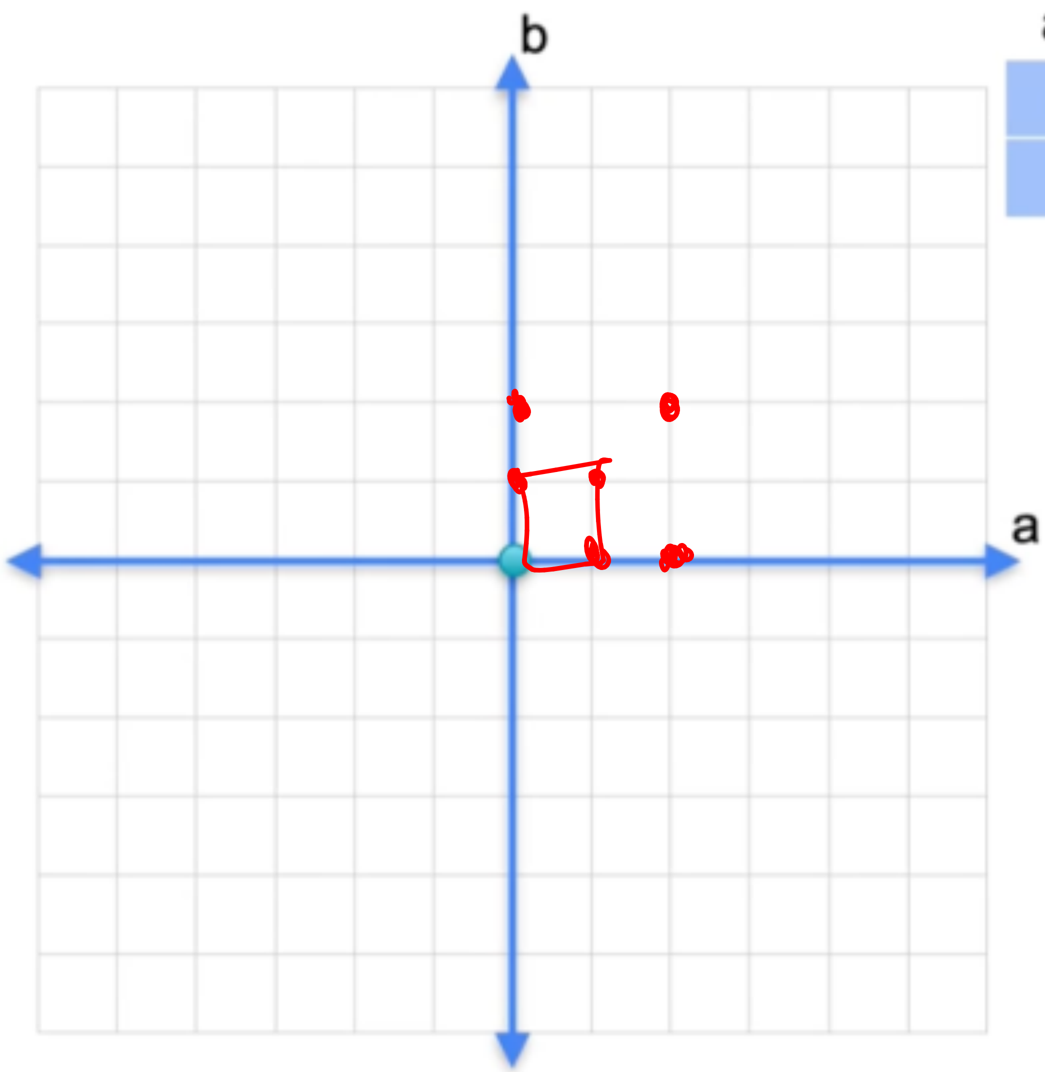
3

4x3 x3 x 1

4x1

Linear Transformations: transfor A $\longrightarrow$ B in a structured way.

