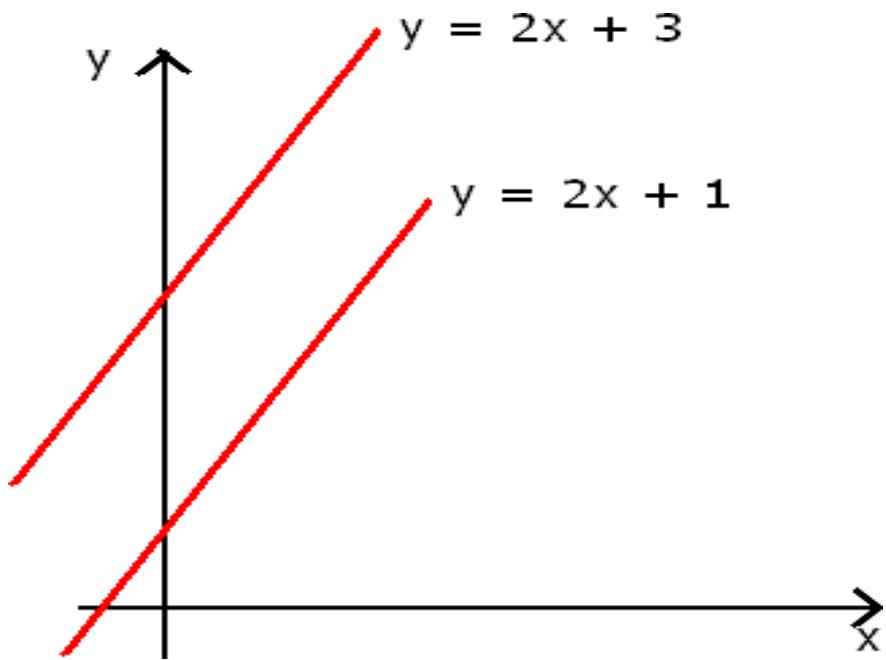


All about Linear Regression

Abu Bakar Siddique Mahi

- Theory Part:
 - Straight Line
 - Curve Line
 - Slope
 - Intercept
 - Cost Function
 - Loss Function
 - Mean Absolute Error (MAE)
 - Mean Squared Error (MSE)
 - Gradient Descent
- Coding with Python:
 - Implementing Linear Regression
 - Simple ML Project on Rent Prediction
- Discussion on Assignment:
 - Weight Prediction Based on Height

All about Linear Regression



$$\begin{aligned} X &= 10, 30, 50 \\ Y &= 2*10 + 3 = 23 \\ Y &= 2*30 + 3 = 63 \\ Y &= 2*50 + 3 = 103 \end{aligned}$$

Fig: Straight Line

All about Linear Regression

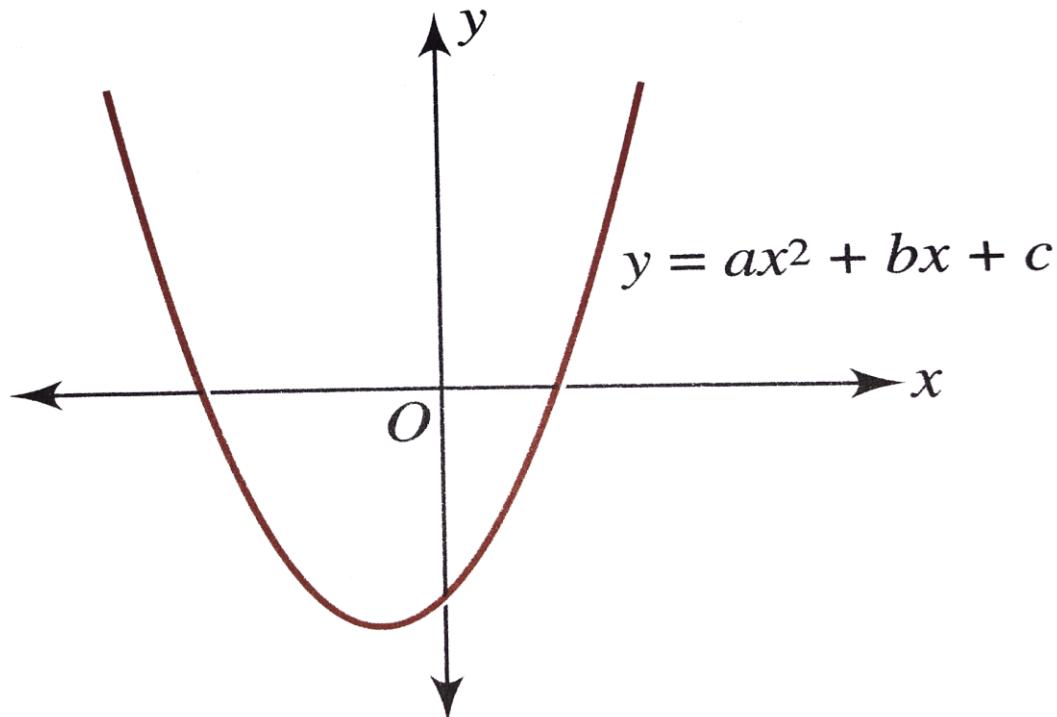
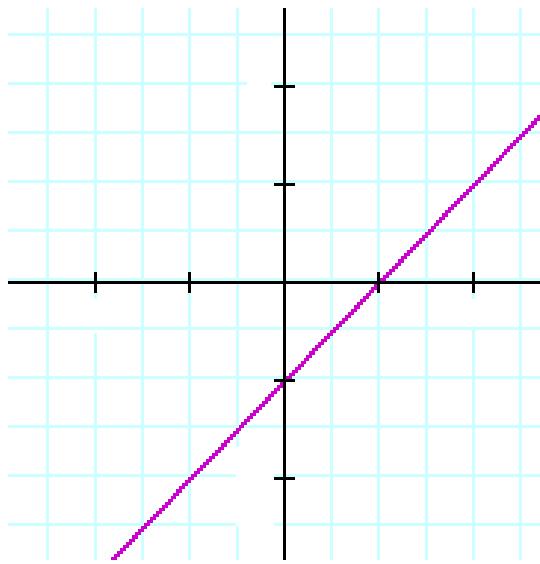
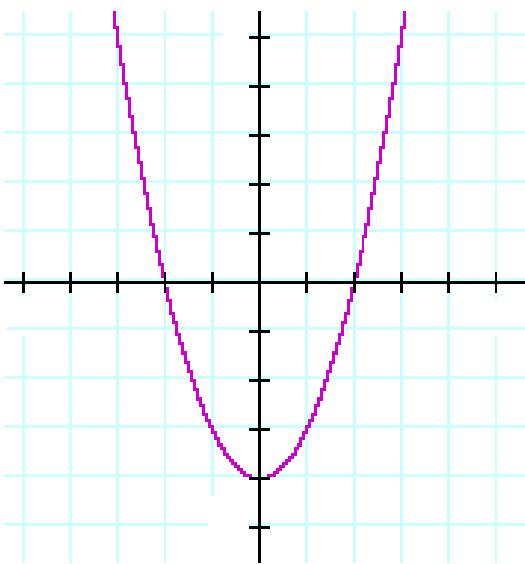


