All about Linear Regression

(Least Squares Method)

AIQuest

- Theory Part:
  - Straight Line
  - Curve Line
  - Slope
  - Intercept
  - Cost Function
  - Lose Function
  - Mean Absolute Error (MAE)
  - Mean Squared Error (MSE)
  - Gradient Decent

- Coding with Python:
  - Implementing Linear Regression
  - Simple ML Project on Rent Prediction

- Discussion on Assignment:
  - Weight Prediction Based on Height

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Linear Line

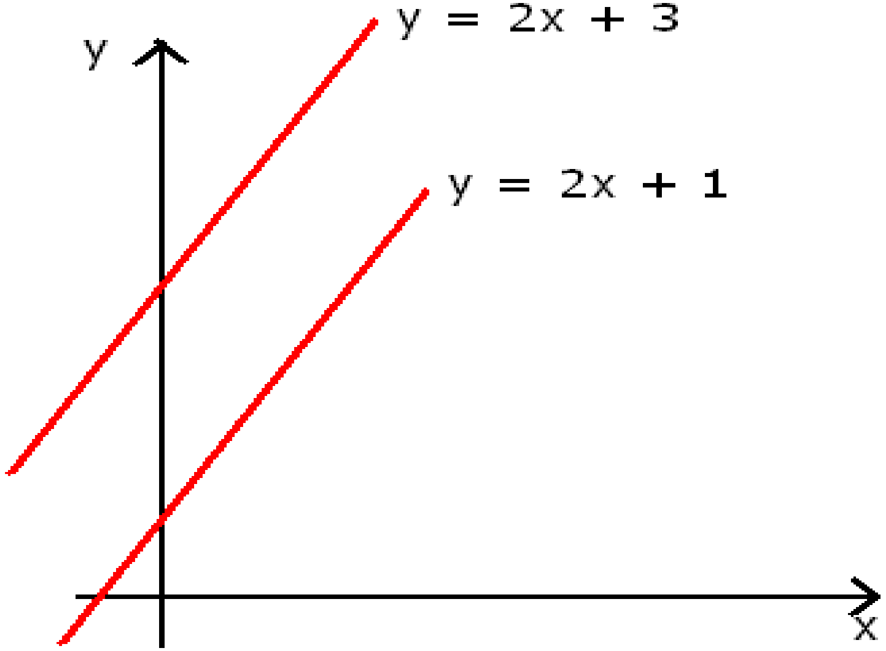


Fig: Straight Line

X = 10, 30, 50

Y = 2*10 + 3 =23

Y = 2*30 + 3 = 63

Y = 2*50 + 3 = 103

Non-Linear Curve Line

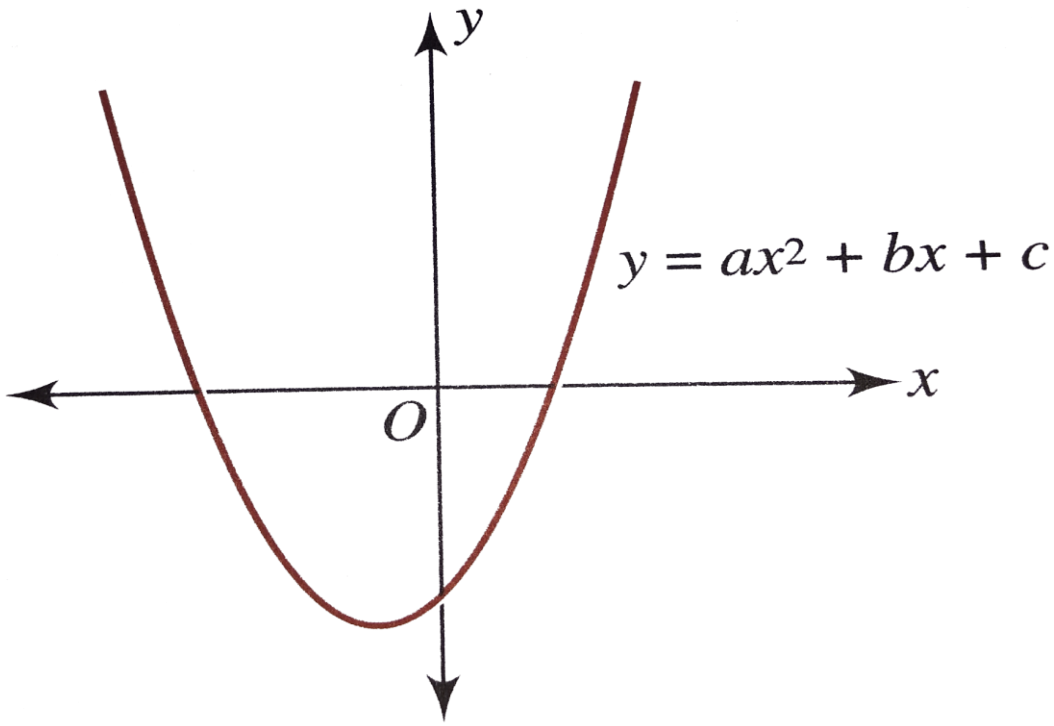
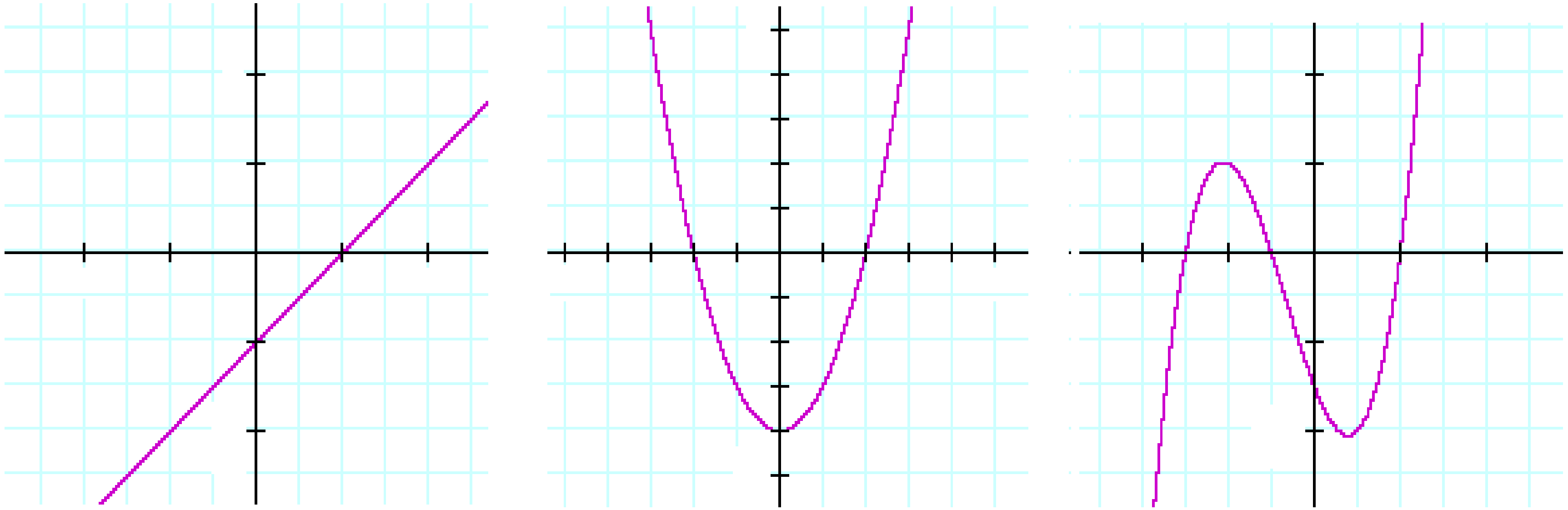


Fig: Curve Line

Linear vs Non-Linear Curve Line

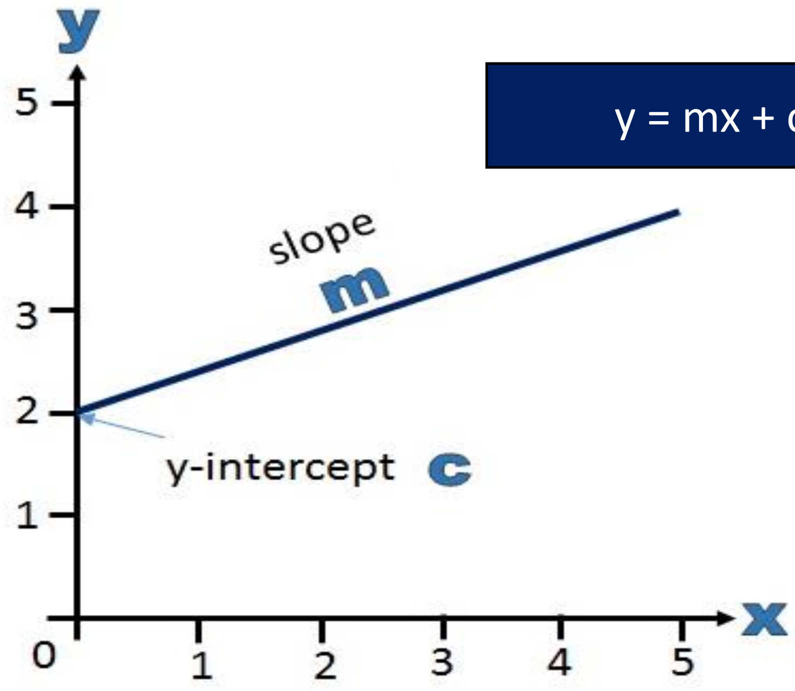


$y = ax + b$ $y = ax^2 + bx + c$ $y = ax^3 + bx^2 + cx + d$

Fig: Lines

All about Linear Regression

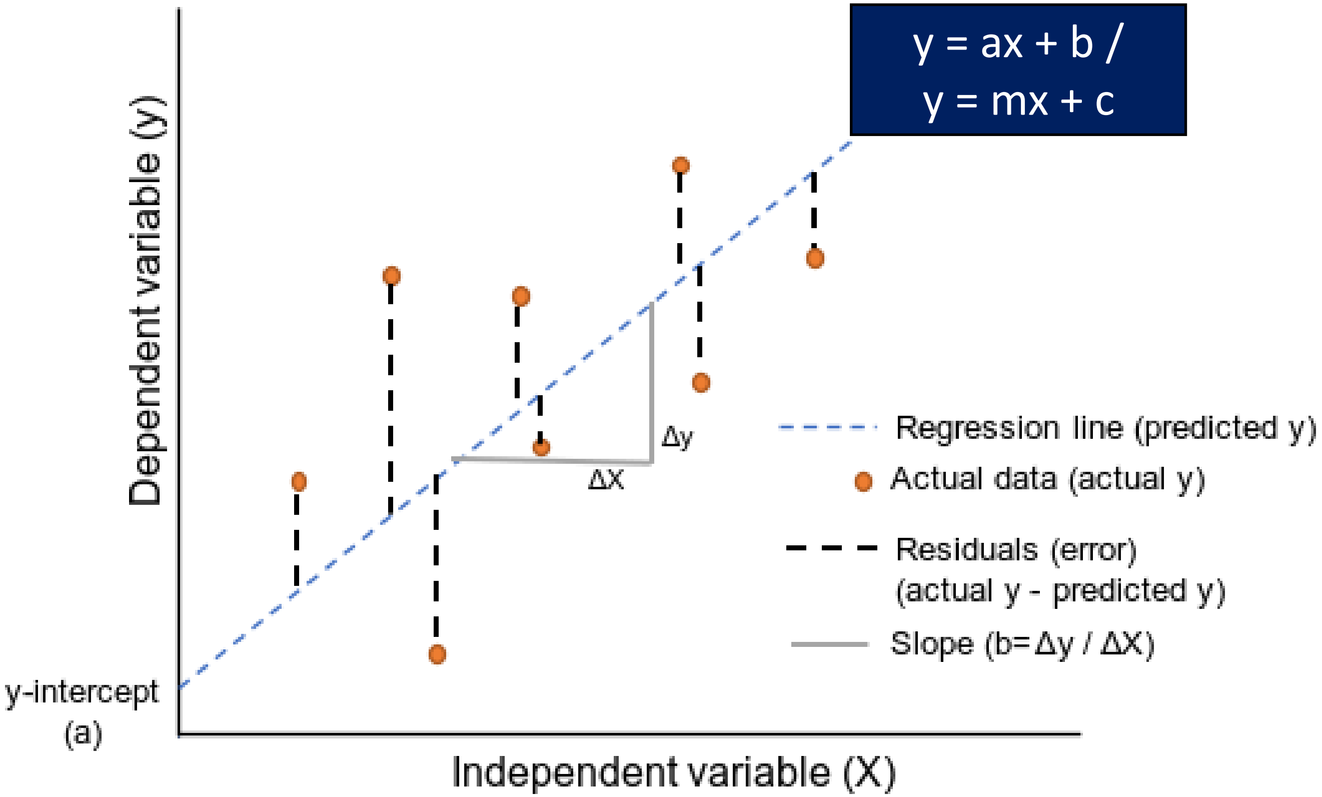
Linear regression is a statistical model that allows to explain a dependent variable y based on variation in one or multiple independent variables (denoted x). It does this based on linear relationships between the independent and dependent variables.



$y = mx + c$

All about Linear Regression

Linear regression is a statistical model that allows to explain a dependent variable y based on variation in one or multiple independent variables (denoted x). It does this based on linear relationships between the independent and dependent variables.