Matrices as linear transformations



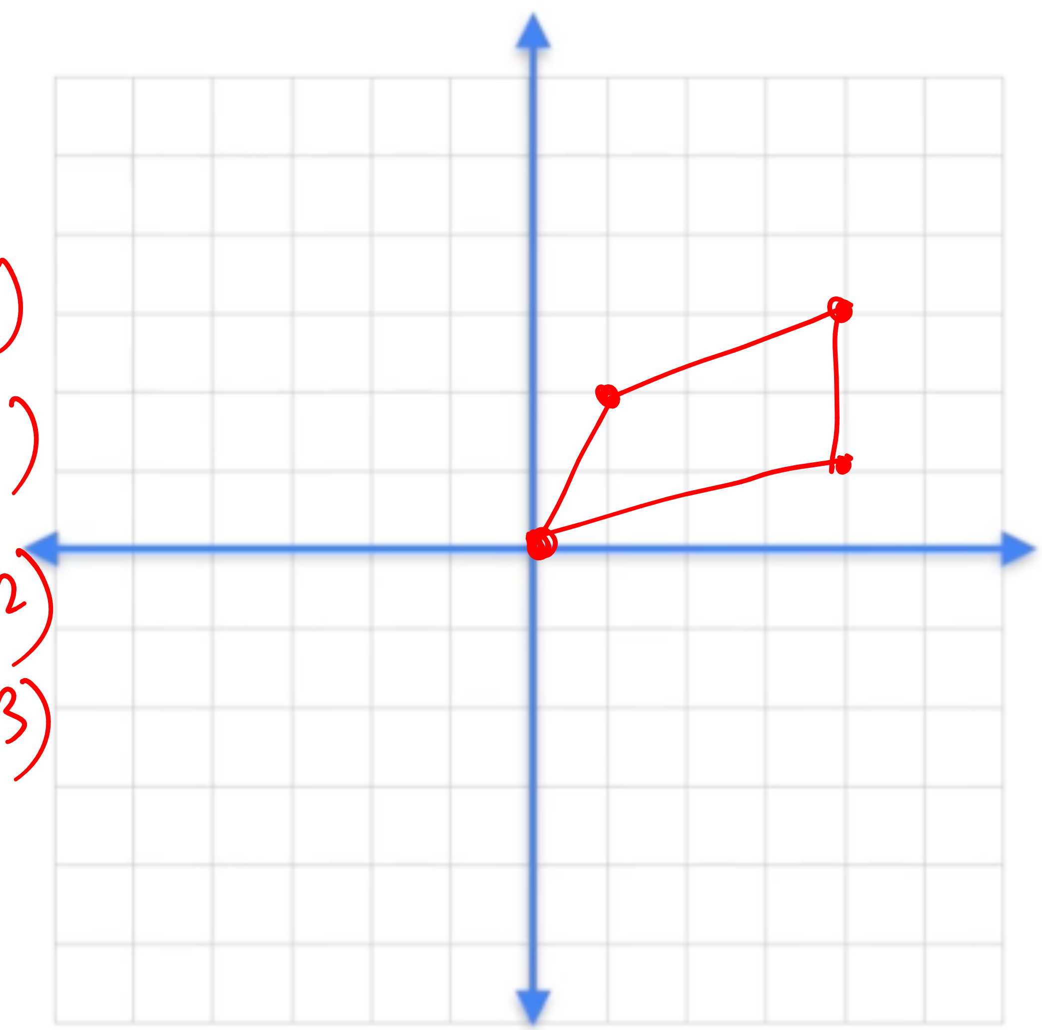
a	b	
3	1	0
1	2	0

$(0,0) \to (0,0)$

$(1,0) = (3,1)$

$(0,1) \Rightarrow (1,2)$

$(1,1) \to (4,3)$



The 0 0 that becomes the vector 0 0,

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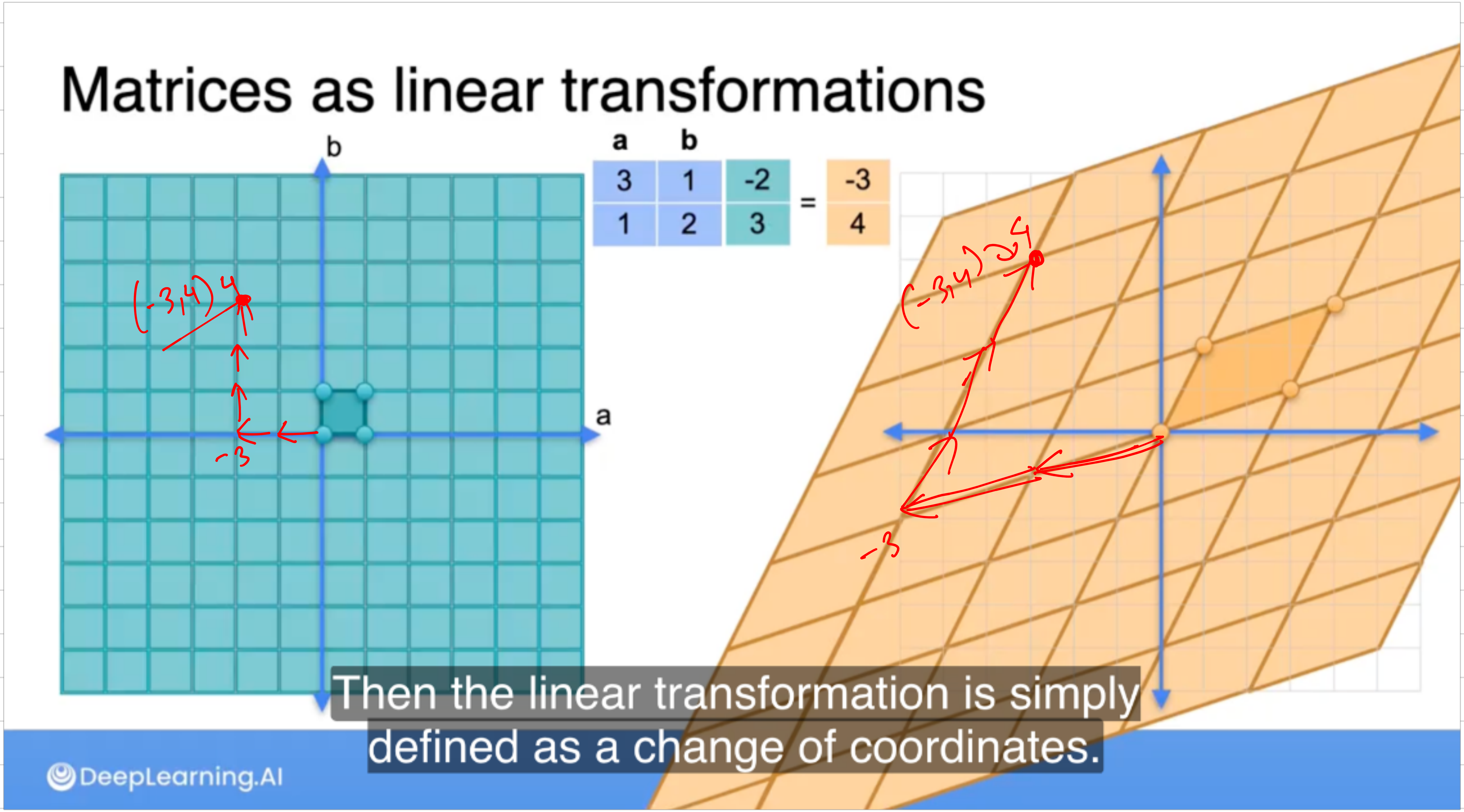
Matrices as linear transformations
a
b
3 1 -2 = -3
1 2 3 = 4
(-3,4)
-3
4
Then the linear transformation is simply
defined as a change of coordinates.
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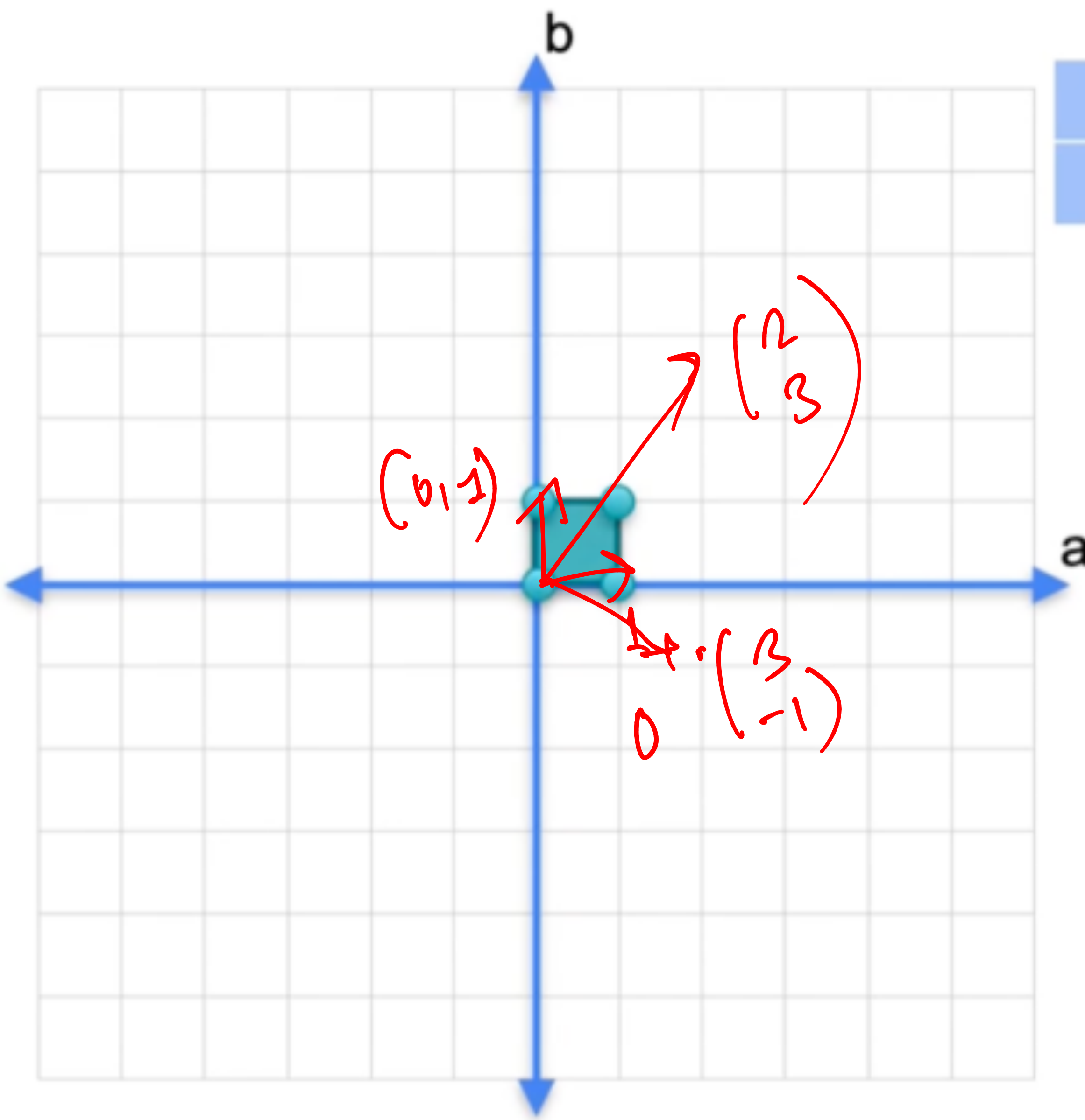
Linear Transformations as Matrices:

Linear transformations as matrices



a	b
?	?
?	?

a b

? ?

$\Rightarrow \begin{bmatrix}2\\3\end{bmatrix}$

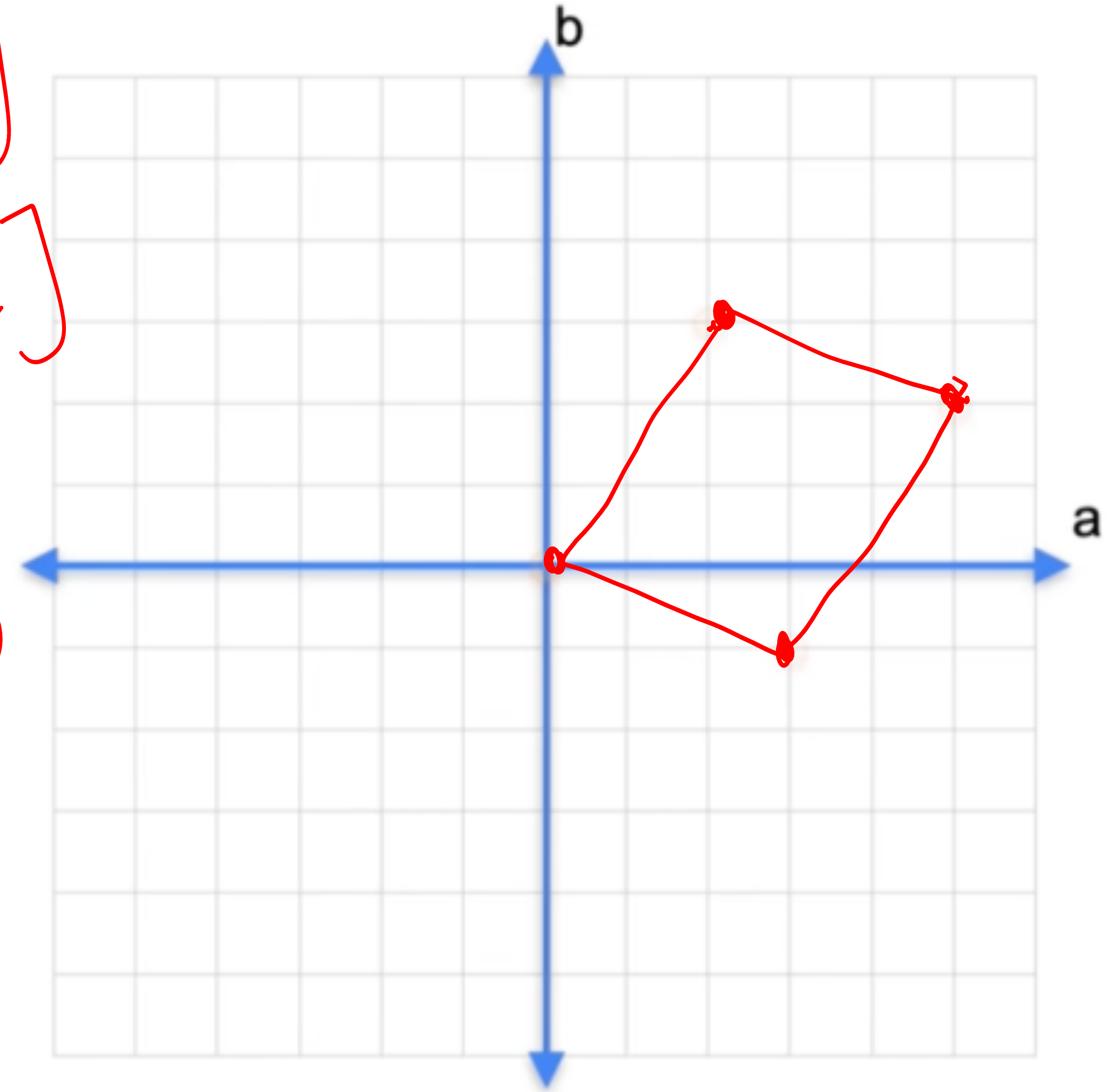
$\Rightarrow \begin{bmatrix}3\\-1\end{bmatrix}$

$(0,0) \to (0,0)$

$(1,0)$ $(3,-1)$

$(1,0) \to (3,-1)$

$(0,1) \to (2,3)$



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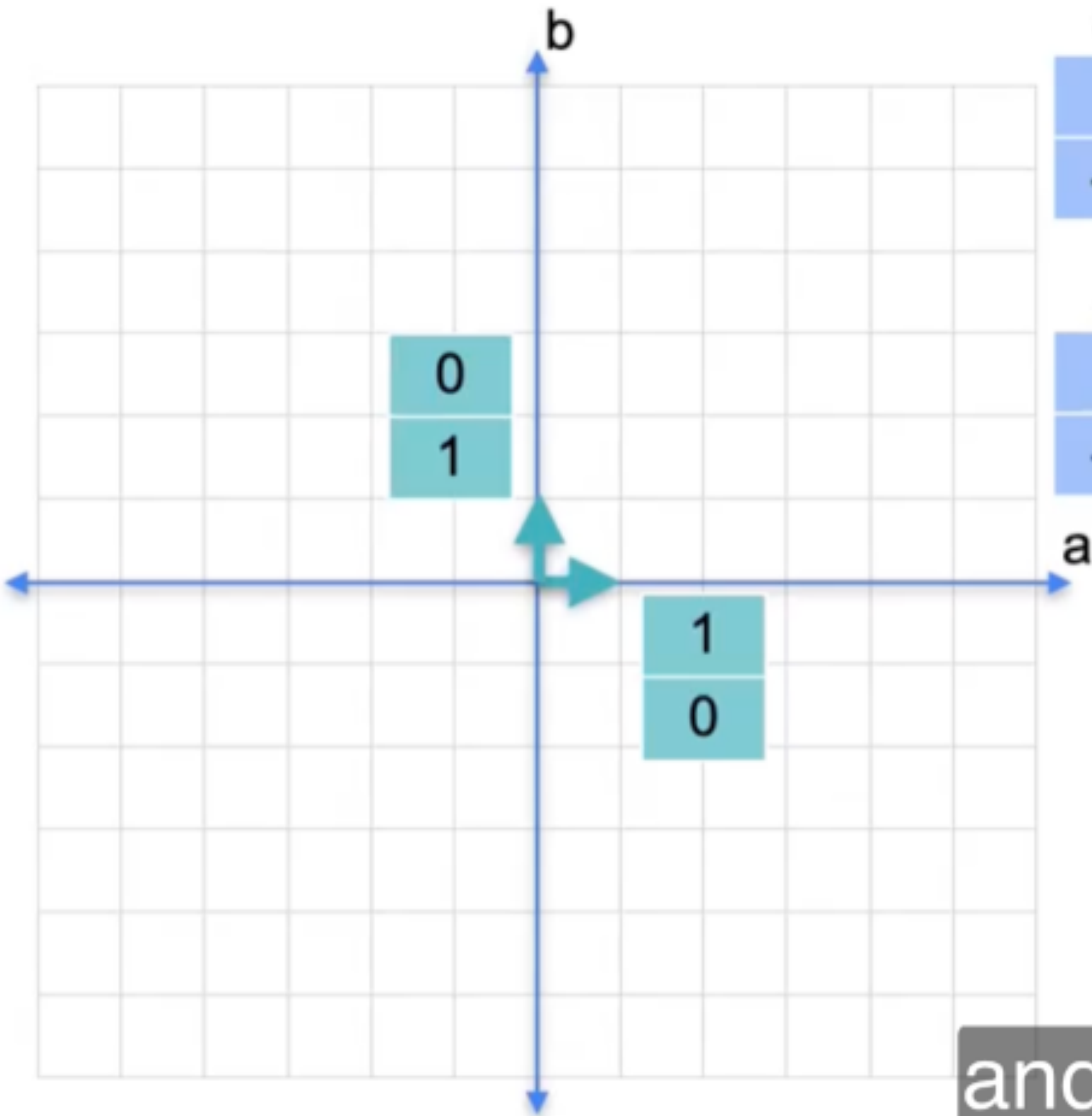
basis into this one over here,

