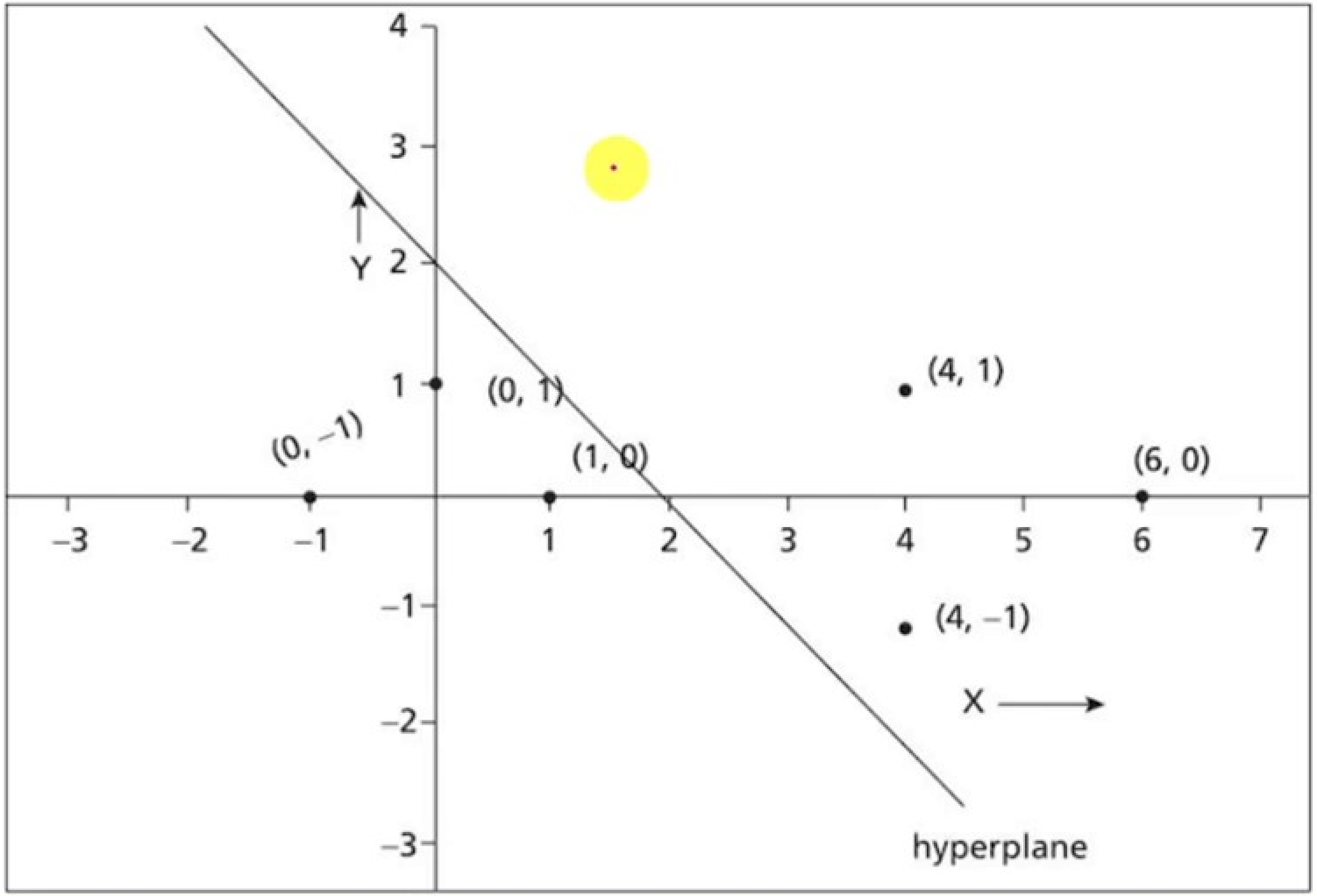
Support Vector Machine



Solved Example

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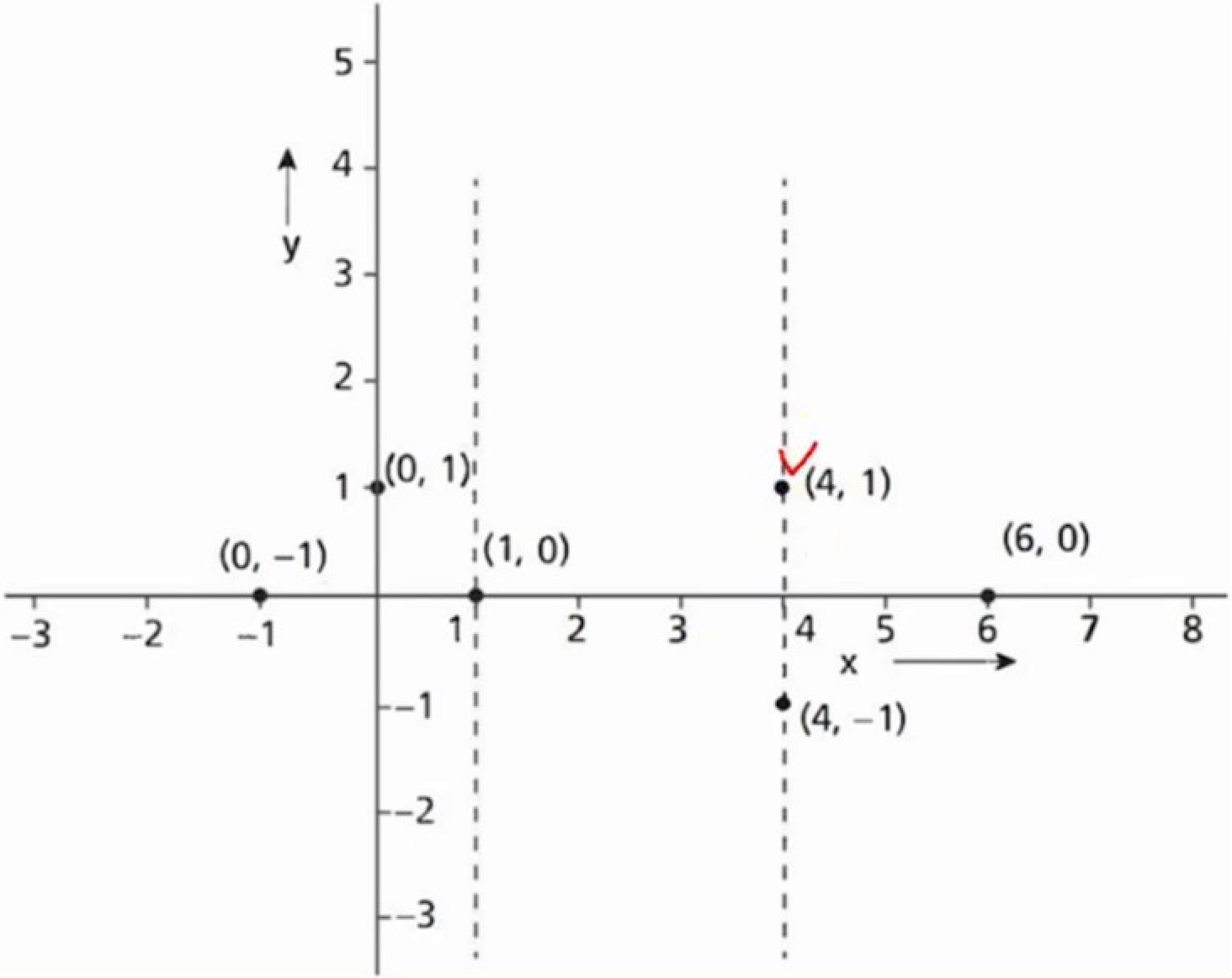