Fig: Curve Line

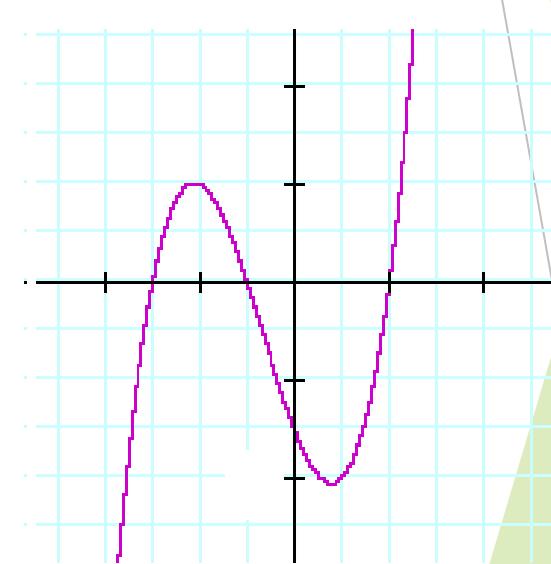
All about Linear Regression



$$y = ax + b$$



$$y = ax^2 + bx + c$$

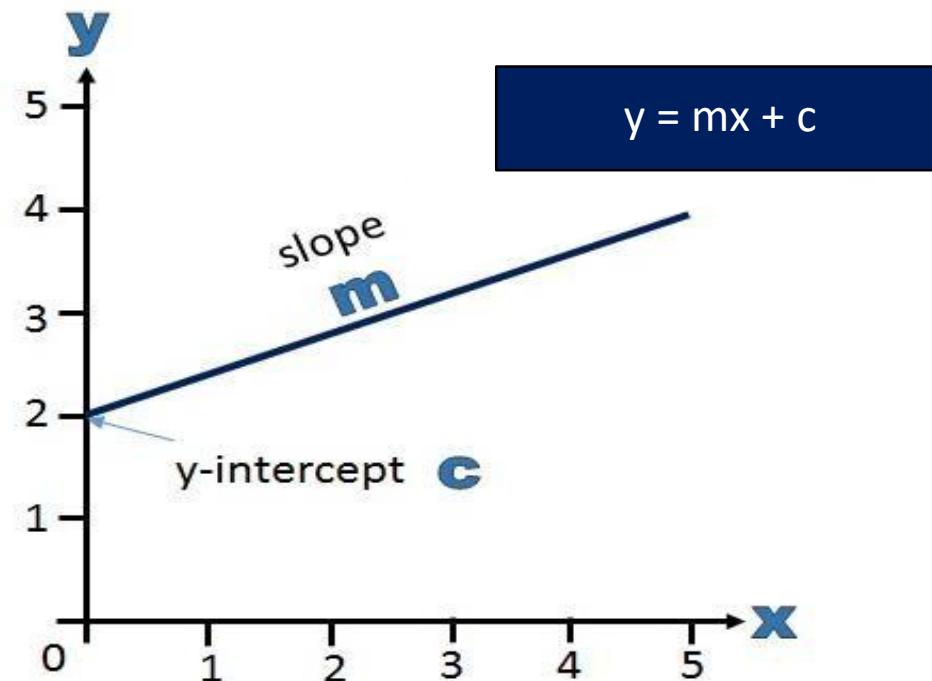


$$y = ax^3 + bx^2 + cx + d$$

Fig: Lines

