Machine Learning for Robotics

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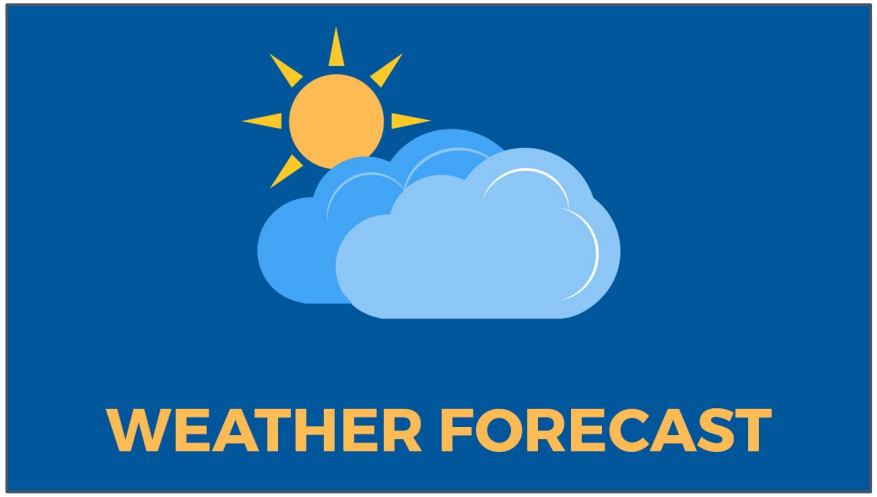
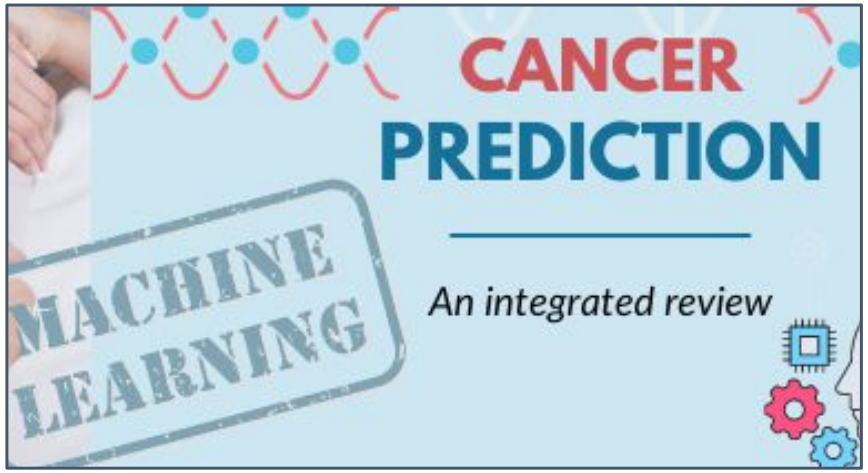
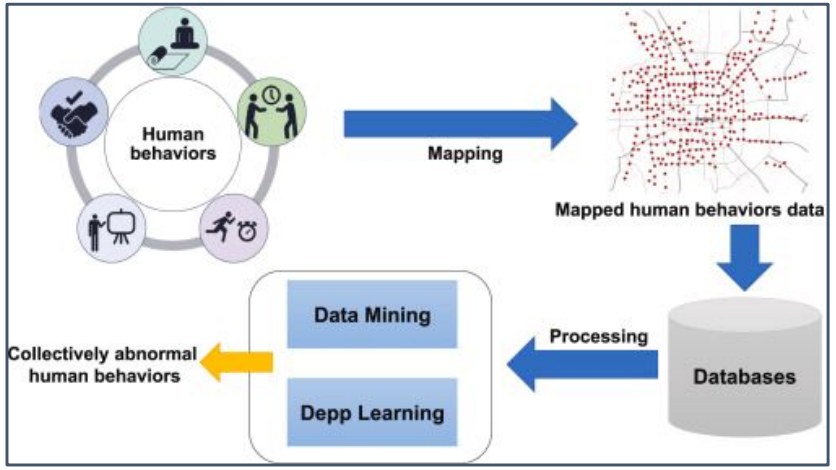
Class 01- Introduction to Machine Learning

Machine Learning

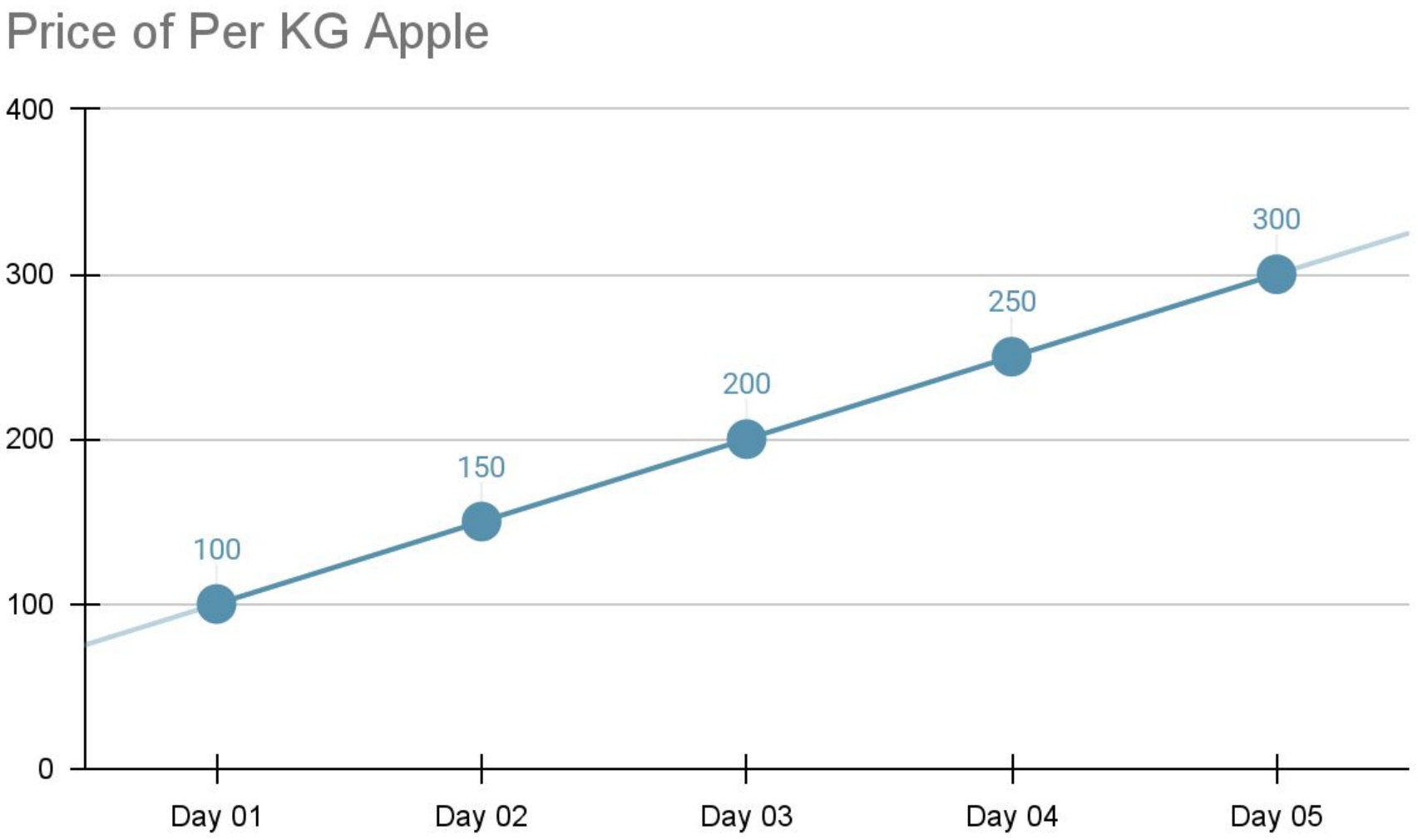
Machine Learning is all about **prediction**.







Machine Learning



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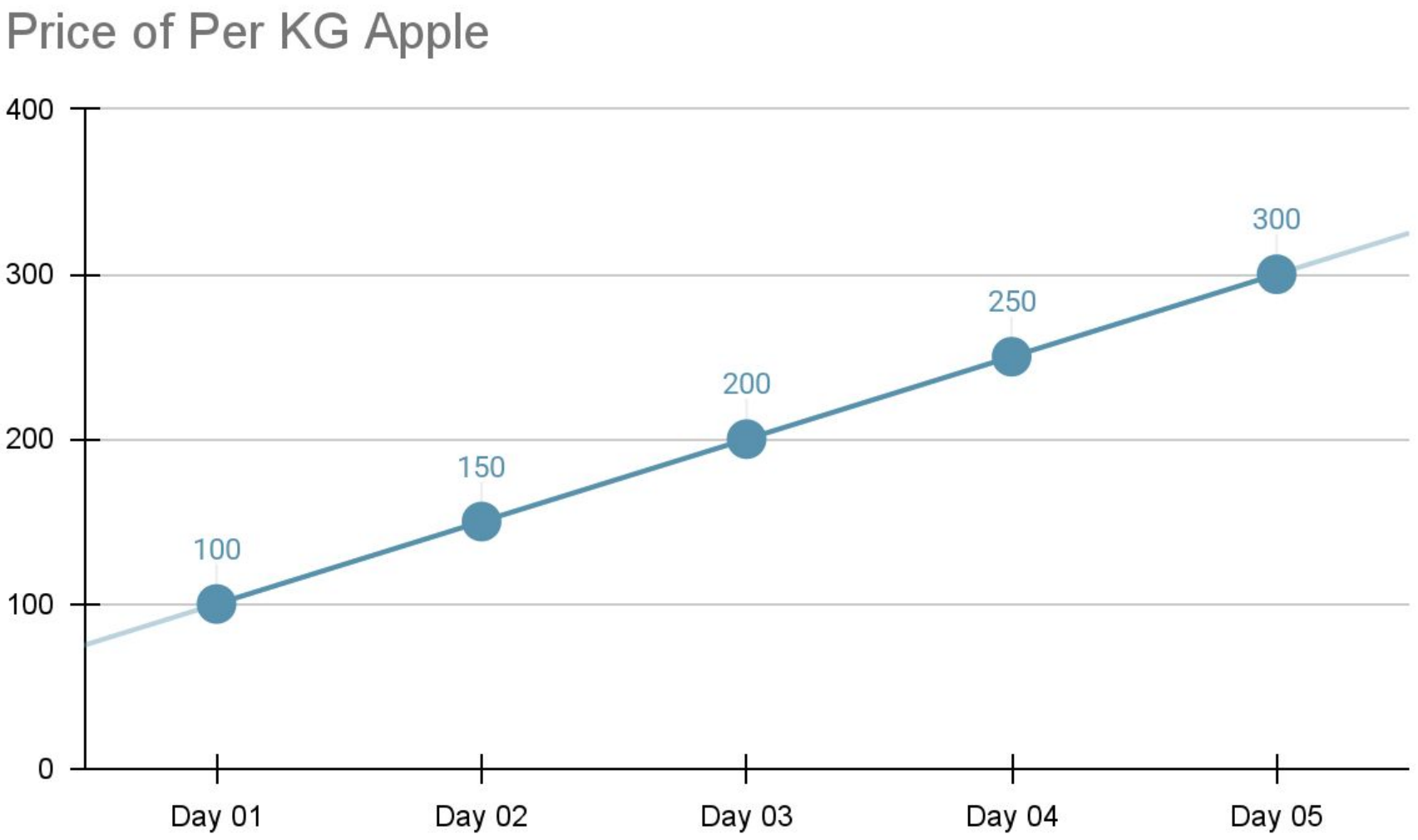
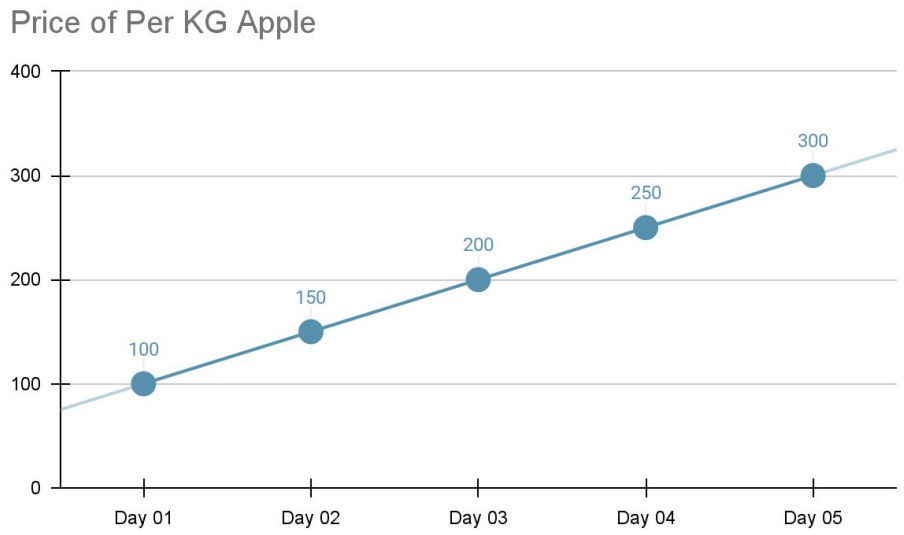


What will be the price of Apple at Day 06?

Machine Learning

To calculate the price of Day - 6,

- we can use **y = m.x + b** formula (ideal equation of a straight line)
- we know that **x = 6 (day)** and we need to calculate **y (price)**
- but, first we need to figure out the value of **m (slope)** and **b (intercept)**



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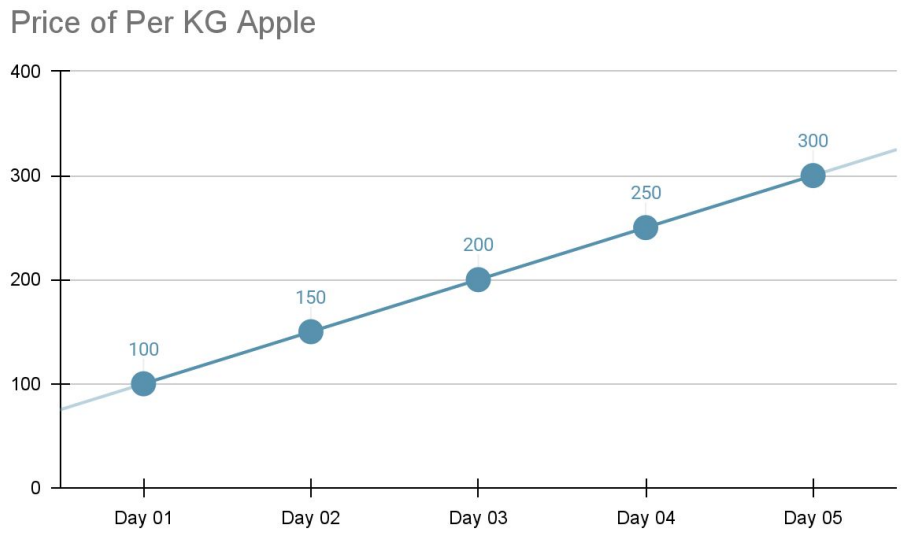
To calculate the value of m, c:

- We know if two points (x1, y1) and (x2, y2) are given, then we can use

  m = (y2 - y1) / (x2 - x1)