Linear transformations as matrices

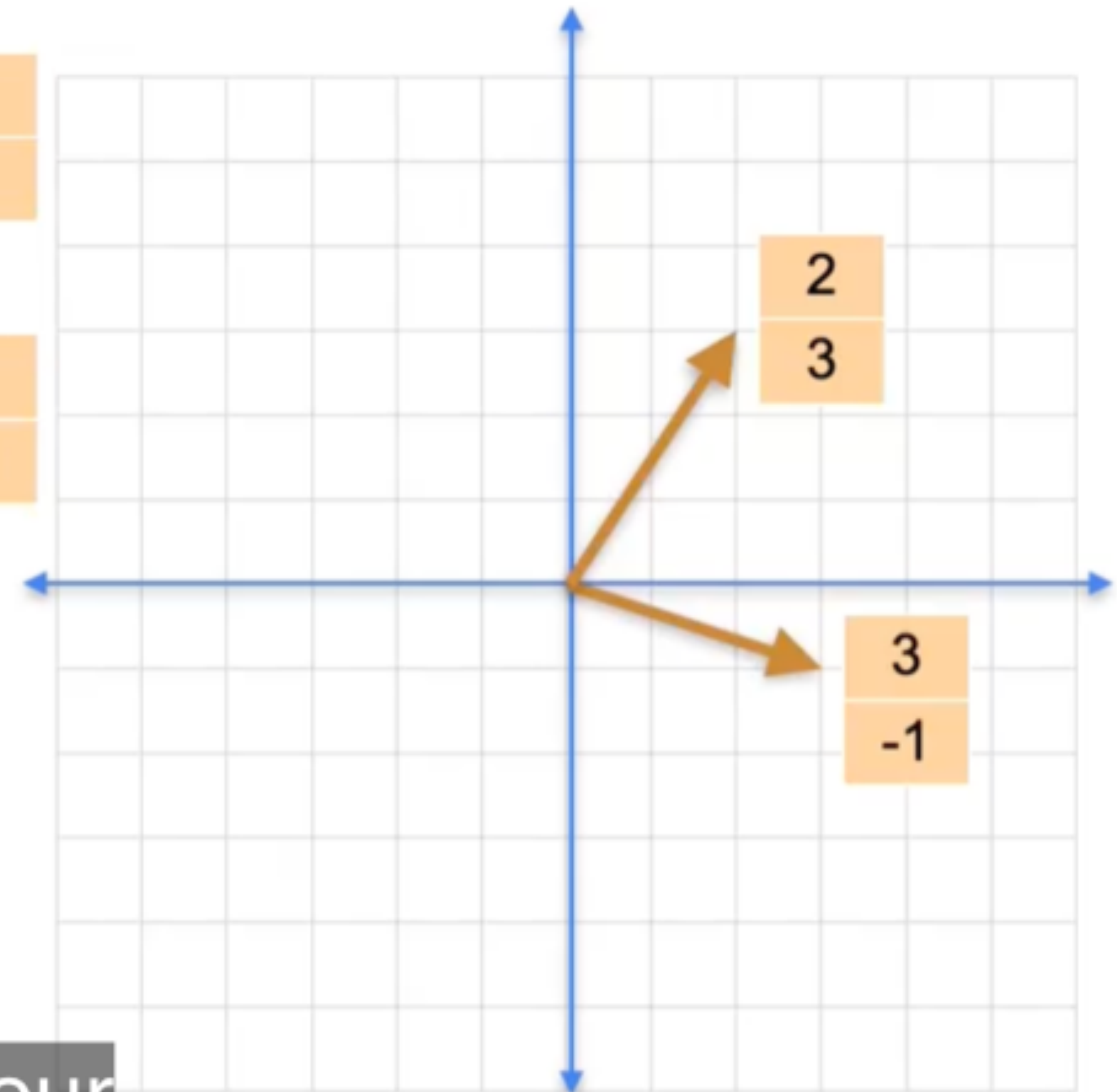


$$\begin{array}{cc} a & b \\ \end{array}$$
$$\begin{bmatrix} 3 & 2 \\ -1 & 3 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 2 \\ 3 \end{bmatrix}$$

$$\begin{array}{cc} a & b \\ \end{array}$$
$$\begin{bmatrix} 3 & 2 \\ -1 & 3 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 3 \\ -1 \end{bmatrix}$$

$(1,0) \rightarrow (3,-1)$

$(0,1) \rightarrow (2,3)$



and those are your
columns of the matrix.

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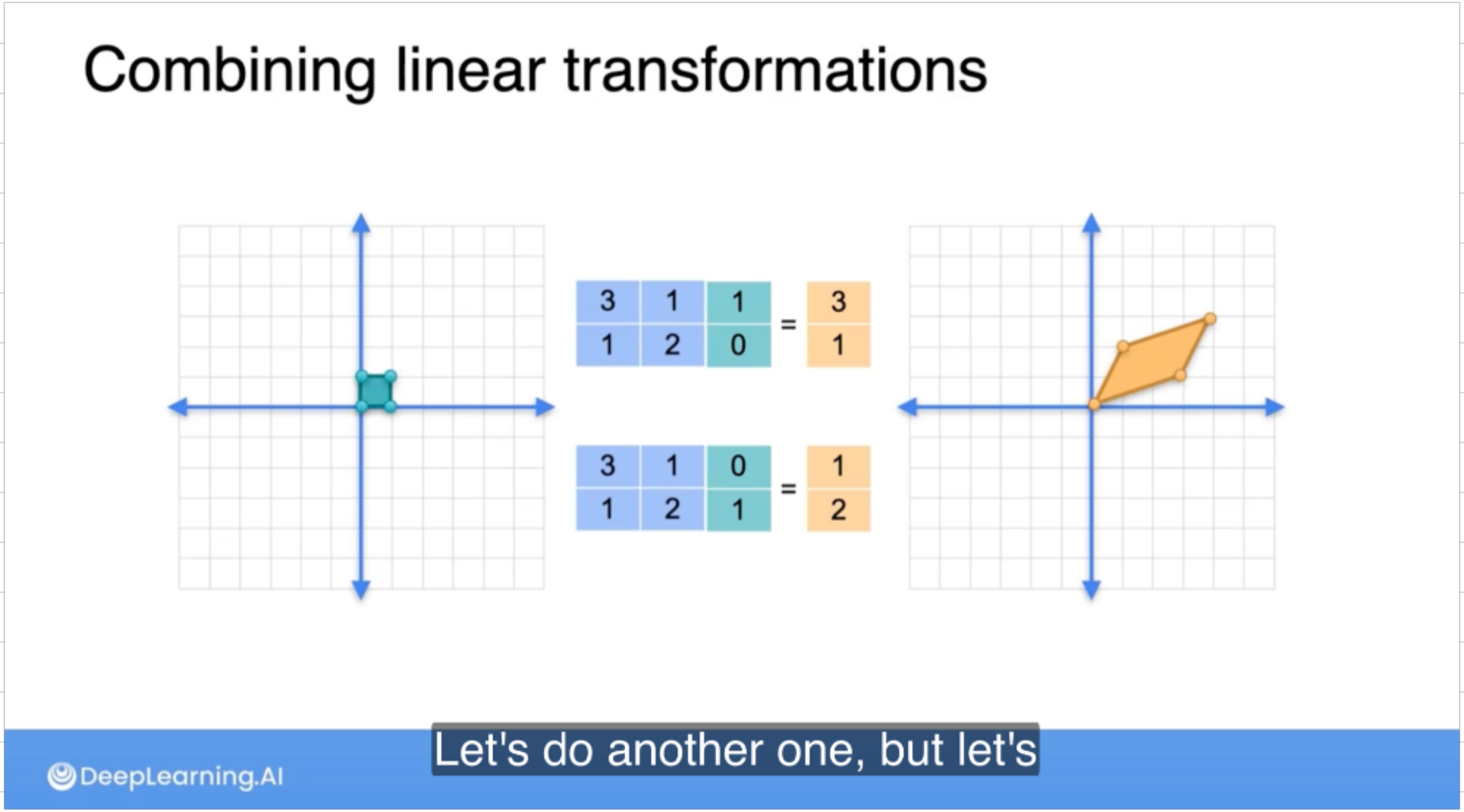
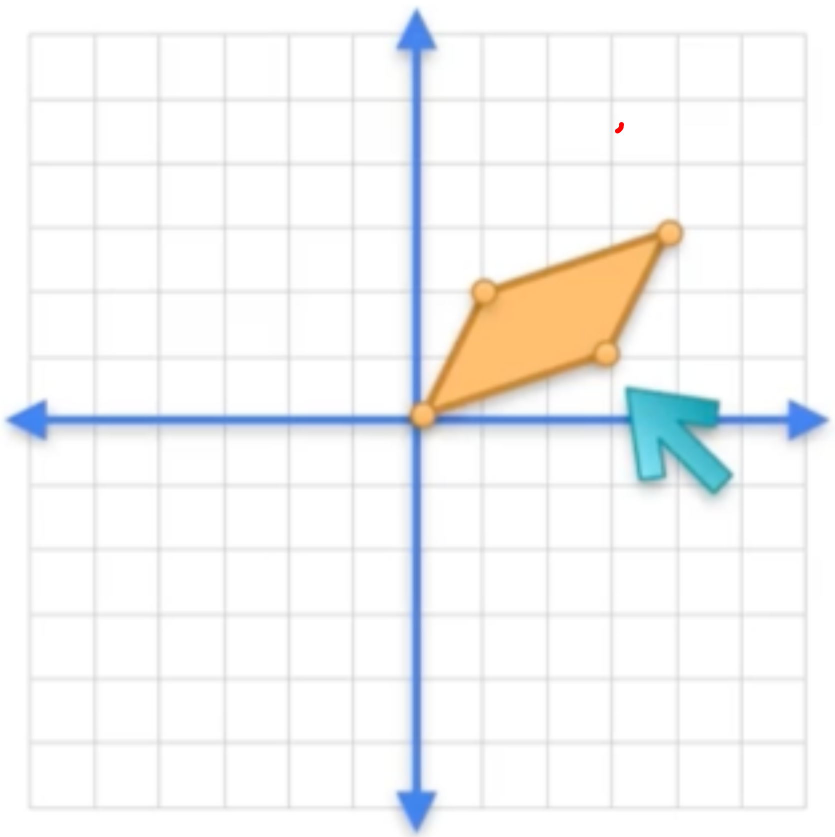
Multiplication of Matrices