$y = ax + b$ /

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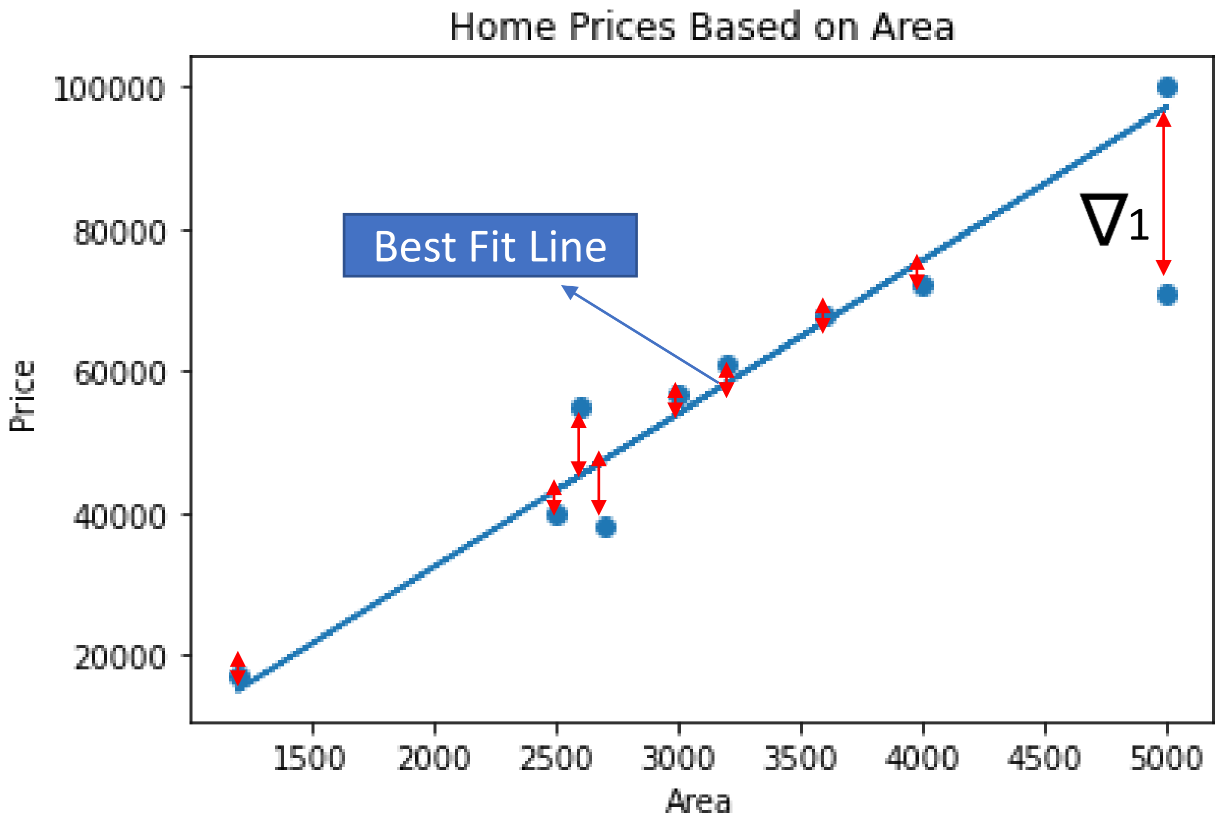
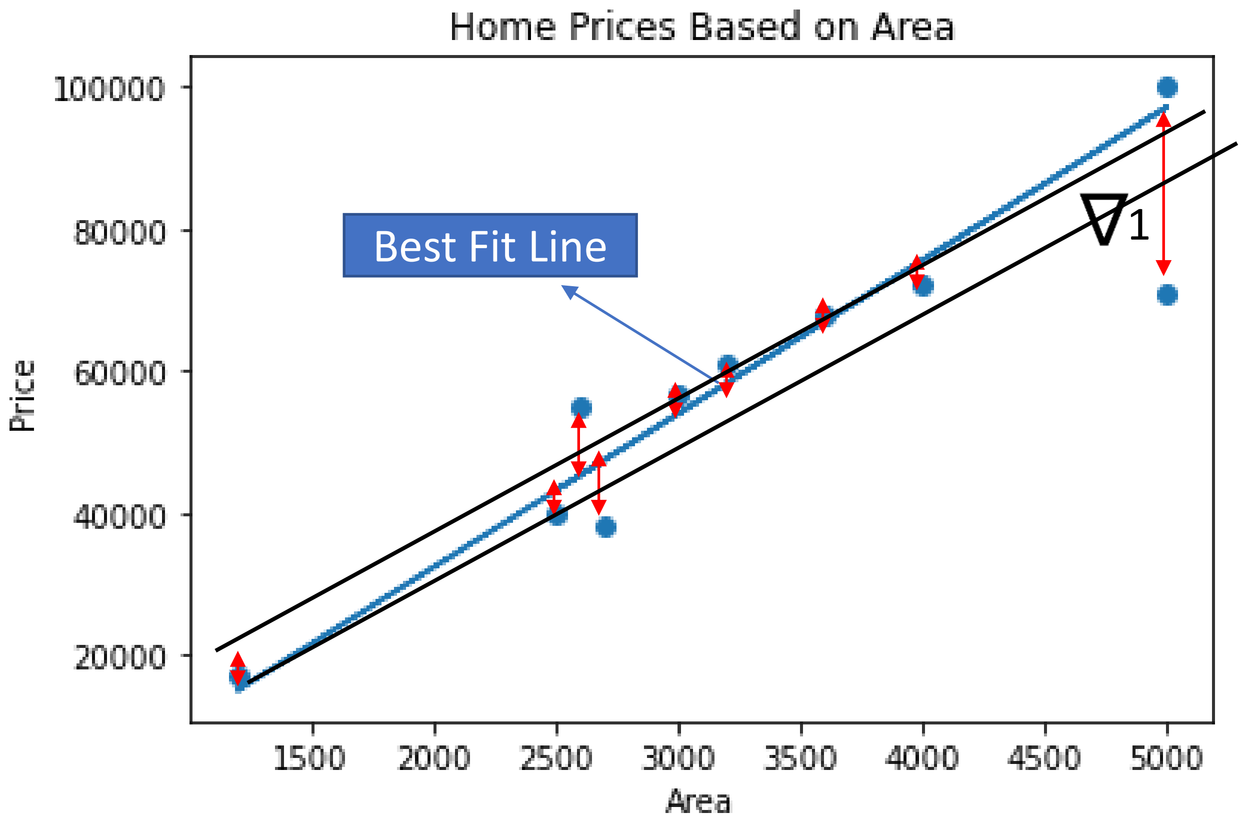
All about Linear Regression



y = mx + b ; or,
Y = 9.782* X + 1.48

Coefficient = 9.782
Intercept = 1.48

All about Linear Regression



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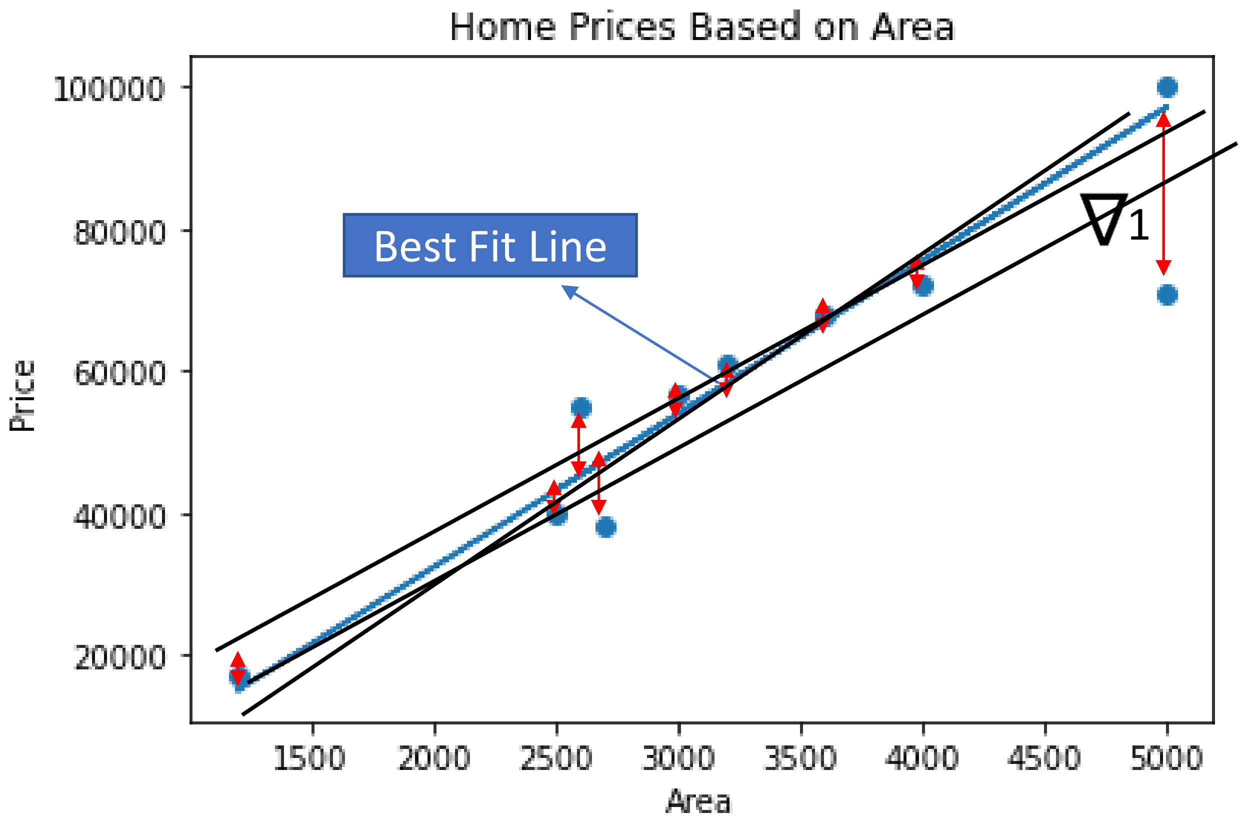
All about Linear Regression



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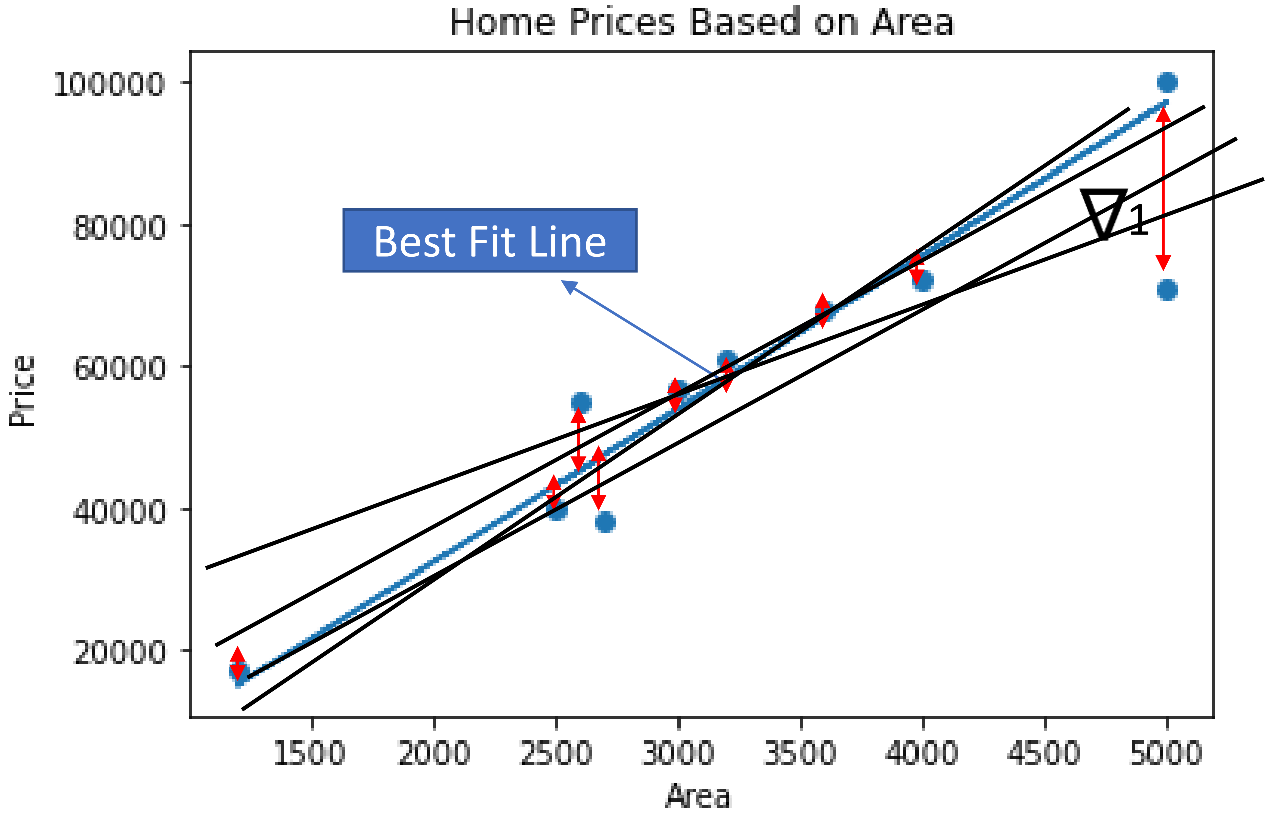
All about Linear Regression



Home Prices Based on Area

y = mx + b ; or,
Y = 9.782* X + 1.48

Coefficient = 9.782
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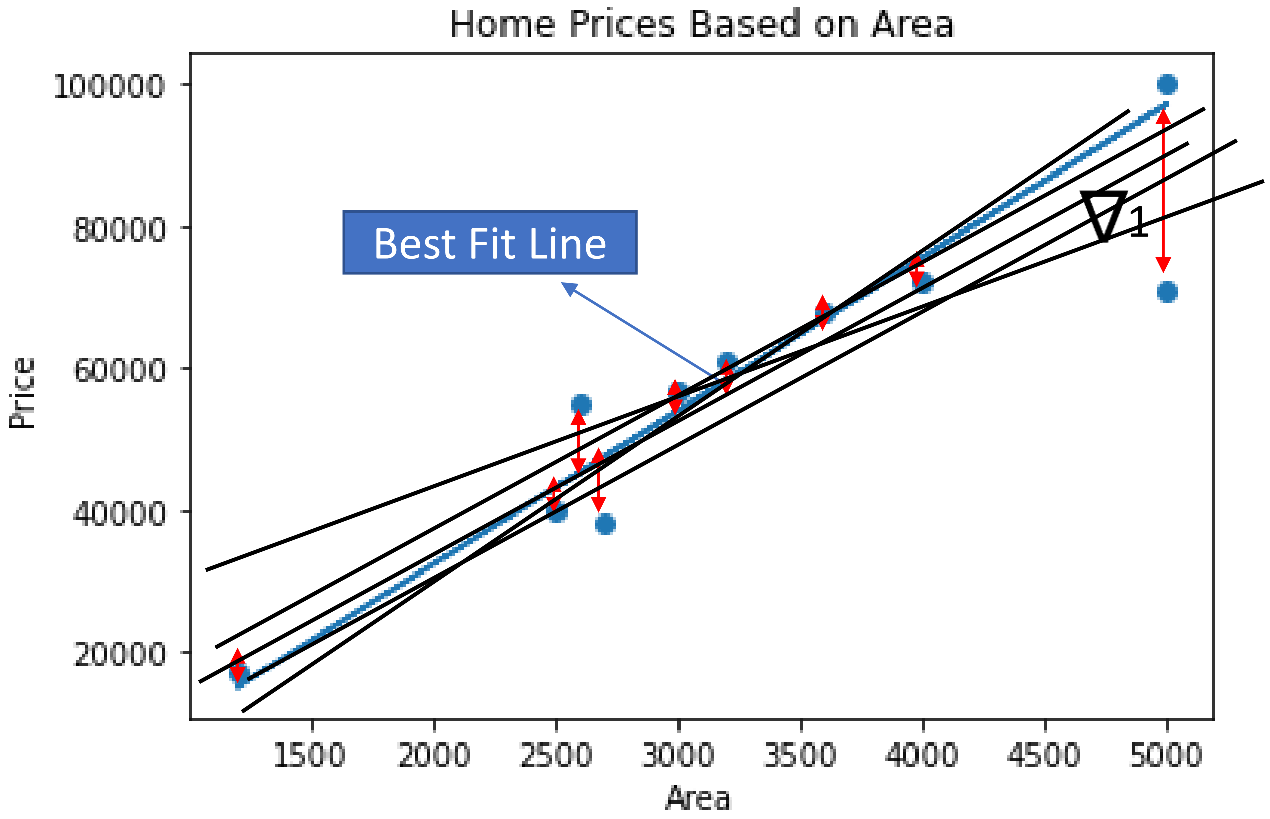
All about Linear Regression