  b = y1 - m.x1



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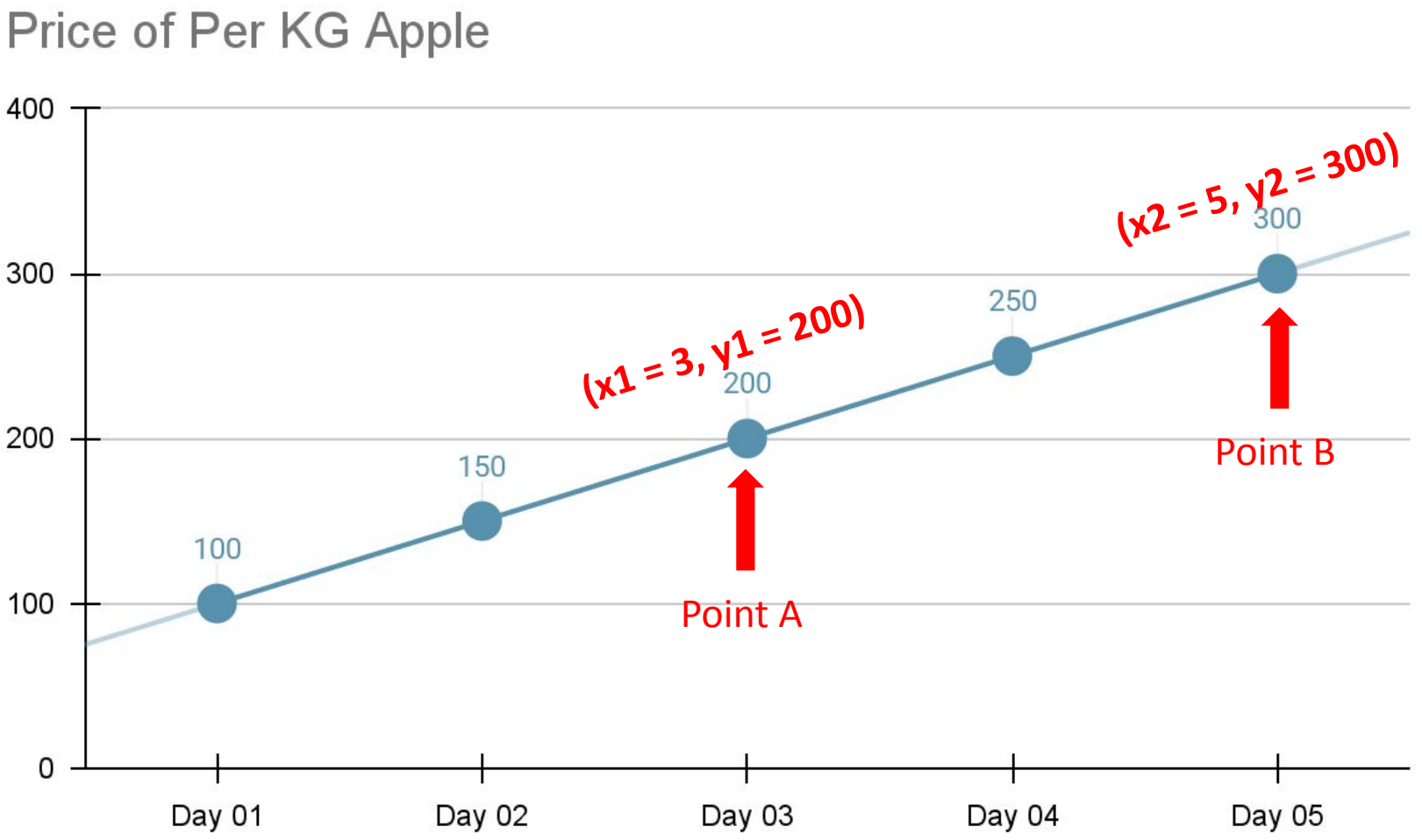
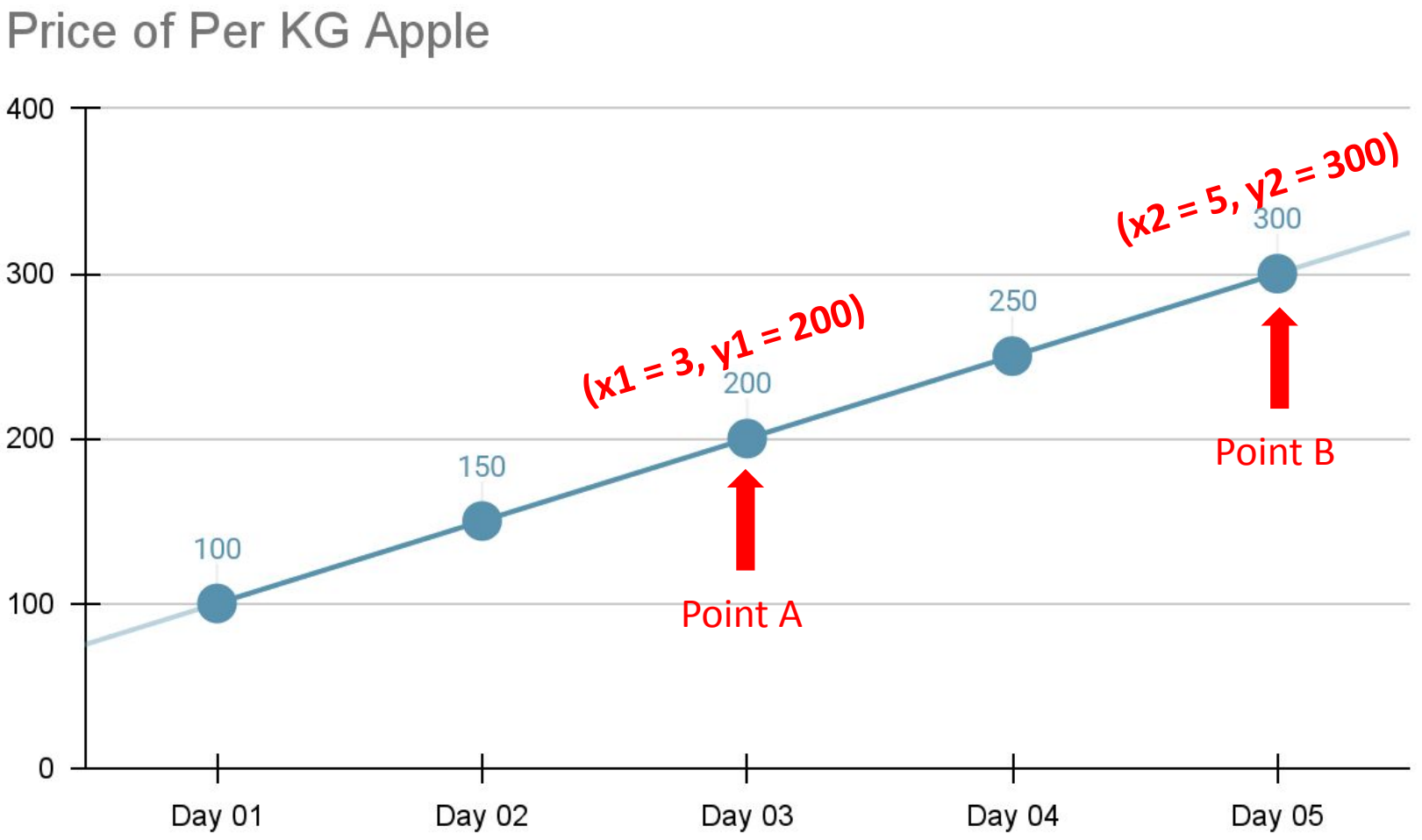


Machine Learning

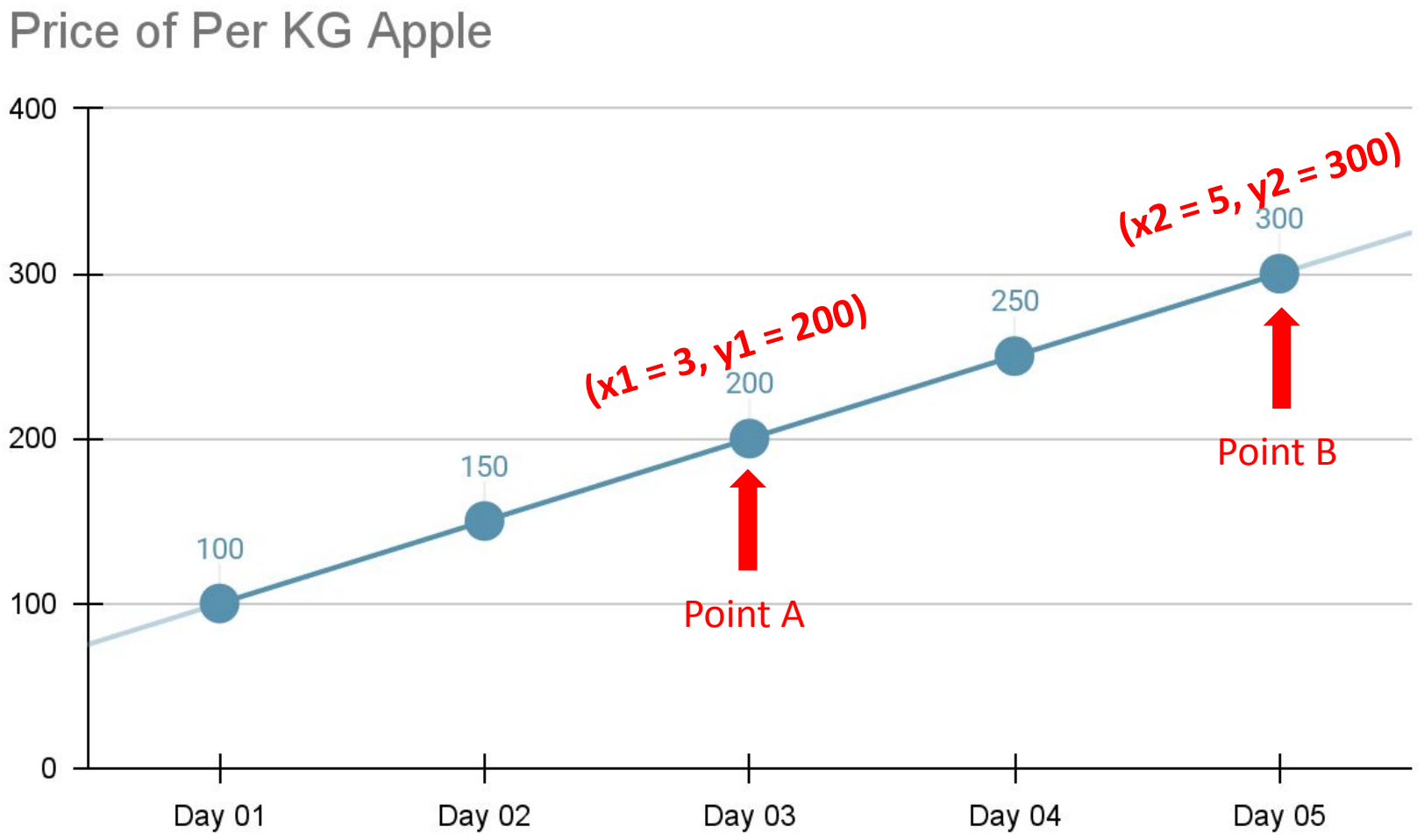
m = (y2 - y1) / (x2 - x1)
m = (300 - 200) / (5 - 2)
m = 50



Machine Learning

m = (y2 - y1) / (x2 - x1)
m = (300 - 200) / (5 - 2)
m = 50

b = y1 - m.x1
b = 200 - 50.3
b = 150



Machine Learning

So, x = 6 (day), m = 50 (slope), b = 50 (intercept)
Our Equation: y = m.x + b

Machine Learning

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Machine Learning

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The price of apple on Day 06 is 350 tk

Machine Learning

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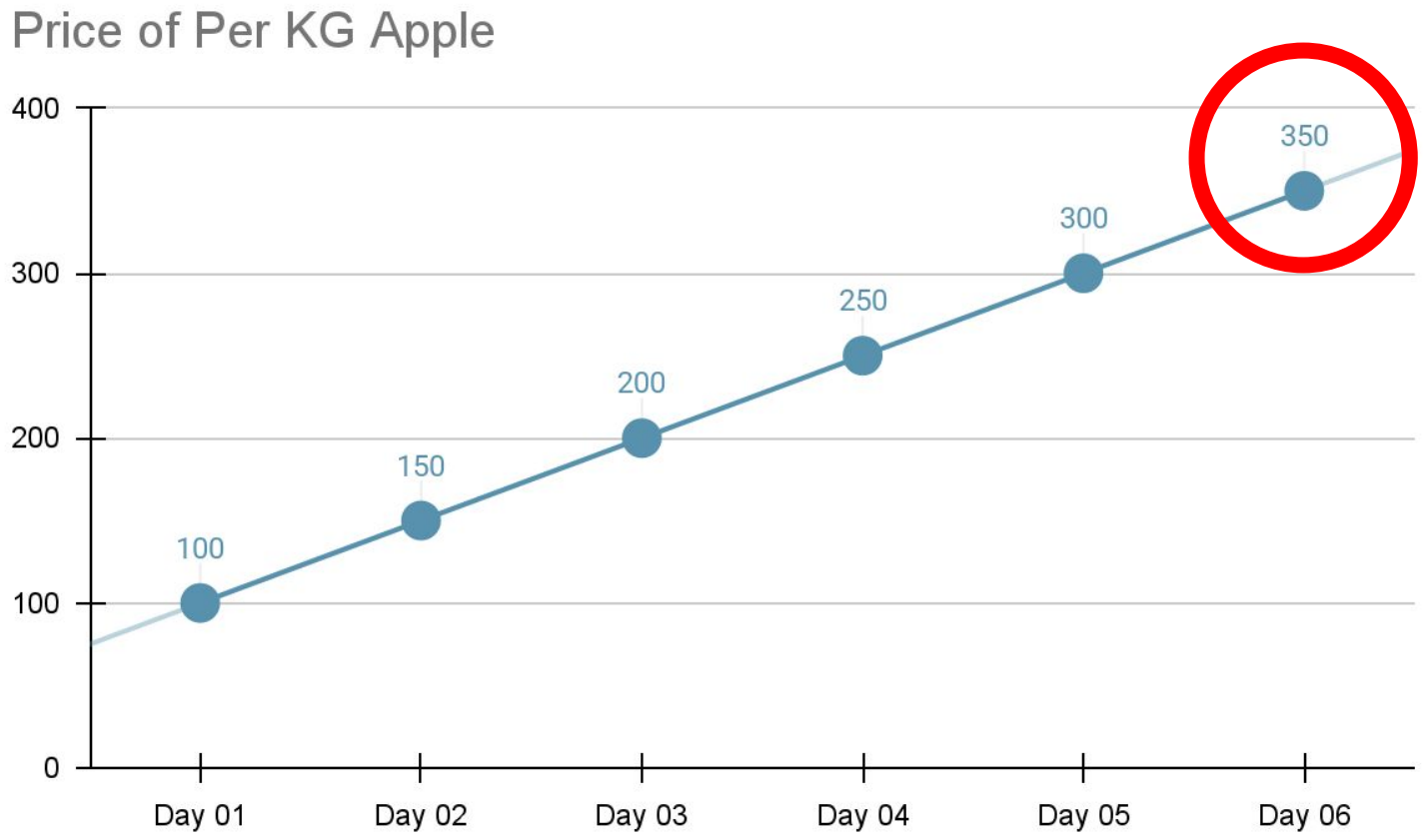

Machine Learning

Now, We can predict the price of Apple for any DAY!!!

Machine Learning

Let's predict the price of Mango!!!

Machine Learning

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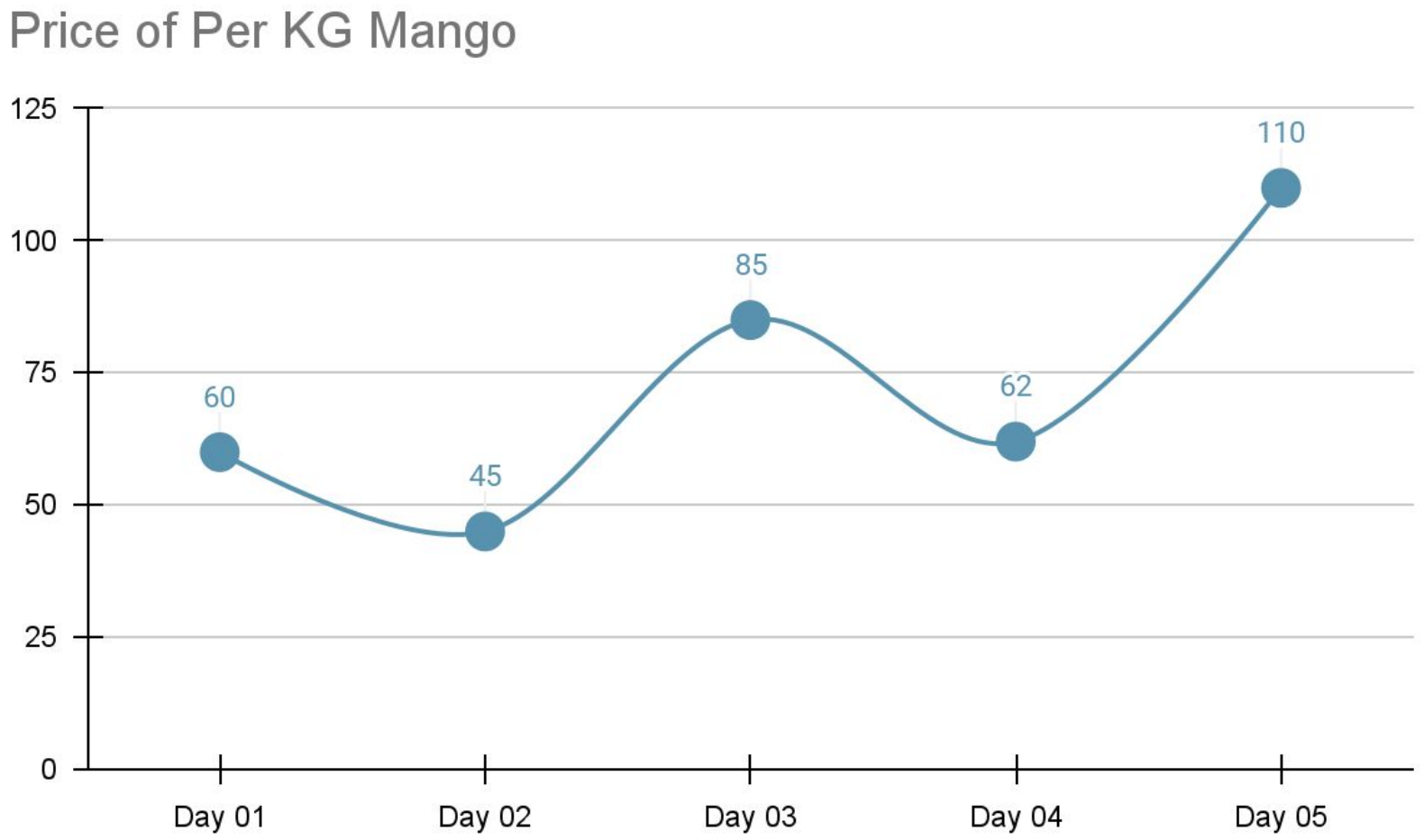