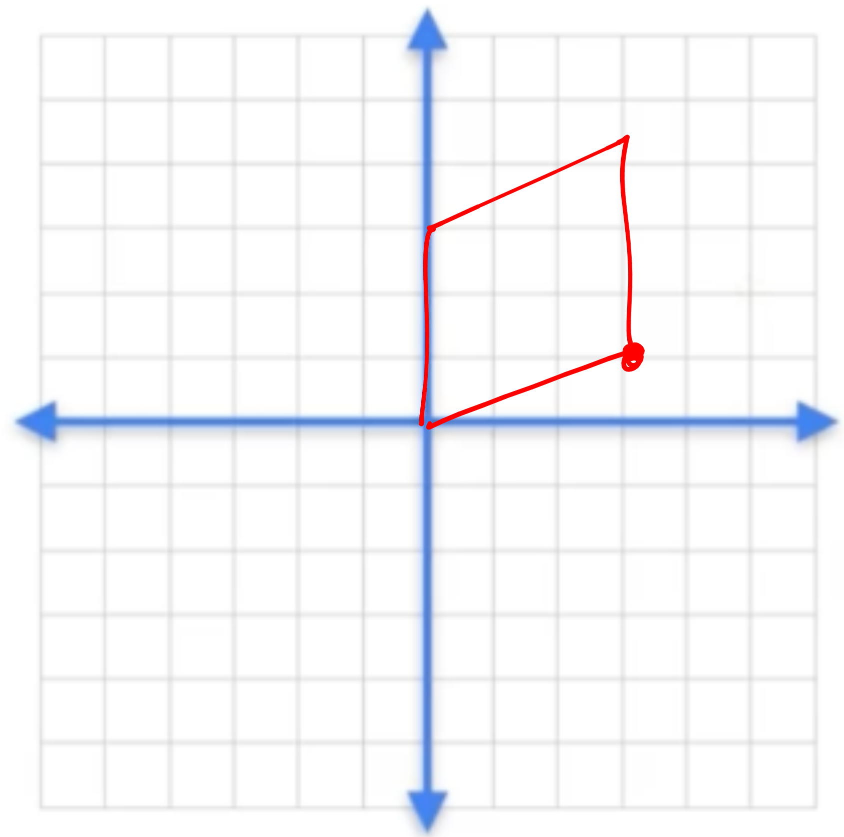


Combining linear transformations



$$\begin{bmatrix} 2 & -1 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 5 \\ 2 \end{bmatrix}$$

$$\begin{matrix} 2 & -1 & 1 & & 0 \\ 0 & +2 & 2 & & 4 \end{matrix}$$



goes to point 2, 5 on the right.

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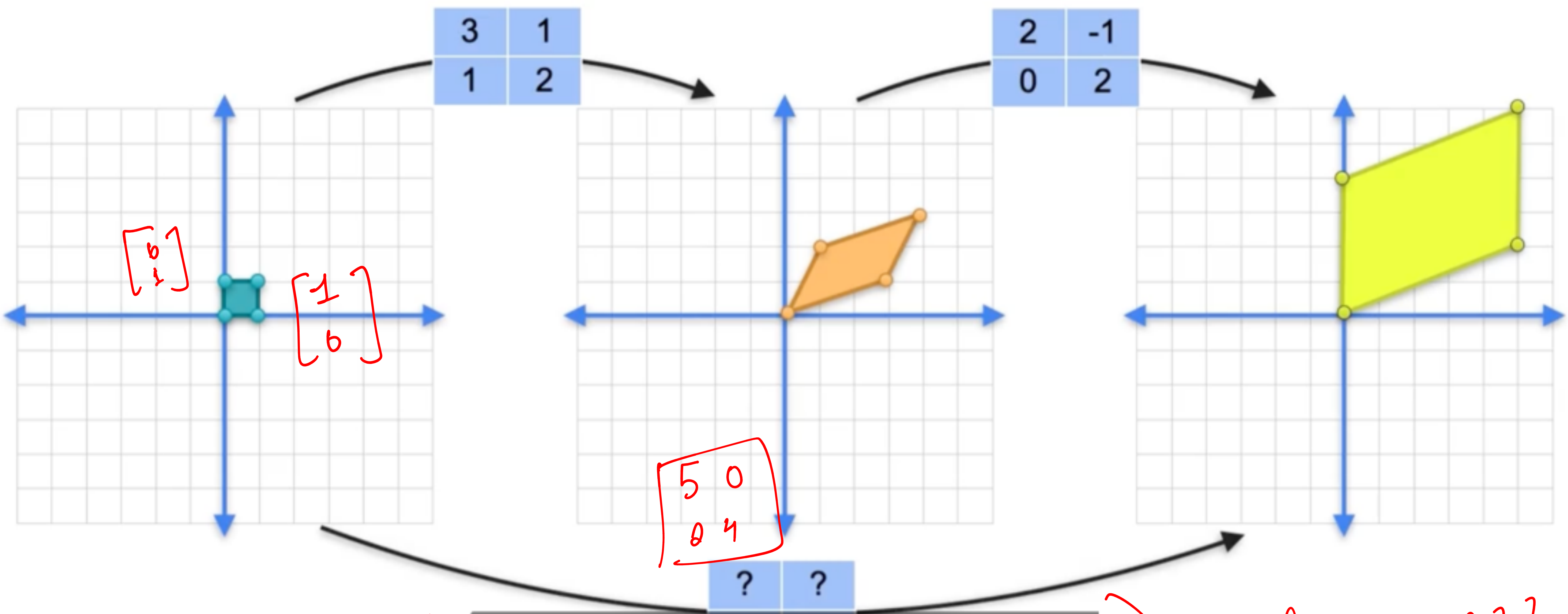
Combining linear transformations



and that has to correspond to some matrix.

what Matrix???

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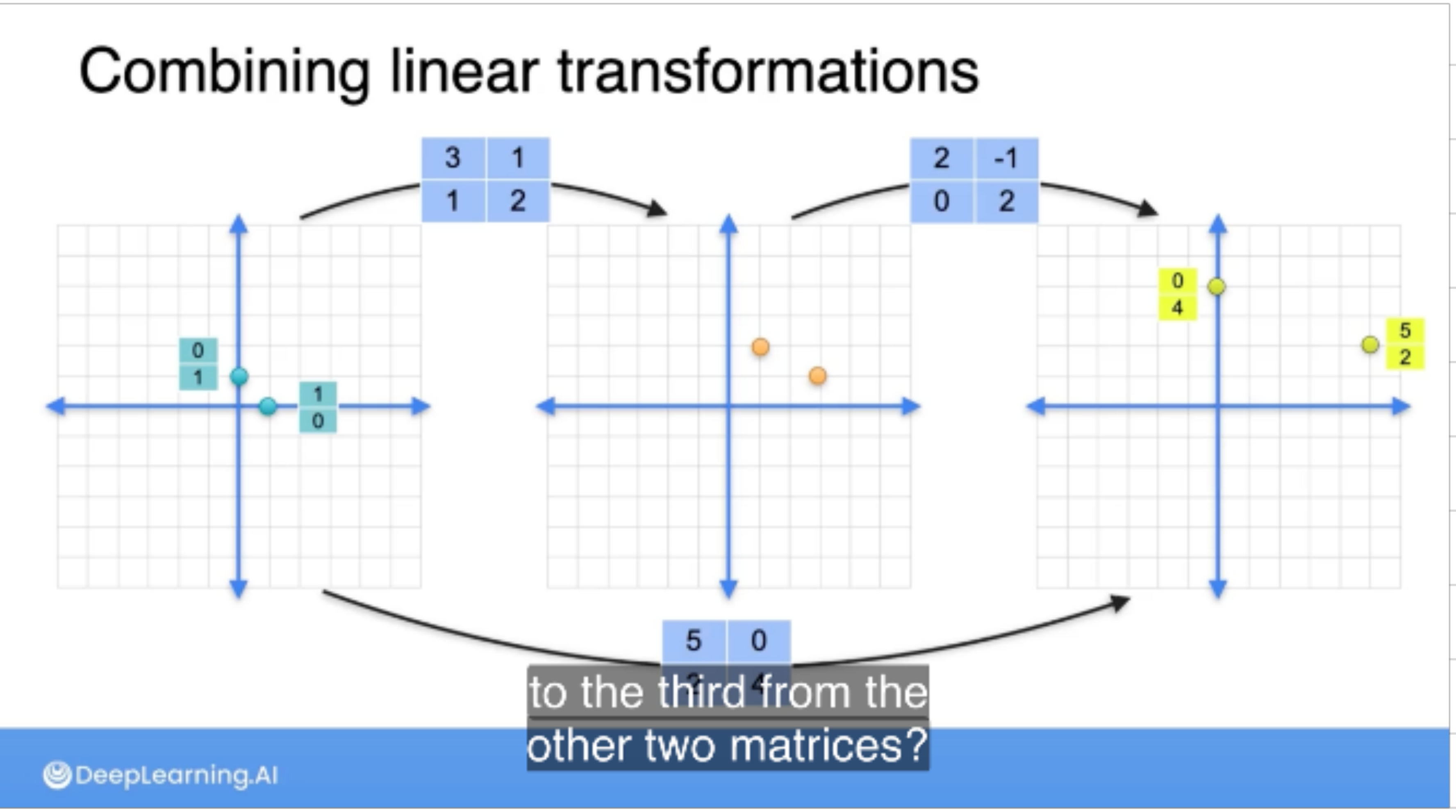


$$\begin{array}{cc} a & b \\ \end{array} \qquad \begin{array}{cc} e & f \\ \end{array}$$