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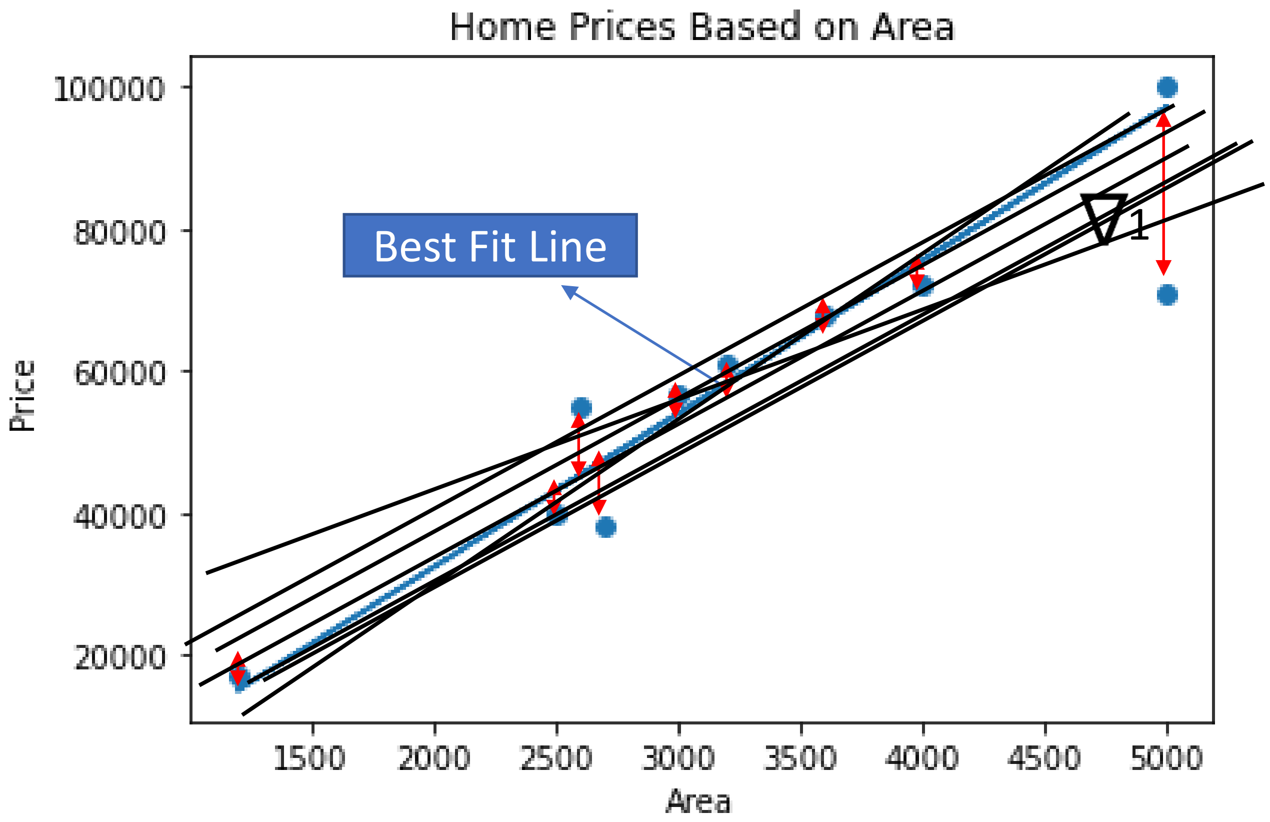
All about Linear Regression



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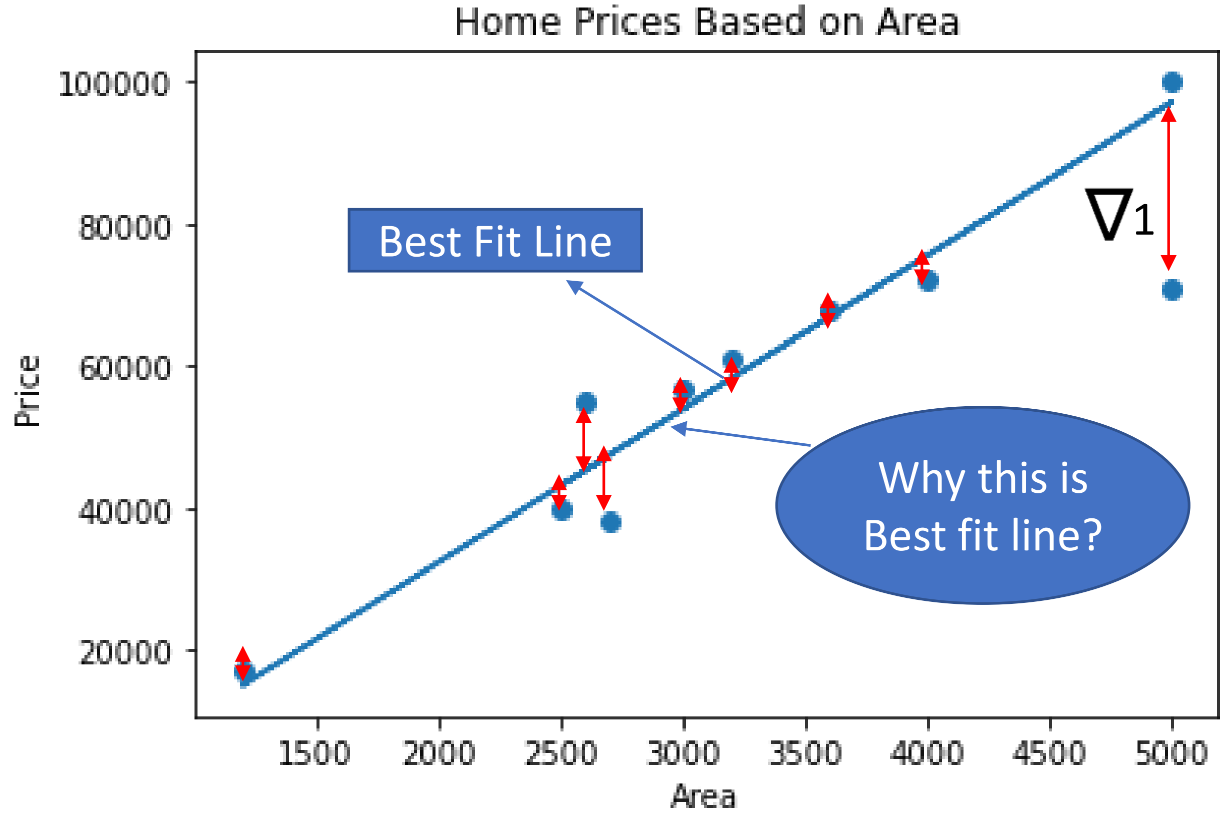
All about Linear Regression



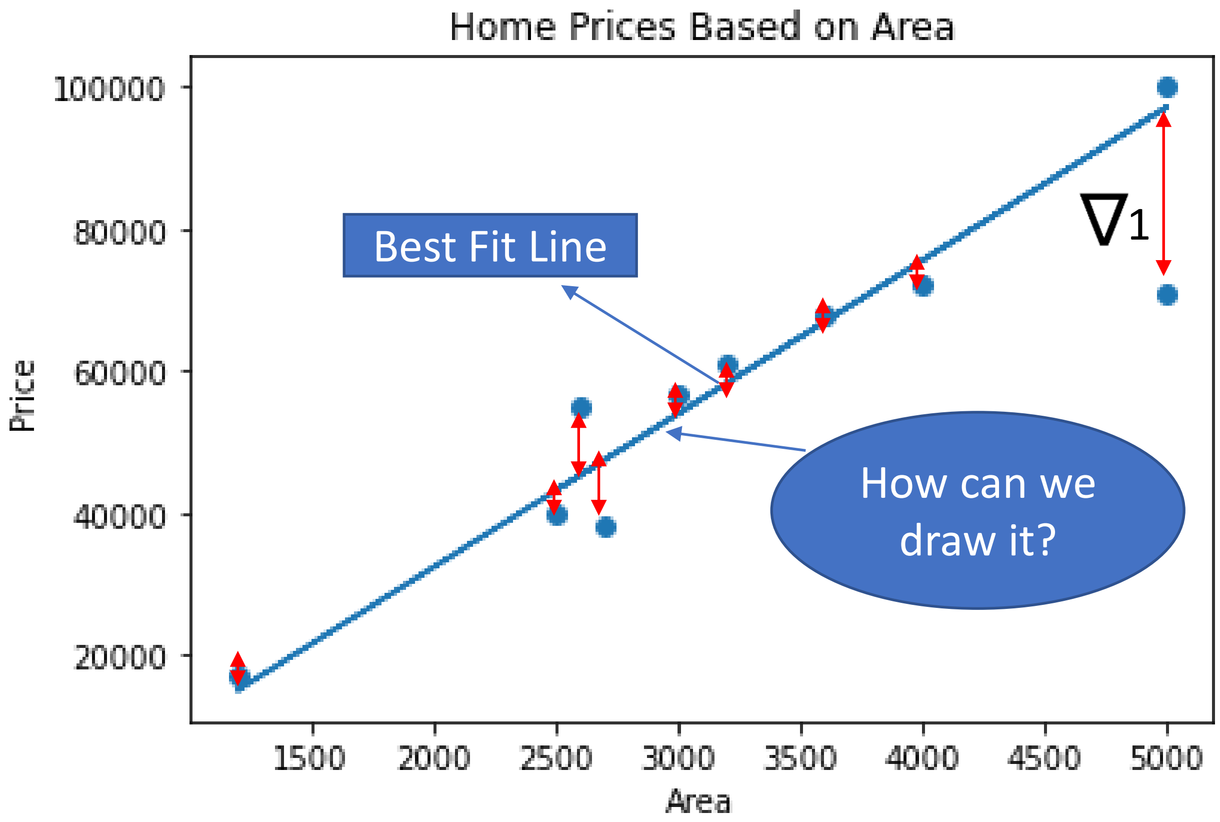
Best Fit Line

Why this is Best fit line?

y = mx + b ; or,
Y = 9.782* X + 1.48

Coefficient = 9.782
Intercept = 1.48

All about Linear Regression



Best Fit Line

How can we draw it?

y = mx + b ; or,
Y = 9.782* X + 1.48

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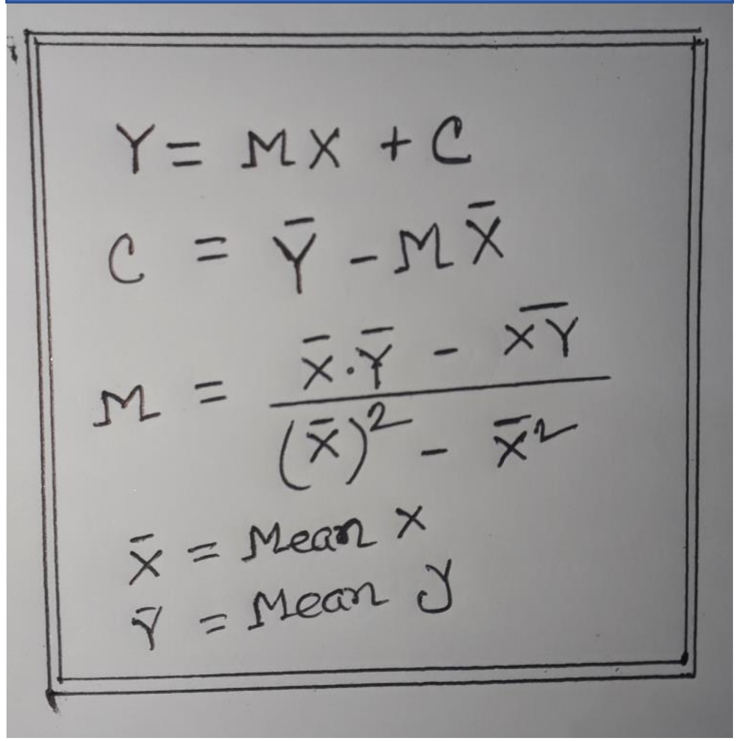
All about Linear Regression

(Least Squares Method)

Formula of Linear Regression



$$Y = MX + C$$

$$C = \bar{Y} - M\bar{X}$$

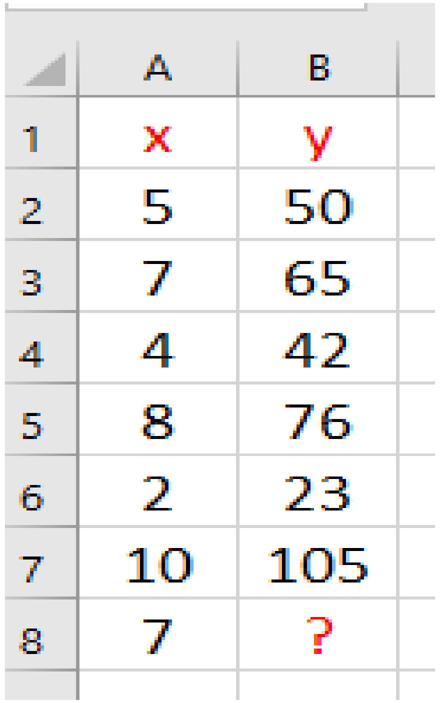
$$M = \frac{\bar{X} \cdot \bar{Y} - \overline{XY}}{(\bar{X})^2 - \overline{X^2}}$$

$\bar{X}$ = Mean X

$\bar{Y}$ = Mean Y

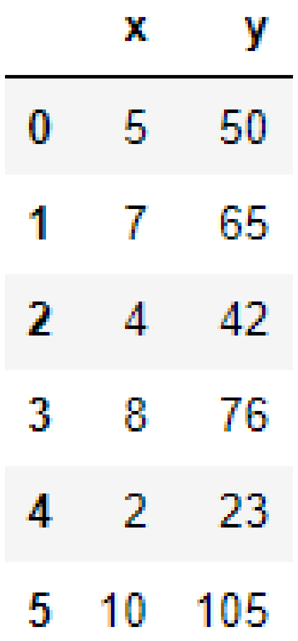
Now Solve it

Data Set



	A	B
1	x	y
2	5	50
3	7	65
4	4	42
5	8	76
6	2	23
7	10	105
8	7	?