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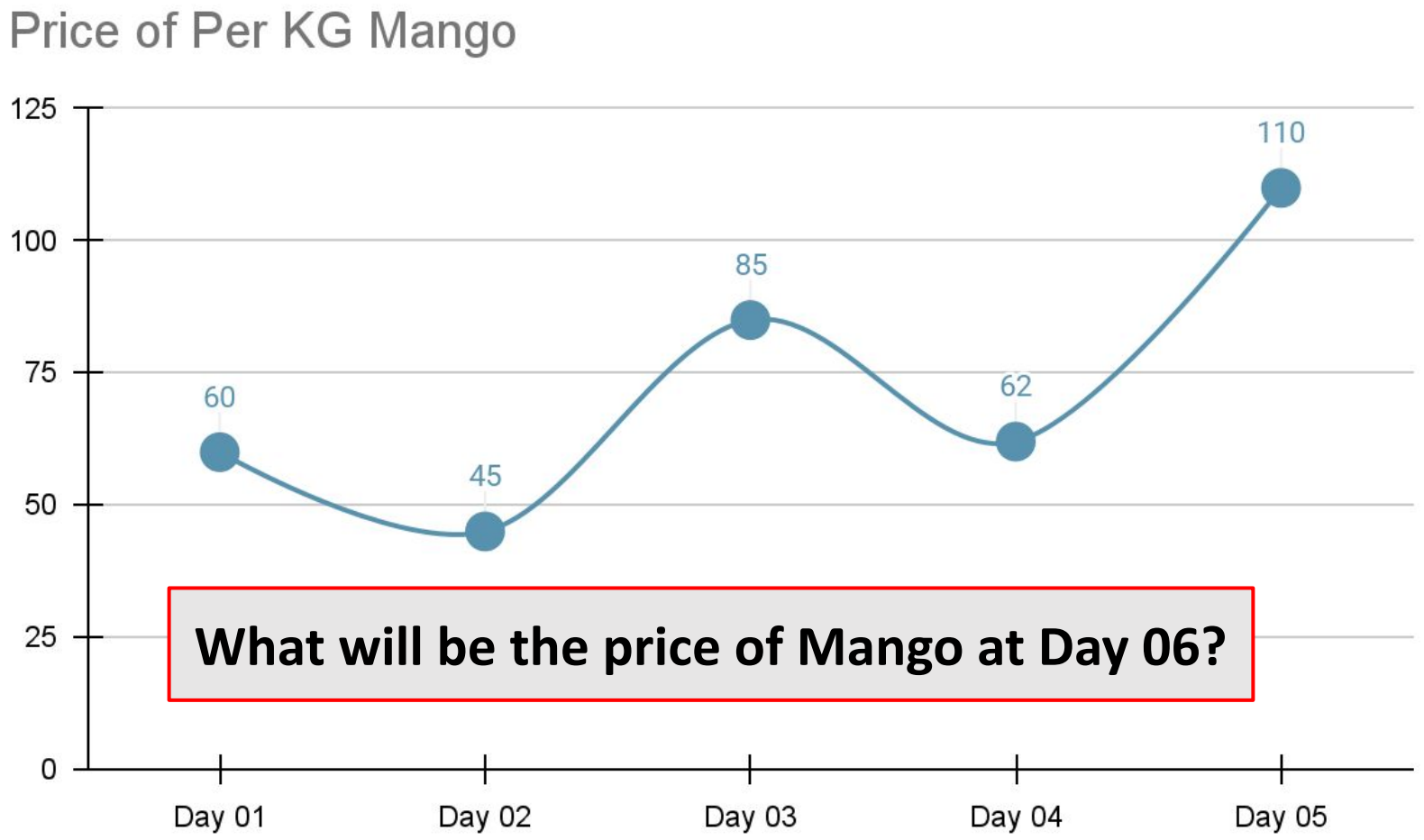
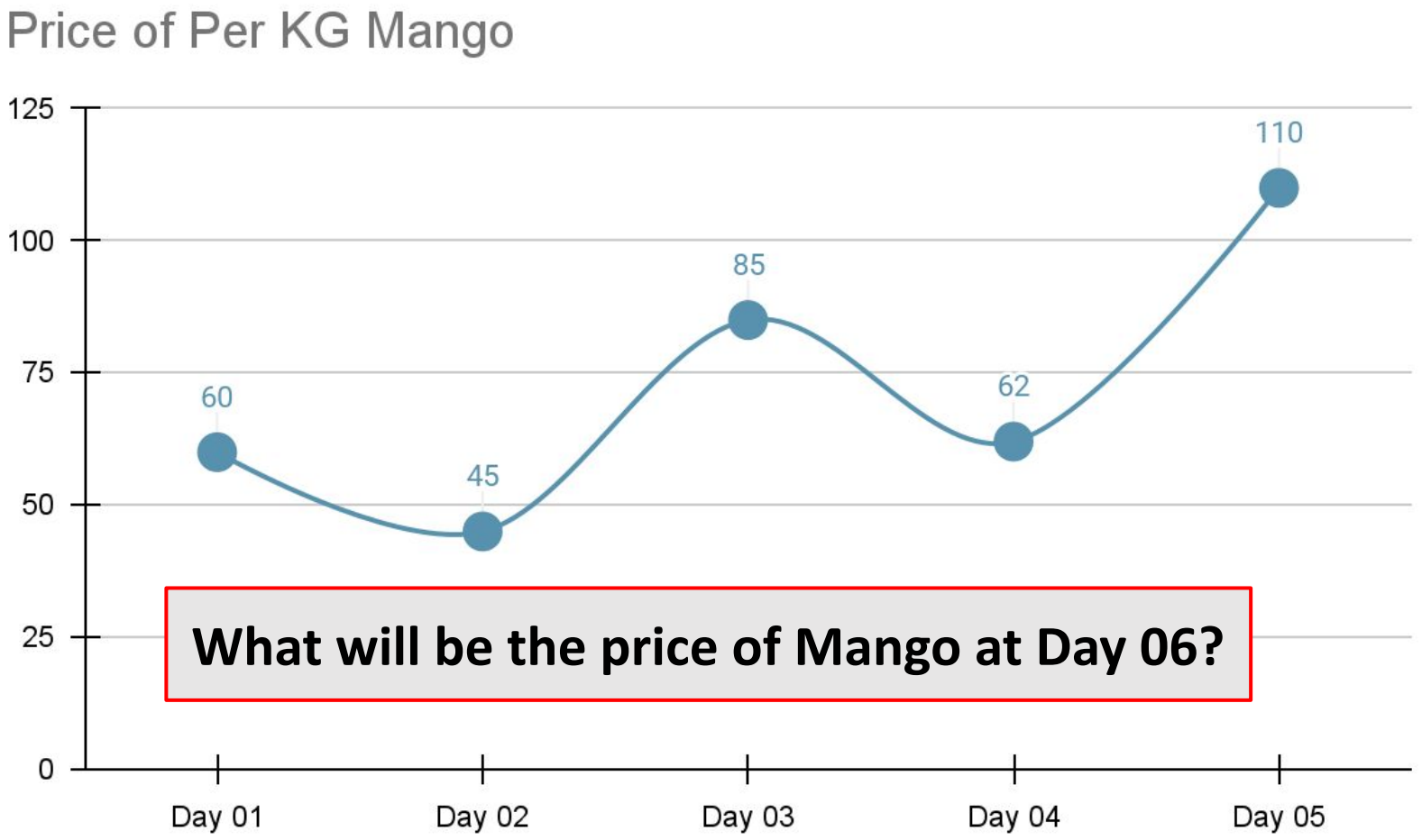


Machine Learning

Let's analyse the data from graph!



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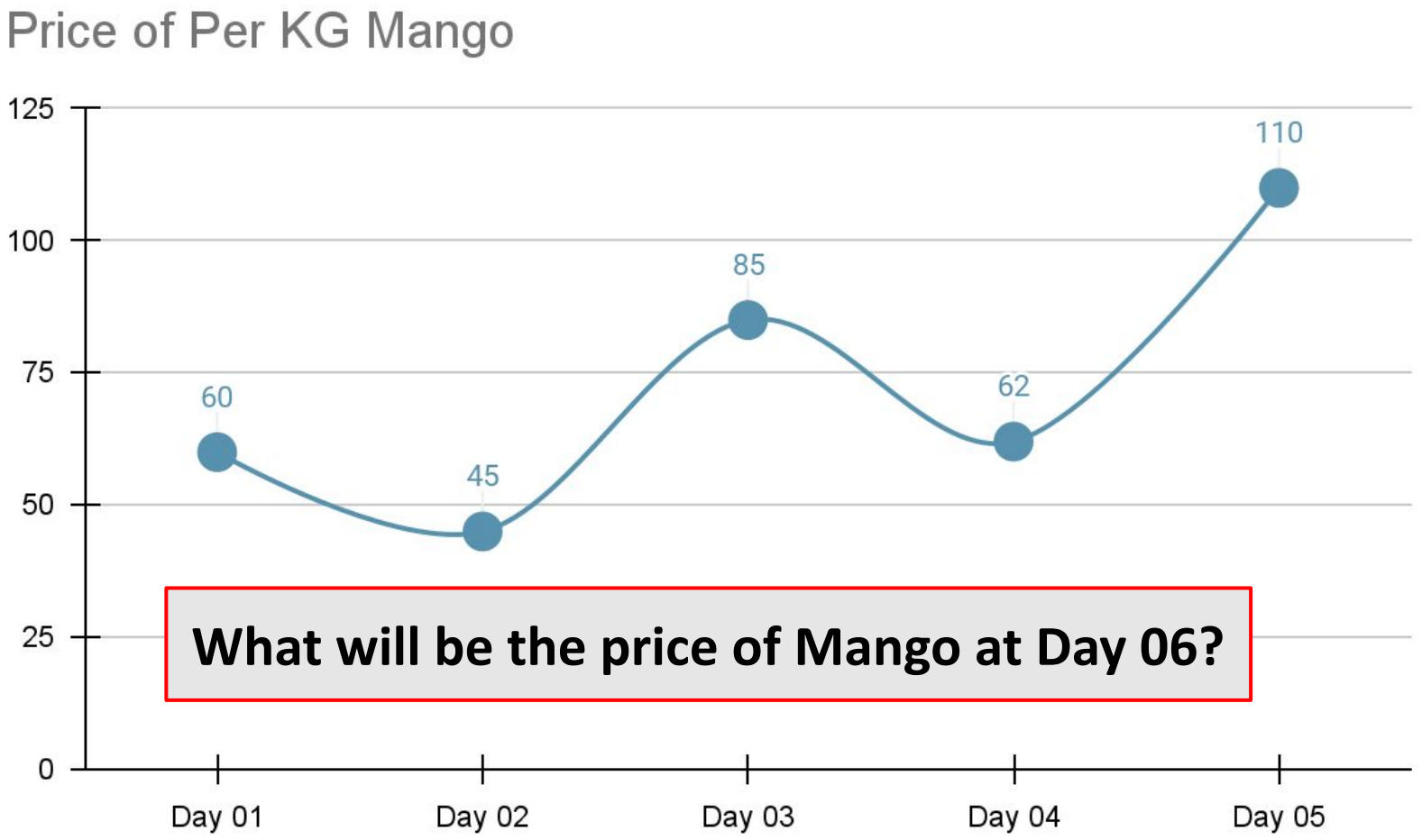
Let's analyse the data from graph!

- The data points are not on a straight line.



Machine Learning

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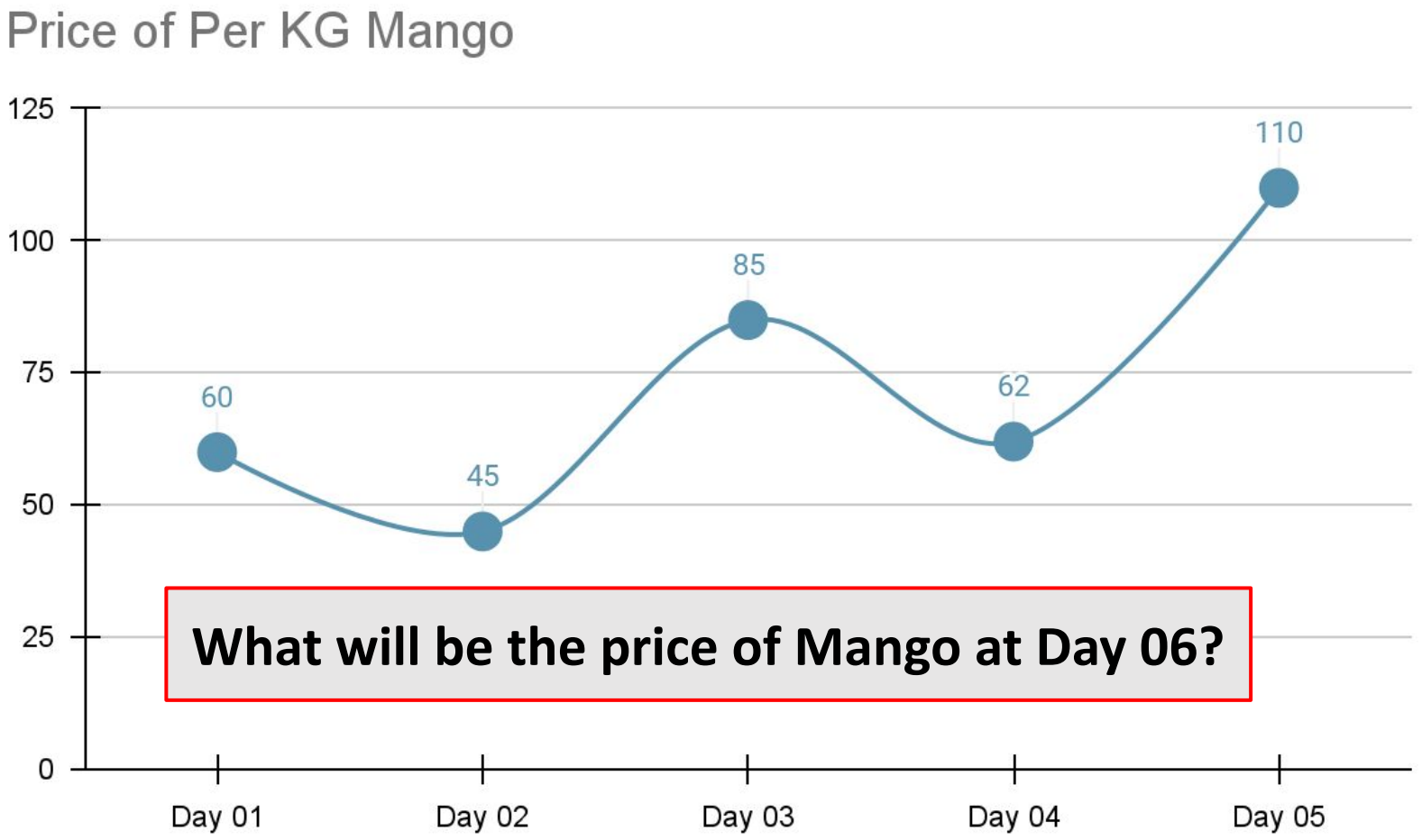
- The data points are not on a straight line.
- The data points do not have a straightforward linear relationship.



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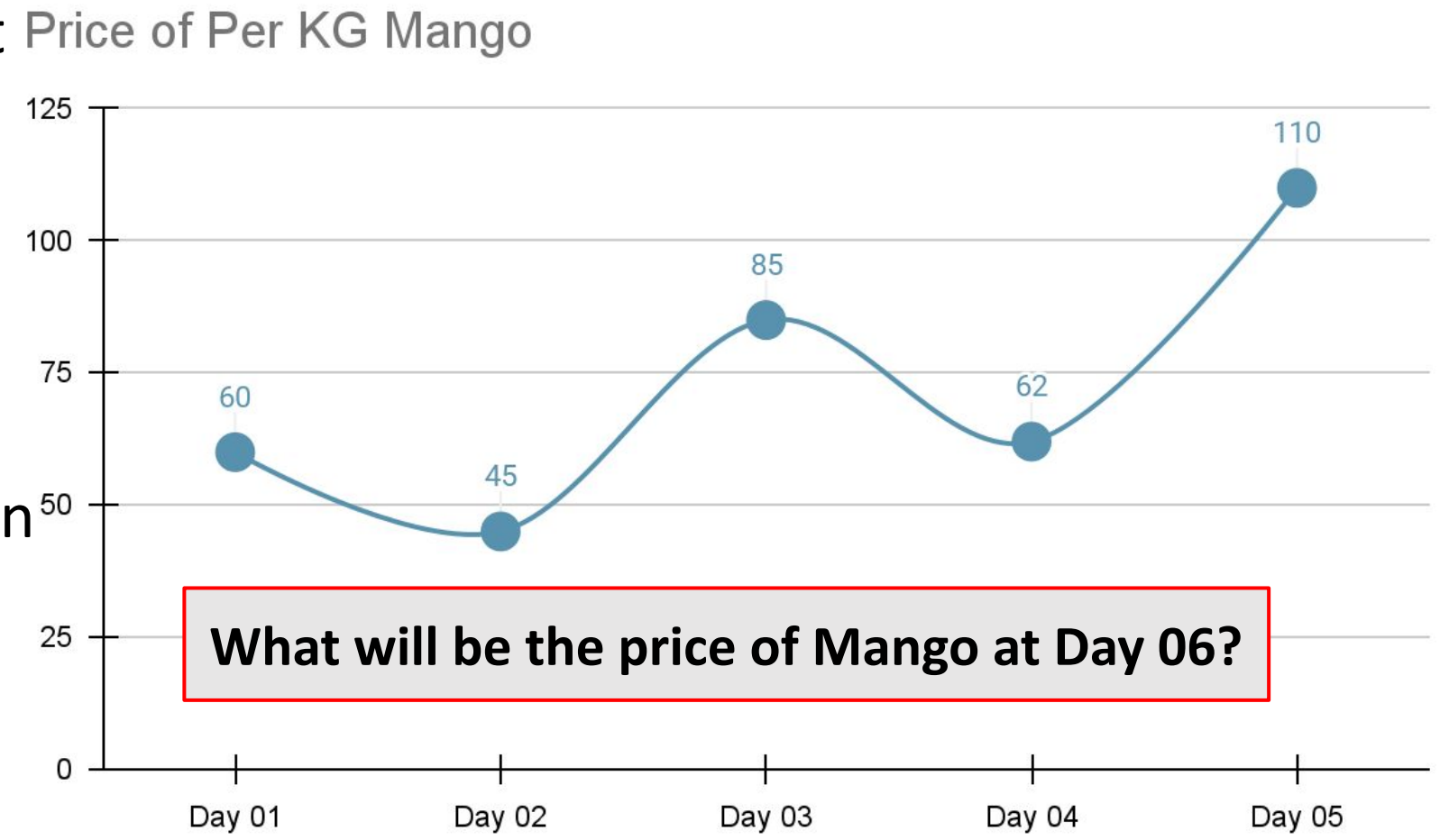
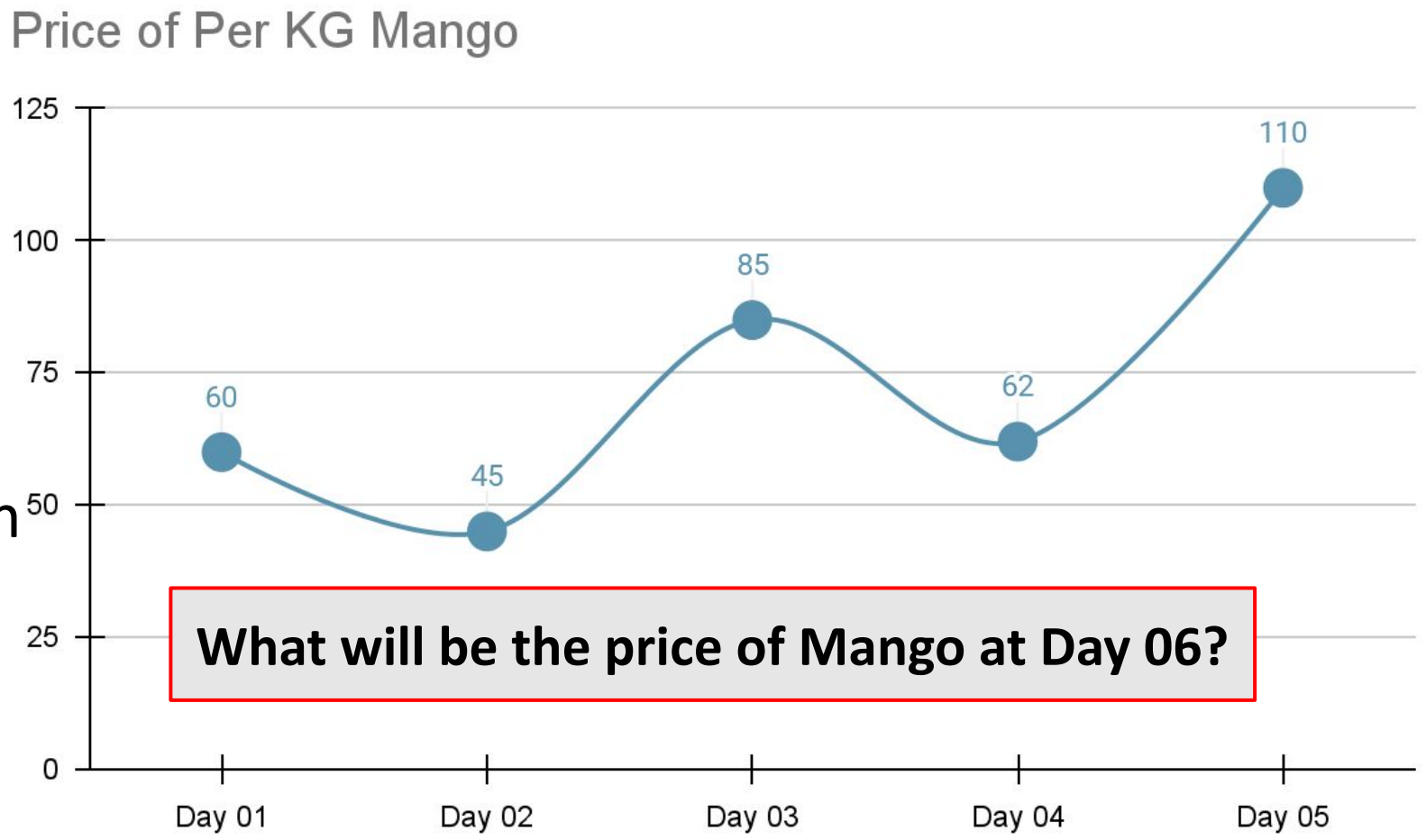
- So, we need to find a Linear Relation between the data points.