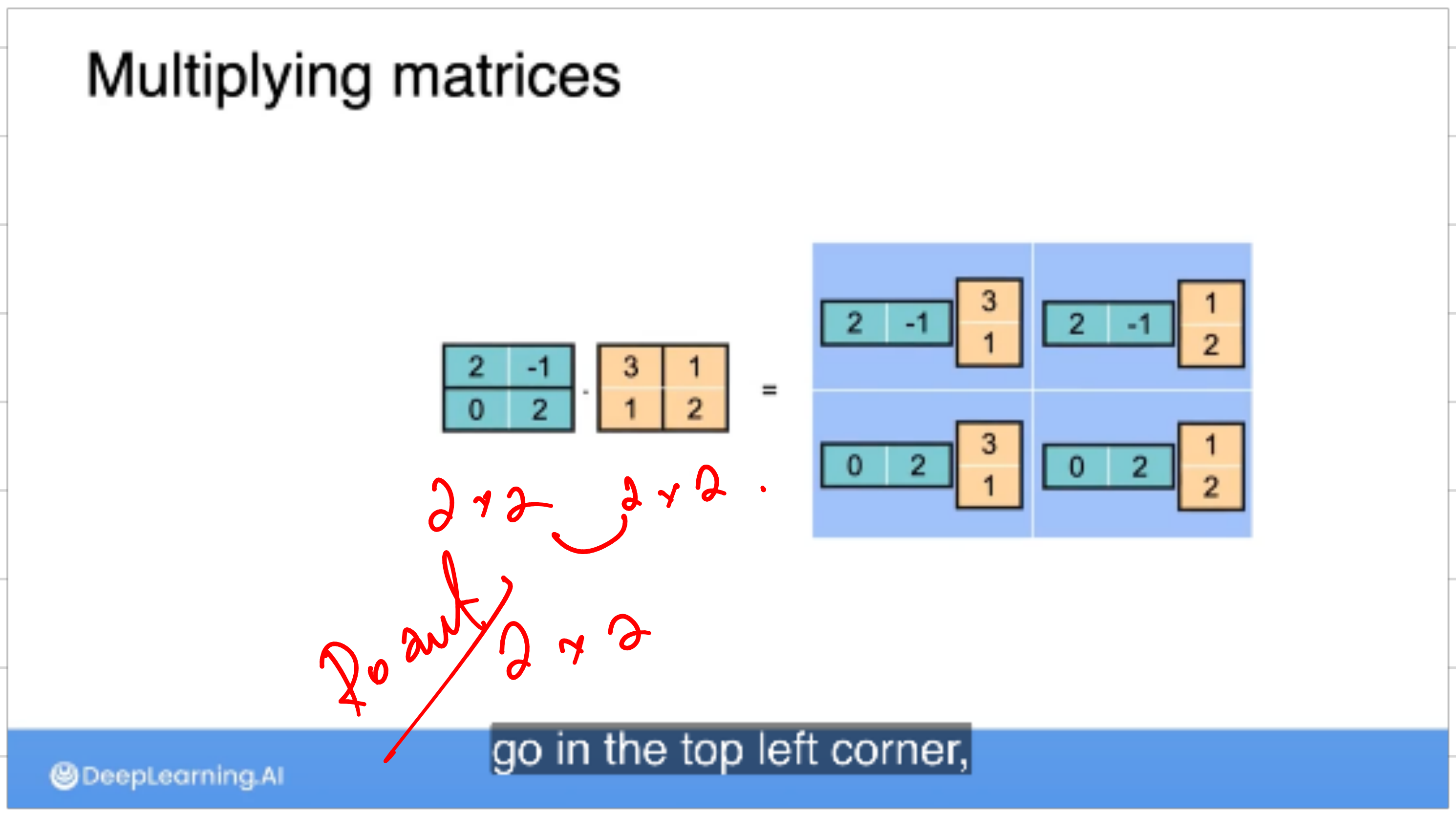
$$\begin{bmatrix} 2 & -1 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} 3 & 1 \\ 1 & 2 \end{bmatrix} \Rightarrow \begin{bmatrix} 5 & 0 \\ 2 & 4 \end{bmatrix}$$

$$\begin{array}{cc} c & d \\ \end{array} \qquad \begin{array}{cc} g & h \\ \end{array}$$

$$\begin{bmatrix} a.e + b \times g & a.f + bh \\ c \times e + dg & cf + dh \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 2 \cdot 3 + (-1) \times 1 & 2 \times 1 + (-1) \times 2 \\ 0 \cdot 3 + 2 \times 1 & 0 \cdot 1 + 2 \times 2 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 5 & 0 \\ 2 & 4 \end{bmatrix}$$



2×2 2×2.

Result 2×2

$$(2 \times 3)\ (3 \times 4) \Rightarrow 2 \times 4$$ Matrix Result.

$$\begin{bmatrix} 3 & 1 & 4 \\ 2 & -1 & 2 \end{bmatrix} \quad \begin{bmatrix} 3 & 0 & 1 & -2 \\ 1 & 5 & 2 & 0 \\ -2 & 1 & 4 & 0 \end{bmatrix} \quad \begin{array}{c|cccc} & C_1 & C_2 & C_3 & C_4 \\ \hline R_1 & 2 & 9 & 21 & -6 \\ R_2 & 1 & -3 & 8 & -4 \end{array}$$

$$\begin{bmatrix} 3 & 1 & 4 \end{bmatrix} \begin{bmatrix} 3 \\ 1 \\ -2 \end{bmatrix} = \left(3 \times 3 + 1 \times 1 + (-8)\right) =$$

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

$$\begin{bmatrix} 3 & 1 & 4 \end{bmatrix} \begin{bmatrix} 0 \\ 5 \\ 1 \end{bmatrix} = (0 + 5 + 4) = 9$$

$$\Rightarrow 6 - 1 - 4$$
$$\Rightarrow 5 - 4$$
$$\Rightarrow 1$$

2×3 $\quad$ 3×4

$$\begin{bmatrix} 3 & 1 & 4 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \end{bmatrix} = 3 + 2 + 8 \; 16 =$$