All about Linear Regression



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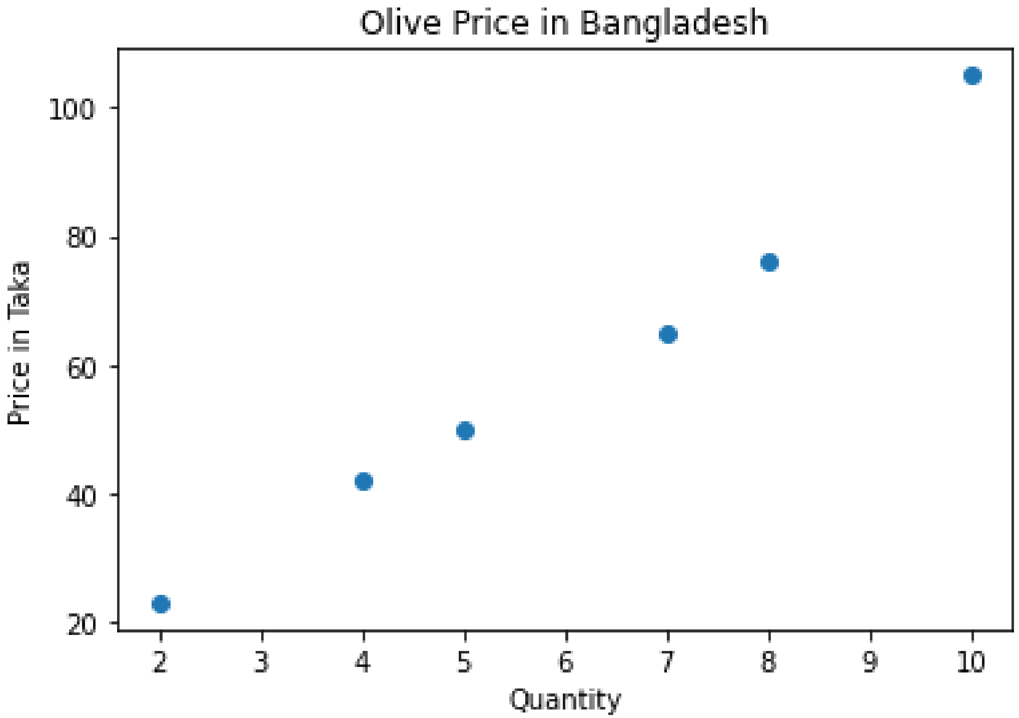
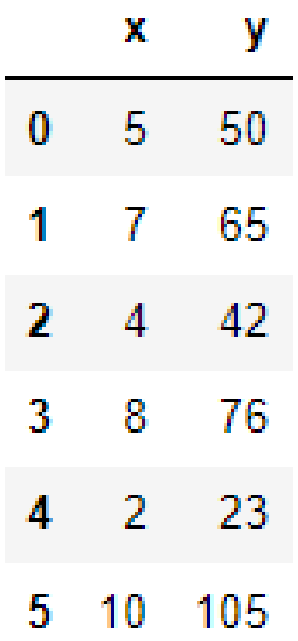


All about Linear Regression



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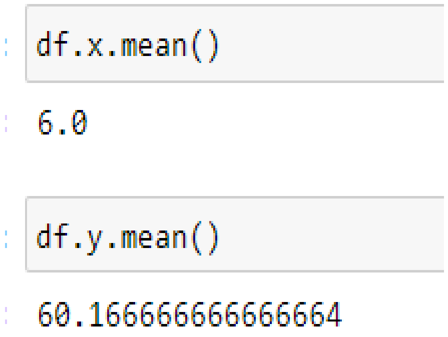
Mean Values

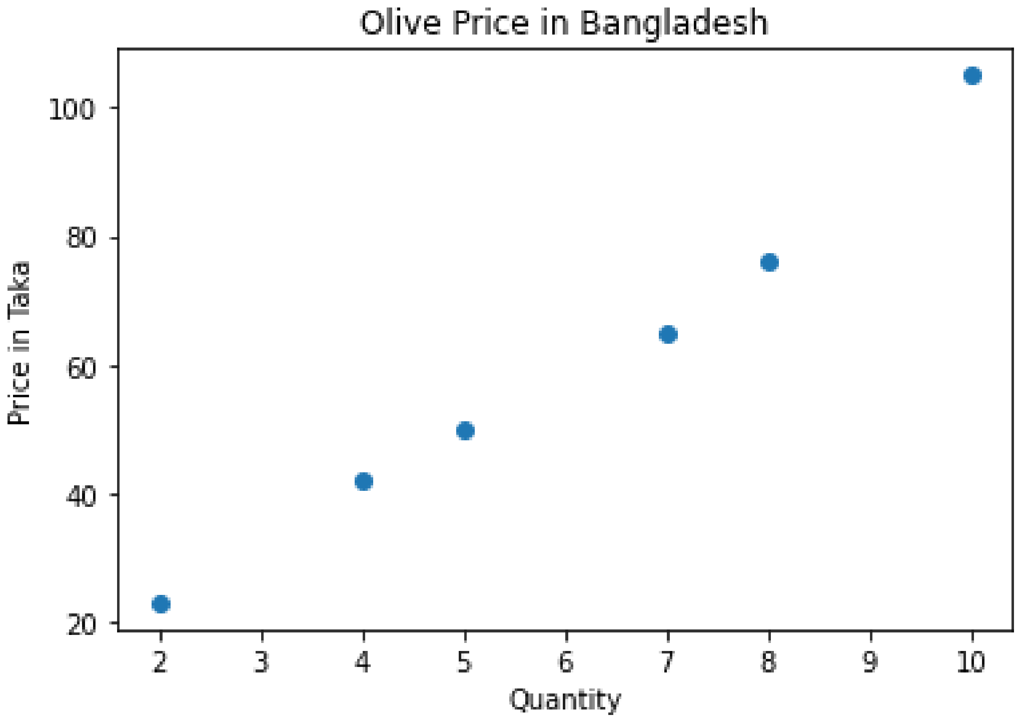


```
df.x.mean()
```

```
6.0
```

```
df.y.mean()
```

```
60.166666666666664
```



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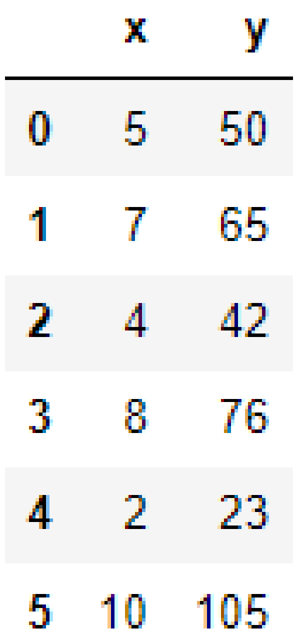

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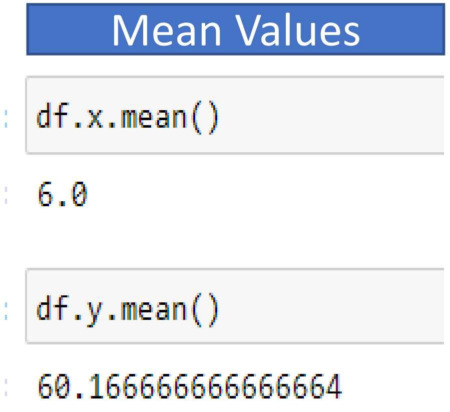

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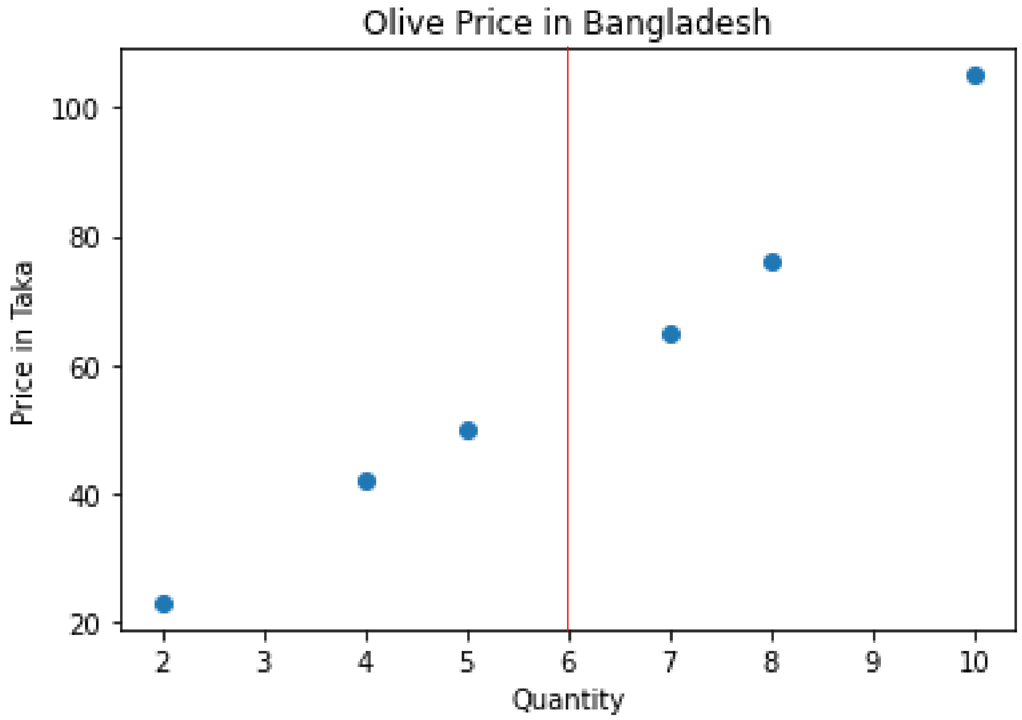

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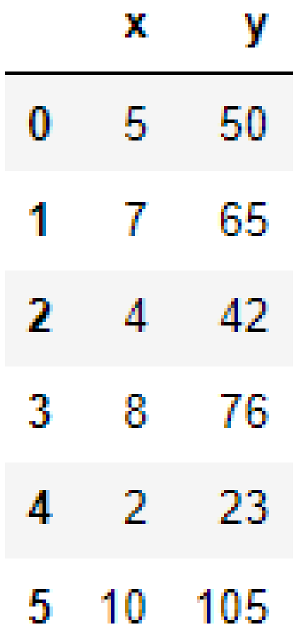

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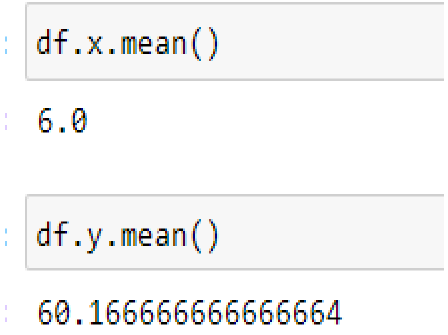

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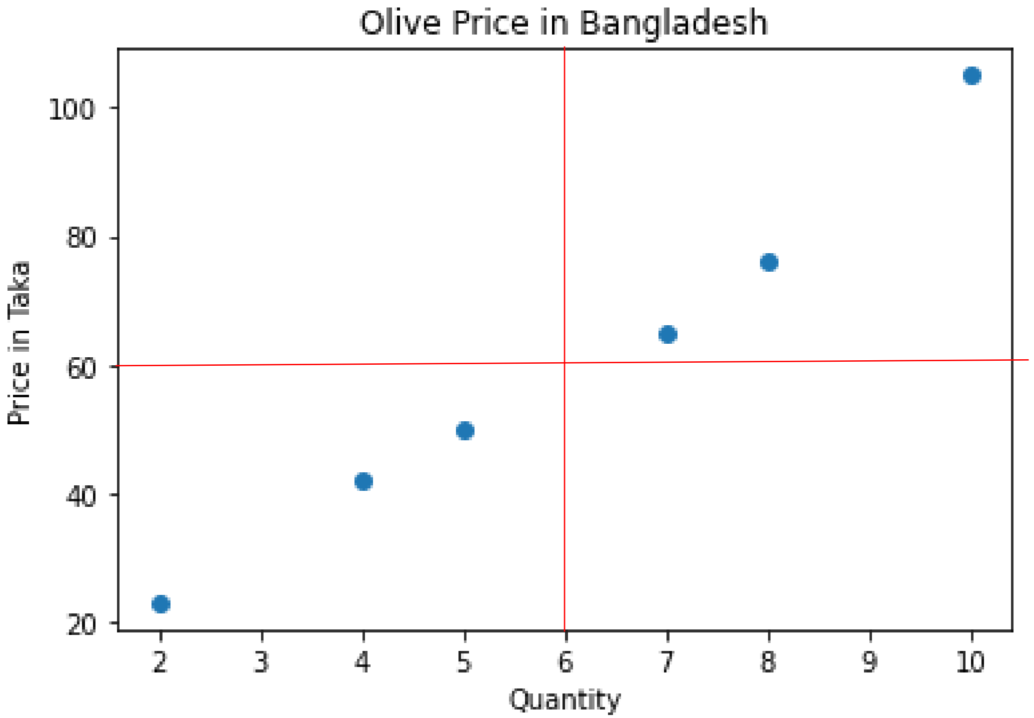
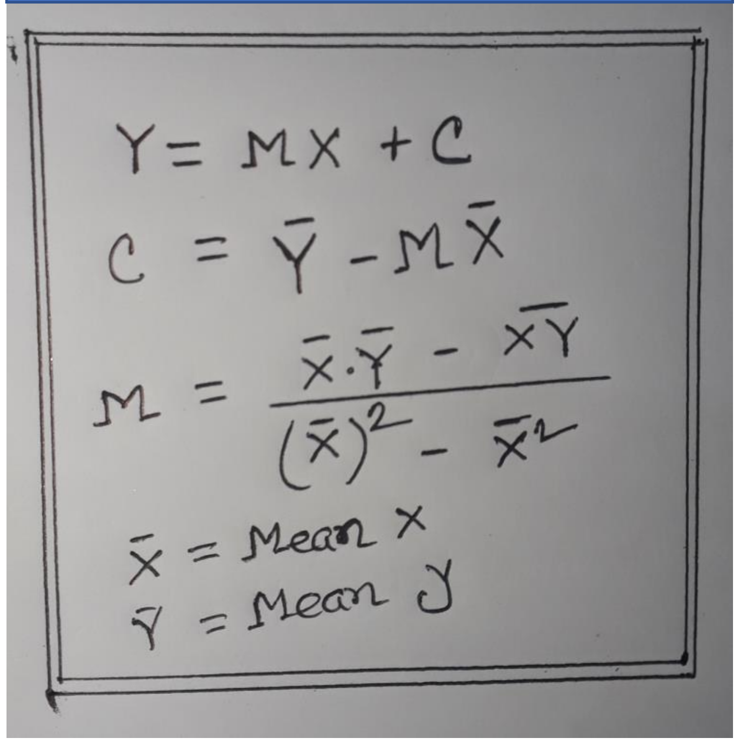