Machine Learning

Let's analyse the data from graph!

- The data points are not on a straight line.
- The data points do not have a straightforward linear relationship.
- So, we need to find a Linear Relation between the data points.
- Can you tell what is our main purpose in ML?



Machine Learning

Remember, Our main goal is to predict (guess) the value, not calculate the actual value.

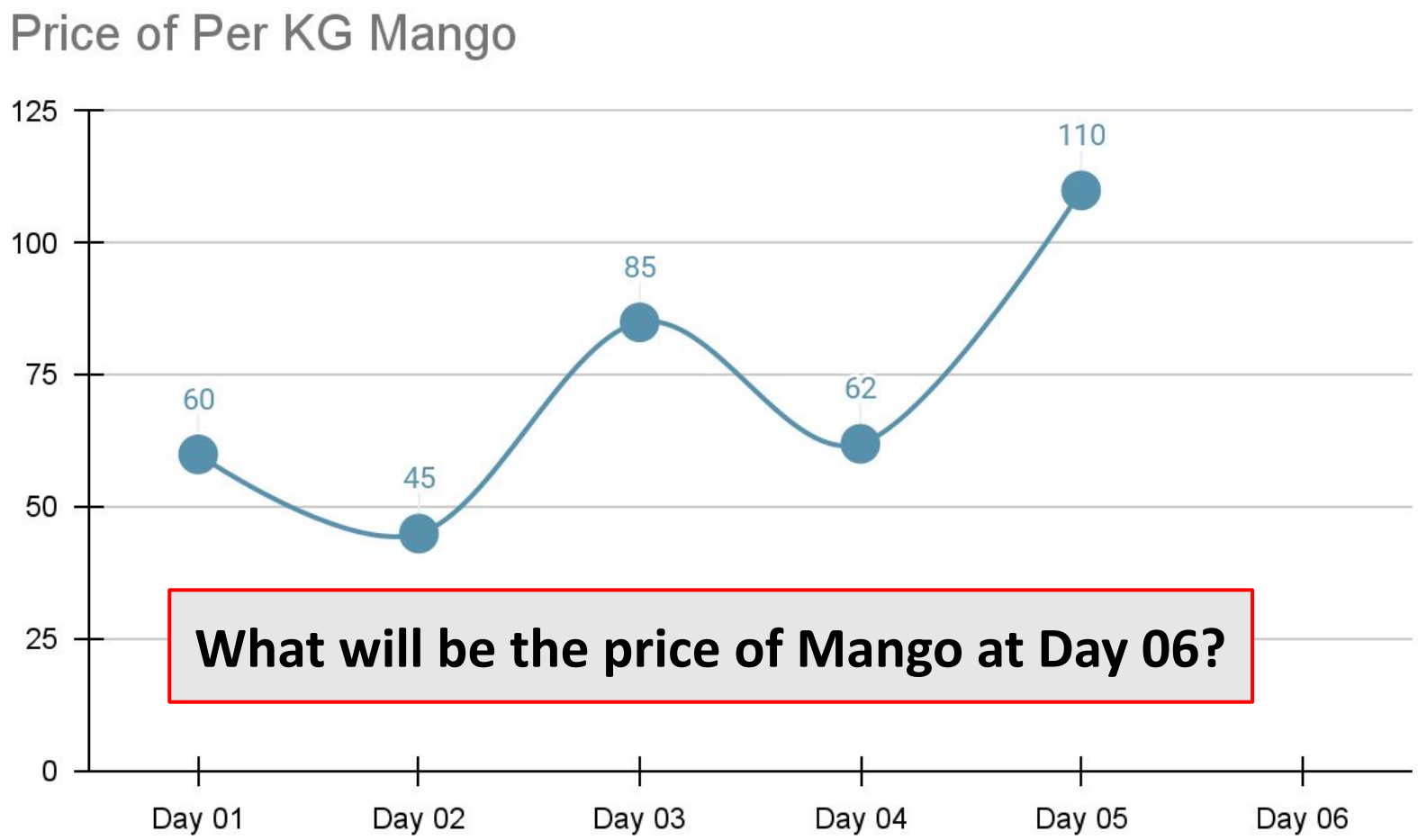
Machine Learning

Remember, Our main goal is to predict (guess) the value, not calculate the actual value.

When we guess something, there is always room for error.

Machine Learning

Can we guess the price for day - 6?



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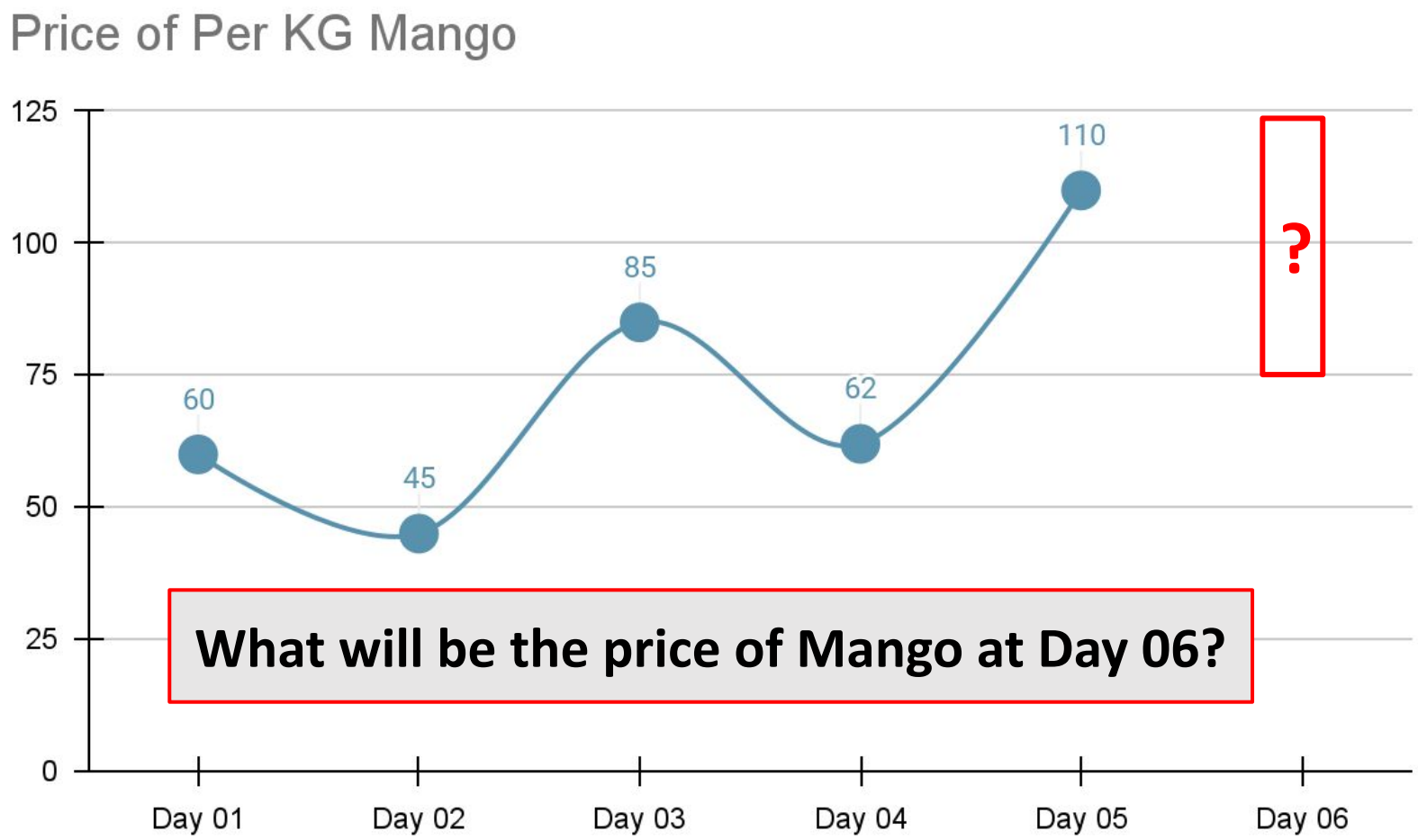
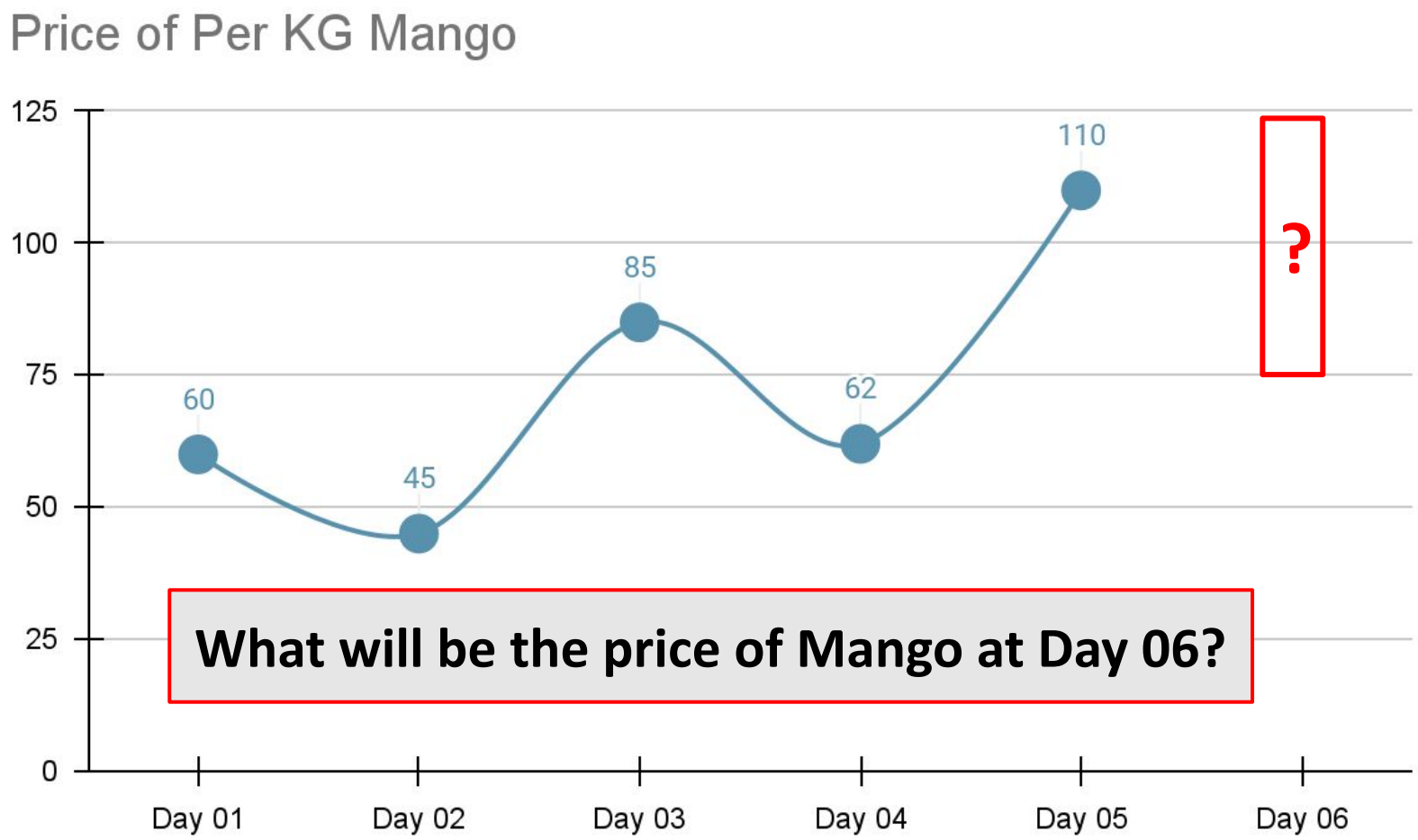