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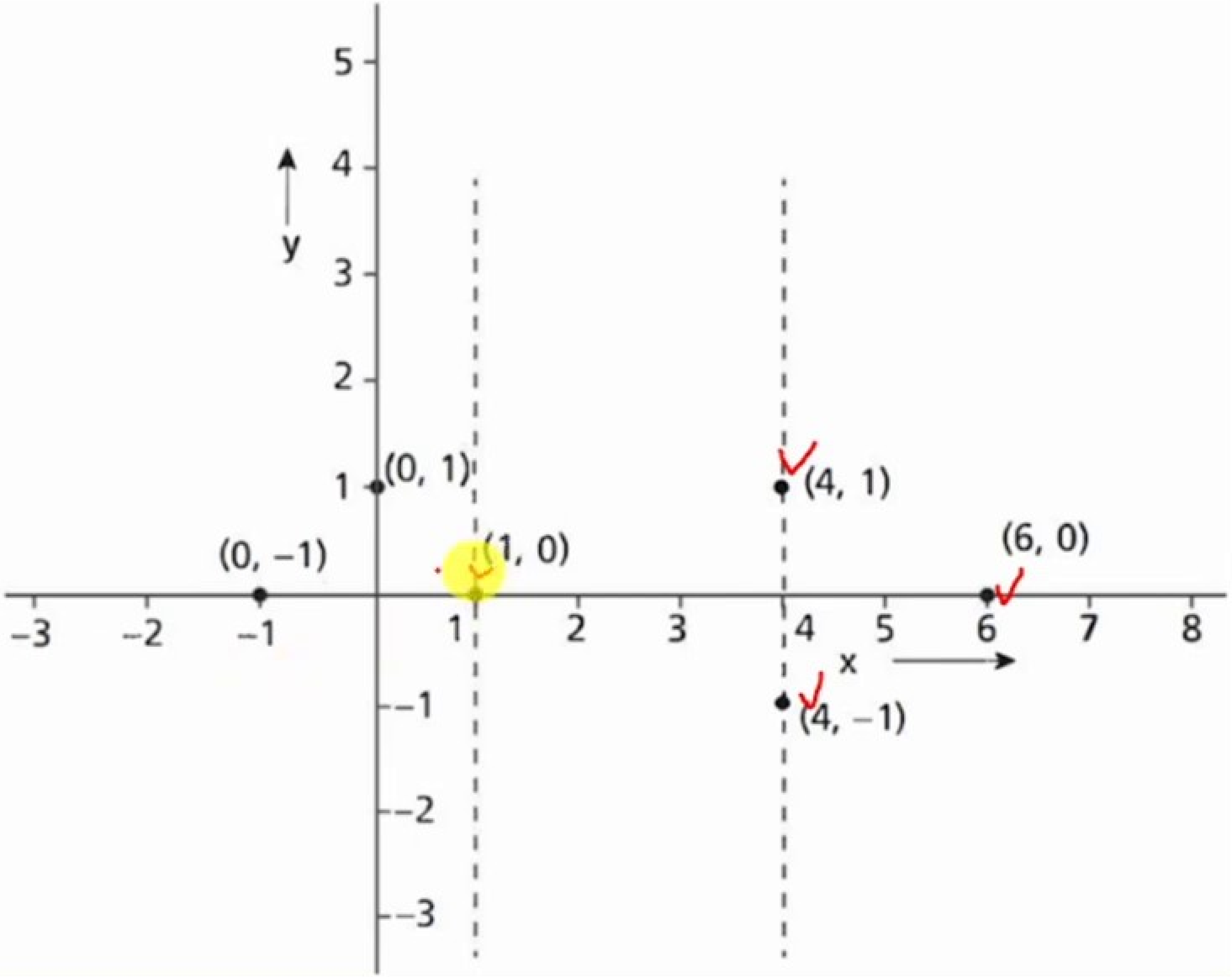

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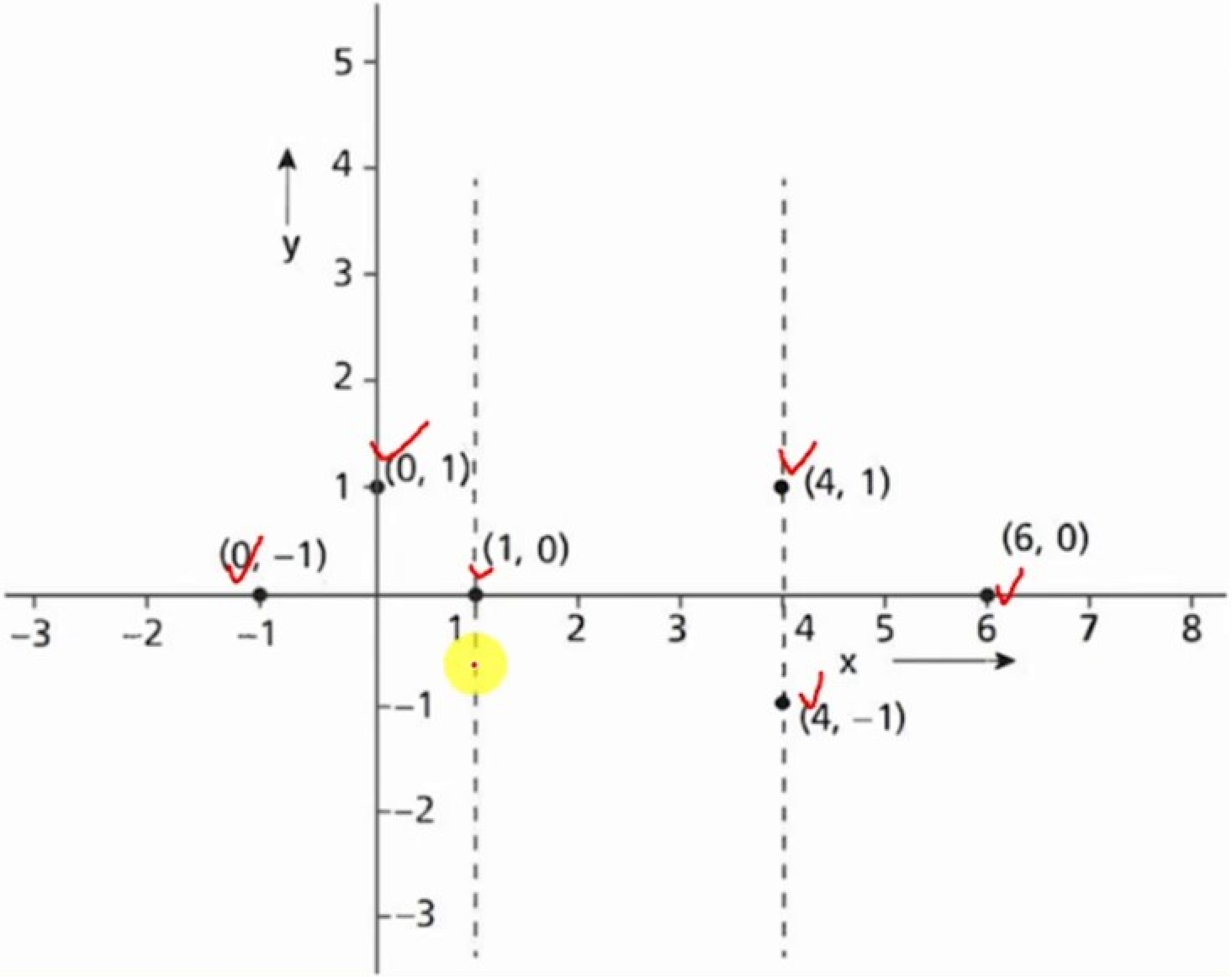