All about Linear Regression

Formula of Linear Regression



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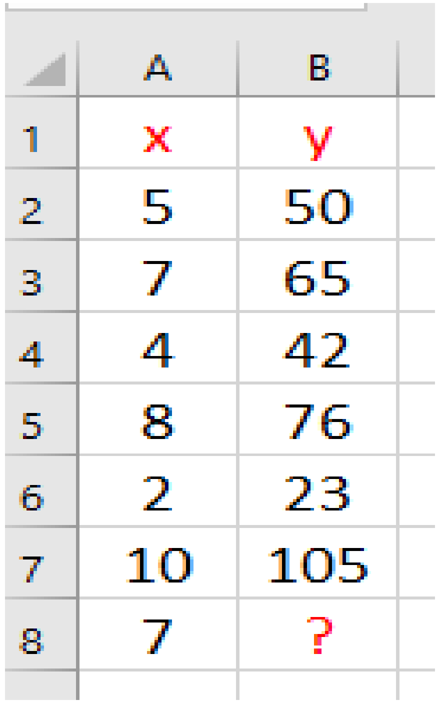

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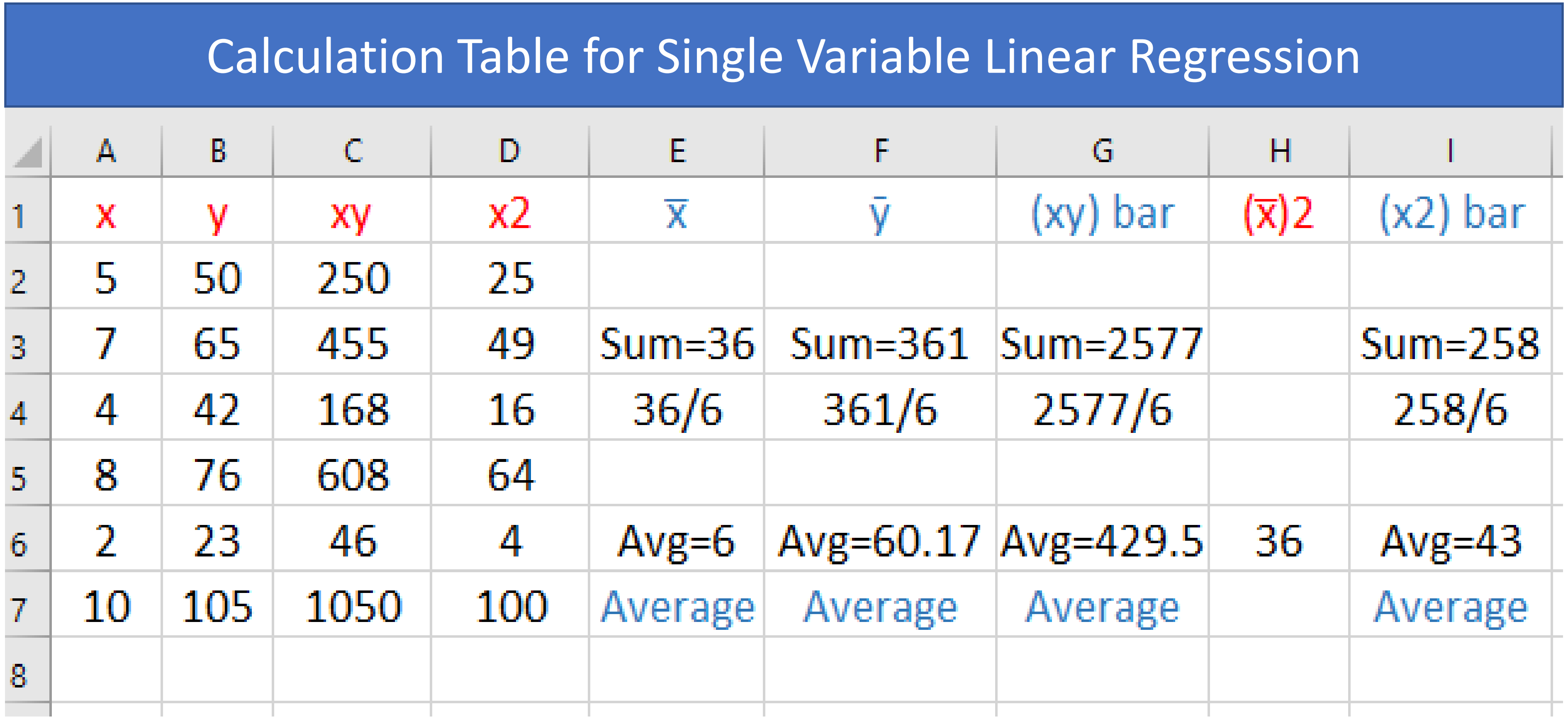
All about Linear Regression

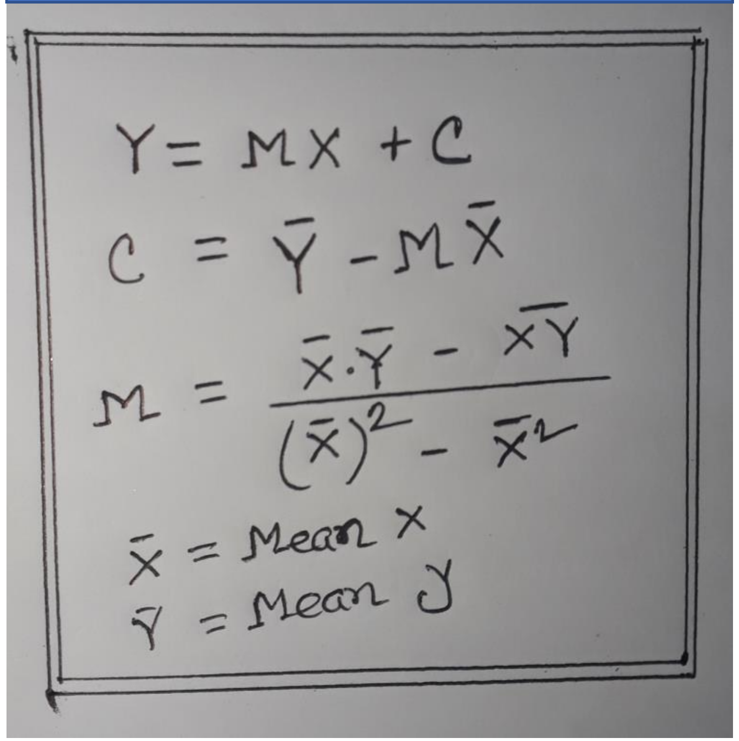


Calculation Table for Single Variable Linear Regression

	A	B	C	D	E	F	G	H	I
1	x	y	xy	x2	$\bar{x}$	$\bar{y}$	(xy) bar	$(\bar{x})2$	(x2) bar
2	5	50	250	25					
3	7	65	455	49	Sum=36	Sum=361	Sum=2577		Sum=258
4	4	42	168	16	36/6	361/6	2577/6		258/6
5	8	76	608	64					
6	2	23	46	4	Avg=6	Avg=60.17	Avg=429.5	36	Avg=43
7	10	105	1050	100	Average	Average	Average		Average
8									

All about Linear Regression

Formula of Linear Regression



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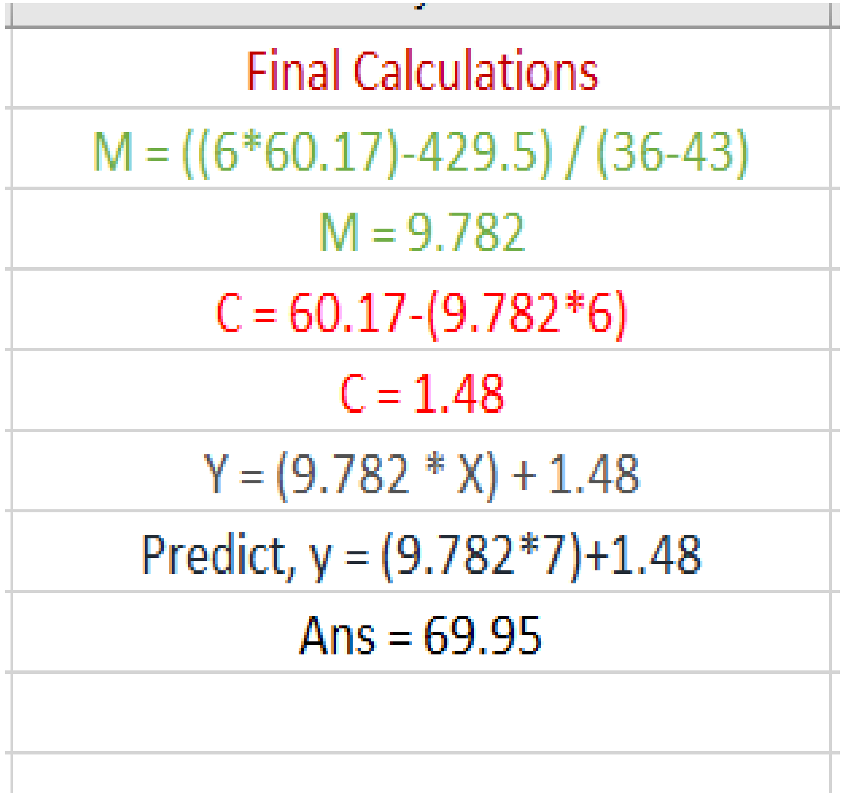


Final Calculations

M = ((6*60.17)-429.5) / (36-43)

M = 9.782

C = 60.17-(9.782*6)

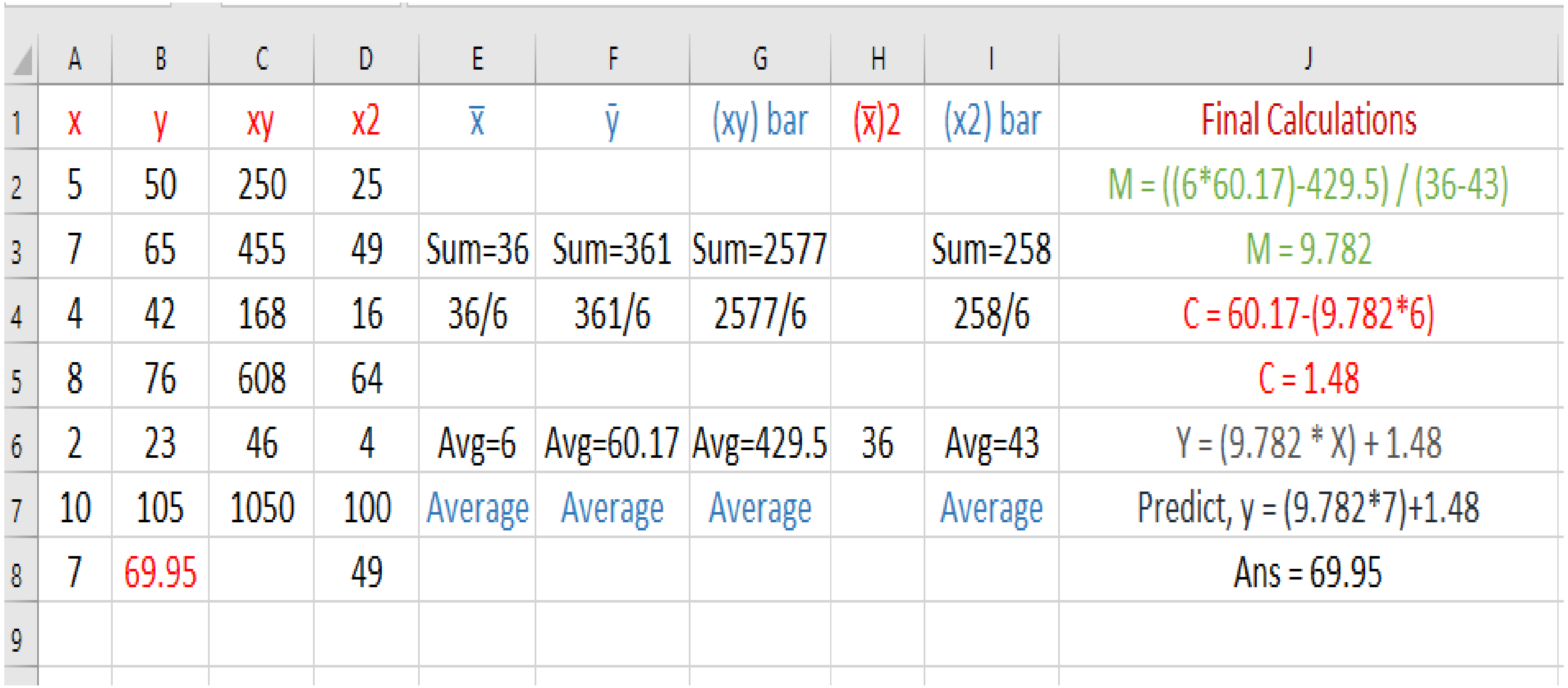
C = 1.48

Y = (9.782 * X) + 1.48

Predict, y = (9.782*7)+1.48

Ans = 69.95

All about Linear Regression



	A	B	C	D	E	F	G	H	I	J
1	x	y	xy	x2	$\bar{x}$	$\bar{y}$	(xy) bar	($\bar{x}$)2	(x2) bar	Final Calculations
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3	7	65	455	49	Sum=36	Sum=361	Sum=2577		Sum=258	M = 9.782
4	4	42	168	16	36/6	361/6	2577/6		258/6	C = 60.17-(9.782*6)
5	8	76	608	64						C = 1.48
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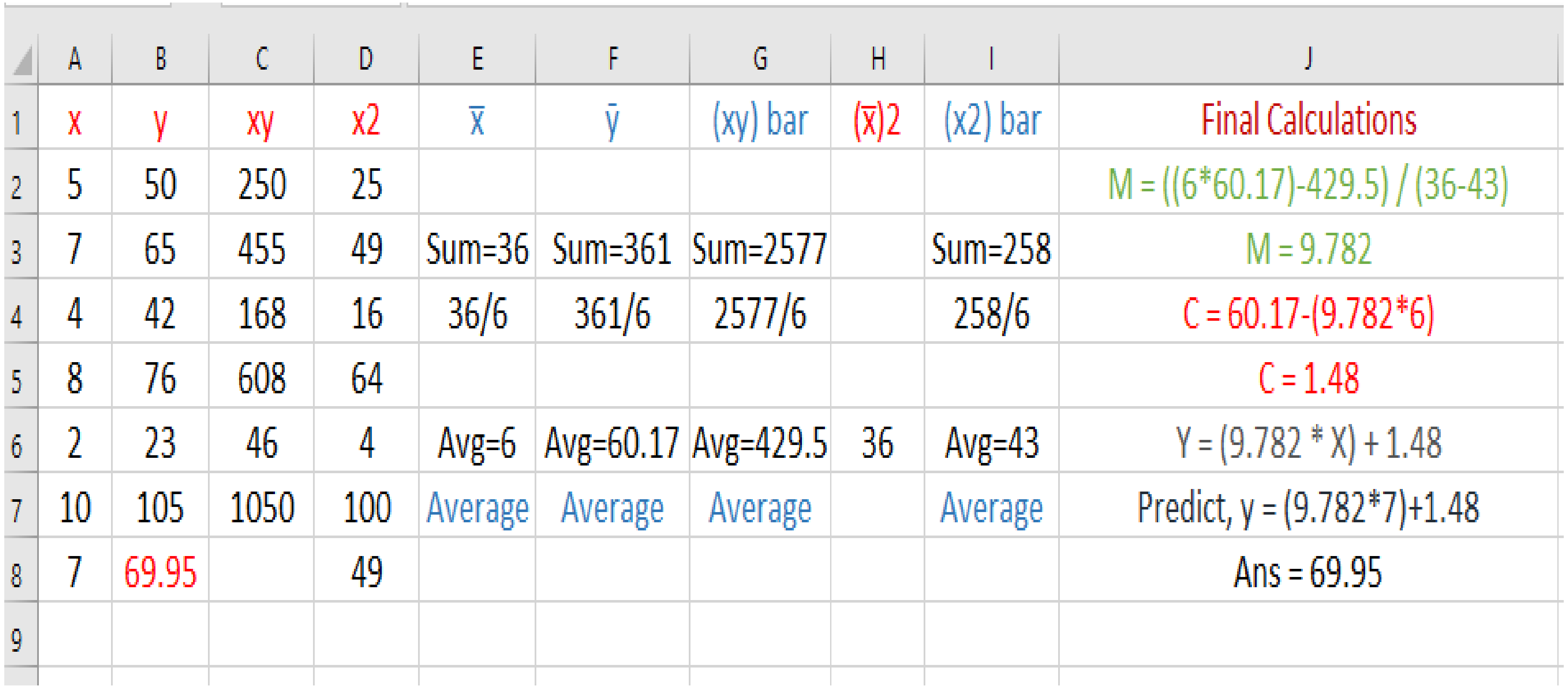
9										