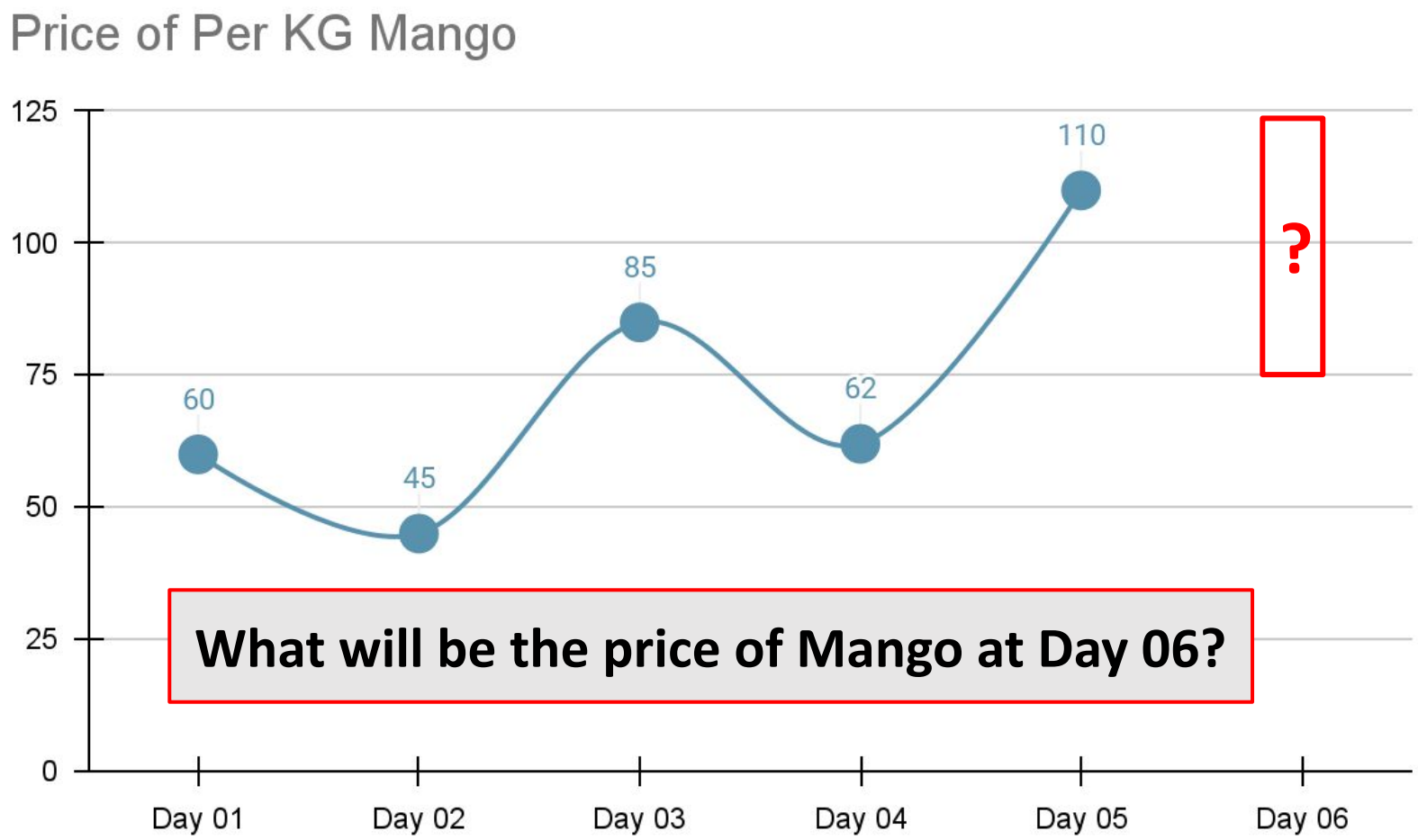
Machine Learning

Price should be between 75 to 120 tk



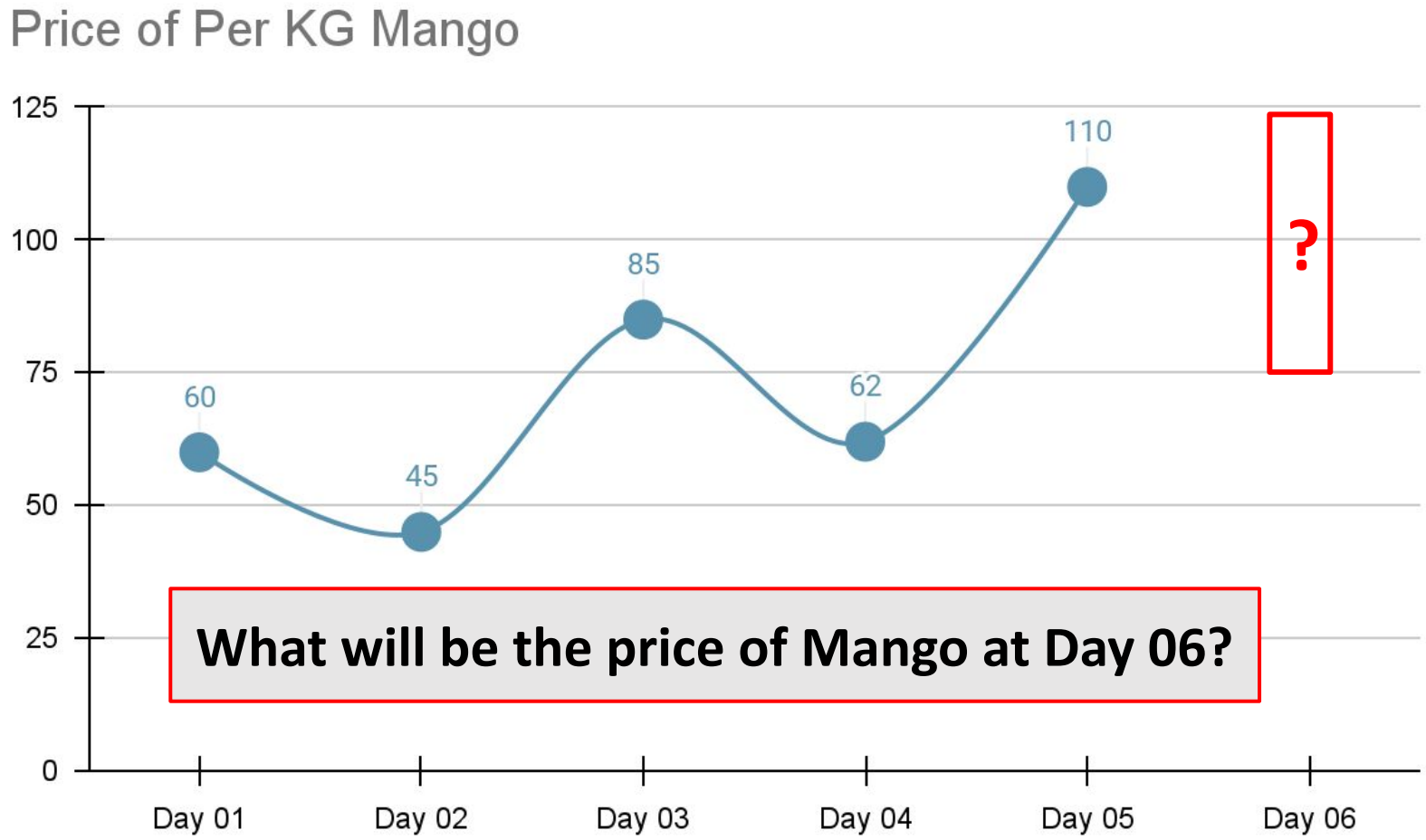
Machine Learning

How did we predict this range?



Machine Learning

Because we have imagined a straight area that passes through the data points.



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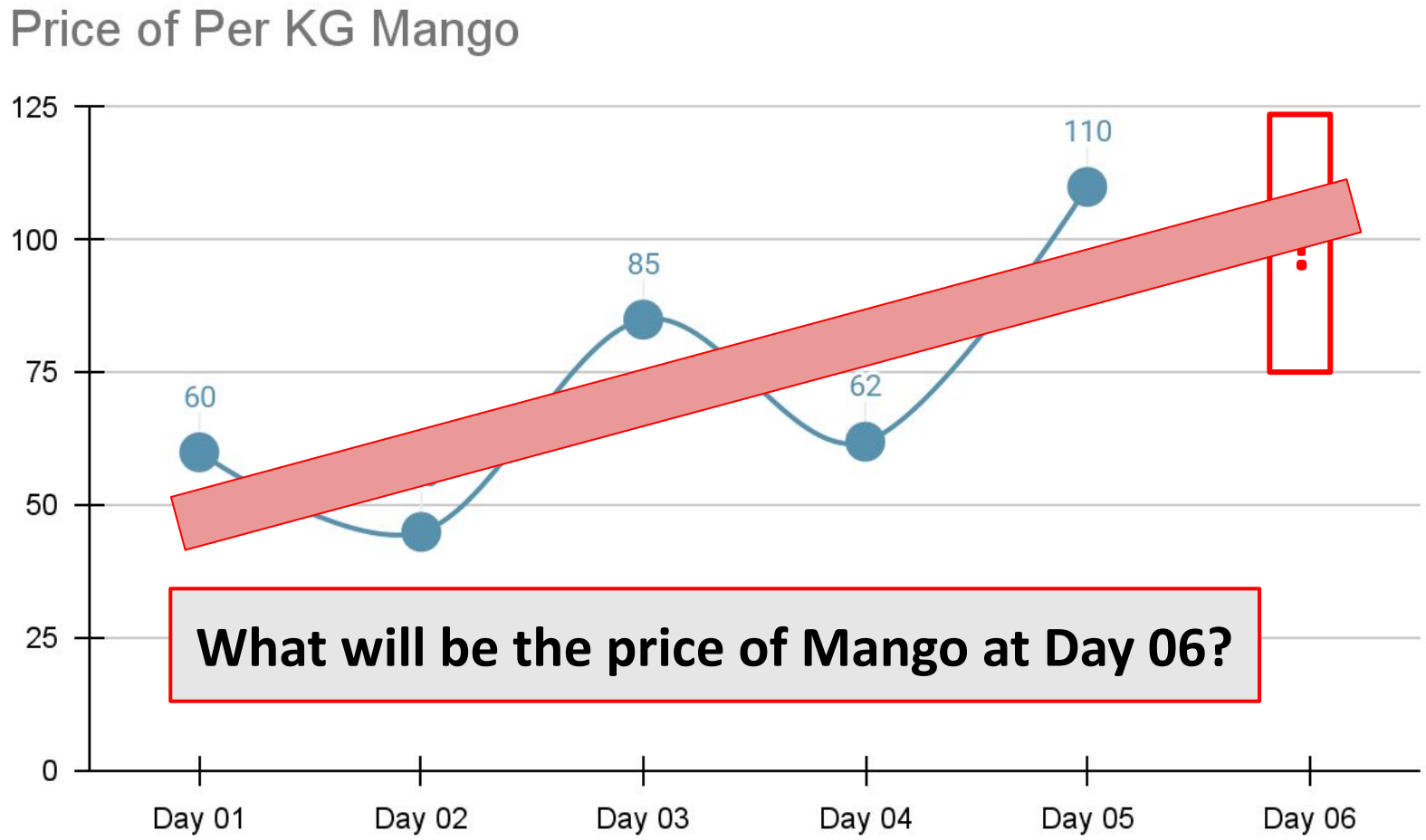
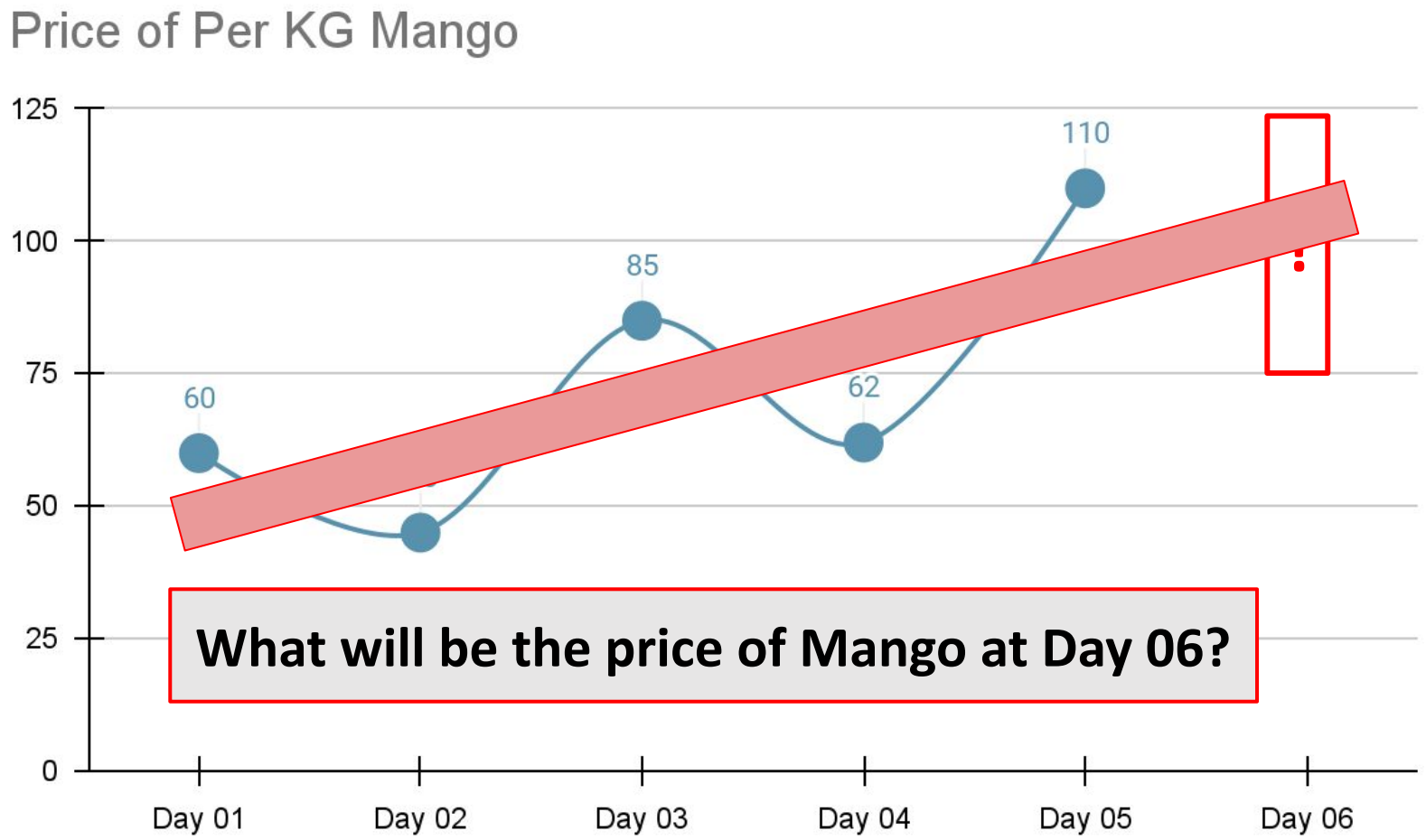


Machine Learning

Now, instead of a straight area, we have to draw a straight line so that the prediction error can be minimized as much as possible.



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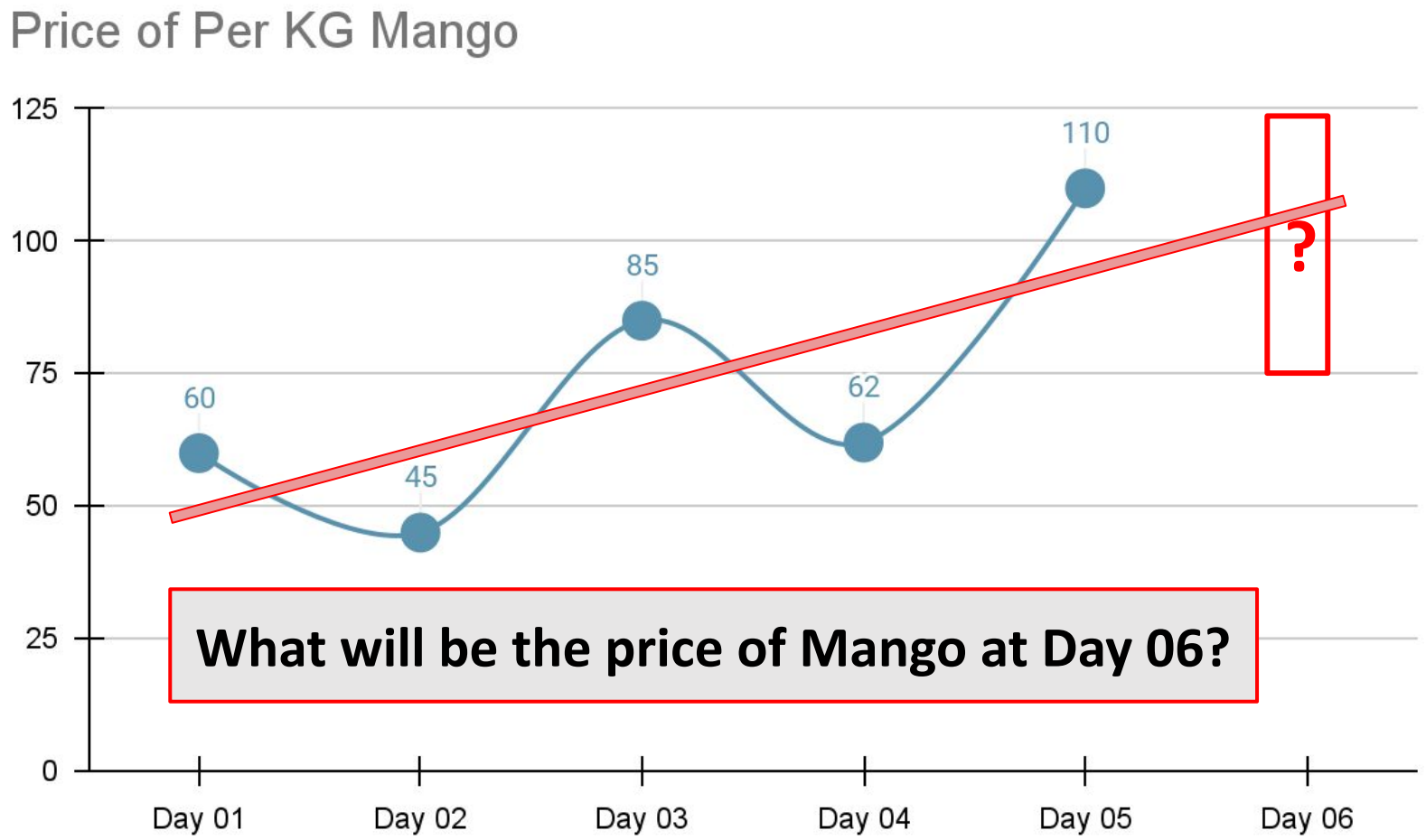

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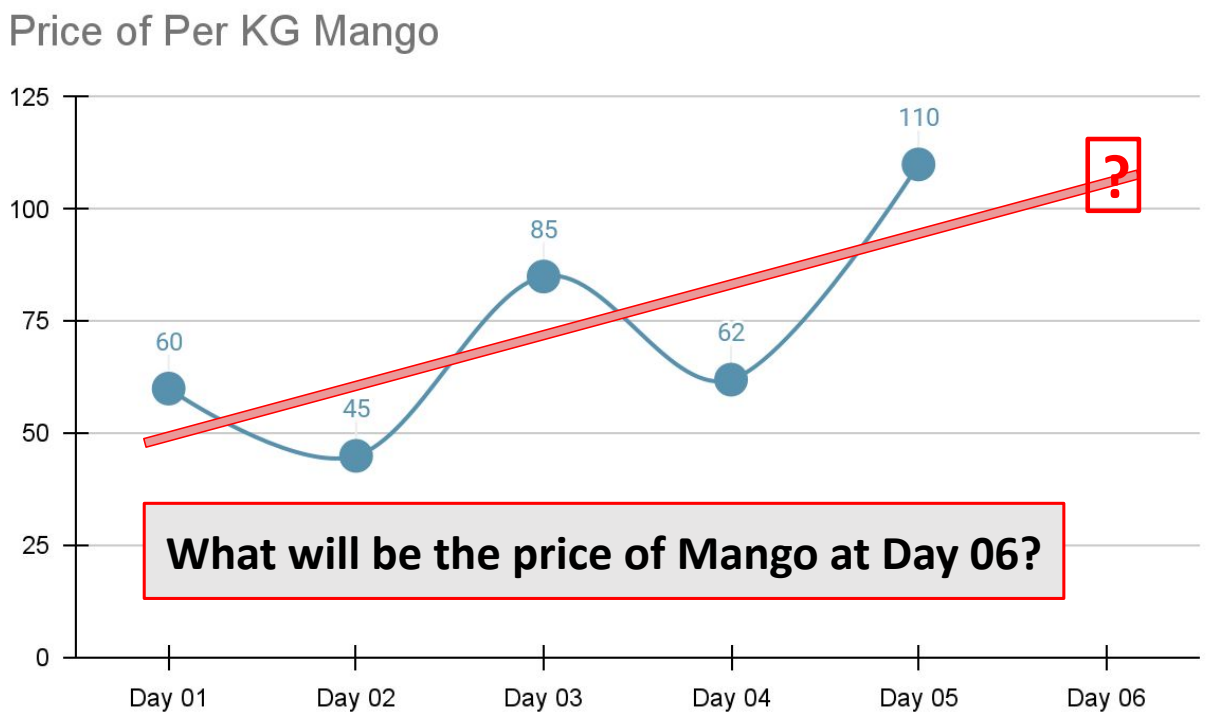
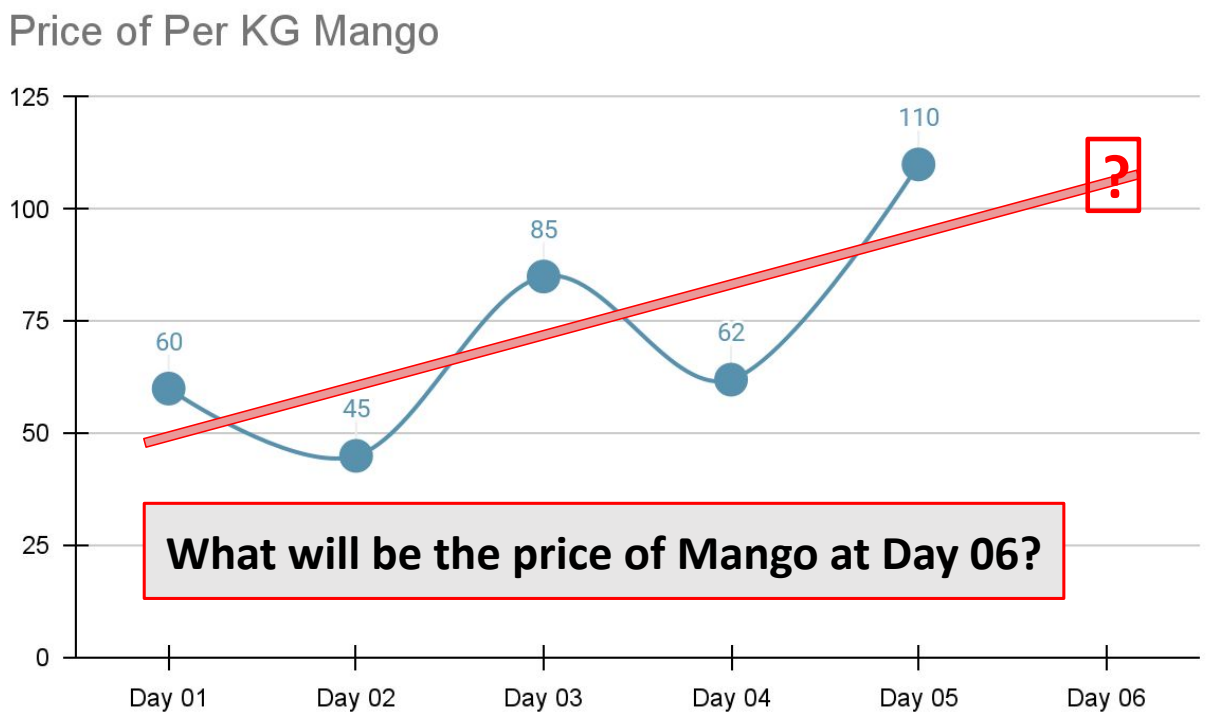
How can we find this straight line?