2×2 $\quad$ 1×2

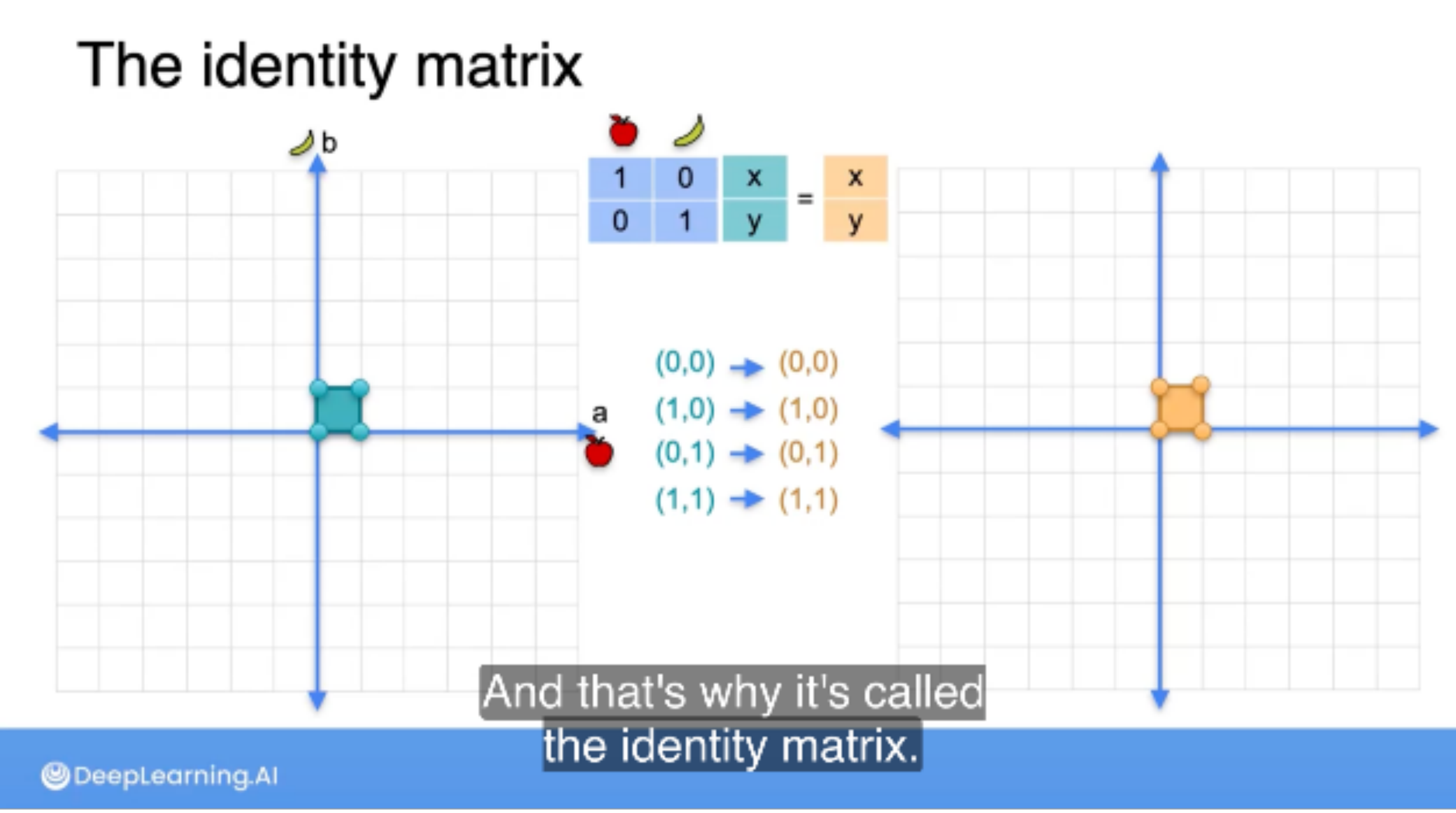
Dimension of the matrices

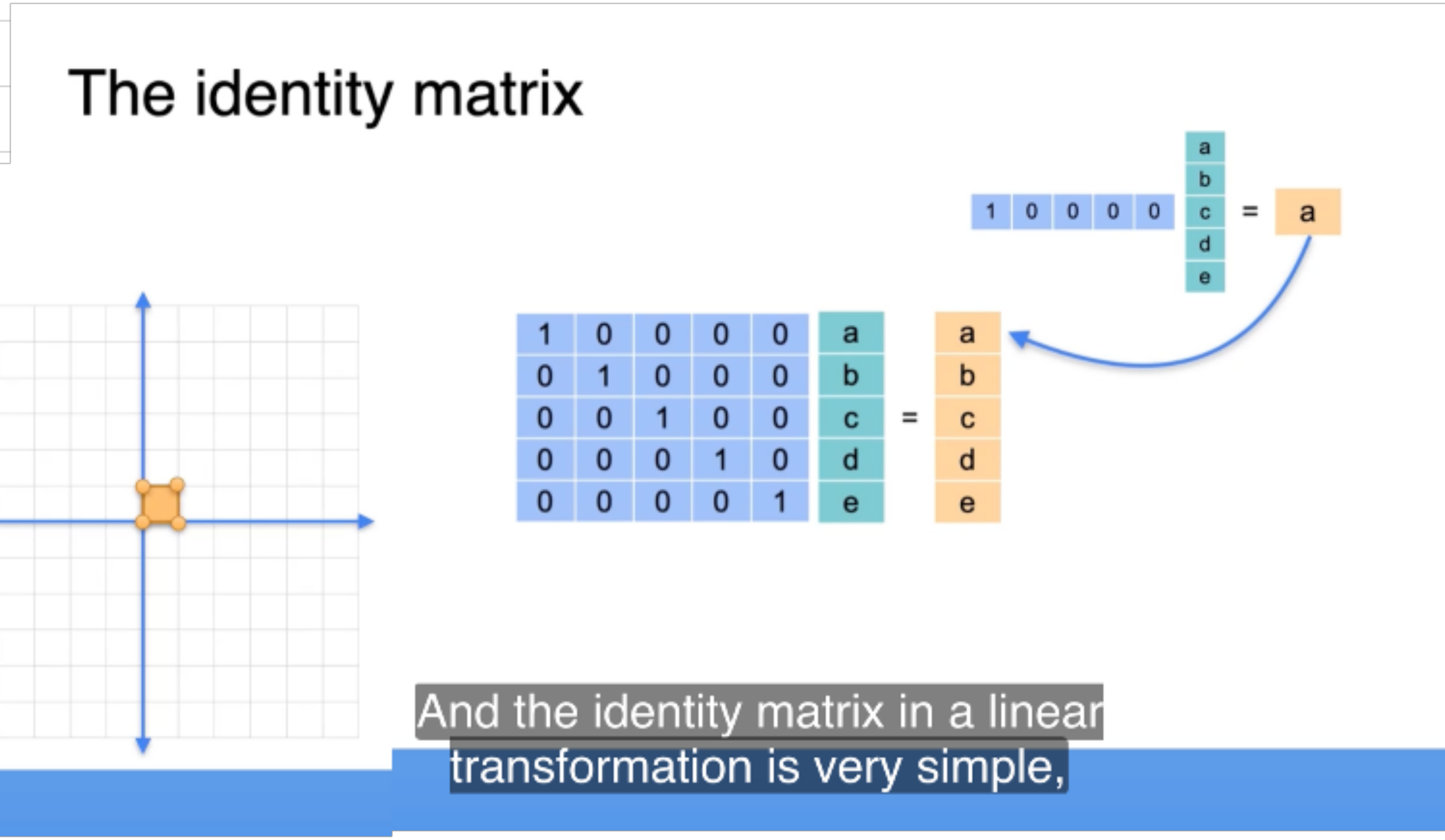
$$\begin{bmatrix} 3 & 1 & 4 \\ 2 & -1 & 2 \end{bmatrix} \cdot \begin{bmatrix} 3 & 0 & 1 & -2 \\ 1 & 5 & 2 & 0 \\ -2 & 1 & 4 & 0 \end{bmatrix} = \begin{bmatrix} 2 & 9 & 21 & -6 \\ 1 & -3 & 8 & -4 \end{bmatrix}$$

$$\boxed{2} \times \boxed{3} \qquad \boxed{3} \times \boxed{4} \qquad \boxed{2} \times \boxed{4}$$

- Columns of first matrix must match rows of second (numbers in red match)
- Result takes number of rows from first matrix (numbers in blue match)
- Result takes number of columns from second matrix (numbers in purple match)

The Identity Matrix.?



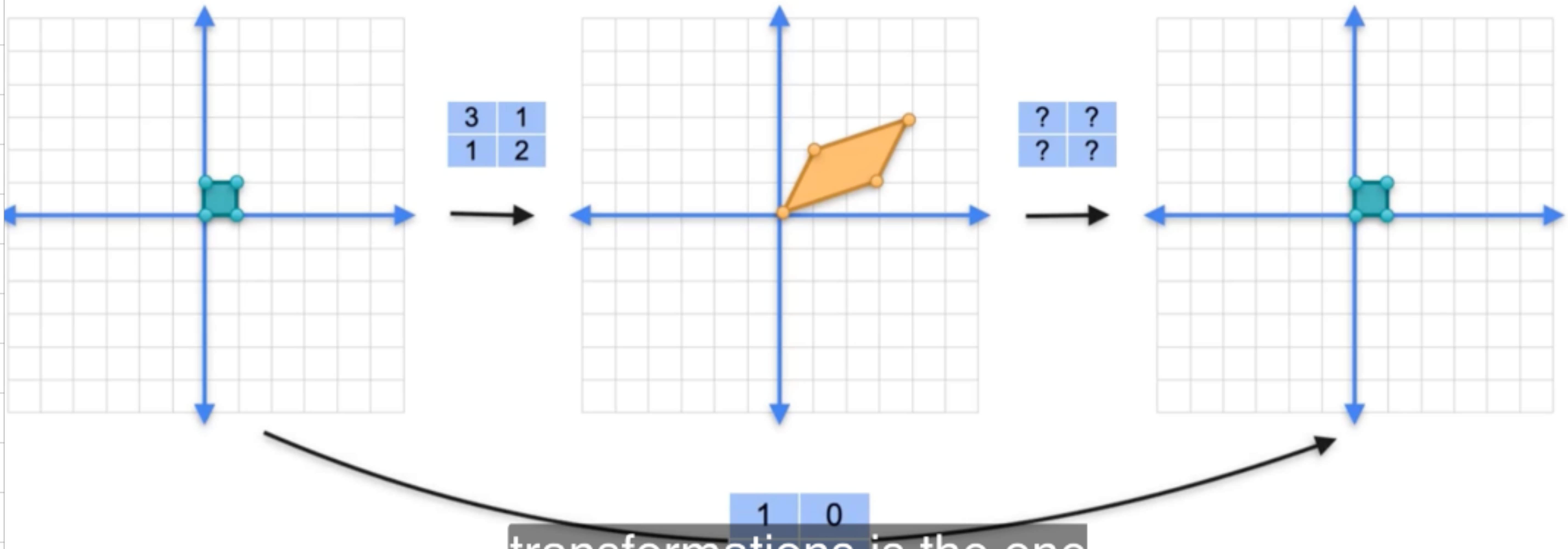


In linear transformation the Inverse matrix is the one that undoes the job of the original matrix, namely that one that returns the plane to where it was the begining.

Matrix Inverse (only if |D| ≠ 0) (Inverse of -5 is $-\frac{1}{5}$)

Matrix inverses

$$\begin{bmatrix} 3 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} a & b \\ c & d \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$



transformations is the one
corresponding to the identity matrix,

$$\begin{bmatrix} 5 & 2 \\ 1 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 5 & 2 \end{bmatrix} \begin{bmatrix} a \\ c \end{bmatrix} = 1$$

$$\begin{bmatrix} 5 & 2 \end{bmatrix} \begin{bmatrix} b \\ d \end{bmatrix} = 0$$

$$\begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} a \\ c \end{bmatrix} = 0$$

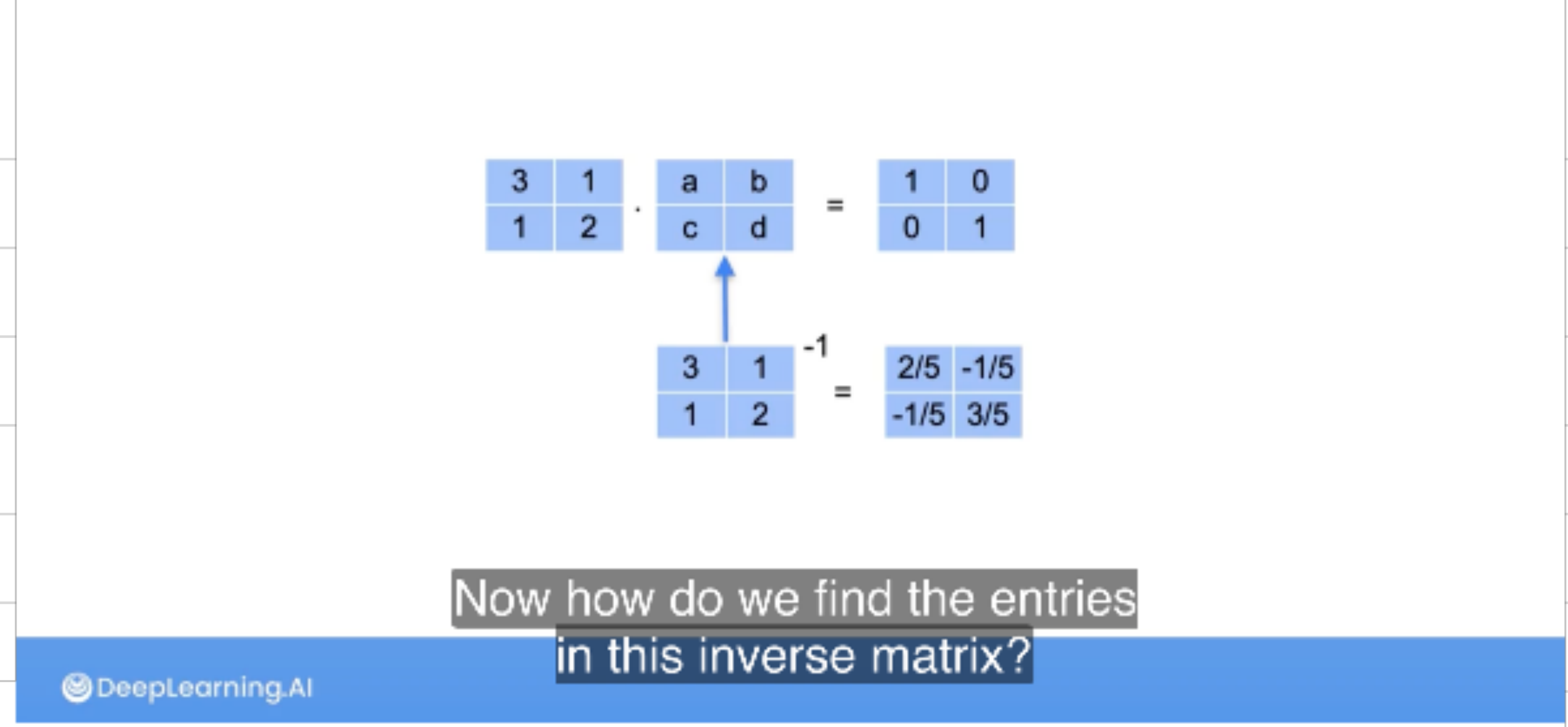
$$\begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} b \\ d \end{bmatrix} = 1$$