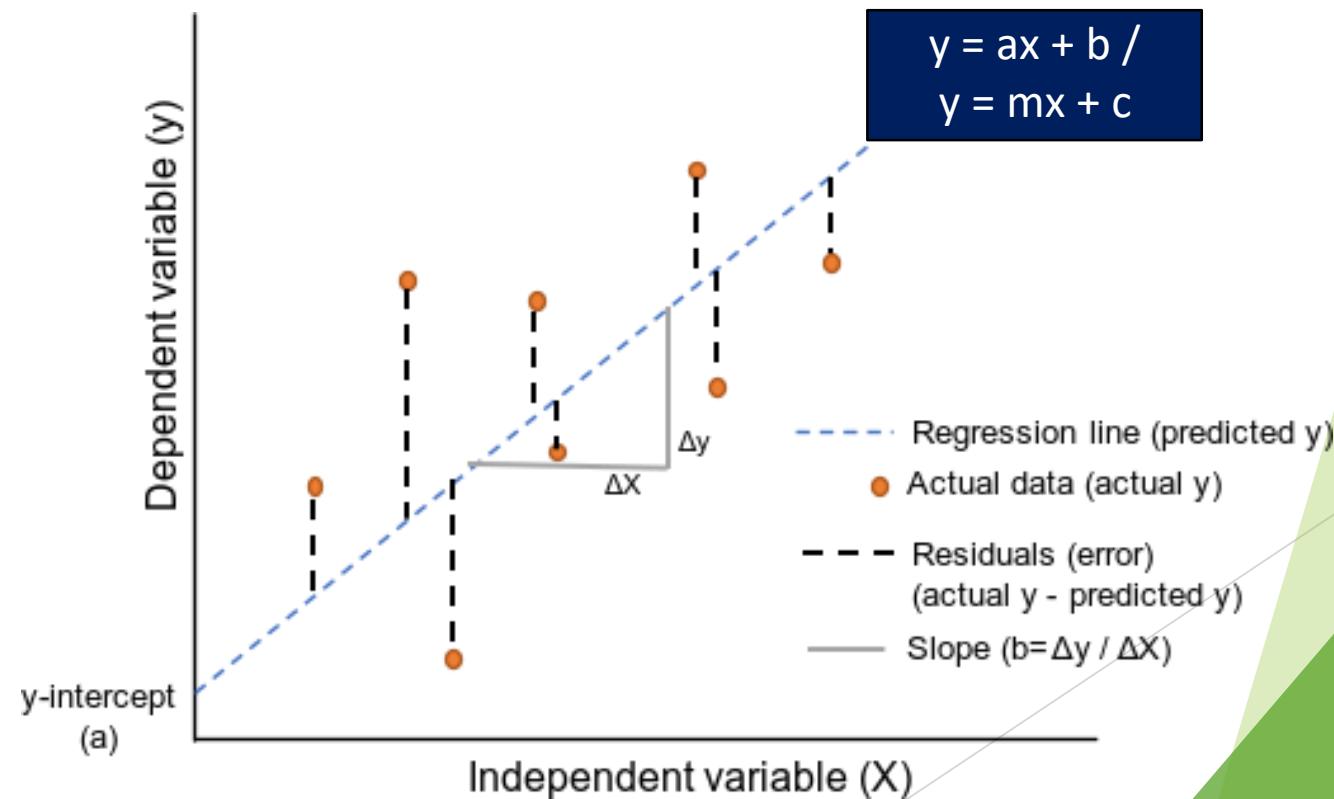
All about Linear Regression

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.

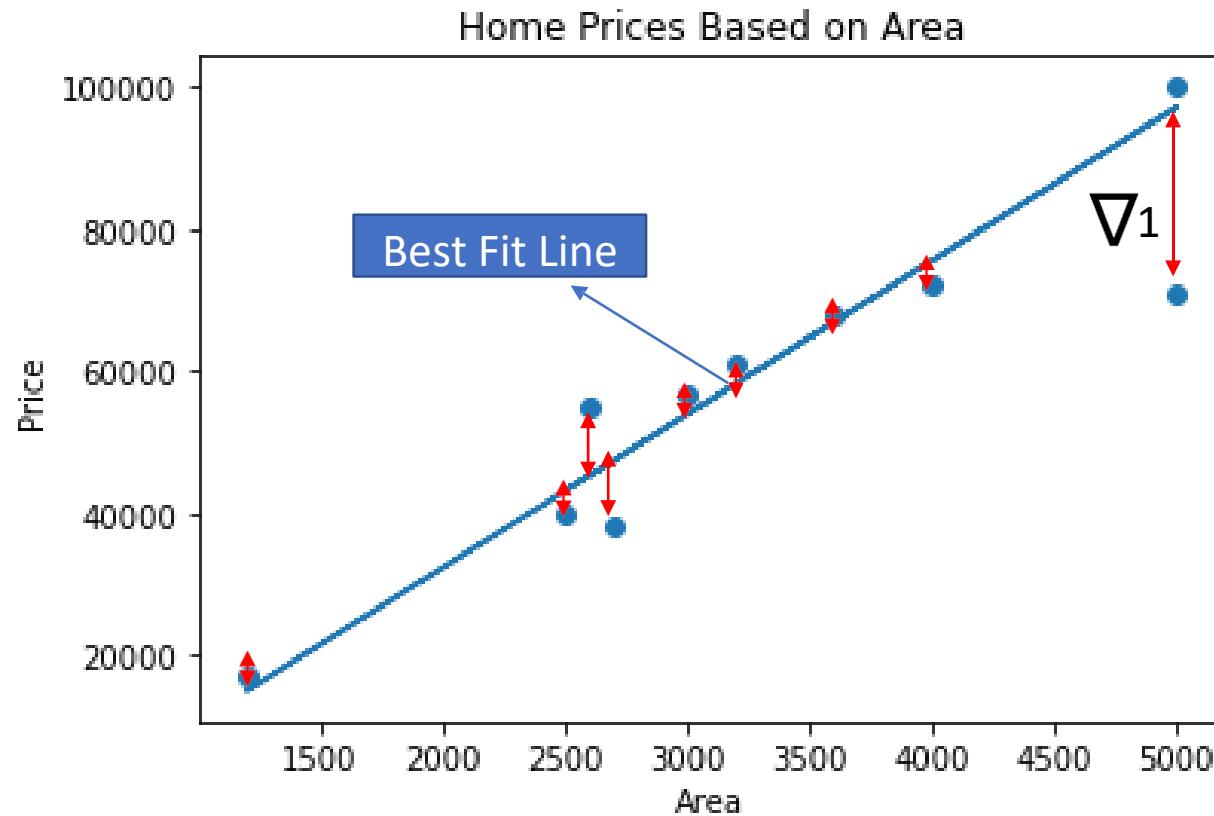


All about Linear Regression

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.