Machine Learning

How can we find this straight line?

- **We know, equation of a straight line is: y = mx + b**



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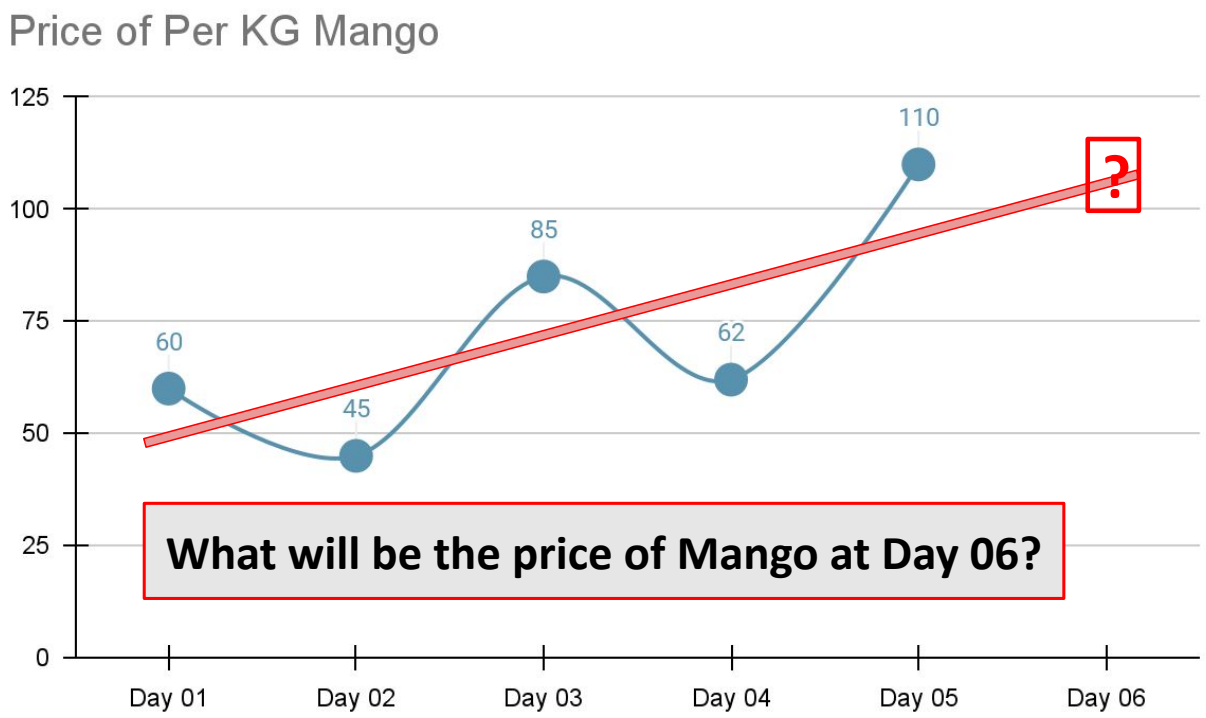

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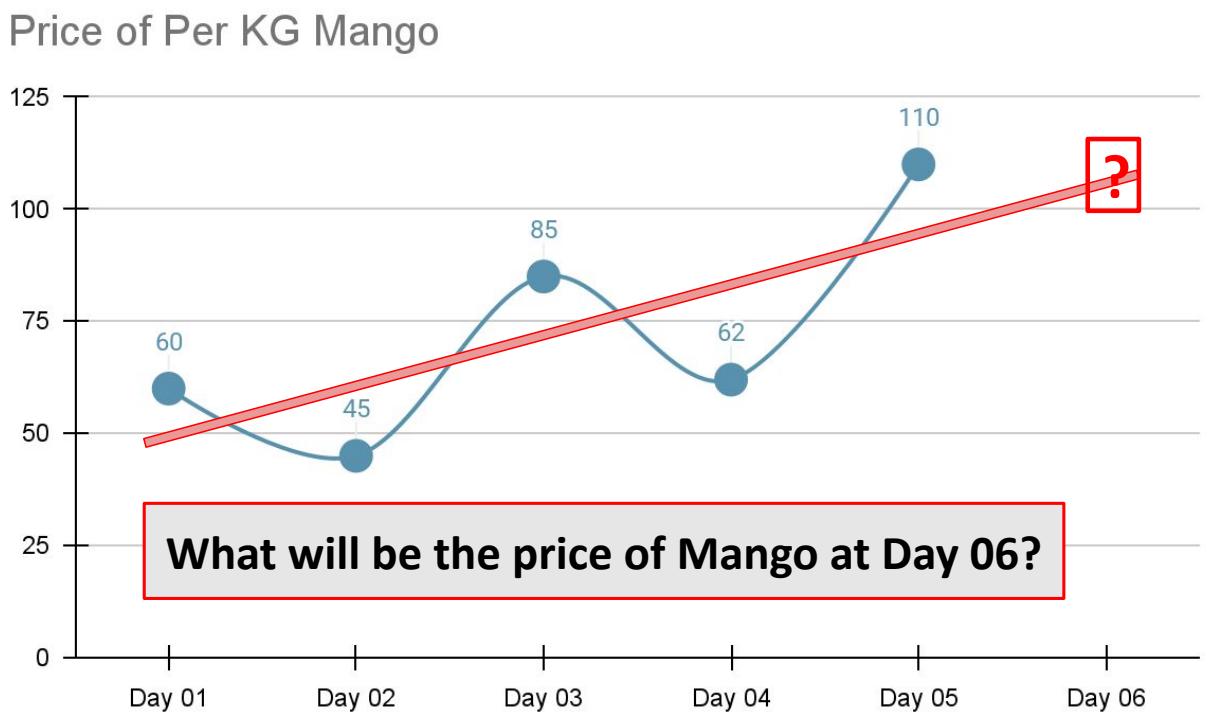
- **Like before, the values of m and b need to be calculated.**



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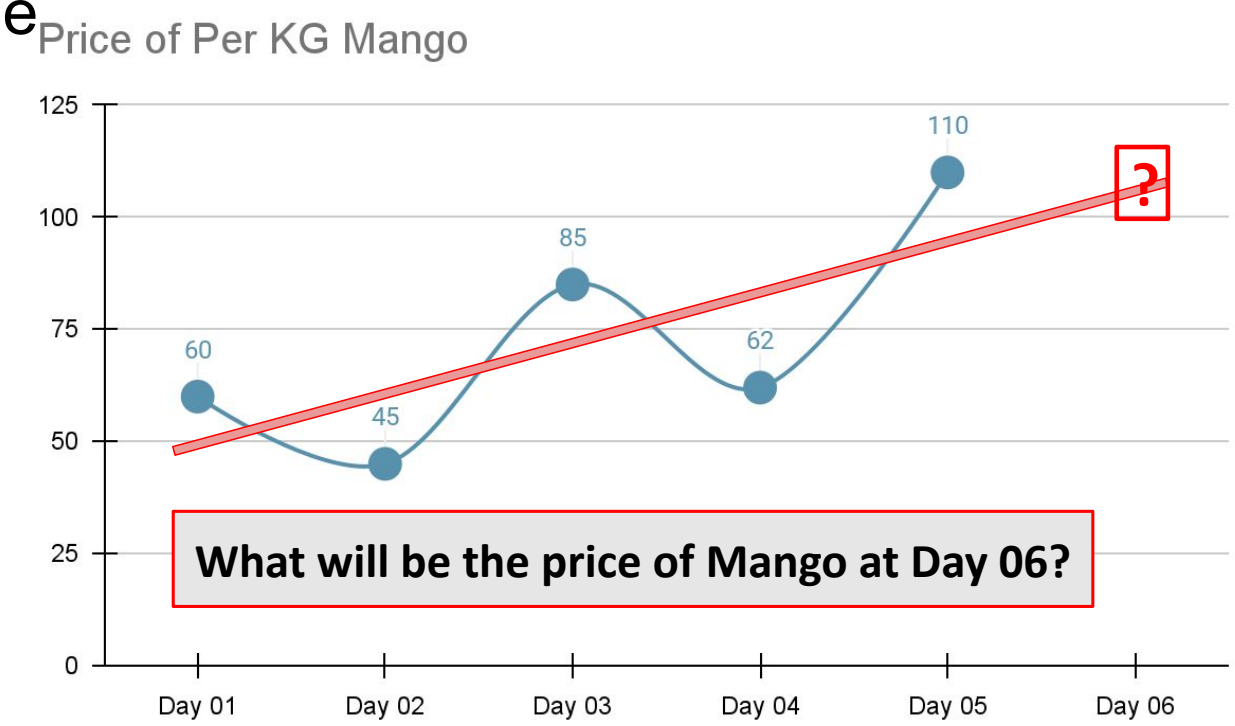

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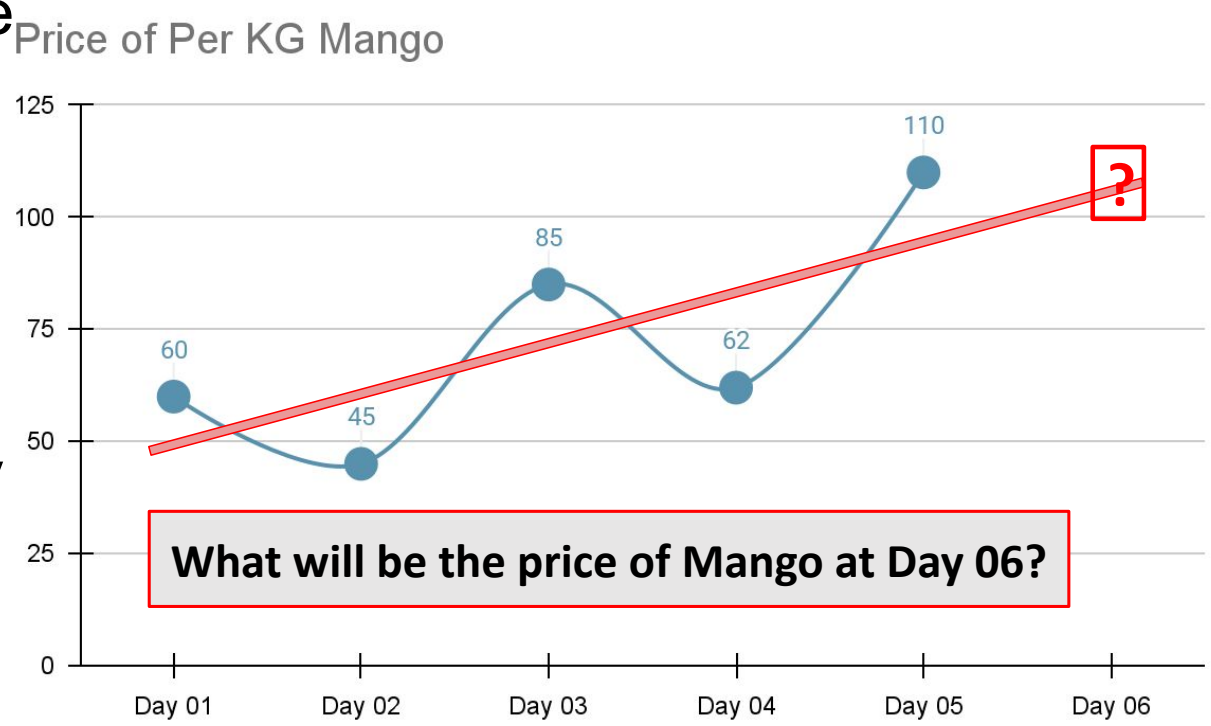
- **So, again we need to guess the values for m,b**



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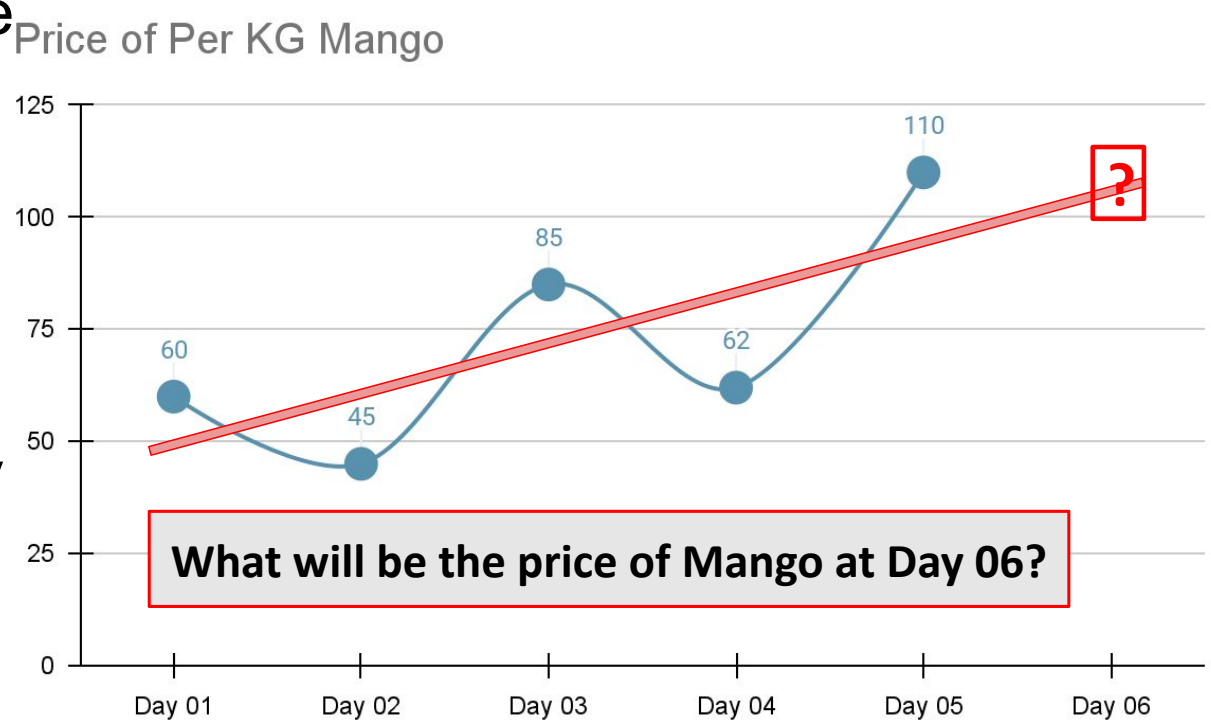
- So, again we need to guess the values for m,b
- **We can guess infinite values and draw infinite lines.**