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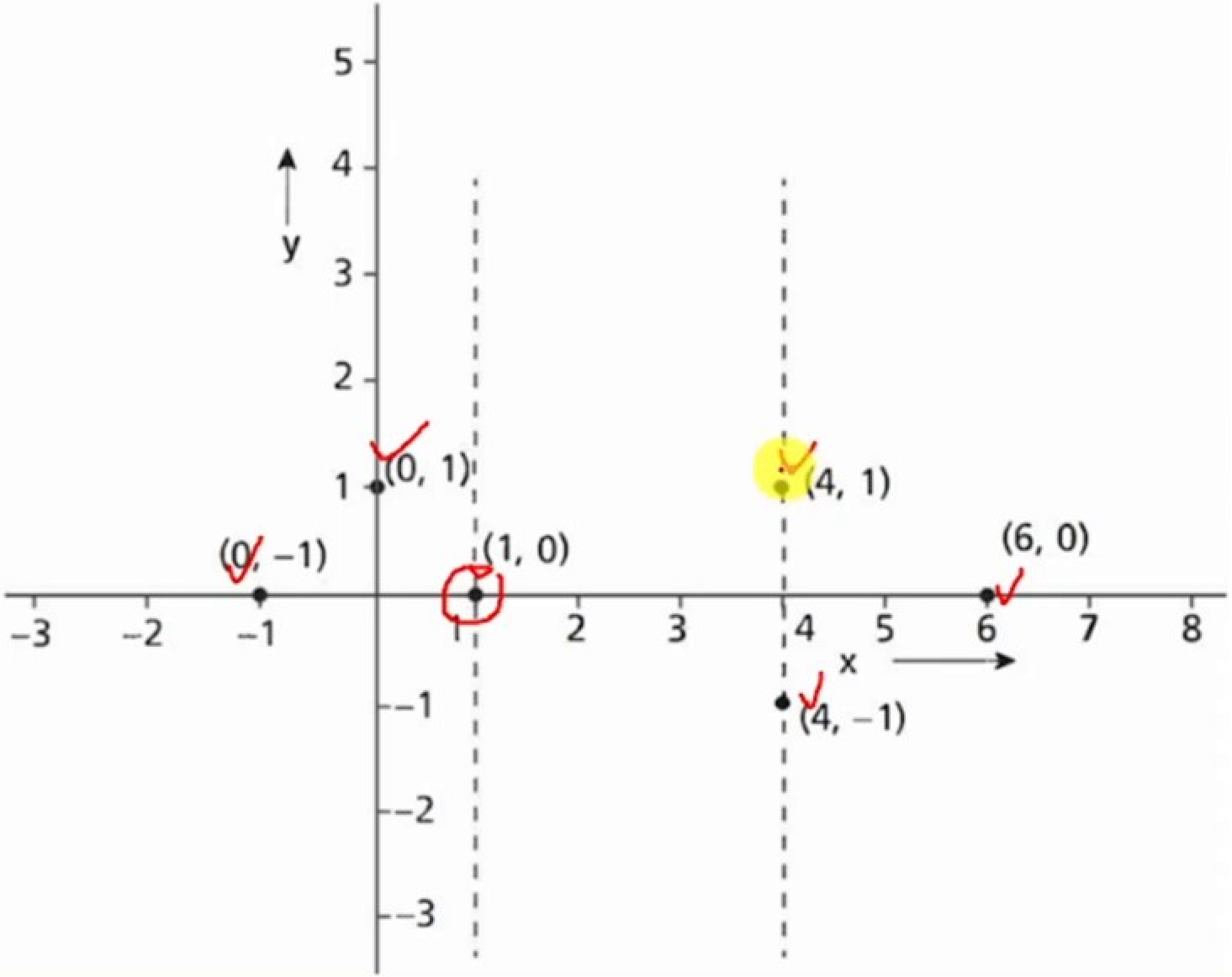

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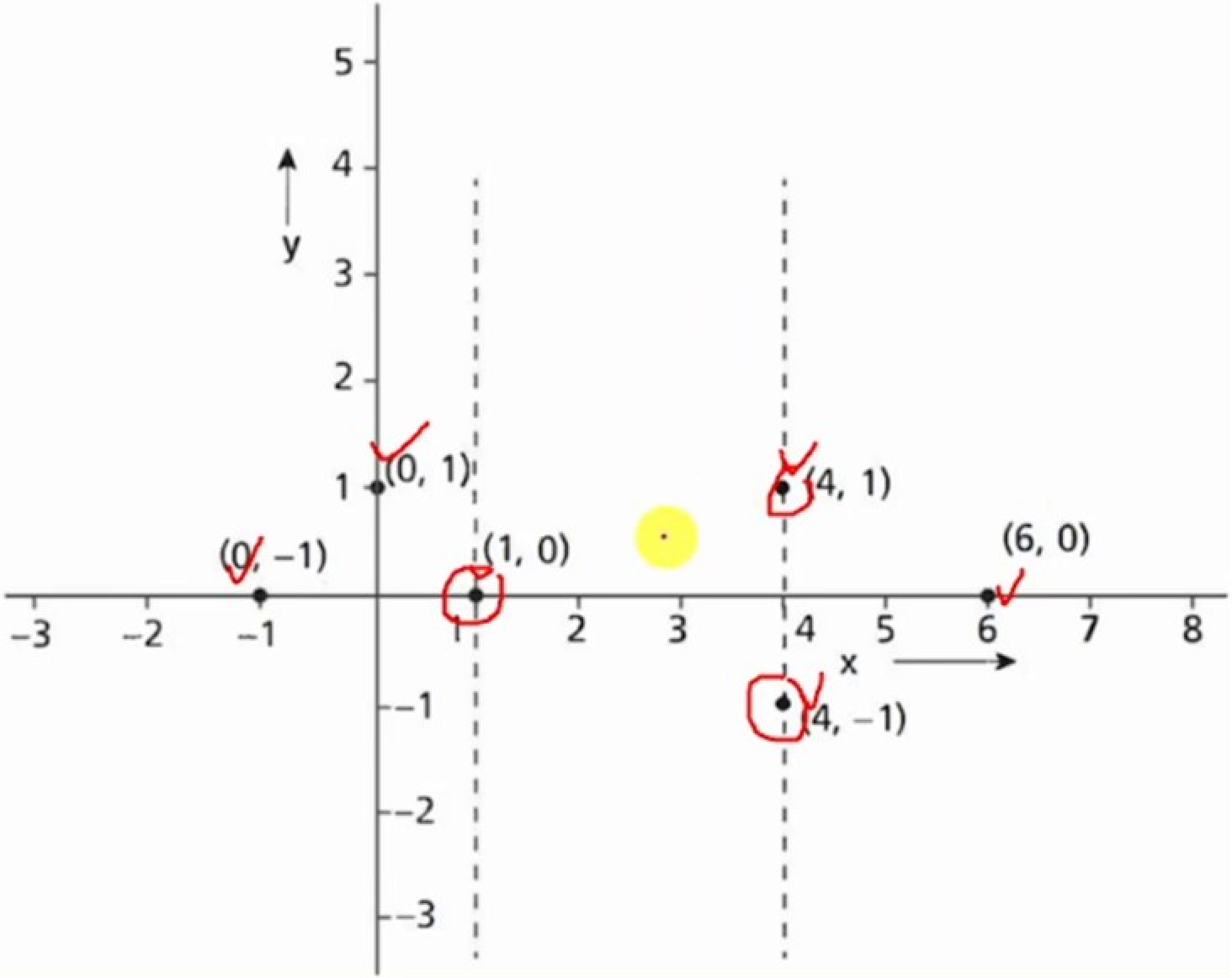
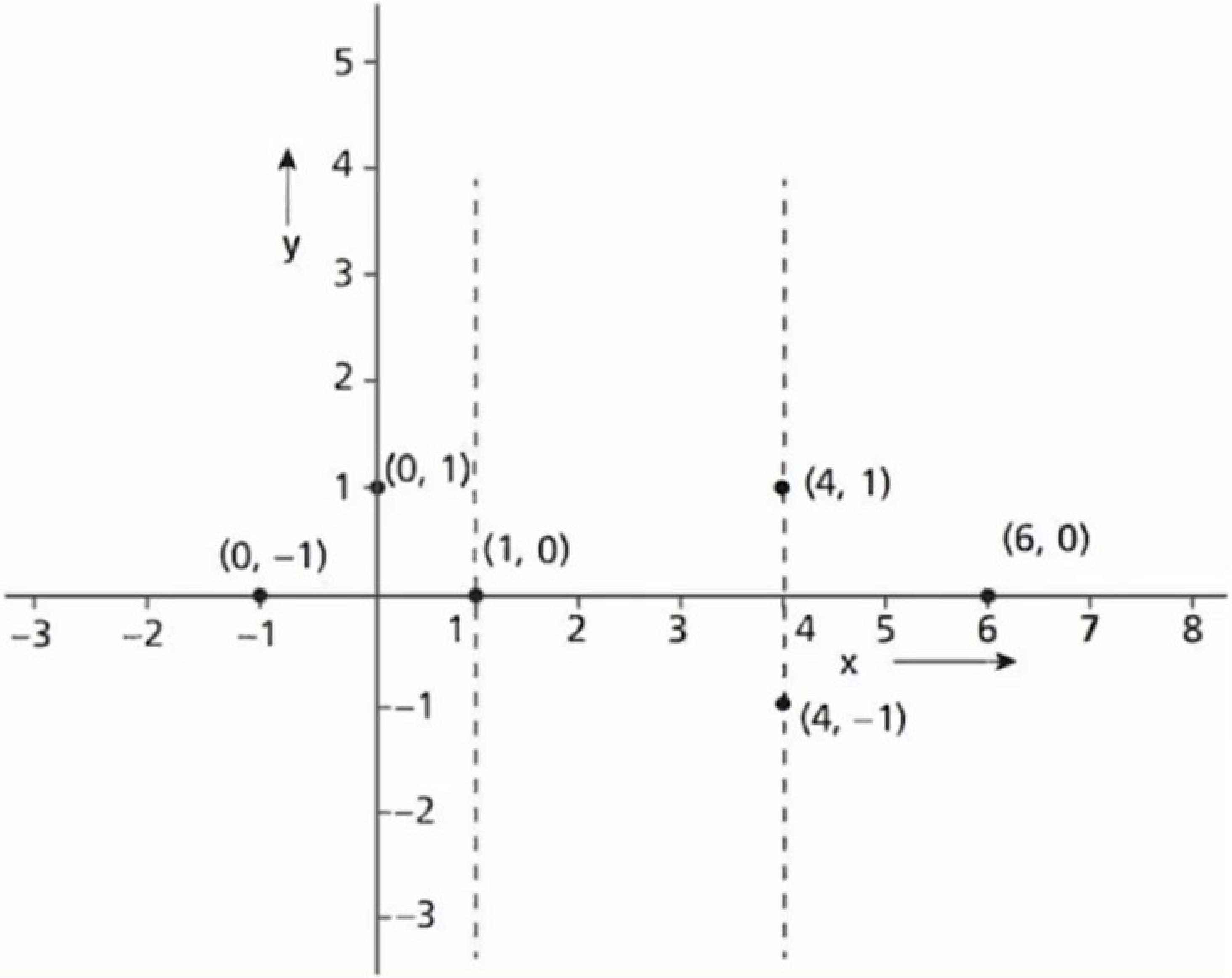