All about Linear Regression



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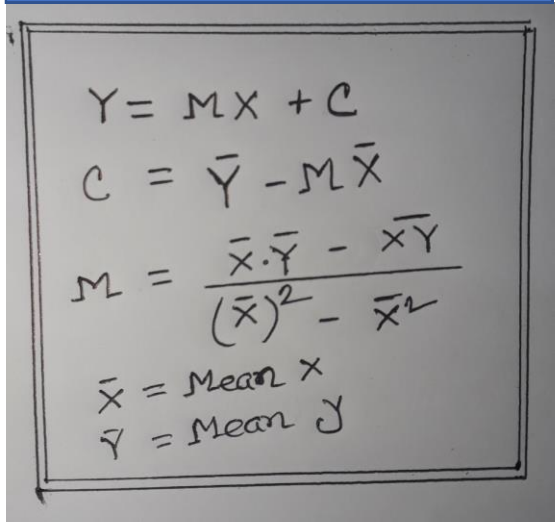
Formula of Linear Regression



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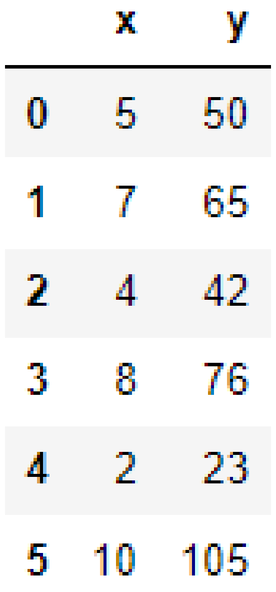
All about Linear Regression

Data Set



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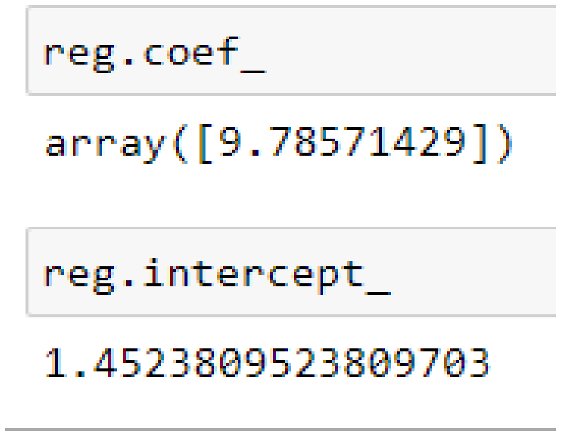
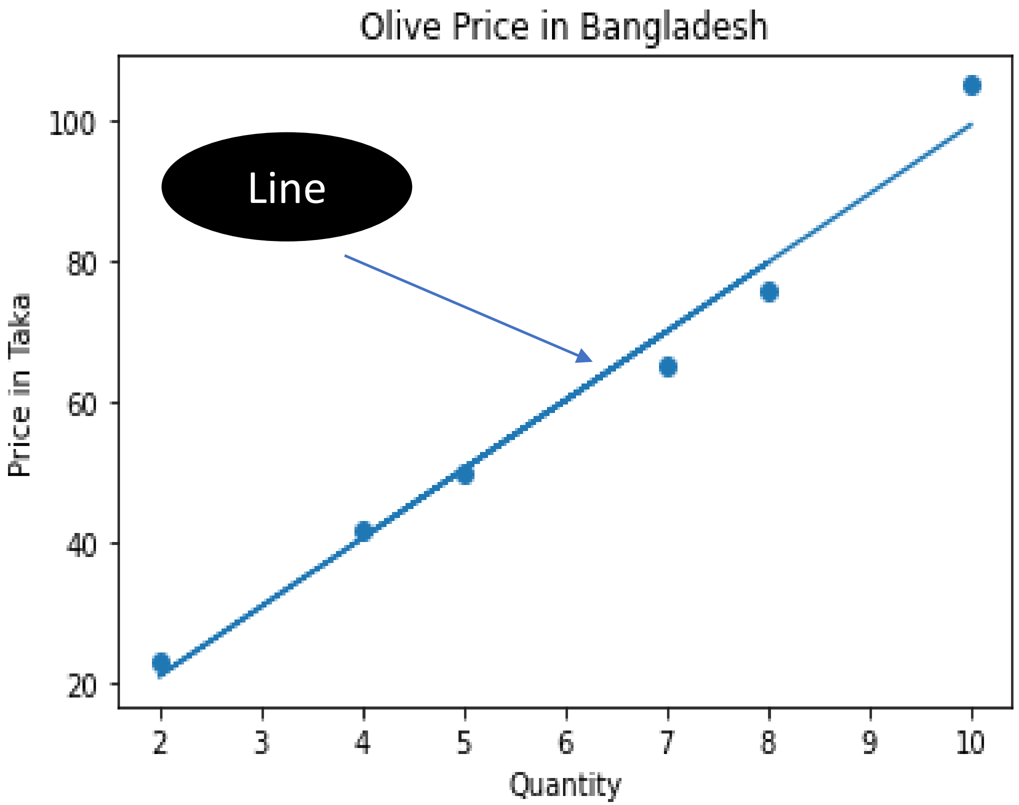
Value of M & C

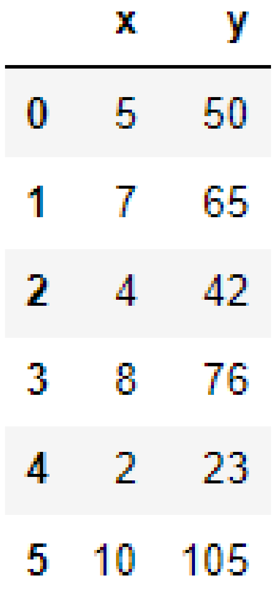


```
reg.coef_

array([9.78571429])

reg.intercept_

1.4523809523809703
```



All about Linear Regression

Data Set



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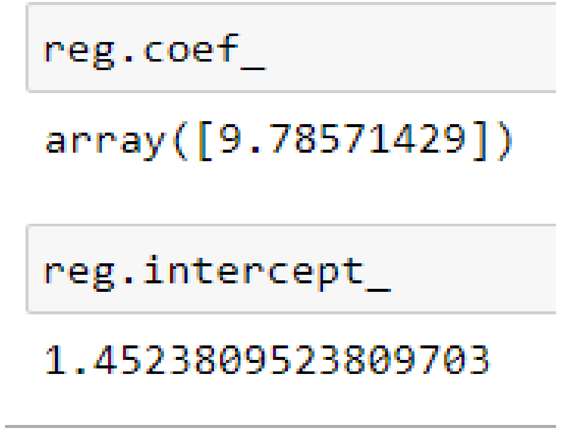

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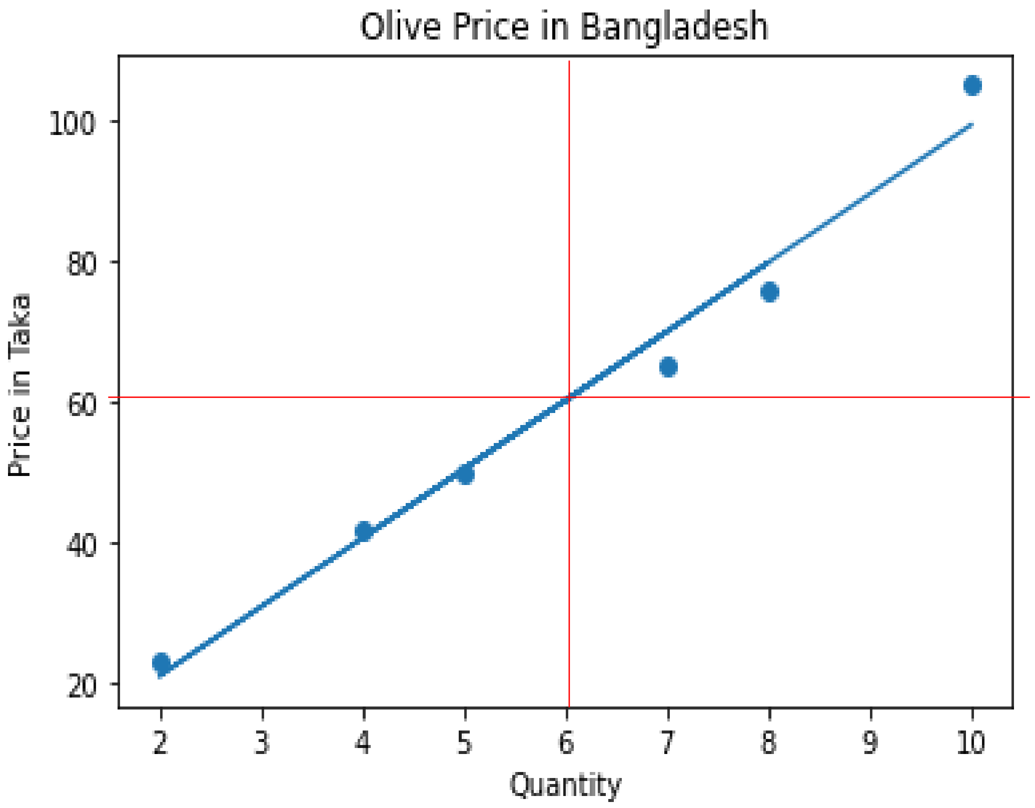

All about Linear Regression

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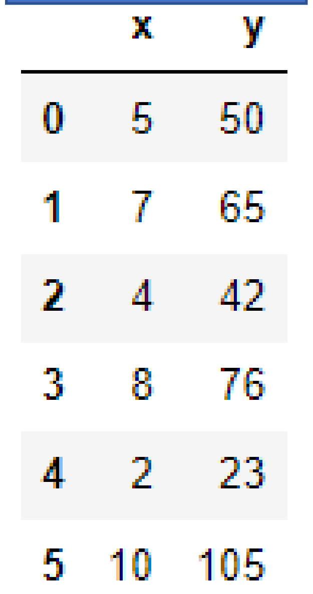

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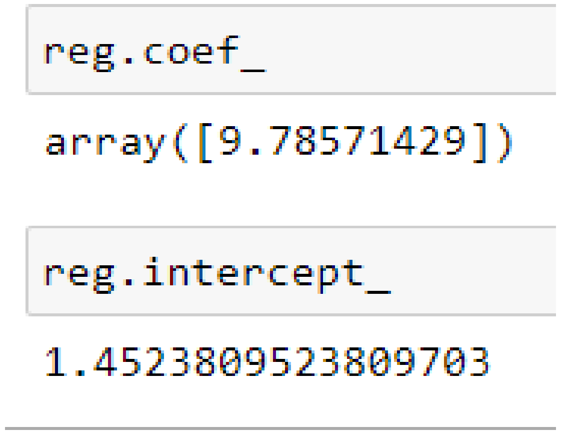

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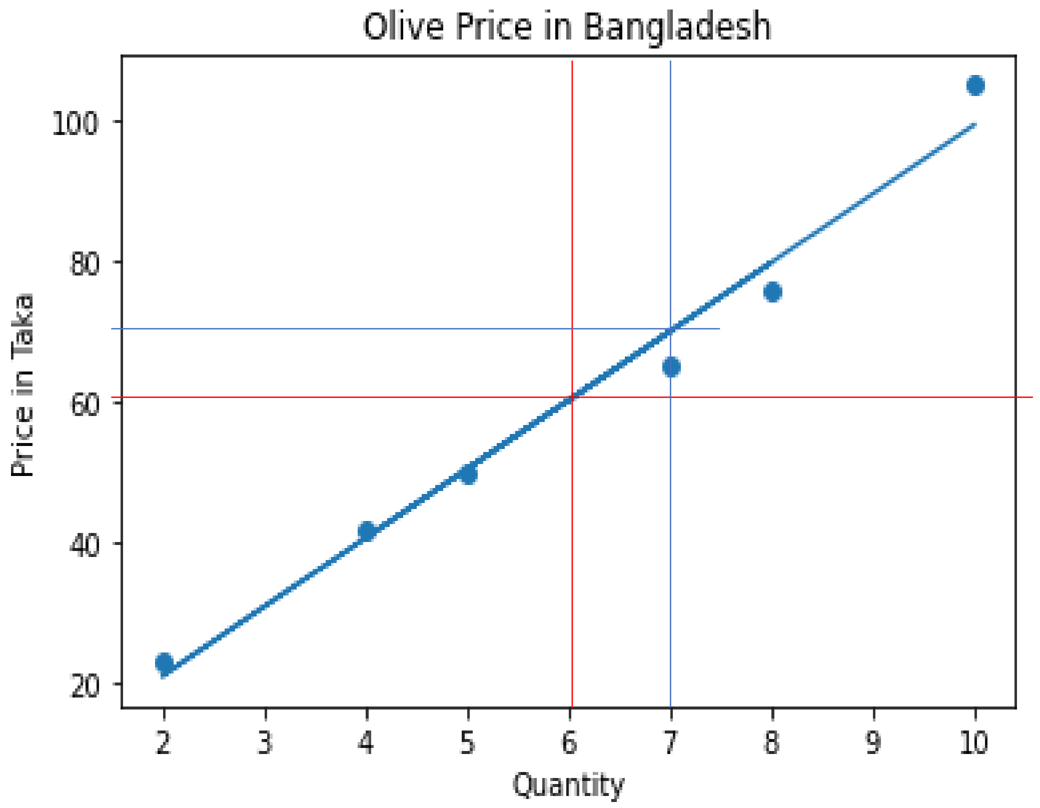
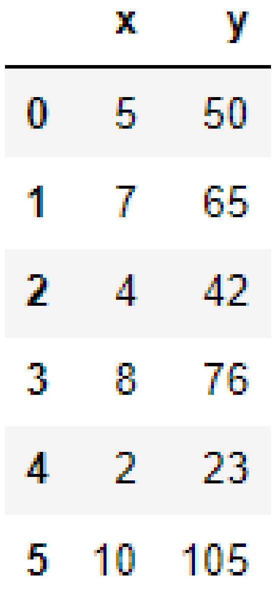