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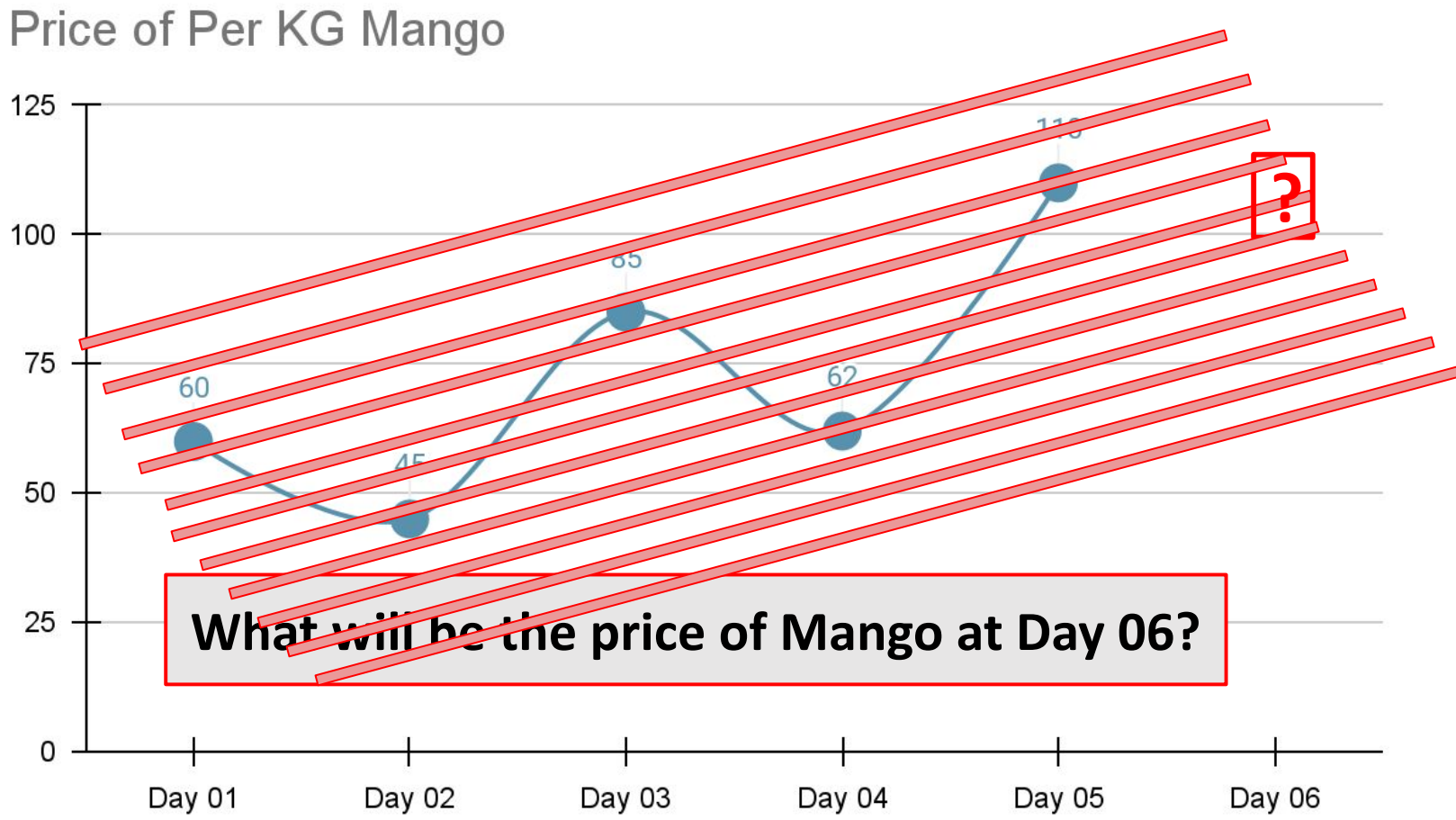
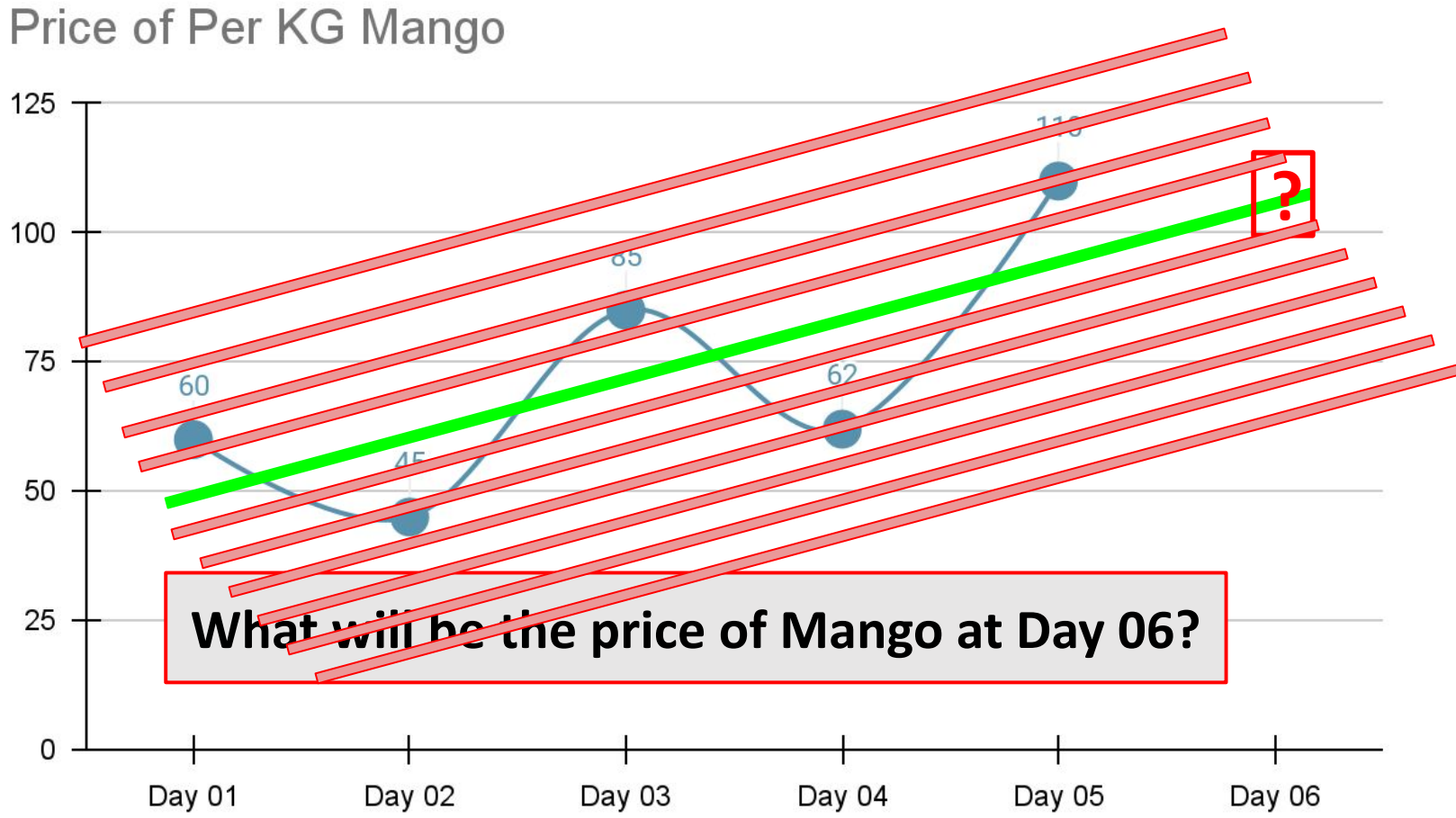


Machine Learning

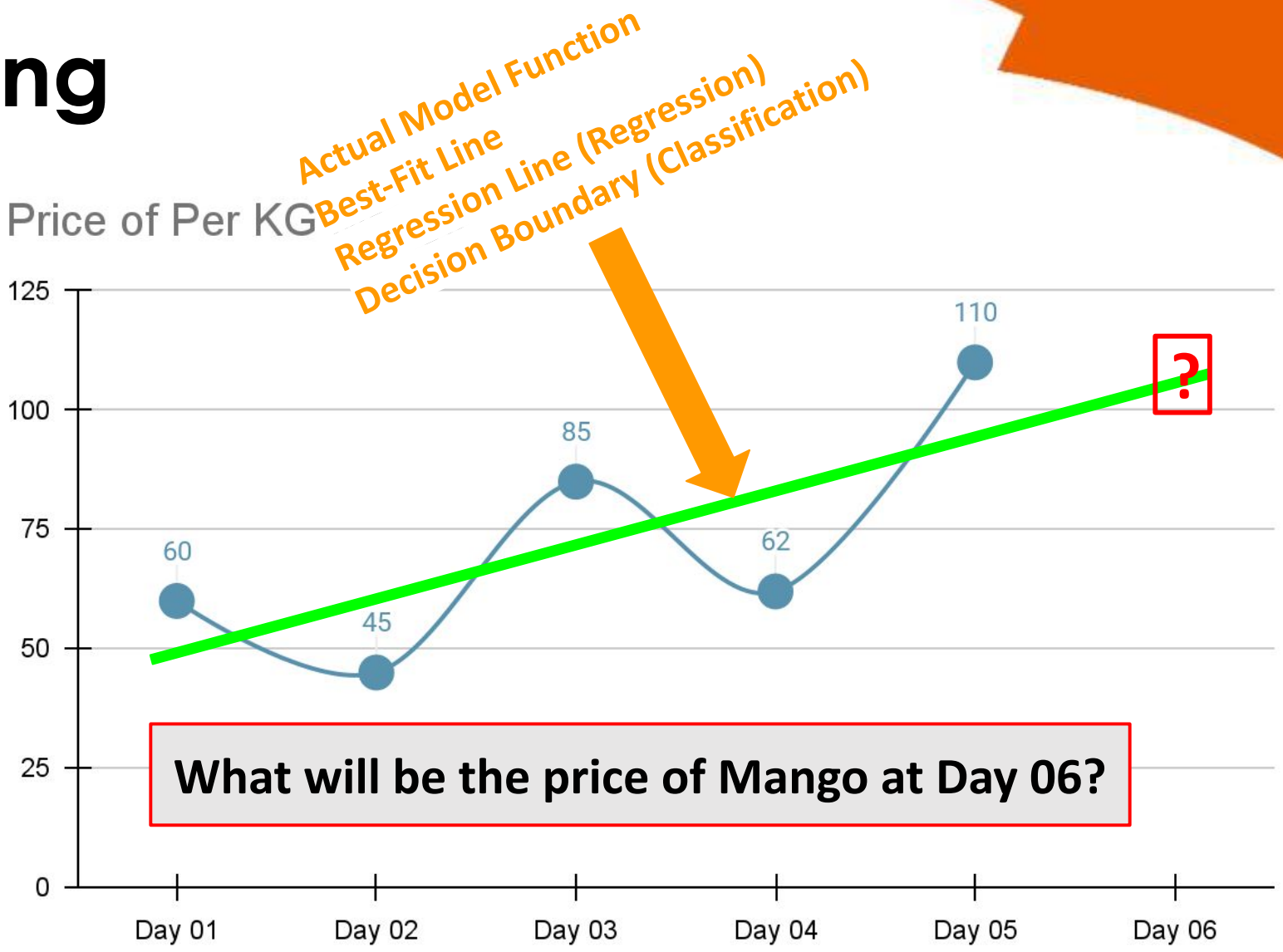
- We can guess infinite values and draw infinite lines.

- **Condition:** We need to calculate m and b in such a way that our prediction error is minimized as much as possible.



Machine Learning

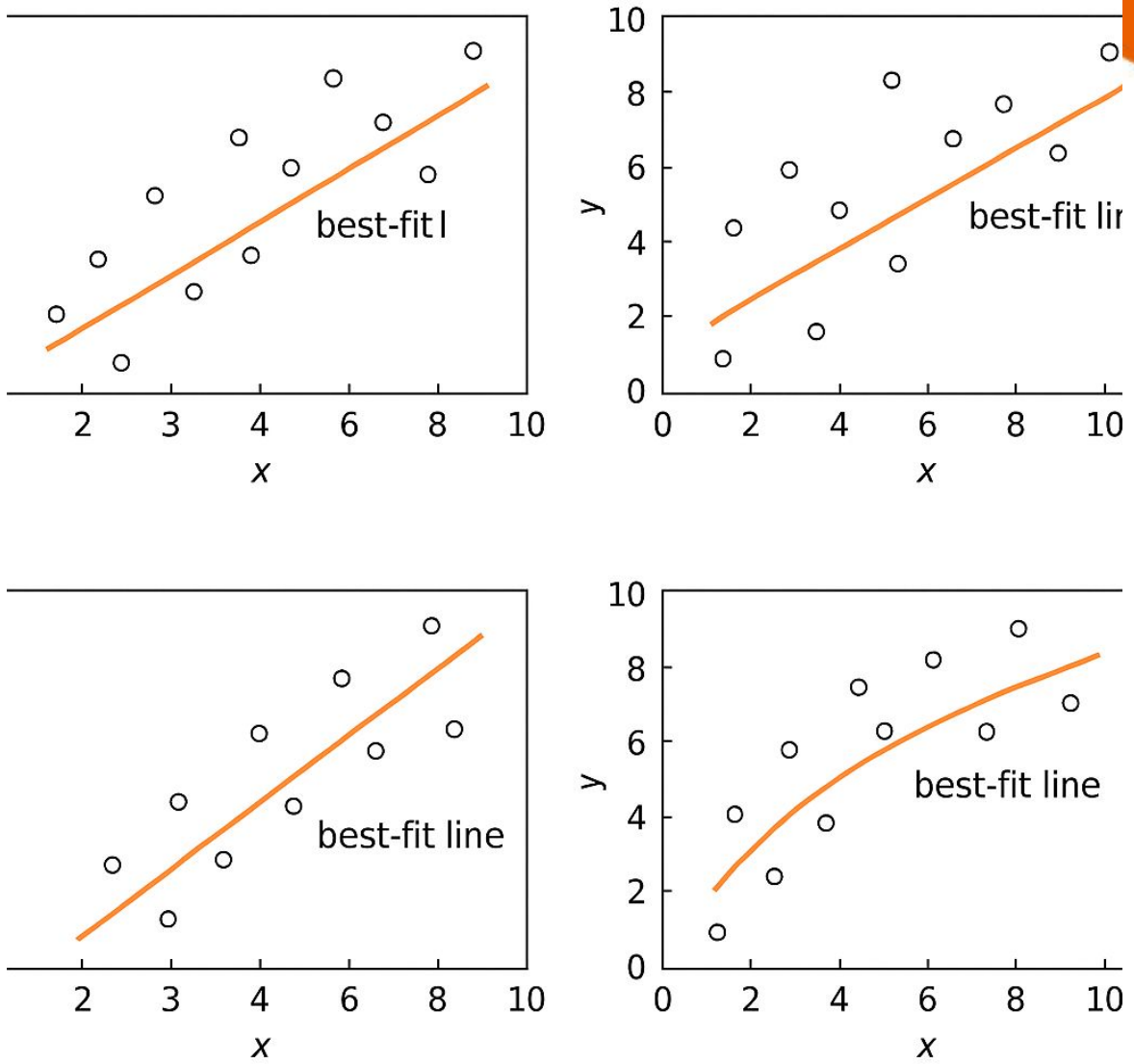
- In general, we just call it the model or hypothesis function (the function the algorithm learns).
- In regression, that line is usually called the regression line or line of best fit.
- In classification, a similar line is often called the decision boundary.



Machine Learning

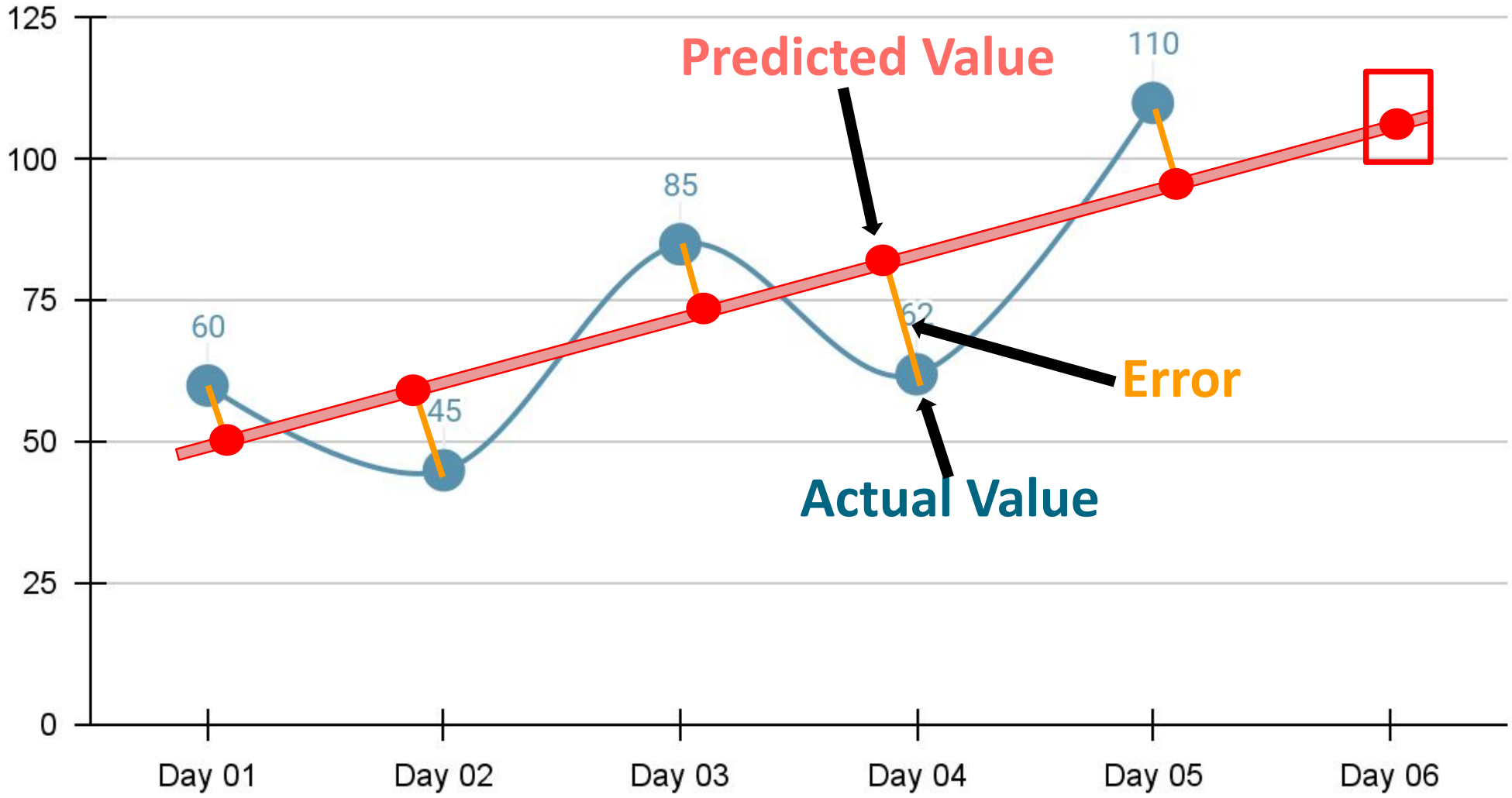
Data যেমনই হোক, আমাদের জীবনের লক্ষ্য, উদ্দেশ্য, সাধনা একটাই-

Best-Fit Line খুঁজে বের করা



Machine Learning

The Error: *Difference between Actual Value and Predicted Value*



Machine Learning

- **“Error”** is usually formalized as **loss function** which measures error for one example.

Input	Actual Result	Predicted Result	Loss Function
Day 1	60	56	4
Day 2	45	49	-4
Day 3	85	79	6
Day 4	62	61	1
Day 5	110	95	15

Machine Learning

- **“Cost Function”** is usually the average (or sum) of the loss over the whole dataset.

Input	Actual Result	Predicted Result	Loss Function
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Day 2	45	49	-4
Day 3	85	79	6
Day 4	62	61	1
Day 5	110	95	15
Cost			**4.4 (avg)**

Machine Learning

- **Cost function** (average loss over many samples) is what really indicates the overall performance of the model.
- **Loss** tells you how good or bad a single prediction is.