Support Vector Machine – Solved Example

- It can be observed that the support vectors are (1, 0), (4, 1) and (4, -1)

$$s_1 = \begin{pmatrix} 1 \\ 0 \end{pmatrix}, s_2 = \begin{pmatrix} 4 \\ 1 \end{pmatrix}, s_3 = \begin{pmatrix} 4 \\ -1 \end{pmatrix}$$



Support Vector Machine – Solved Example

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- The augmented vector can be obtained by adding the bias given as follows:

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From these, a set of three equations can be obtained based on these three support vectors as follows:

$$\alpha_1 \tilde{s}_1 \tilde{s}_1 + \alpha_2 \tilde{s}_2 \tilde{s}_1 + \alpha_3 \tilde{s}_3 \tilde{s}_1 = -1$$
$$\alpha_1 \tilde{s}_1 \tilde{s}_2 + \alpha_2 \tilde{s}_2 \tilde{s}_2 + \alpha_3 \tilde{s}_3 \tilde{s}_2 = +1$$
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Support Vector Machine – Solved Example

$$\alpha_1 \begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix} + \alpha_2 \begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix} + \alpha_3 \begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}$$

$$= 2\alpha_1 + 5\alpha_2 + 5\alpha_3 = -1$$

$$\tilde{s}_1 = \begin{pmatrix}1\\0\\1\end{pmatrix}, \tilde{s}_2 = \begin{pmatrix}4\\1\\1\end{pmatrix}, \tilde{s}_3 = \begin{pmatrix}4\\-1\\1\end{pmatrix}$$

$$\alpha_1 \tilde{s}_1 \tilde{s}_1 + \alpha_2 \tilde{s}_2 \tilde{s}_1 + \alpha_3 \tilde{s}_3 \tilde{s}_1 = -1$$

$$\alpha_1 \tilde{s}_1 \tilde{s}_2 + \alpha_2 \tilde{s}_2 \tilde{s}_2 + \alpha_3 \tilde{s}_3 \tilde{s}_2 = +1$$

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$$= 2\alpha_1 + 5\alpha_2 + 5\alpha_3 = -1$$

$$\tilde{s}_1 = \begin{pmatrix}1\\0\\1\end{pmatrix},\ \tilde{s}_2 = \begin{pmatrix}4\\1\\1\end{pmatrix},\ \tilde{s}_3 = \begin{pmatrix}4\\-1\\1\end{pmatrix}$$

$$\alpha_1\tilde{s}_1\tilde{s}_1 + \alpha_2\tilde{s}_2\tilde{s}_1 + \alpha_3\tilde{s}_3\tilde{s}_1 = -1$$
$$\alpha_1\tilde{s}_1\tilde{s}_2 + \alpha_2\tilde{s}_2\tilde{s}_2 + \alpha_3\tilde{s}_3\tilde{s}_2 = +1$$
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Support Vector Machine – Solved Example

$$\alpha_1\begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}+\alpha_2\begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}+\alpha_3\begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}$$

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$$\alpha_1\tilde{s}_1\tilde{s}_1 + \alpha_2\tilde{s}_2\tilde{s}_1 + \alpha_3\tilde{s}_3\tilde{s}_1 = -1$$
$$\alpha_1\tilde{s}_1\tilde{s}_2 + \alpha_2\tilde{s}_2\tilde{s}_2 + \alpha_3\tilde{s}_3\tilde{s}_2 = +1$$
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Support Vector Machine – Solved Example

$$\alpha_1 \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} + \alpha_2 \begin{pmatrix} 4 \\ 1 \\ 1 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} + \alpha_3 \begin{pmatrix} 4 \\ -1 \\ 1 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$$

$$= 2\alpha_1 + 5\alpha_2 + 5\alpha_3 = -1$$

$$\tilde{s}_1 = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}, \tilde{s}_2 = \begin{pmatrix} 4 \\ 1 \\ 1 \end{pmatrix}, \tilde{s}_3 = \begin{pmatrix} 4 \\ -1 \\ 1 \end{pmatrix}$$

$$\alpha_1 \tilde{s}_1 \tilde{s}_1 + \alpha_2 \tilde{s}_2 \tilde{s}_1 + \alpha_3 \tilde{s}_3 \tilde{s}_1 = -1$$
$$\alpha_1 \tilde{s}_1 \tilde{s}_2 + \alpha_2 \tilde{s}_2 \tilde{s}_2 + \alpha_3 \tilde{s}_3 \tilde{s}_2 = +1$$
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Support Vector Machine – Solved Example

$$\alpha_1\begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}+\alpha_2\begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}+\alpha_3\begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}$$

$$= 2\alpha_1 + 5\alpha_2 + 5\alpha_3 = -1$$

$$\tilde{s}_1 = \begin{pmatrix}1\\0\\1\end{pmatrix}, \tilde{s}_2 = \begin{pmatrix}4\\1\\1\end{pmatrix}, \tilde{s}_3 = \begin{pmatrix}4\\-1\\1\end{pmatrix}$$

$$\alpha_1\begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix}+\alpha_2\begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix}+\alpha_3\begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix}$$

$$= 5\alpha_1 + 18\alpha_2 + 16\alpha_3 = +1$$

$$\alpha_1\begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix}+\alpha_2\begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix}+\alpha_3\begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix}$$

$$= 5\alpha_1 + 16\alpha_2 + 18\alpha_3 = +1$$

$$\alpha_1\tilde{s}_1\tilde{s}_1 + \alpha_2\tilde{s}_2\tilde{s}_1 + \alpha_3\tilde{s}_3\tilde{s}_1 = -1$$

$$\alpha_1\tilde{s}_1\tilde{s}_2 + \alpha_2\tilde{s}_2\tilde{s}_2 + \alpha_3\tilde{s}_3\tilde{s}_2 = +1$$

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Support Vector Machine – Solved Example

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$$= 2\alpha_1 + 5\alpha_2 + 5\alpha_3 = -1$$

$$\tilde{s}_1 = \begin{pmatrix}1\\0\\1\end{pmatrix}, \tilde{s}_2 = \begin{pmatrix}4\\1\\1\end{pmatrix}, \tilde{s}_3 = \begin{pmatrix}4\\-1\\1\end{pmatrix}$$

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$$\alpha_1\tilde{s}_1\tilde{s}_1 + \alpha_2\tilde{s}_2\tilde{s}_1 + \alpha_3\tilde{s}_3\tilde{s}_1 = -1$$
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$$=2\alpha_1+5\alpha_2+5\alpha_3=-1$$

$$\tilde{s}_1=\begin{pmatrix}1\\0\\1\end{pmatrix},\ \tilde{s}_2=\begin{pmatrix}4\\1\\1\end{pmatrix},\ \tilde{s}_3=\begin{pmatrix}4\\-1\\1\end{pmatrix}$$