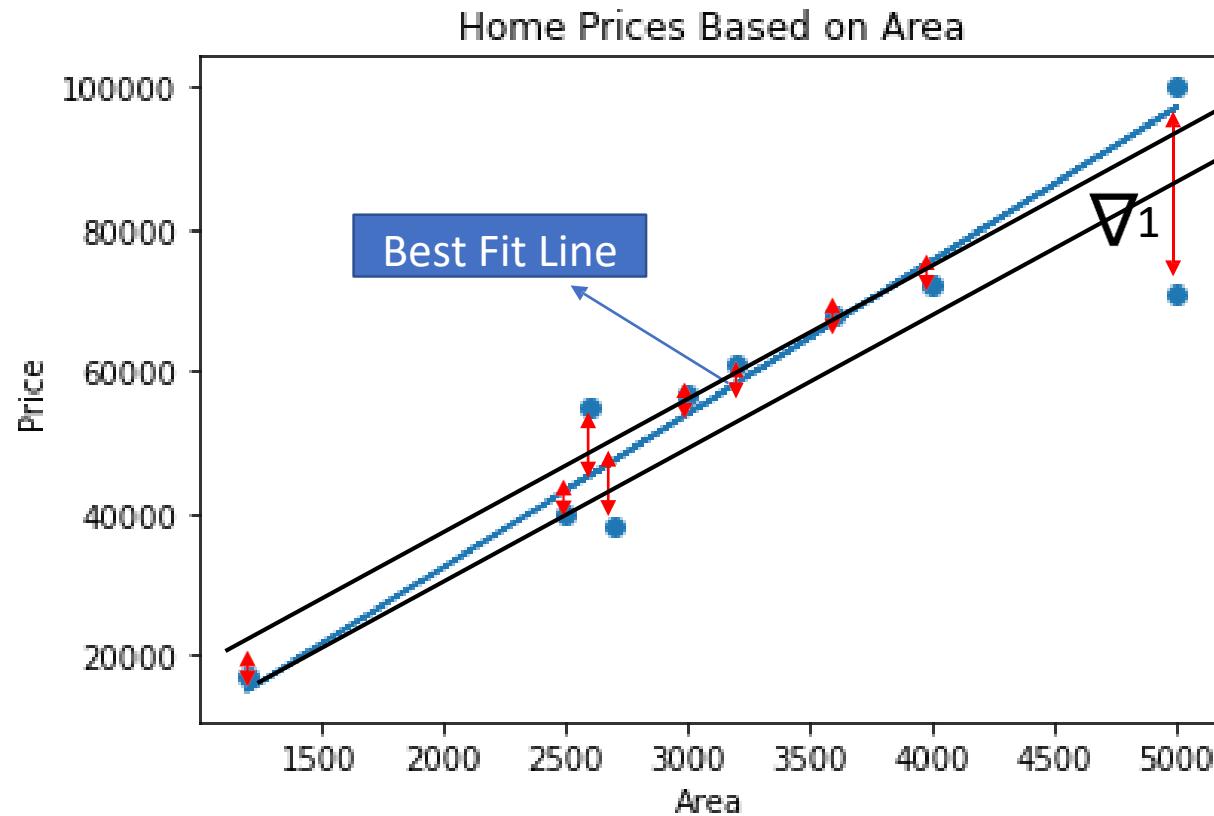
All about Linear Regression



$$y = mx + b ; \text{ or, } Y = 9.782 * X + 1.48$$

Coefficient = 9.782
Intercept = 1.48