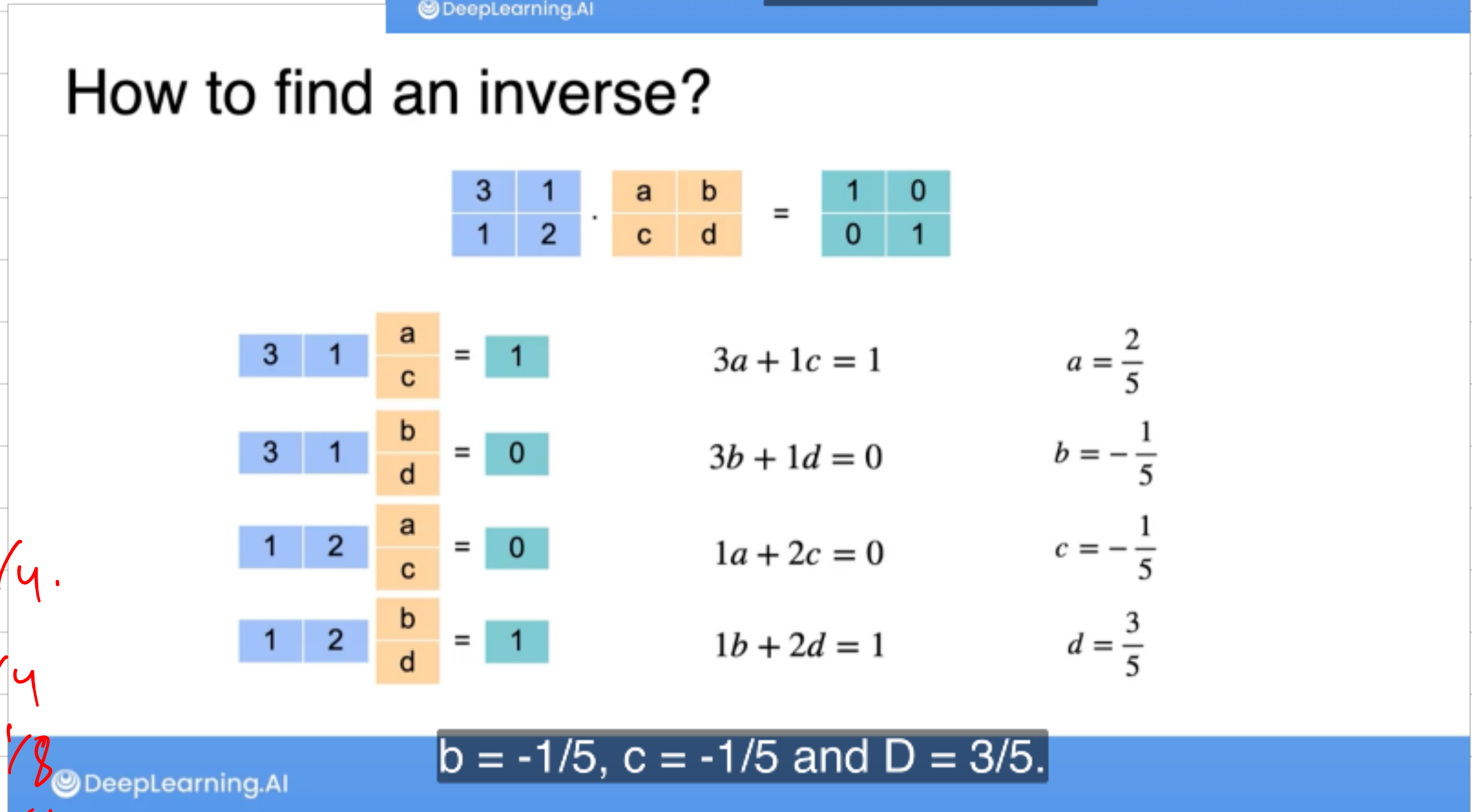
$5a + 2c = 1$ | $a = 1/4$.

$5b + 2d = 0$ | $b = -1/4$

$1a + 1c = 0$ | $c = -1/8$

$1b + 1d = 1$ | $d = 5/8$





$$\begin{bmatrix} 1 & 1 \\ 2 & 2 \end{bmatrix} \begin{bmatrix} a & b \\ c & d \end{bmatrix} \qquad |D| \Rightarrow 2-2 \Rightarrow 0.$$

$$\begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} a \\ c \end{bmatrix} \Rightarrow 1$$

$$\begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} b \\ d \end{bmatrix} \Rightarrow 0$$

$$\begin{bmatrix} 2 & 2 \end{bmatrix} \begin{bmatrix} a \\ c \end{bmatrix} \Rightarrow 0$$

$$\begin{bmatrix} 2 & 2 \end{bmatrix} \begin{bmatrix} b \\ d \end{bmatrix} = 1$$

Solutions

- The inverse doesn't exist!

We need to solve the following system of linear equations:

$$\begin{bmatrix} 1 & 1 \\ 2 & 2 \end{bmatrix} \begin{bmatrix} a & b \\ c & d \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$a + c = 1$
$2b + 2d = 1$
$2a + 2c = 0$
$b + d = 0$
This is clearly a contradiction, since equation 1 says a+c=1, and equation 3 says 2a+2c=0.

So therefore this matrix doesn't have an inverse.

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$a + c = 1$
$b + d = 0$
$2a + 2c = 0$

$2b + 2d = 1.$

Q Rule for Matric to have Inverse?

$5^{-1} = 0.2$
$8^{-1} \Rightarrow 0.125$

$0^{-1} \Rightarrow$??? Not Defined $1/0 \Rightarrow$.

Which matrices have inverses?

$5^{-1} = 0.2$

$8^{-1} = 0.125$

$0^{-1} = ???$

$$\begin{bmatrix} 3 & 1 \\ 1 & 2 \end{bmatrix}^{-1} = \begin{bmatrix} 0.4 & -0.2 \\ -0.2 & 0.6 \end{bmatrix}$$

Non-singular matrix

$$\begin{bmatrix} 5 & 2 \\ 1 & 2 \end{bmatrix}^{-1} = \begin{bmatrix} 0.25 & -0.25 \\ -0.125 & 0.625 \end{bmatrix}$$

Non-singular matrix

$$\begin{bmatrix} 1 & 1 \\ 2 & 2 \end{bmatrix} = \begin{bmatrix} ? & ? \\ ? & ? \end{bmatrix}$$

Singular matrix

Det = 5
Invertible

Det = 8
Invertible

$|D| \neq 0$.

Det = 0.
Non-Invertible.

$|D| = 0$

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You'll be happy to see that this

Neural Networks And Matrices:

(Spam Classifier)

Quiz: Natural language processing

Spam	Lottery	Win
Yes	1	1
Yes	2	1
No	0	0
Yes	0	2
No	0	1
No	1	0
Yes	2	2
Yes	2	0
Yes	1	2

lottery: 3 pts.
win: 2 points.

Scores:
lottery: — points
win: — points.

Solution.
1 point → L
1 point → W

Threshold 1.5 points.

See Proportion

but of course the
appearance doesn't

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Quiz: Natural language processing

Spam	Lottery	Win
Yes	1	1
Yes	2	1
No	0	0
Yes	0	2
No	0	1
No	1	0
Yes	2	2
Yes	2	0
Yes	1	2

Scores:

Lottery: ___ points

Win: ___ points

Examples

Lottery: 3 point
Win: 2 points
"Win, win the lottery!" : 7points

Rule:
If the number of points of the sentence is bigger than ____, then the email is spam.

Goal: Find the best points and threshold
Lottery: ___ point
Win: ___ point
Threshold: ___ points

the classifier are as close as

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Quiz: Natural language processing

Spam	Lottery	Win
Yes	1	1
Yes	2	1
No	0	0
Yes	0	2
No	0	1
No	1	0
Yes	2	2
Yes	2	0
Yes	1	2

Score	> 1.5?
2	Yes
3	Yes
0	No
2	Yes
1	No
1	No
4	Yes
2	Yes
3	Yes

Solution:
Lottery: 1 point
Win: 1 point
Threshold: 1.5 points

it was words, and it used

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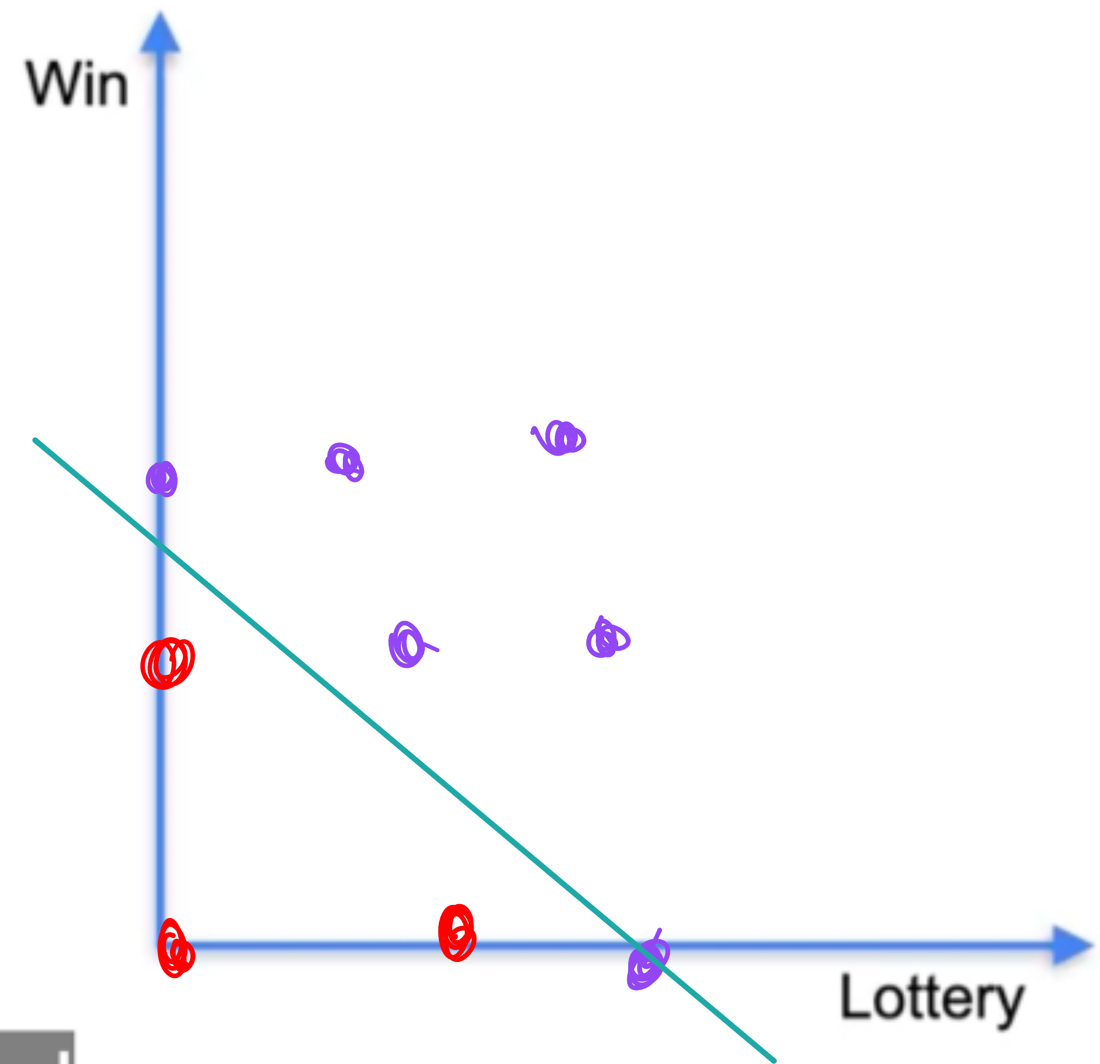
Graphical natural language processing