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$$\alpha_1\tilde{s}_1\tilde{s}_1+\alpha_2\tilde{s}_2\tilde{s}_1+\alpha_3\tilde{s}_3\tilde{s}_1=-1$$
$$\alpha_1\tilde{s}_1\tilde{s}_2+\alpha_2\tilde{s}_2\tilde{s}_2+\alpha_3\tilde{s}_3\tilde{s}_2=+1$$
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$$=2\alpha_1+5\alpha_2+5\alpha_3=-1$$

$$\tilde{s}_1=\begin{pmatrix}1\\0\\1\end{pmatrix},\ \tilde{s}_2=\begin{pmatrix}4\\1\\1\end{pmatrix},\ \tilde{s}_3=\begin{pmatrix}4\\-1\\1\end{pmatrix}$$

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$$\alpha_1\tilde{s}_1\tilde{s}_2+\alpha_2\tilde{s}_2\tilde{s}_2+\alpha_3\tilde{s}_3\tilde{s}_2=+1$$

$$\alpha_1\tilde{s}_1\tilde{s}_3+\alpha_2\tilde{s}_2\tilde{s}_3+\alpha_3\tilde{s}_3\tilde{s}_3=+1$$

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$$= 2\alpha_1 + 5\alpha_2 + 5\alpha_3 = -1$$

$$\tilde{s}_1 = \begin{pmatrix}1\\0\\1\end{pmatrix}, \tilde{s}_2 = \begin{pmatrix}4\\1\\1\end{pmatrix}, \tilde{s}_3 = \begin{pmatrix}4\\-1\\1\end{pmatrix}$$

$$\alpha_1 \begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix} + \alpha_2 \begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix} + \alpha_3 \begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix}$$

$$= 5\alpha_1 + 18\alpha_2 + 16\alpha_3 = +1$$

$$\alpha_1 \begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix} + \alpha_2 \begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix} + \alpha_3 \begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix}$$

$$= 5\alpha_1 + 16\alpha_2 + 18\alpha_3 = +1$$

$$\alpha_1 \tilde{s}_1 \tilde{s}_1 + \alpha_2 \tilde{s}_2 \tilde{s}_1 + \alpha_3 \tilde{s}_3 \tilde{s}_1 = -1$$
$$\alpha_1 \tilde{s}_1 \tilde{s}_2 + \alpha_2 \tilde{s}_2 \tilde{s}_2 + \alpha_3 \tilde{s}_3 \tilde{s}_2 = +1$$
$$\alpha_1 \tilde{s}_1 \tilde{s}_3 + \alpha_2 \tilde{s}_2 \tilde{s}_3 + \alpha_3 \tilde{s}_3 \tilde{s}_3 = +1$$

Support Vector Machine – Solved Example

$$\alpha_1\begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}+\alpha_2\begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}+\alpha_3\begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}$$

$$=\underline{2\alpha_1}+\underline{5\alpha_2}+\underline{5\alpha_3}=\underline{-1}$$

$$\tilde{s}_1=\begin{pmatrix}1\\0\\1\end{pmatrix},\ \tilde{s}_2=\begin{pmatrix}4\\1\\1\end{pmatrix},\ \tilde{s}_3=\begin{pmatrix}4\\-1\\1\end{pmatrix}$$

$$\alpha_1\begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix}+\alpha_2\begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix}+\alpha_3\begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}4\\1\\1\end{pmatrix}$$

$$=\underline{5\alpha_1}+\underline{18\alpha_2}+\underline{16\alpha_3}=+1 \checkmark$$

$$\alpha_1\begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix}+\alpha_2\begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix}+\alpha_3\begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}4\\-1\\1\end{pmatrix}$$

$$\underline{=5\alpha_1+16\alpha_2+18\alpha_3=+1}$$

$$\alpha_1\tilde{s}_1\tilde{s}_1+\alpha_2\tilde{s}_2\tilde{s}_1+\alpha_3\tilde{s}_3\tilde{s}_1=-1$$
$$\alpha_1\underline{\tilde{s}_1\tilde{s}_2}+\alpha_2\tilde{s}_2\tilde{s}_2+\alpha_3\tilde{s}_3\tilde{s}_2=+1$$
$$\alpha_1\tilde{s}_1\tilde{s}_3+\alpha_2\tilde{s}_2\tilde{s}_3+\alpha_3\tilde{s}_3\tilde{s}_3=+1$$

Support Vector Machine – Solved Example

$$\alpha_1 \begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix} + \alpha_2 \begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix} + \alpha_3 \begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}$$

$$= 2\alpha_1 + 5\alpha_2 + 5\alpha_3 = -1$$

$$\tilde{s}_1 = \begin{pmatrix}1\\0\\1\end{pmatrix},\ \tilde{s}_2 = \begin{pmatrix}4\\1\\1\end{pmatrix},\ \tilde{s}_3 = \begin{pmatrix}4\\-1\\1\end{pmatrix}$$

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$$\alpha_1\tilde{s}_1\tilde{s}_1 + \alpha_2\tilde{s}_2\tilde{s}_1 + \alpha_3\tilde{s}_3\tilde{s}_1 = -1$$
$$\alpha_1\tilde{s}_1\tilde{s}_2 + \alpha_2\tilde{s}_2\tilde{s}_2 + \alpha_3\tilde{s}_3\tilde{s}_2 = +1$$
$$\alpha_1\tilde{s}_1\tilde{s}_3 + \alpha_2\tilde{s}_2\tilde{s}_3 + \alpha_3\tilde{s}_3\tilde{s}_3 = +1$$

Support Vector Machine – Solved Example

$$\alpha_1 \begin{pmatrix}1\\0\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix} + \alpha_2 \begin{pmatrix}4\\1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix} + \alpha_3 \begin{pmatrix}4\\-1\\1\end{pmatrix}\begin{pmatrix}1\\0\\1\end{pmatrix}$$

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Solving these three simultaneous equations with three unknowns yields the values:

$$\alpha_1 = -3$$

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Support Vector Machine – Solved Example

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Support Vector Machine – Solved Example

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Support Vector Machine – Solved Example

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Support Vector Machine – Solved Example

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Support Vector Machine – Solved Example

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Support Vector Machine – Solved Example

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Support Vector Machine – Solved Example

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Support Vector Machine – Solved Example

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Support Vector Machine – Solved Example

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$$= -3 \times \begin{pmatrix}1\\0\\1\end{pmatrix} + 1 \times \begin{pmatrix}4\\1\\1\end{pmatrix} + 0 \times \begin{pmatrix}4\\-1\\1\end{pmatrix} = \begin{pmatrix}1\\1\\-2\end{pmatrix}$$

Support Vector Machine – Solved Example

The hyperplane is (1, 1) with an offset -2.