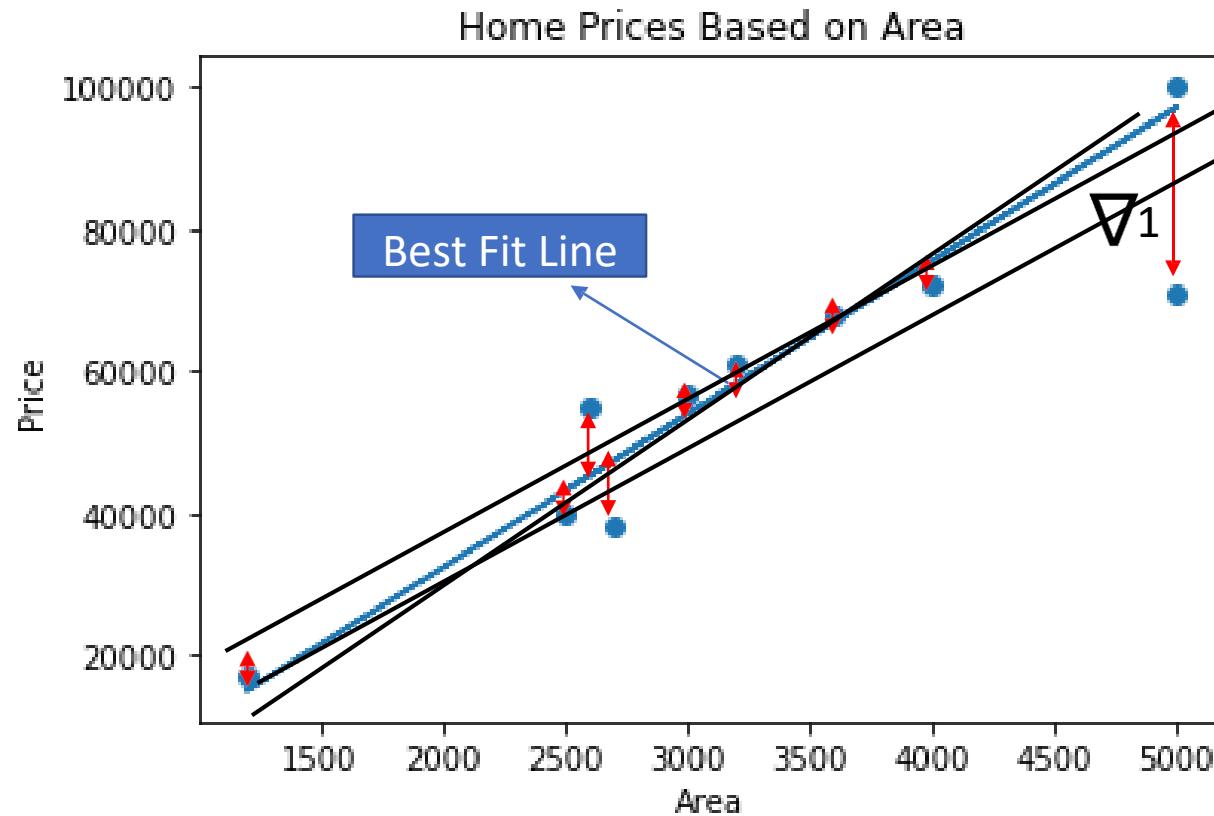
All about Linear Regression



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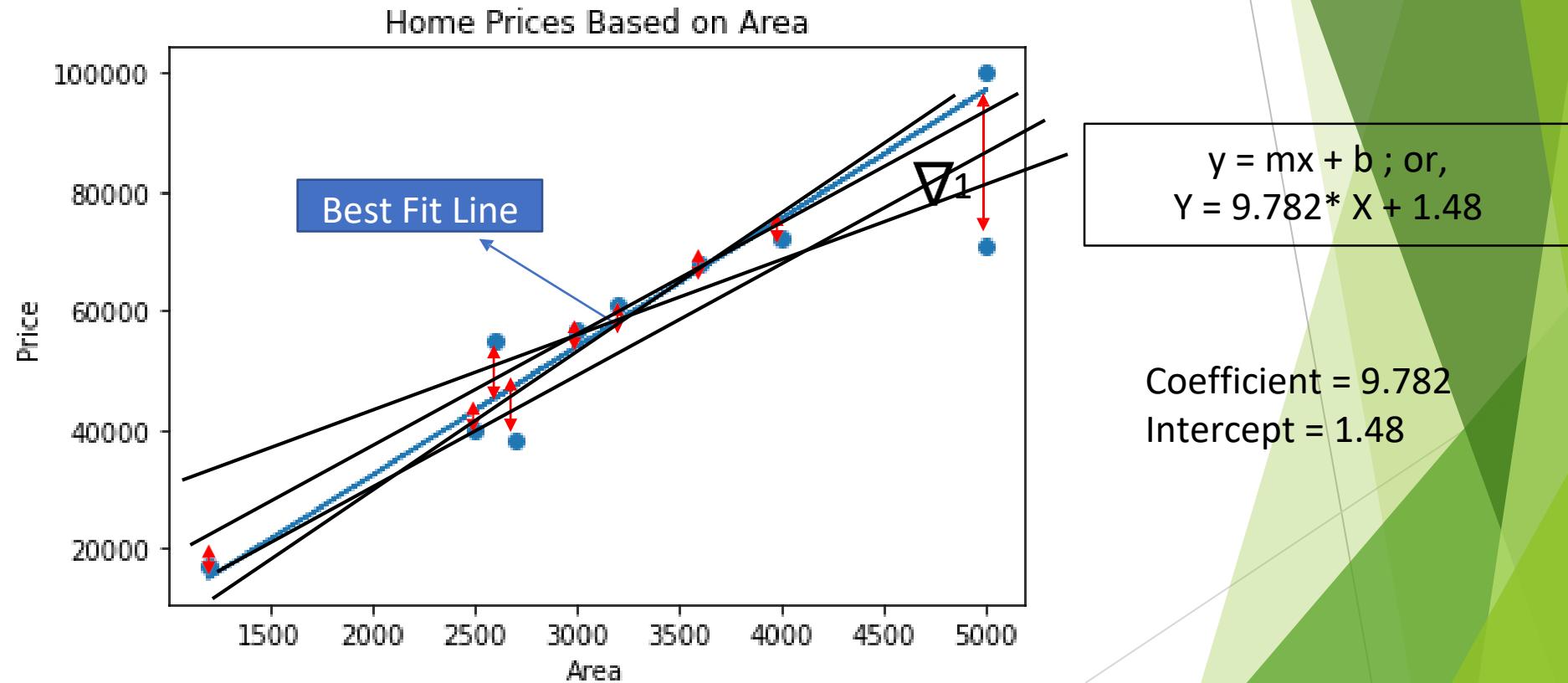
All about Linear Regression