All about Linear Regression

Data Set



	x	y
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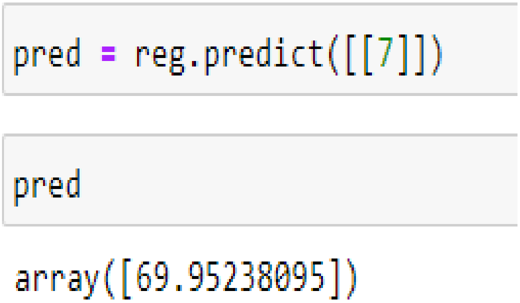
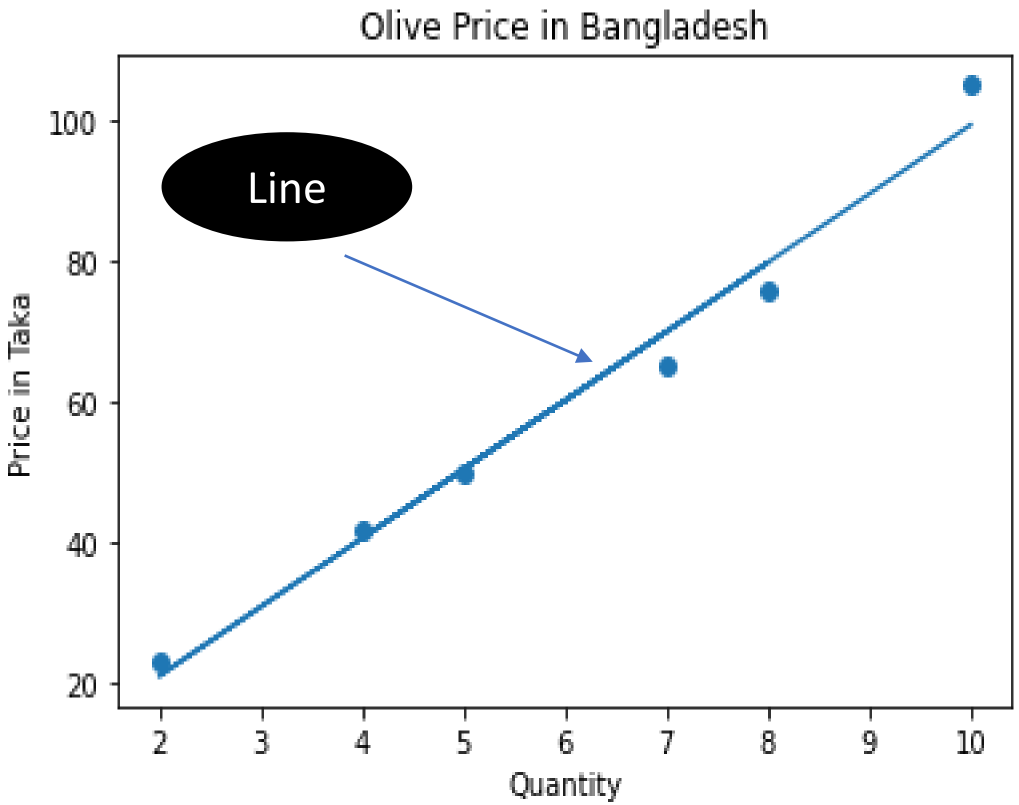
Predict New Value



```
pred = reg.predict([[7]])
```

```
pred
```

```
array([69.95238095])
```



Olive Price in Bangladesh

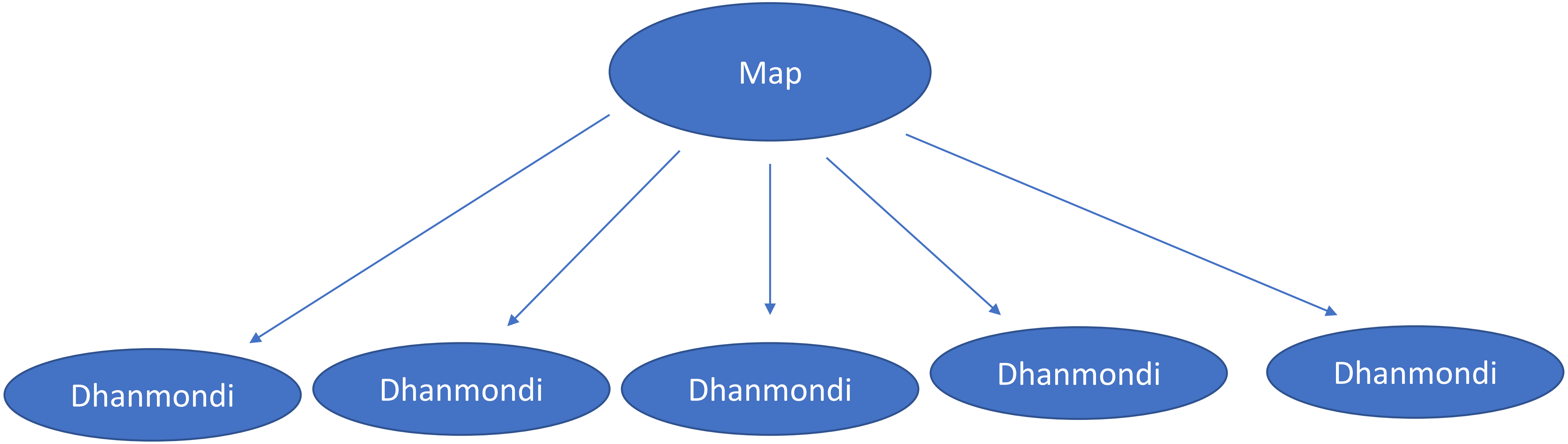
Line

Let's Implement Linear Regression with Python

https://www.aiquest.org

Cost Function

The cost function is a function, which is associates a cost with a decision.



Cost Function

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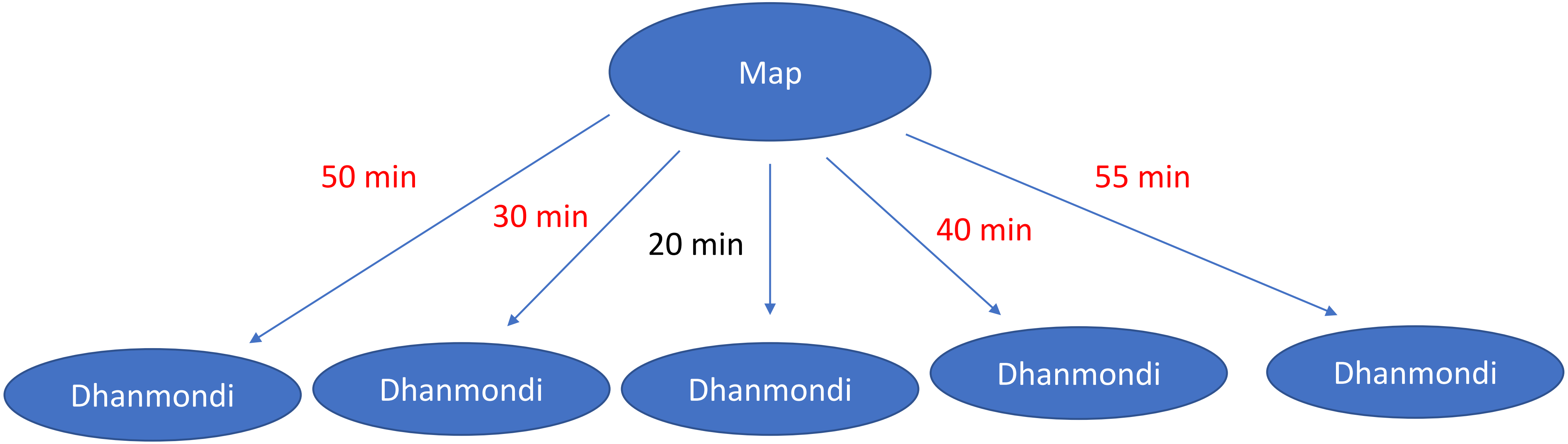

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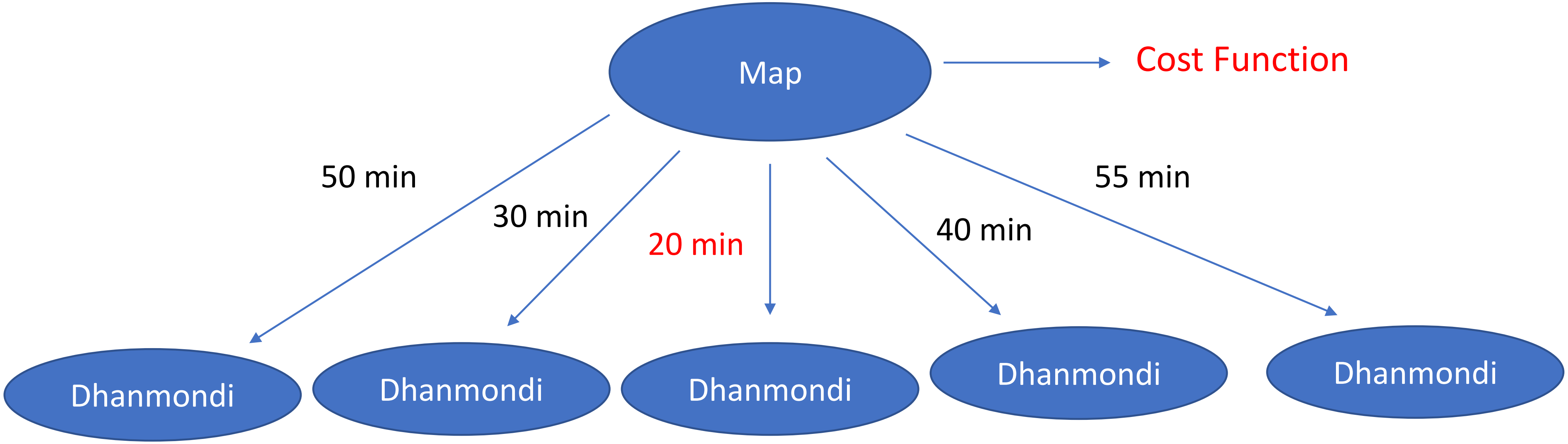


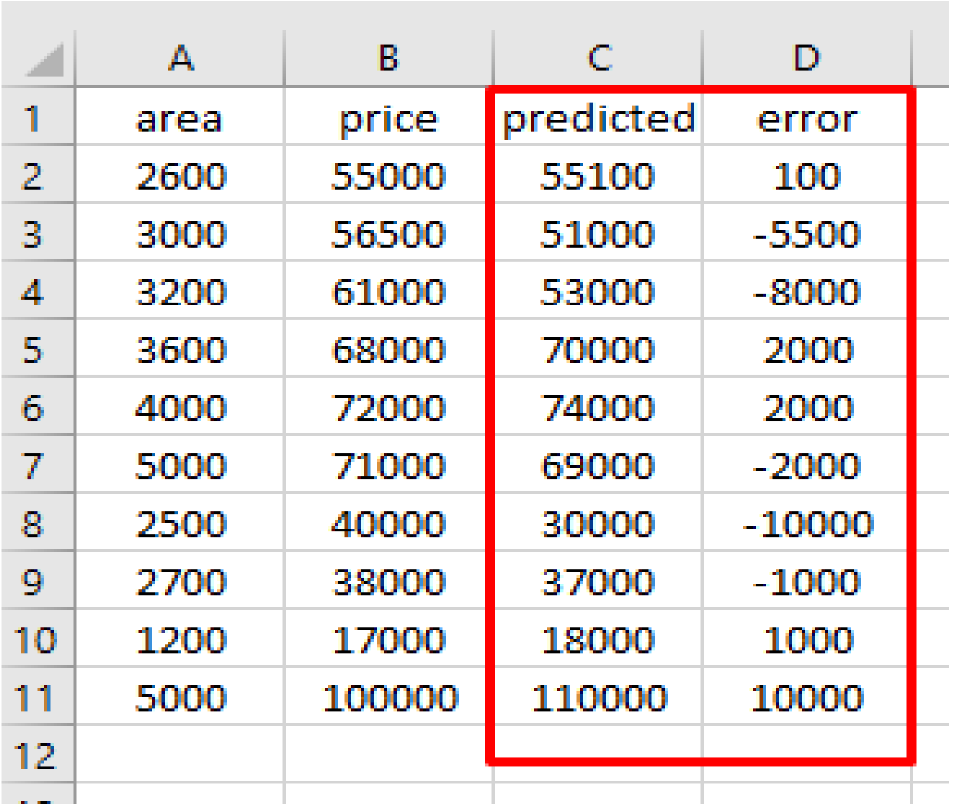
Loss & Cost Function

A loss function is for a single training example. It is also sometimes called an error function. A cost function, on the other hand, is the average loss over the entire training dataset. The optimization strategies aim at minimizing the cost function

Predicted Price (Y) = m * area + c

L1 Loss (error) = (1/n) * | (yi – y^) |
Yi = Area for each row
Y^ = Predicted Value

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2$$



	A	B	C	D
1	area	price	predicted	error
2	2600	55000	55100	100
3	3000	56500	51000	-5500
4	3200	61000	53000	-8000
5	3600	68000	70000	2000
6	4000	72000	74000	2000
7	5000	71000	69000	-2000
8	2500	40000	30000	-10000
9	2700	38000	37000	-1000
10	1200	17000	18000	1000
11	5000	100000	110000	10000
12				

Cost Function

The cost function is a function, which is associates a cost with a decision. It indicates the difference between the predicted and the actual values for a given dataset. An ideal value of the cost function is zero. In regression, the typical cost function (CF) used is the mean squared error (MSE) cost function. The form of the function is shown below.