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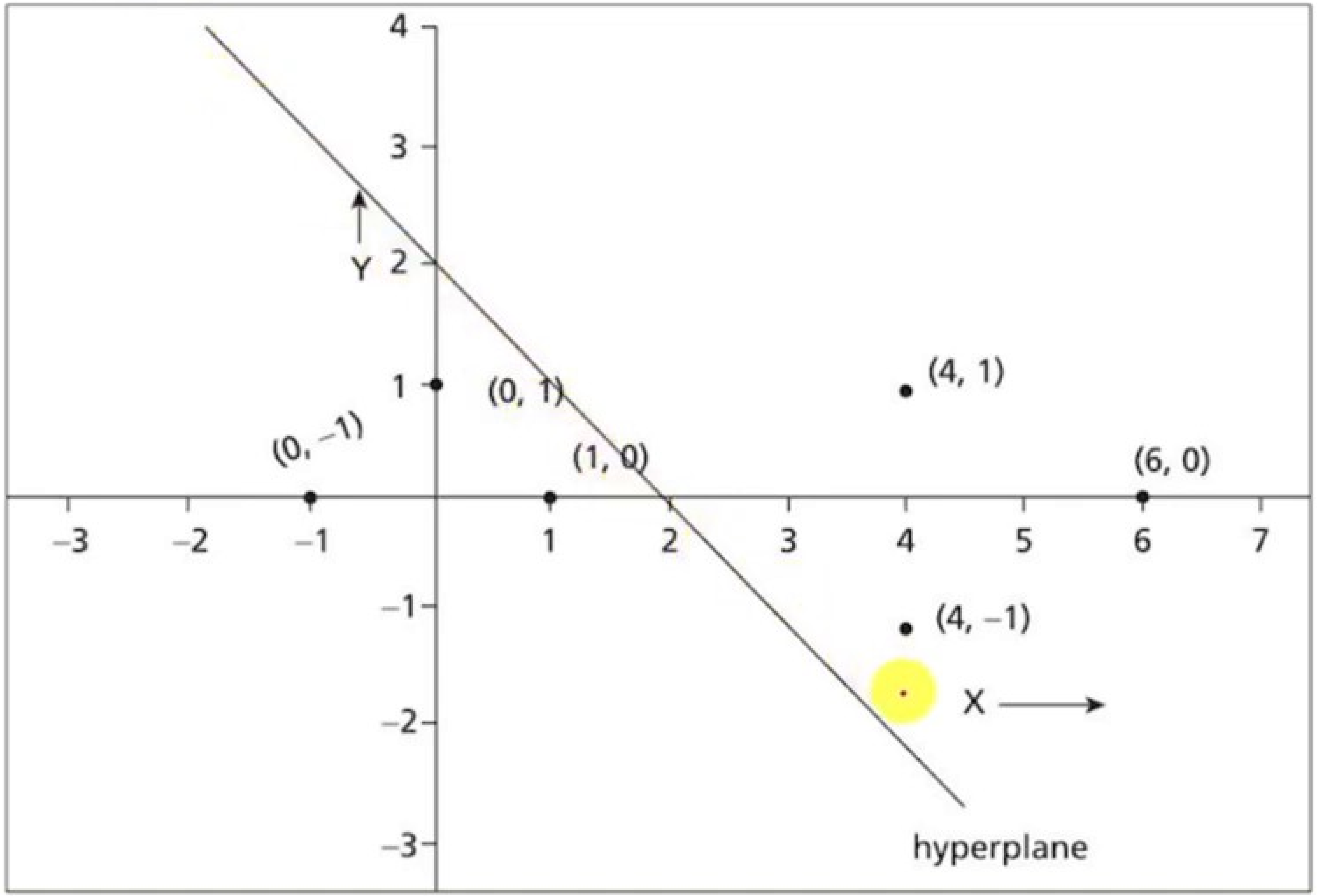

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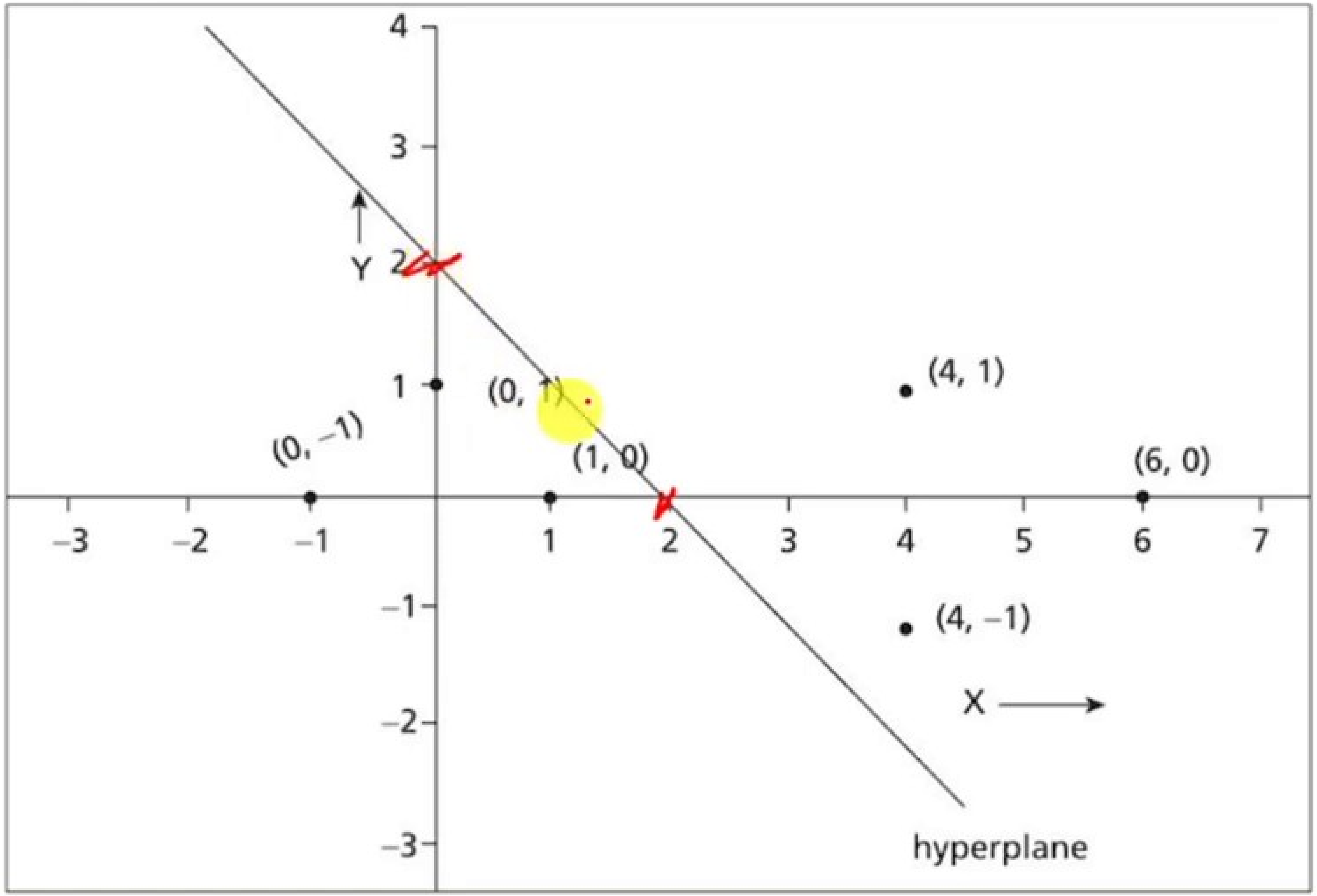

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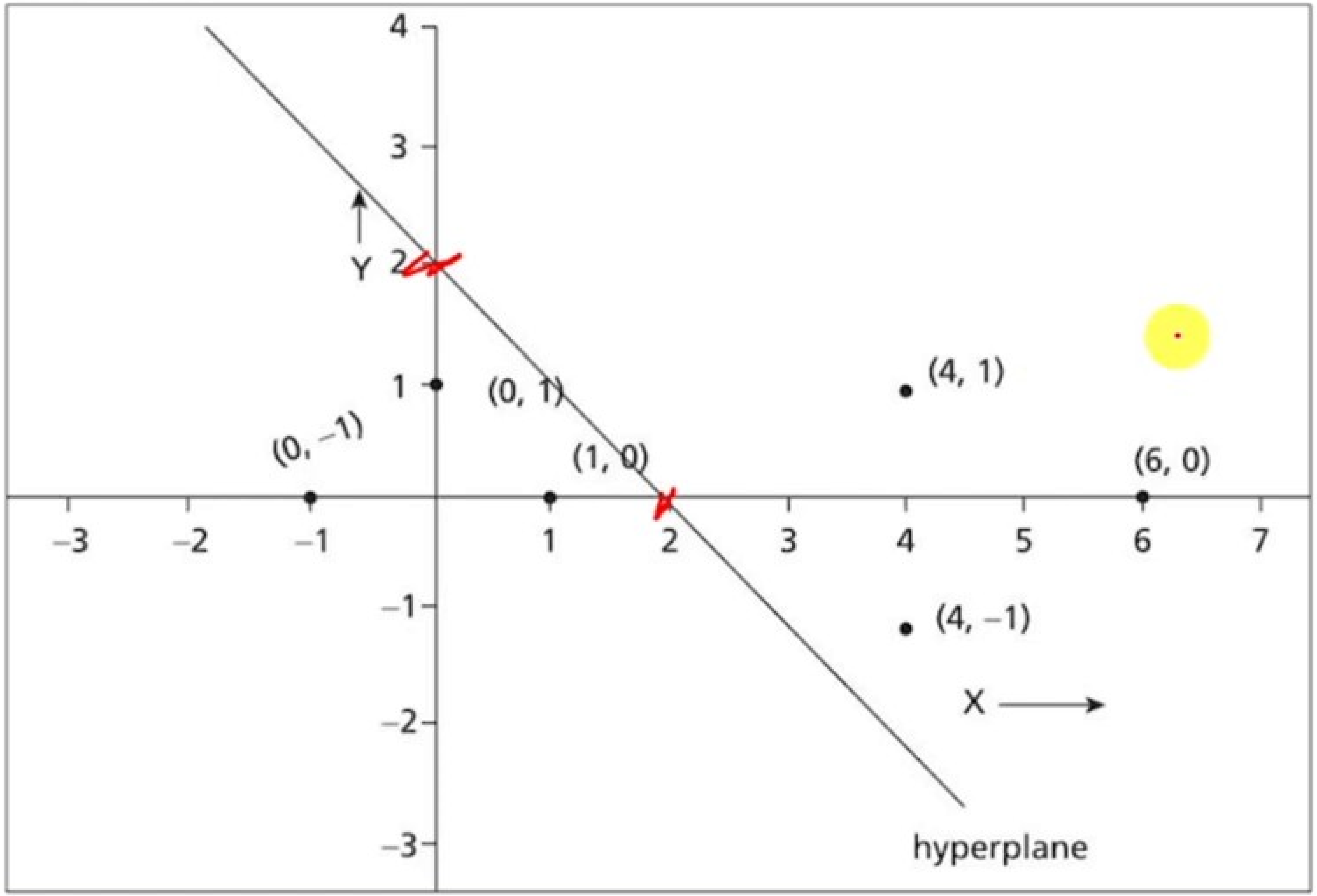