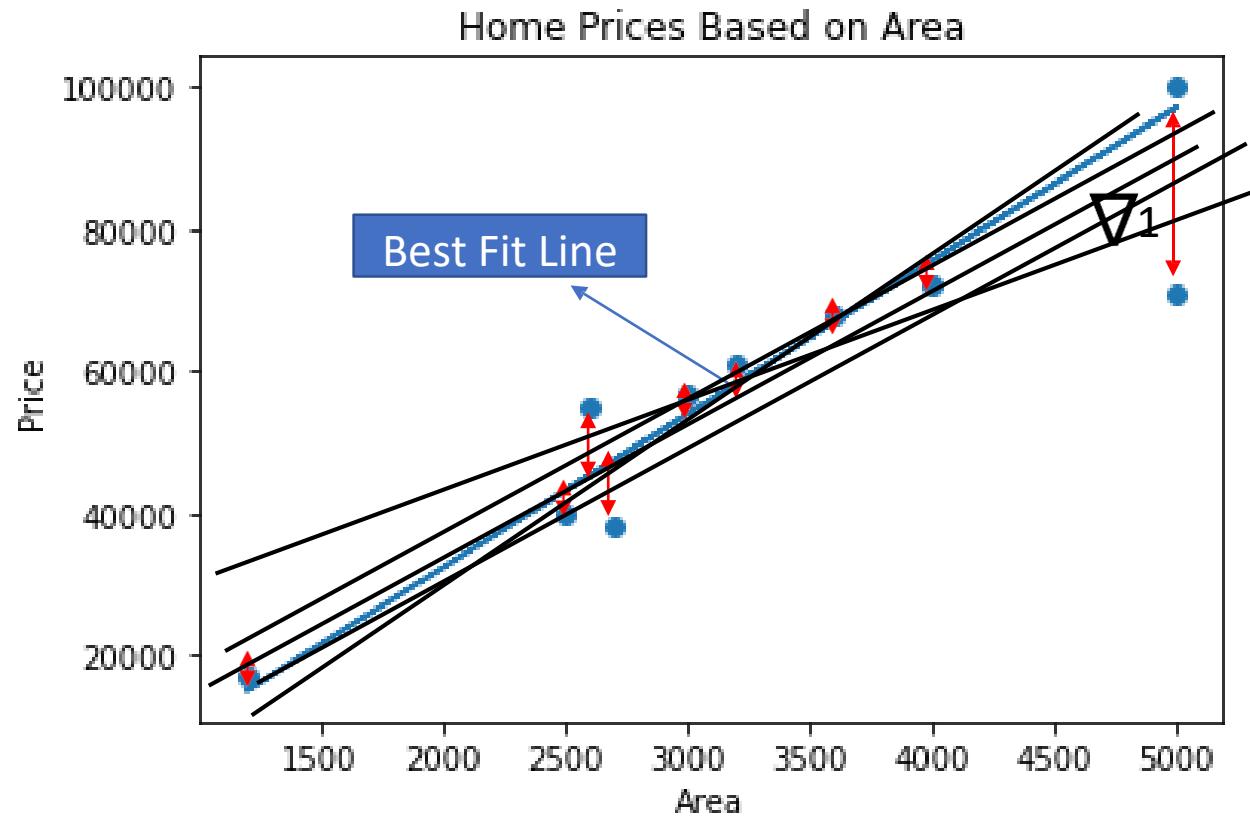
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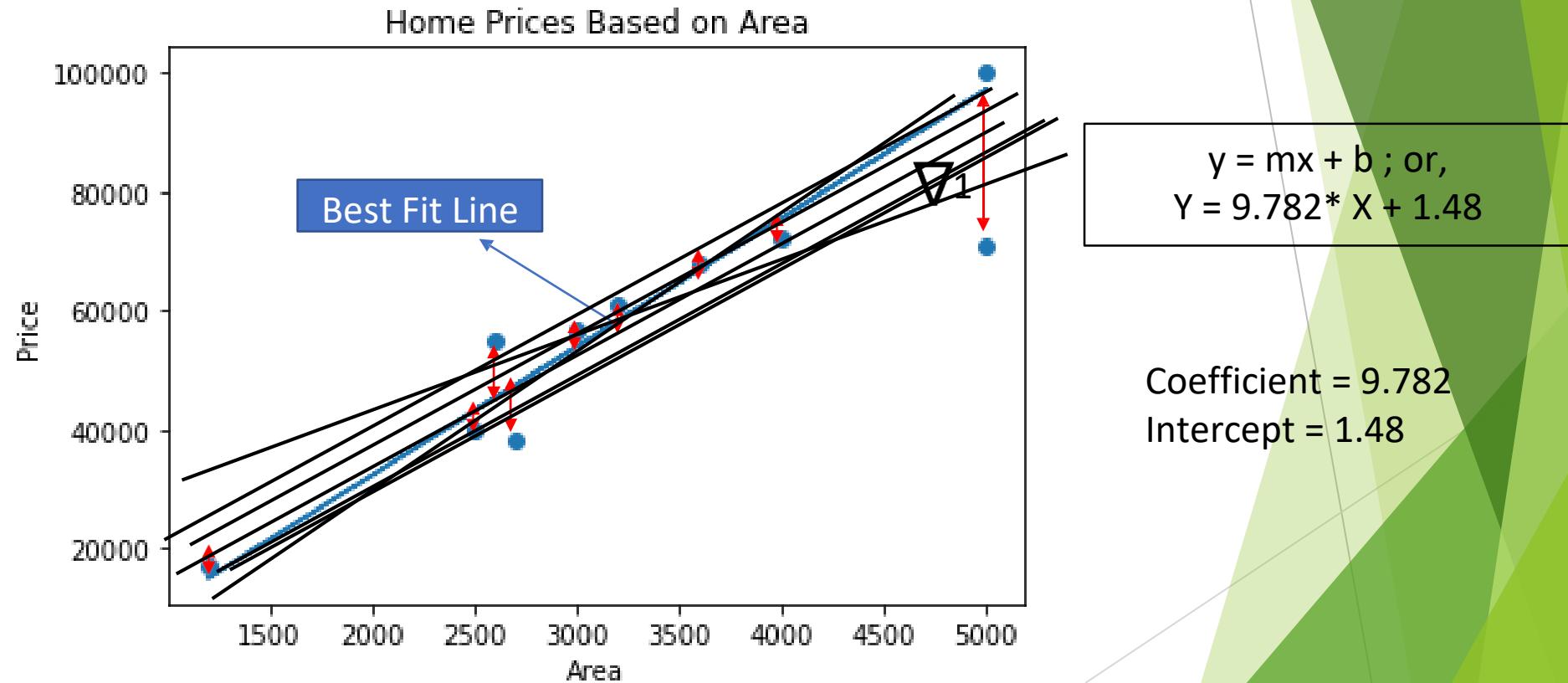
All about Linear Regression