Spam	Lottery	Win
Yes	1	1
Yes	2	1
No	0	0
Yes	0	2
No	0	1
No	1	0
Yes	2	2
Yes	2	0
Yes	1	2



the horizontal
axis is the number

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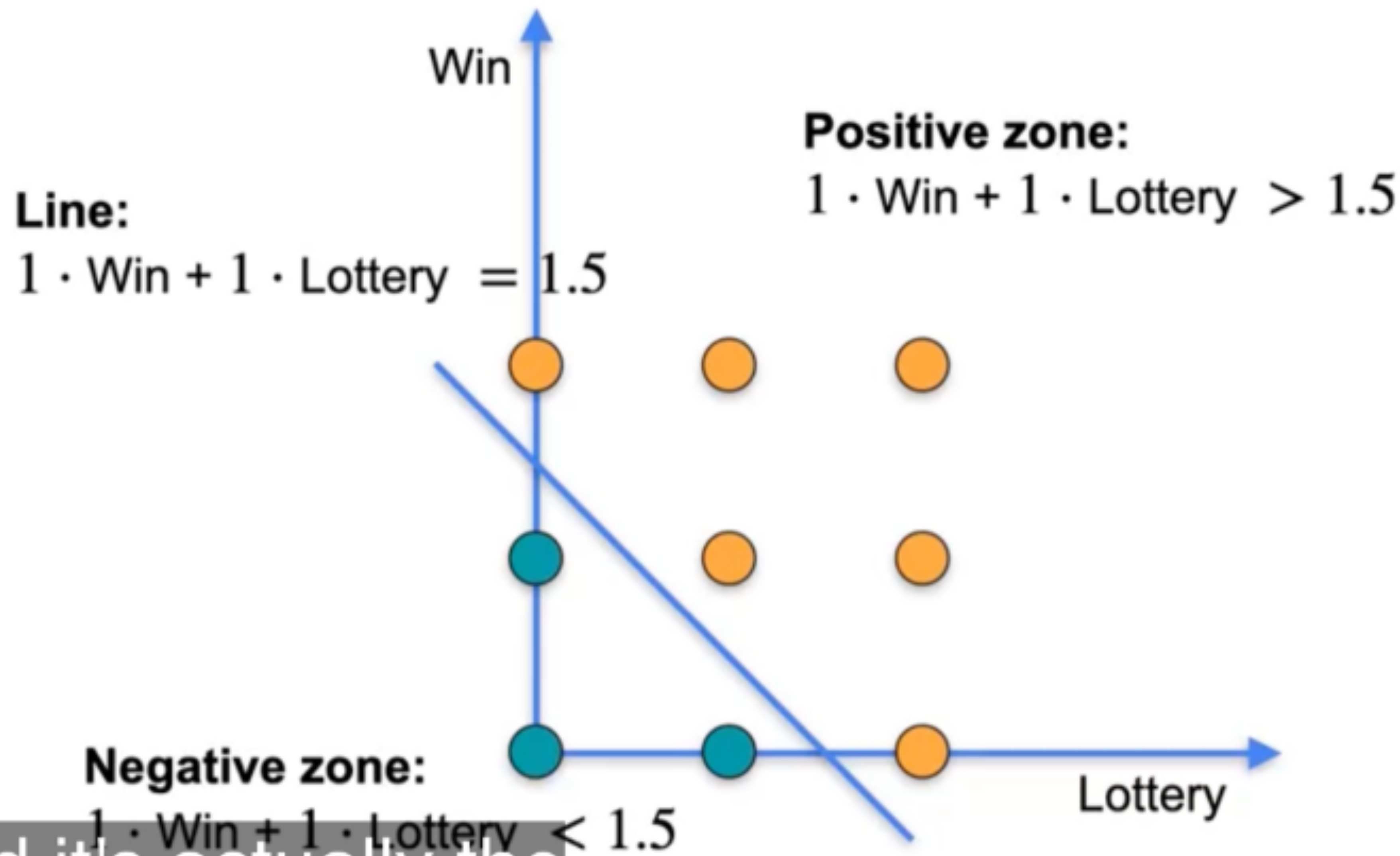
Graphical natural language processing

Spam	Lottery	Win
Yes	1	1
Yes	2	1
No	0	0
Yes	0	2
No	0	1
No	1	0
Yes	2	2
Yes	2	0
Yes	1	2



and it's actually the
simplest neural network.

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Graphical natural language processing

Spam	Lottery	Win
Yes	1	1
Yes	2	1
No	0	0
Yes	0	2
No	0	1
No	1	0
Yes	2	2
Yes	2	0
Yes	1	2

$0.1 + 1.1 \Rightarrow 1 > 1.5$ Yes Spam

0 1

2	1

Model
1
1

Check: > 1.5?

$y \Rightarrow 2.1 + 1.1 \Rightarrow 3$ So, it is Spam because $3 > 1.5$ So, Spam.

the word lottery and one
appearance of the word win.

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Matrix multiplication

Spam	Lottery	Win
Yes	1	1
Yes	2	1
No	0	0
Yes	0	2
No	0	1
No	1	0
Yes	2	2
Yes	2	0
Yes	1	2

=2
=3
=0

W

Model
1
1

=

x

Prod
2
3
0
2
1
1
4
2
3

α

Check: >1.5?

y

Check
Yes
Yes
No
Yes
No
No
Yes
Yes
Yes

in this vector to
get our predictions.

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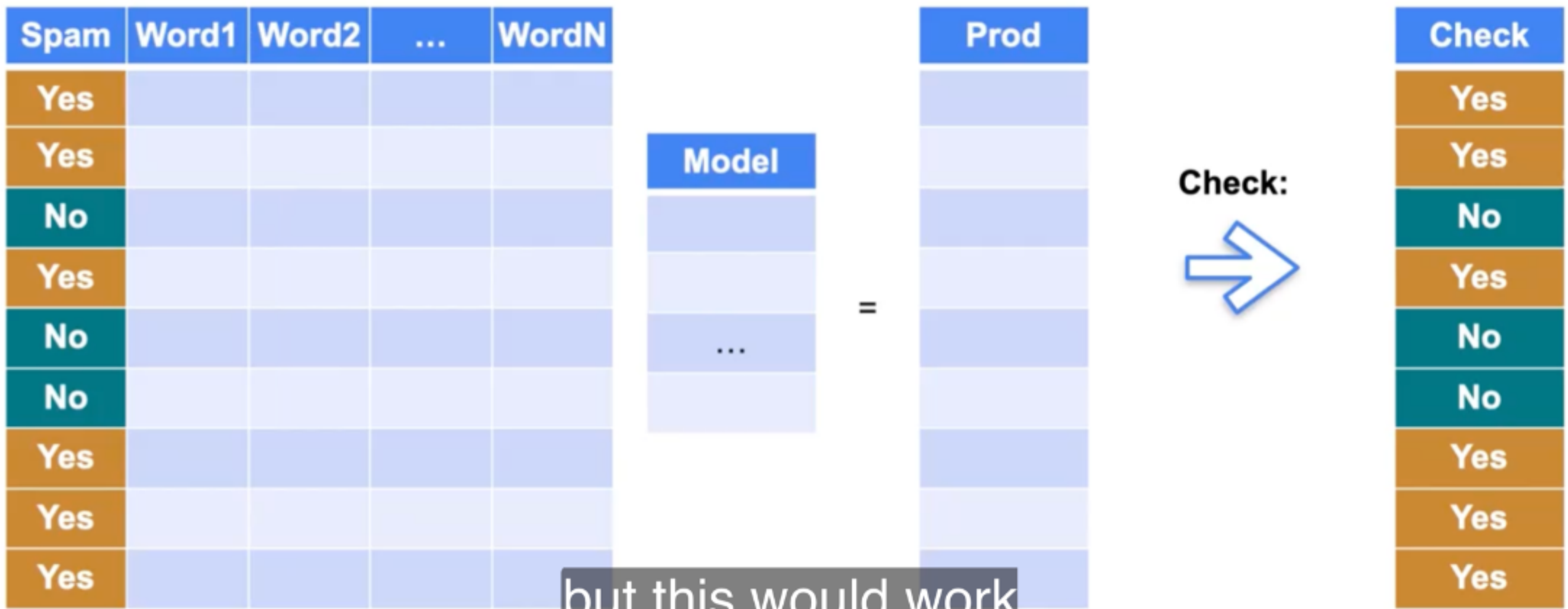
Perceptrons

(Works Similar Above Example)



but this would work exactly the same.

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Threshold and bias

Spam	Lottery	Win	Bias
Yes	1	1	1
Yes	2	1	1
No	0	0	1
Yes	0	2	1
No	0	1	1
No	1	0	1
Yes	2	2	1
Yes	2	0	1
Yes	1	2	1

Threshold

Check

$1 \cdot \text{Win} + 1 \cdot \text{Lottery} \; > 1.5$

$1 \cdot \text{Win} + 1 \cdot \text{Lottery} - 1.5 > 0$

Bias

Check: > 0?

Model
1
1
-1.5

Bias

the results is larger than
the threshold of 1.5,

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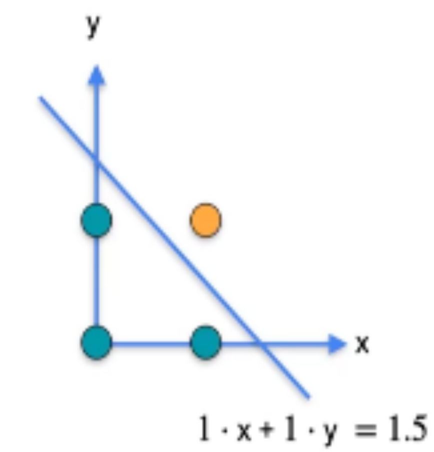
The AND operator

AND	x	y
No	0	0
No	1	0
No	0	1
Yes	1	1



except that now there's only
a subset of the points.

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The AND operator

AND	x	y
No	0	0
No	1	0
No	0	1
Yes	1	1

Model
1
1

=

Dot prod
0
1
1
2

Check: >1.5?

Check
No
No
No
Yes

you get predictions that look

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Source: Linear Algebra for Machine Learning and Data Science Coursera offered by DeepLearning.AI

The perceptron