(1, 0)

Support Vector Machine – Solved Example

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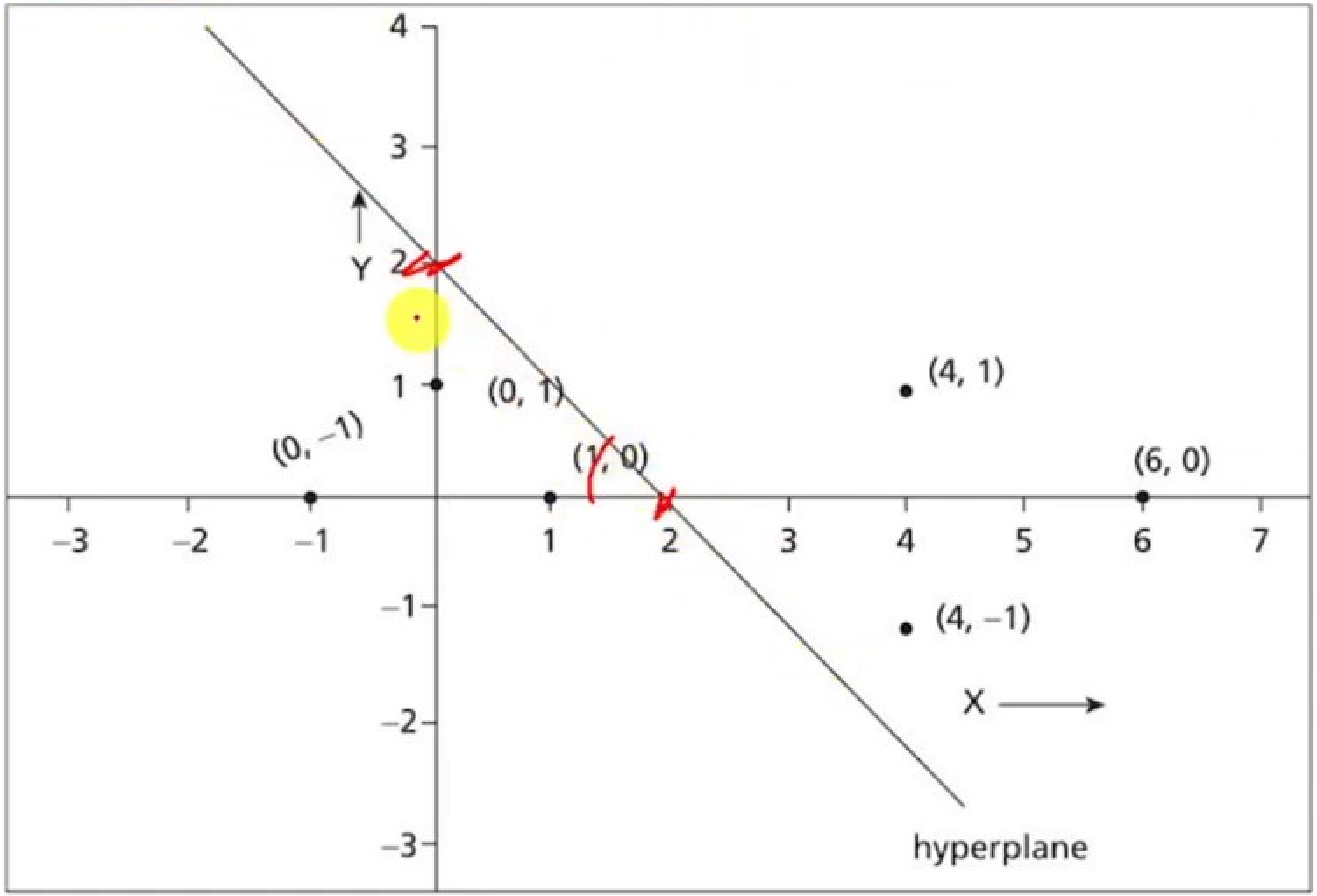

(1, 0)

(0, 1)

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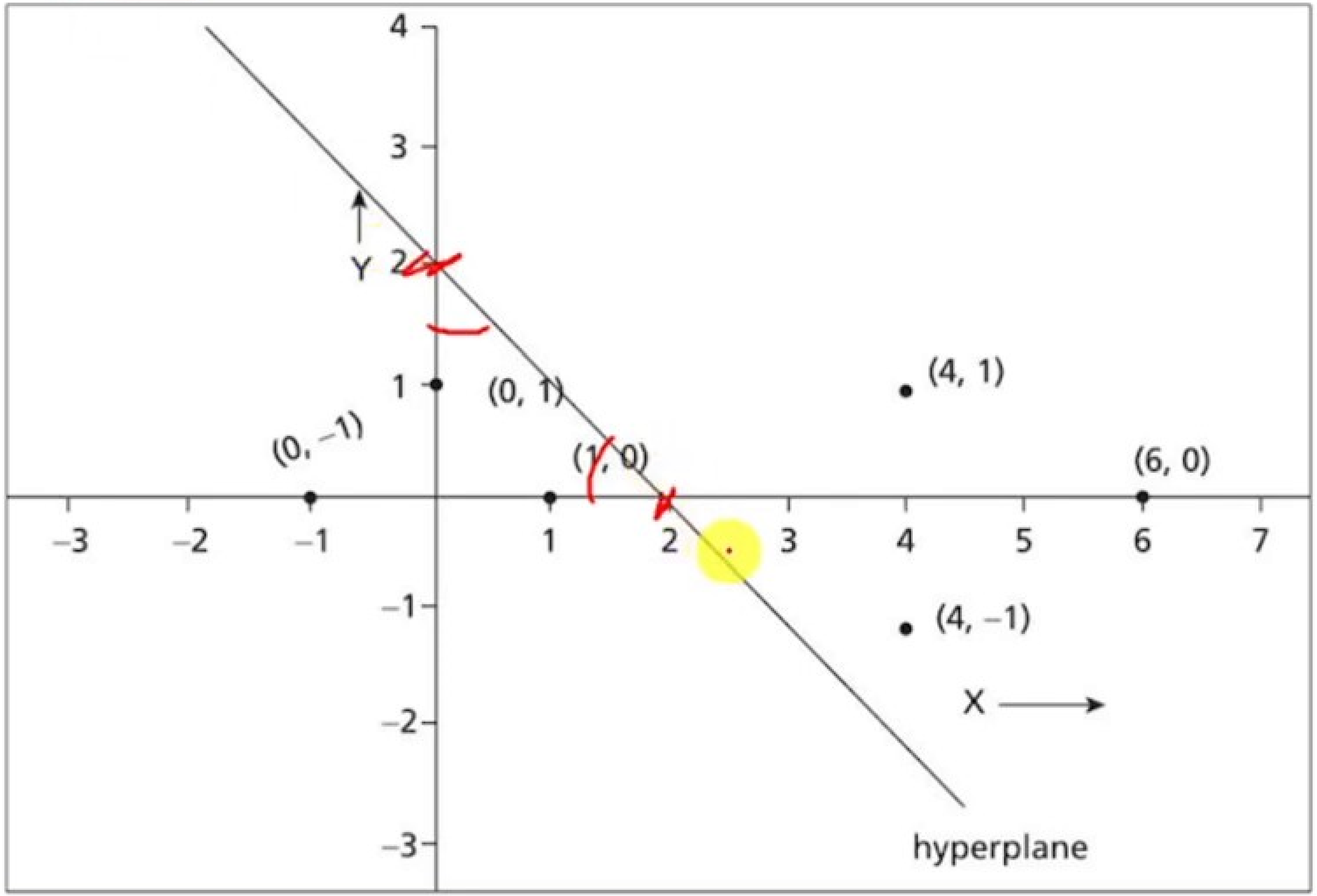