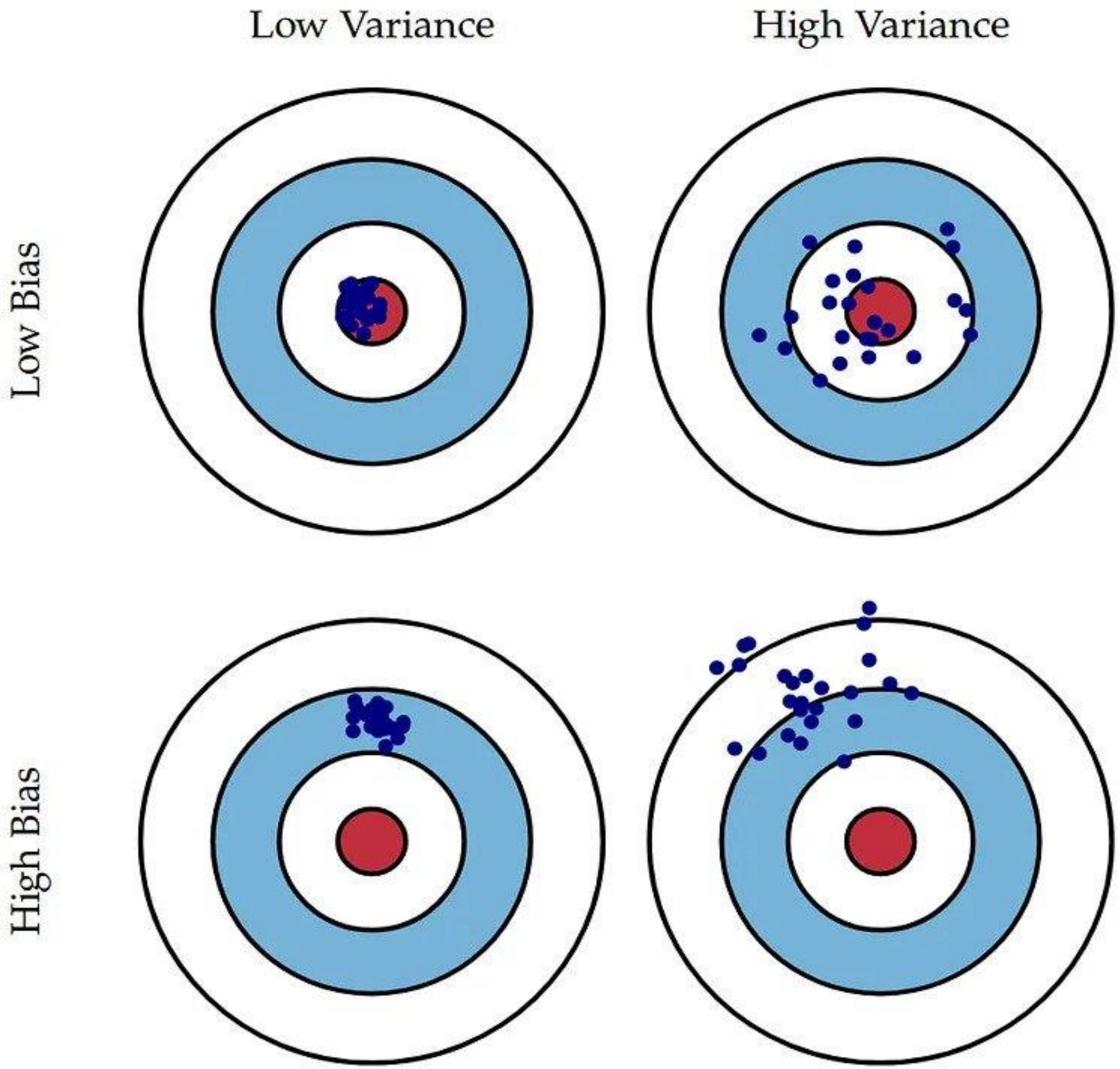
$$\mathrm{MAE} = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n}$$

MAE	= mean absolute error
y_i	= prediction
x_i	= true value
n	= total number of data points

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2$$

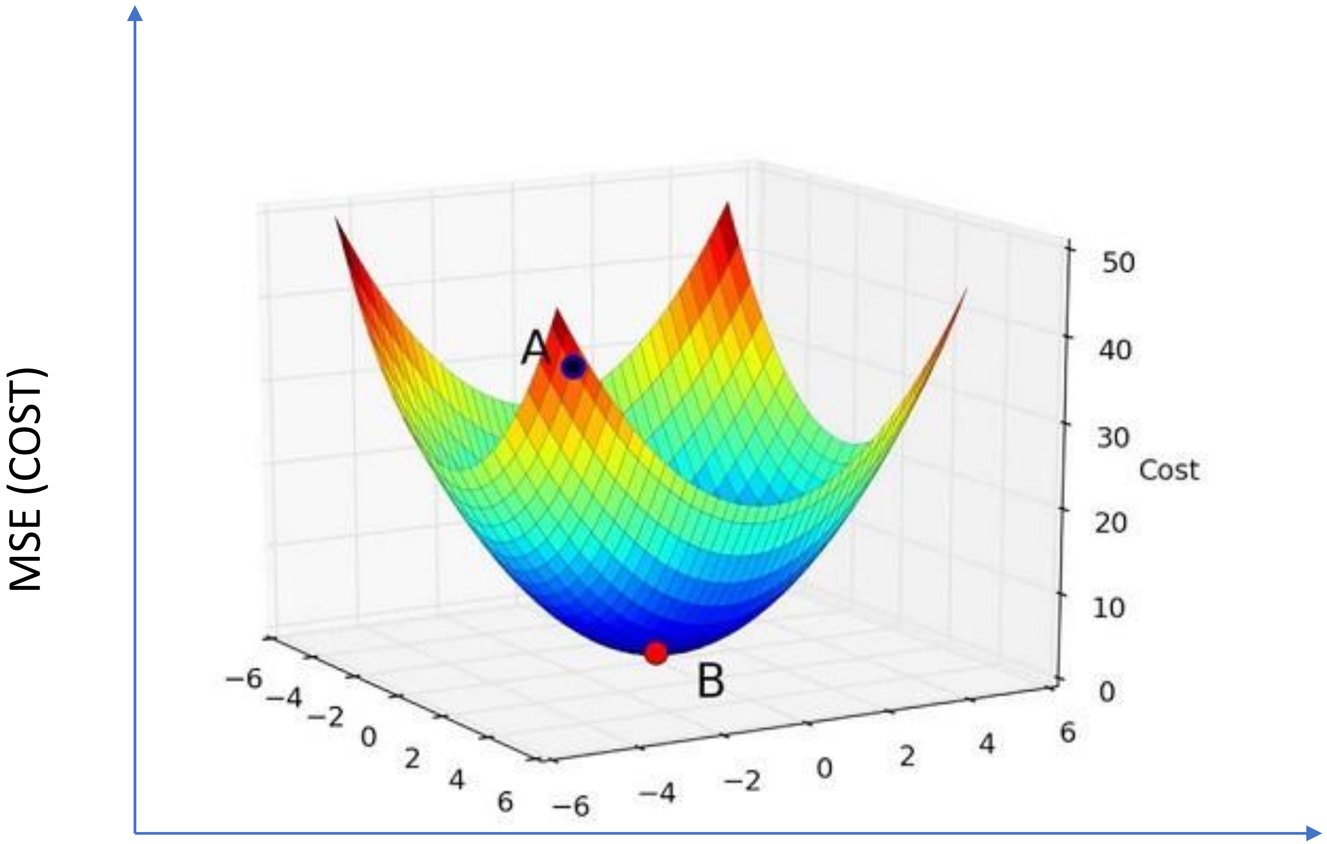
MSE	= mean squared error
n	= number of data points
Y_i	= observed values
$\hat{Y}_i$	= predicted values

Bias-Variance Tradeoff



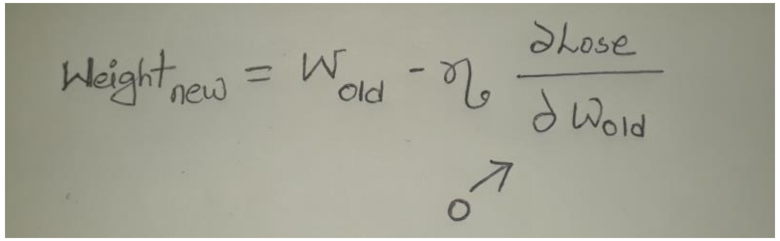
Minimizing the cost function: Optimizer

Gradient Descent



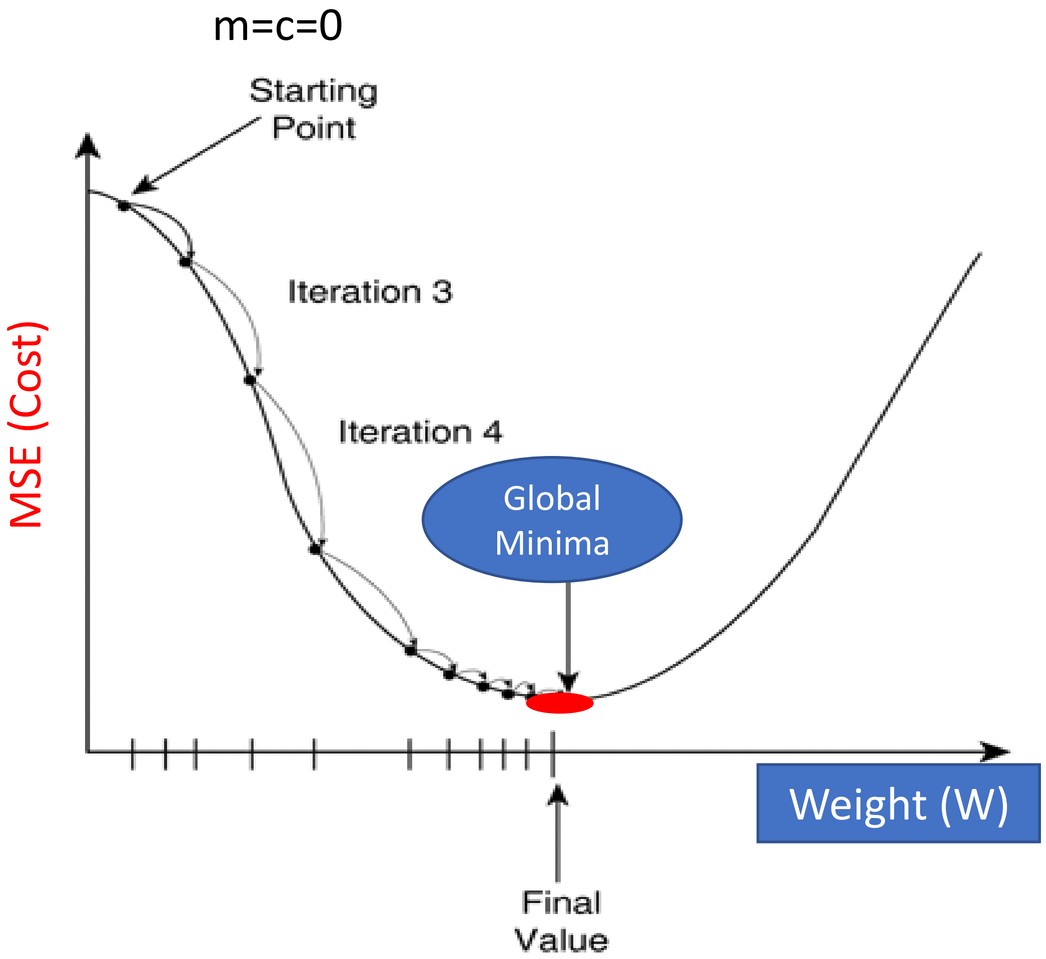
Minimizing the cost function: Optimizer
Gradient Descent

Gradient descent is an efficient optimization algorithm that attempts to find a local or global minima of a function. At this point the model has optimized the weights such that they minimize the cost function. Gradient descent enables a model to learn the gradient or direction that the model should take in order to reduce errors

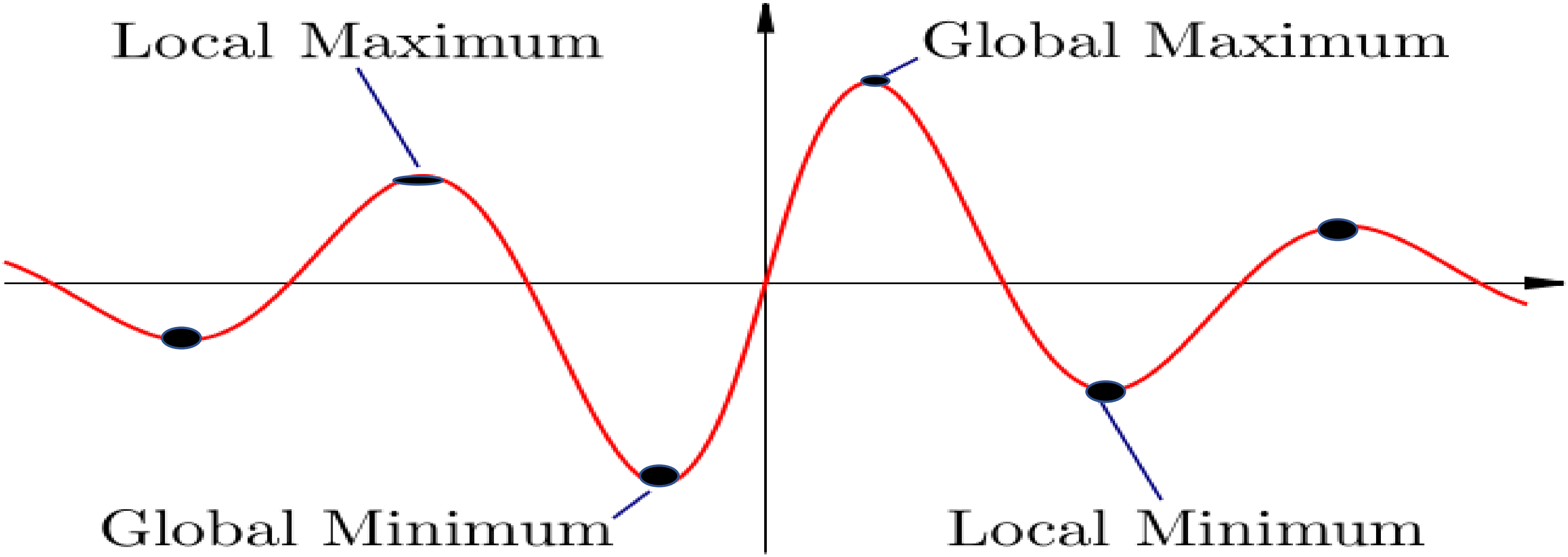


$$Weight_{new} = W_{old} - \eta \frac{\partial Lose}{\partial W_{old}}$$

$o \nearrow$



Minimizing the cost function:
Gradient Descent



Let's Implement Linear Regression with Python

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