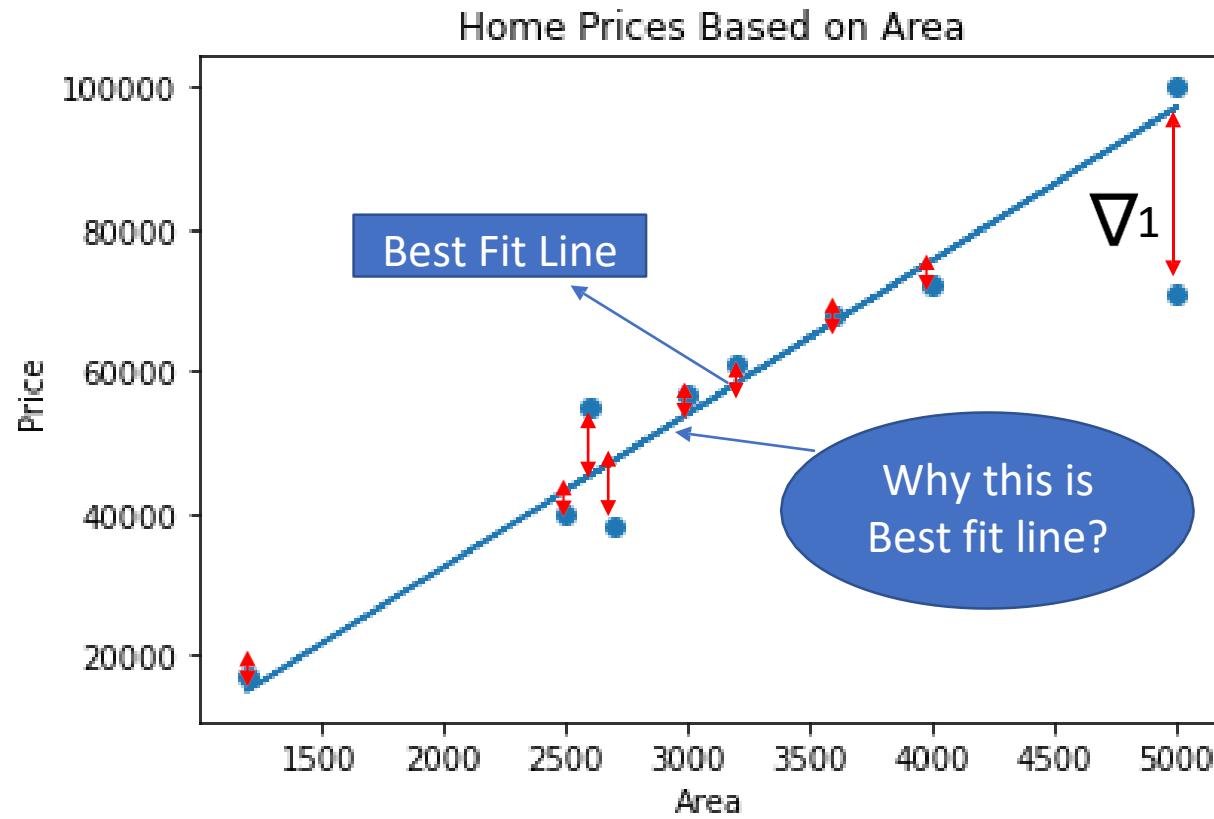
All about Linear Regression



All about Linear Regression



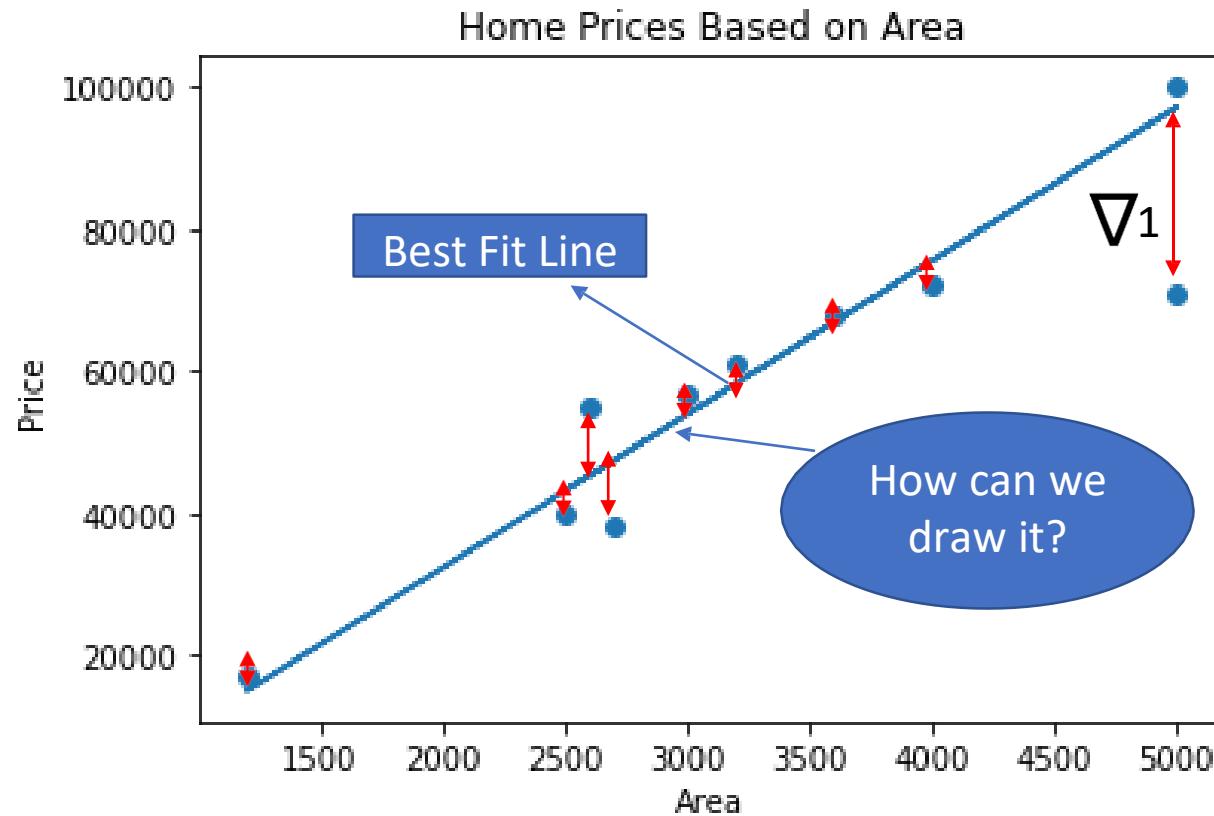
All about Linear Regression



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All about Linear Regression



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All about Linear Regression (Least Squares Method)

Formula of Linear Regression

$$Y = MX + C$$
$$C = \bar{Y} - M\bar{X}$$