(1, 0)
(0, 1)

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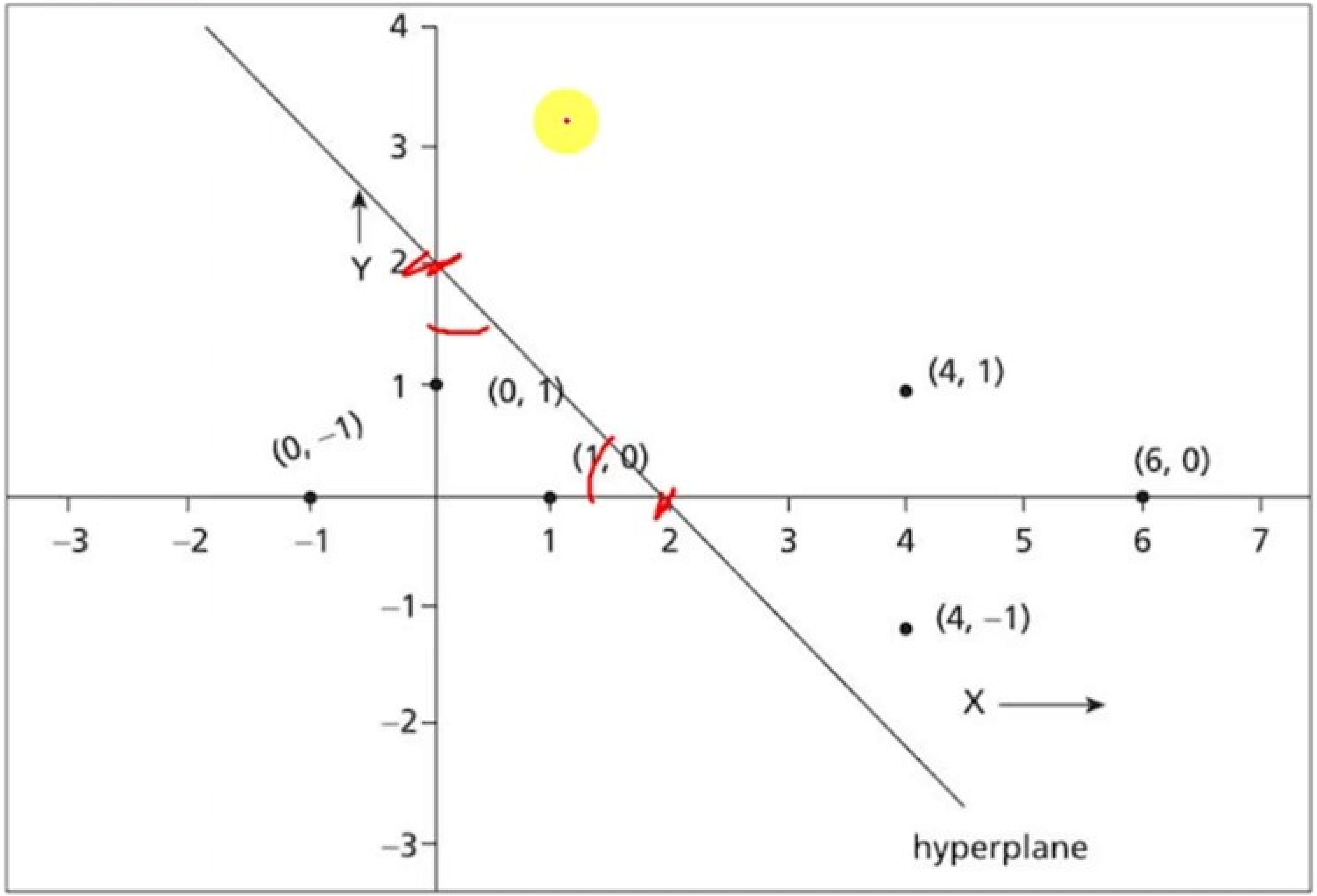

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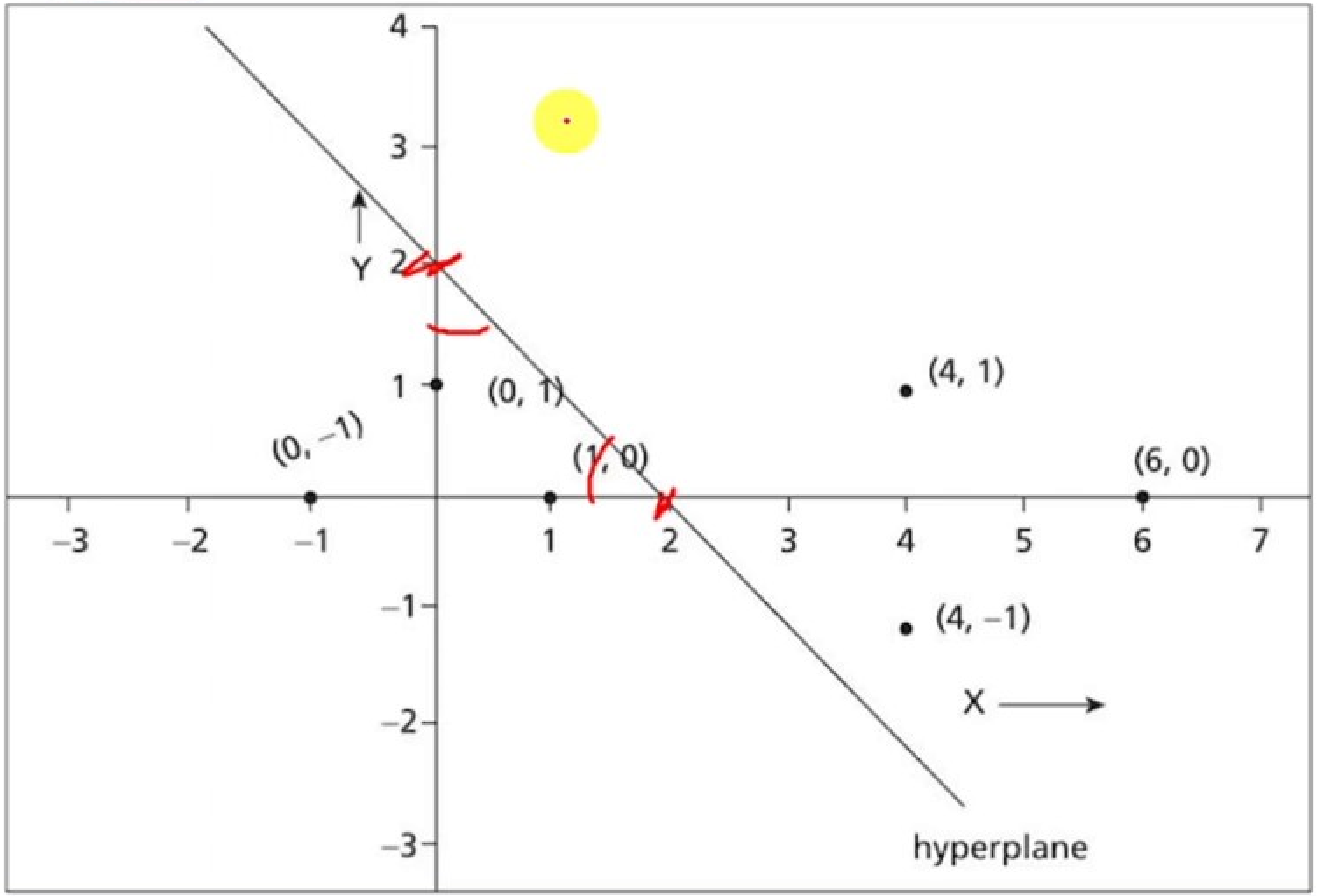

(1, 0)
(0, 1)