***Mathematical formula of Cost function changes depending on the machine learning model.**

Machine Learning

Finding the BEST-FIT Line:

1. Numerical Analysis (least squares) Method :

$$m = \frac{\overline{xy} - \bar{x}\bar{y}}{\overline{x^2} - (\bar{x})^2}$$

$$b = \bar{y} - m \cdot \bar{x}$$

- $\bar{x}$ is the mean of x.
- $\bar{y}$ is the mean of y.
- $\overline{xy}$ is the mean of the product of x and y.
- $(\bar{x})^2$ is the square of the mean of x.
- $\overline{x^2}$ is the mean of x^2.

Machine Learning

1. Numerical Analysis (least squares) Method :

1. Mean of x

$$\bar{x} = \frac{1+2+3+4+5}{5} = \frac{15}{5} = 3$$

2. Mean of y

$$\bar{y} = \frac{60+45+85+62+110}{5} = \frac{362}{5} = 72.4$$

Input x	Actual Result y
Day 1	60
Day 2	45
Day 3	85
Day 4	62
Day 5	110

Machine Learning

1. Numerical Analysis (least squares) Method :

3. Mean of xy

First compute xy for each pair:

- Day 1: $1 \times 60 = 60$
- Day 2: $2 \times 45 = 90$
- Day 3: $3 \times 85 = 255$
- Day 4: $4 \times 62 = 248$
- Day 5: $5 \times 110 = 550$

Sum:

$$60 + 90 + 255 + 248 + 550 = 1203$$

Mean:

$$\overline{xy} = \frac{1203}{5} = 240.6$$

Input x	Actual Result y
Day 1	60
Day 2	45
Day 3	85
Day 4	62
Day 5	110

Machine Learning

1. Numerical Analysis (least squares) Method :

4. Mean of x^2

First compute x^2:

- $1^2 = 1$
- $2^2 = 4$
- $3^2 = 9$
- $4^2 = 16$
- $5^2 = 25$

Sum:

$$1 + 4 + 9 + 16 + 25 = 55$$

Mean:

$$\overline{x^2} = \frac{55}{5} = 11$$

Input x	Actual Result y
Day 1	60
Day 2	45
Day 3	85
Day 4	62
Day 5	110

Machine Learning

1. Numerical Analysis (least squares) Method :

$$m = \frac{\overline{xy} - \bar{x}\bar{y}}{\overline{x^2} - (\bar{x})^2} = \frac{240.6 - (3)(72.4)}{11 - 3^2} = \frac{240.6 - 217.2}{11 - 9} = \frac{23.4}{2} = 11.7$$

$$b = \bar{y} - m \cdot \bar{x} = 72.4 - (11.7)(3) = 72.4 - 35.1 = 37.3$$

- $\bar{x} = 3$
- $\bar{y} = 72.4$
- $\overline{xy} = 240.6$
- $\overline{x^2} = 11$

Machine Learning

1. Numerical Analysis (least squares) Method :

Price of Mango on Day 6 is:

price = 11.7 * 6 + 37.3 => 107.5 tk

Machine Learning

Finding the BEST-FIT Line:

1. Numerical Analysis (least squares) Method

Machine Learning

Finding the BEST-FIT Line:

1. Numerical Analysis (least squares) Method
2. Gradient Descent Algorithm (most important)

Machine Learning

2. Gradient Descent Algorithm

What it is:
Gradient descent is an **optimization algorithm** used to **find the best parameters** (like m and b in a line) that **minimize a cost function**.

Core idea:

1. Start with a random guess of the parameters.
2. Compute the **gradient** (the direction of steepest increase of the cost).
3. Move a small step in the **opposite** direction (downhill) to reduce the cost.
4. Repeat this process until the cost stops decreasing much.

Machine Learning

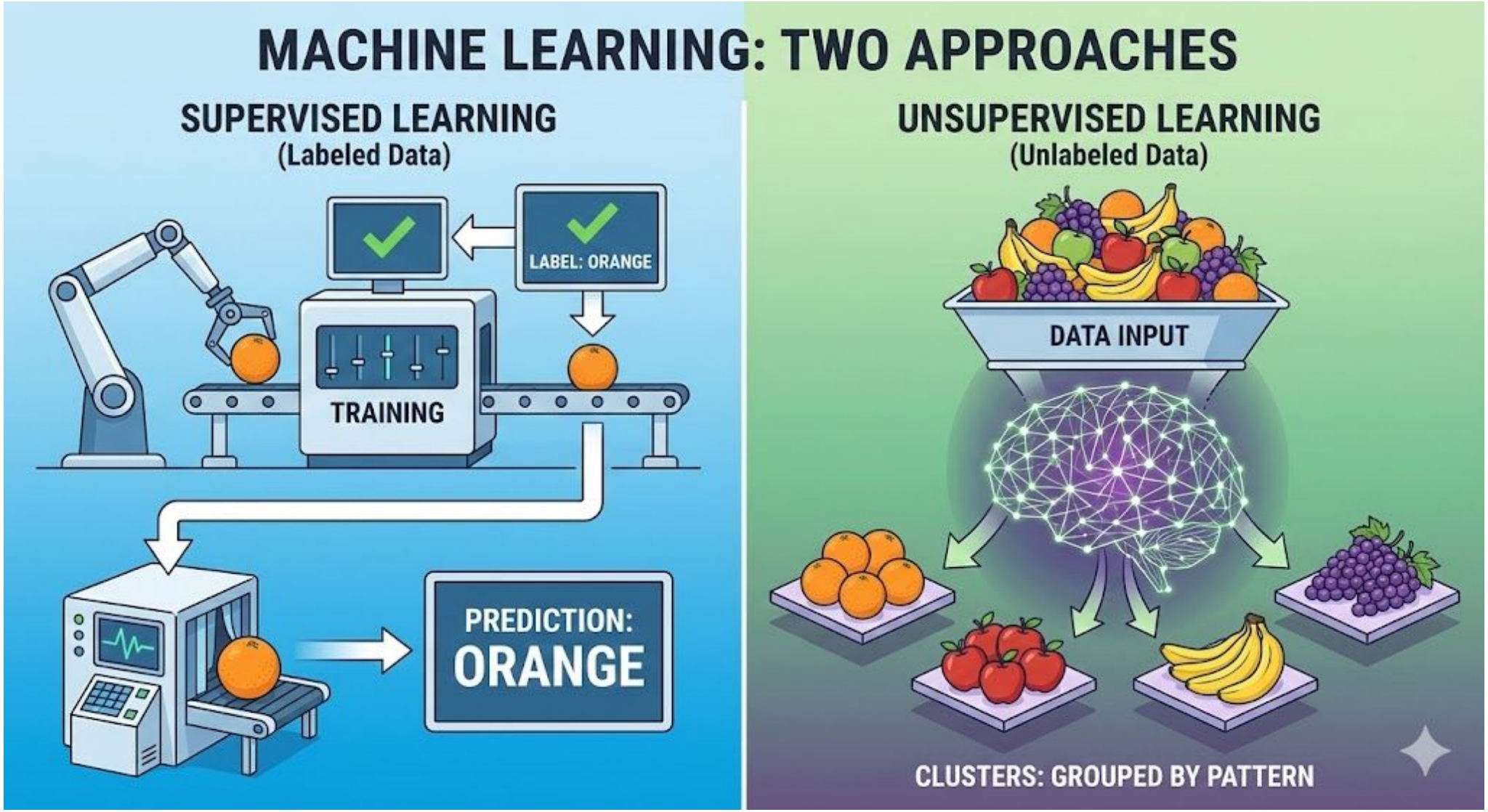
We have just started our Machine Learning Journey!

Machine Learning

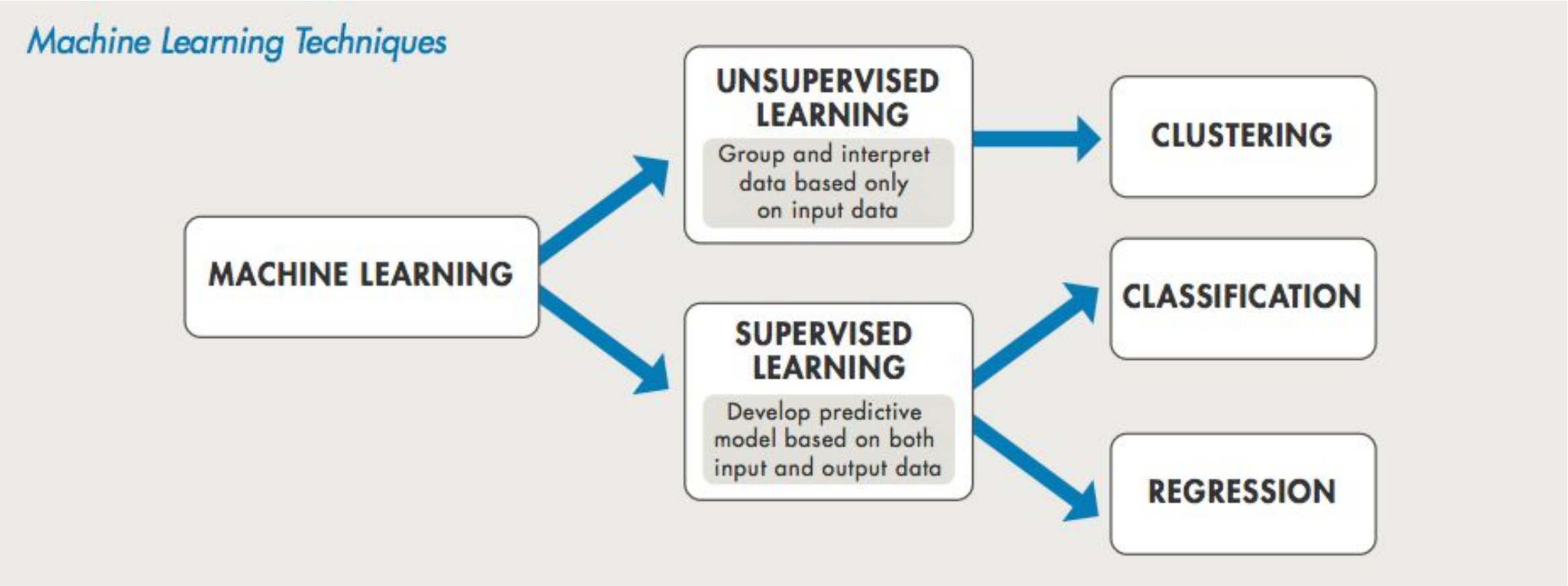
Three Main Types of Learning:

- **Supervised Learning:** Learn from input–output pairs (features, label)
- **Unsupervised Learning:** Learn patterns from data without labels
- **Reinforcement Learning (RL):** Learn by interacting with an environment and receiving rewards

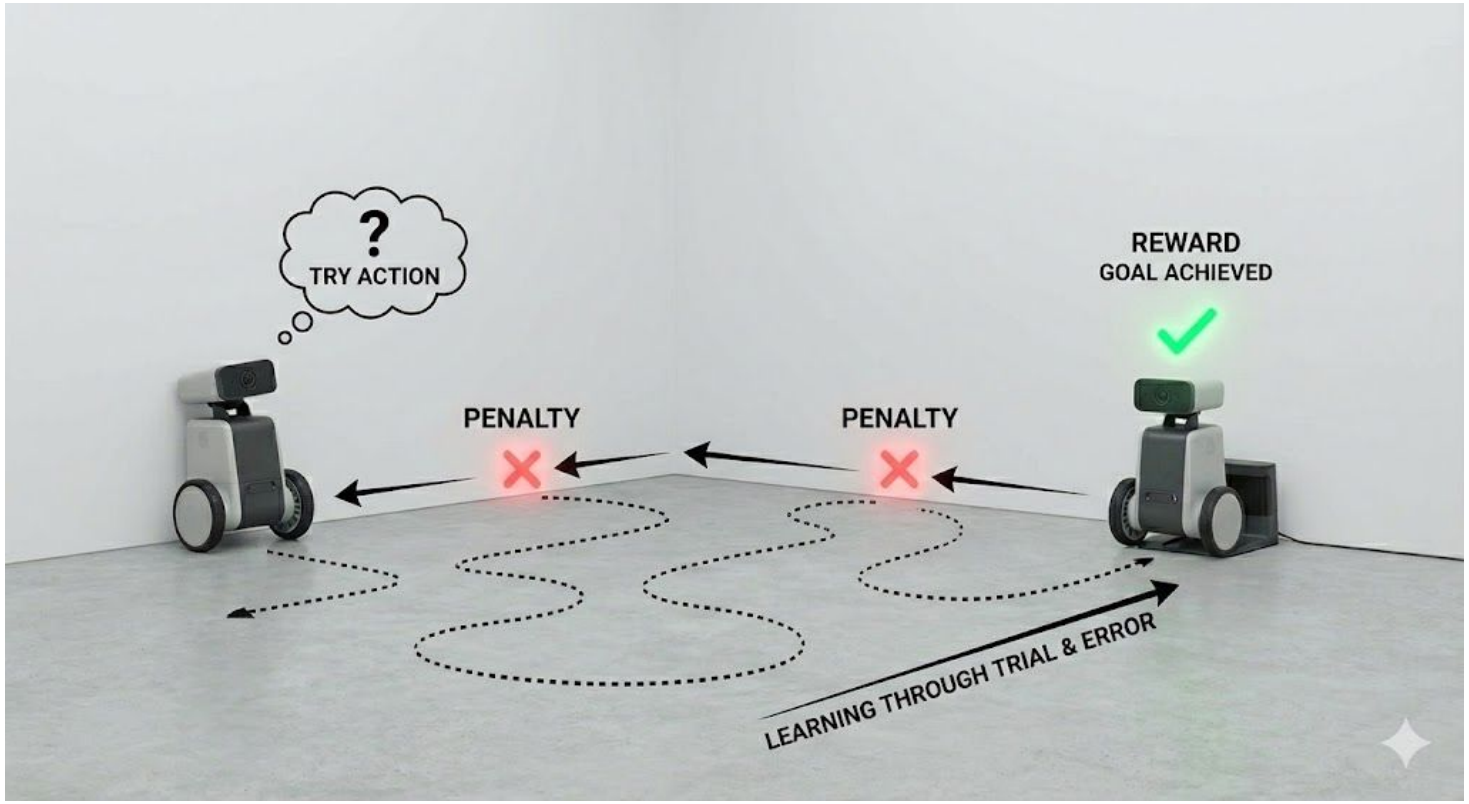
Machine Learning



Machine Learning



Machine Learning



- **Reinforcement Learning (RL)**
  ভুল থেকে শিক্ষা নেওয়া!!

Domain of AI

Artificial Intelligence

Any technique that enables computers to mimic human behaviour

1956

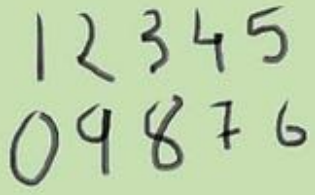
Machine Learning

Ability to learn without explicitly being programmed

1997

Deep Learning

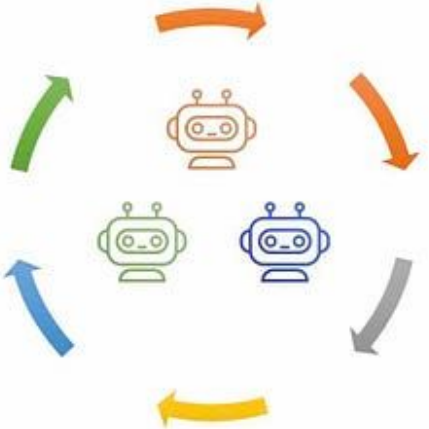
Extract patterns from Data using neural networks



2012

Agentic AI

A software that can **perceive**, **reason**, & then **act** autonomously.

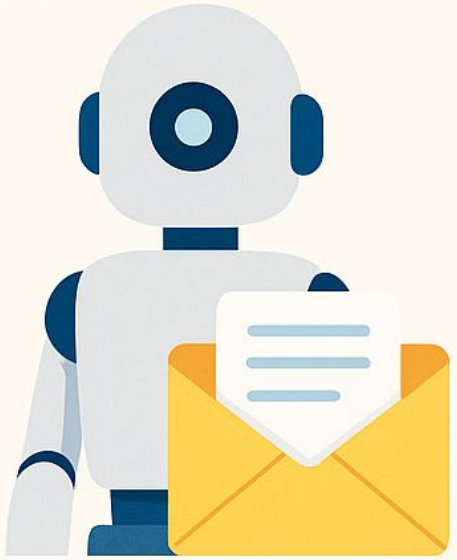


2025

Types of AI

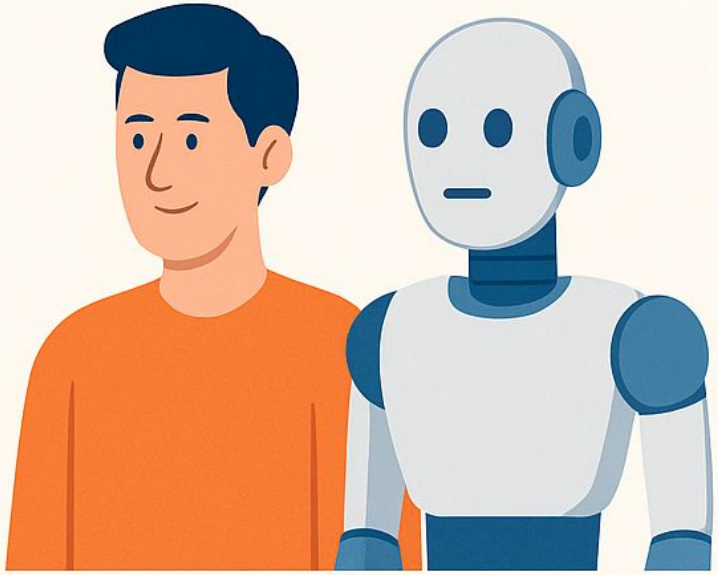
Narrow AI (ANI)

focused on a specific task



General AI (AGI)

human-level flexible intelligence (future goal)



Super AI (ASI)

beyond human intelligence (theoretical)

Intelligent Robots: When AI Meets Robotics

ANY QUESTIONS ?

THANK YOU

Contact Me

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