$$M = \frac{\bar{X} \cdot \bar{Y} - \bar{X}\bar{Y}}{(\bar{X})^2 - \bar{X}^2}$$
$$\bar{X} = \text{Mean } X$$
$$\bar{Y} = \text{Mean } Y$$

Now
Solve it

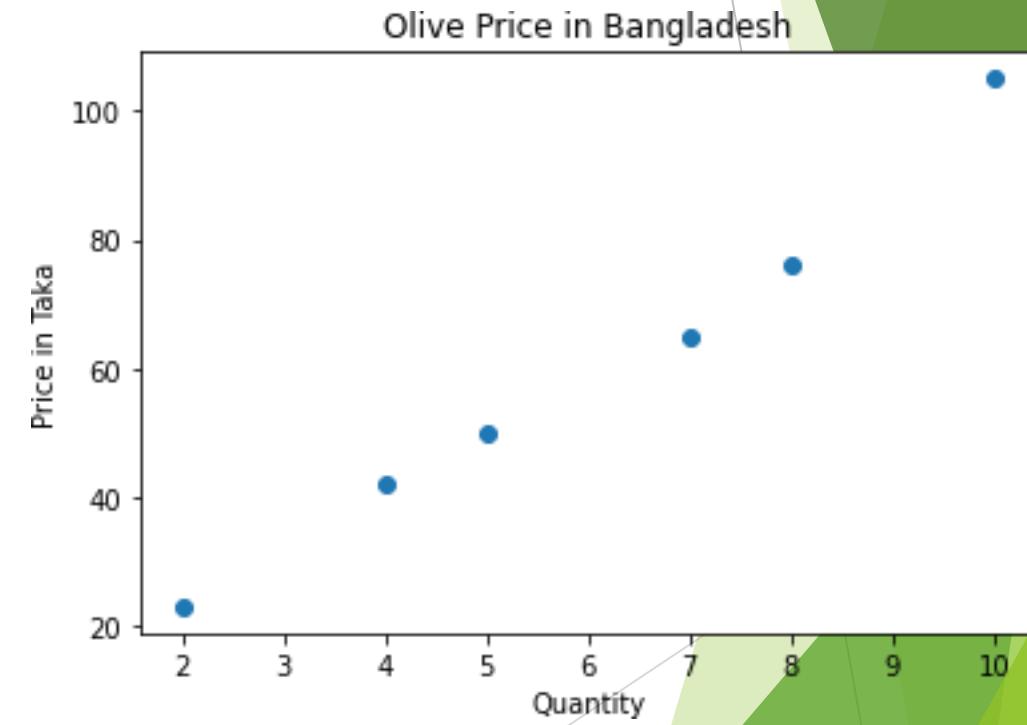


Data Set

	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

x	y
0	50
1	65
2	42
3	76
4	23
5	105



All about Linear Regression

	x	y
0	5	50
1	7	65
2	4	42
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5	10	105

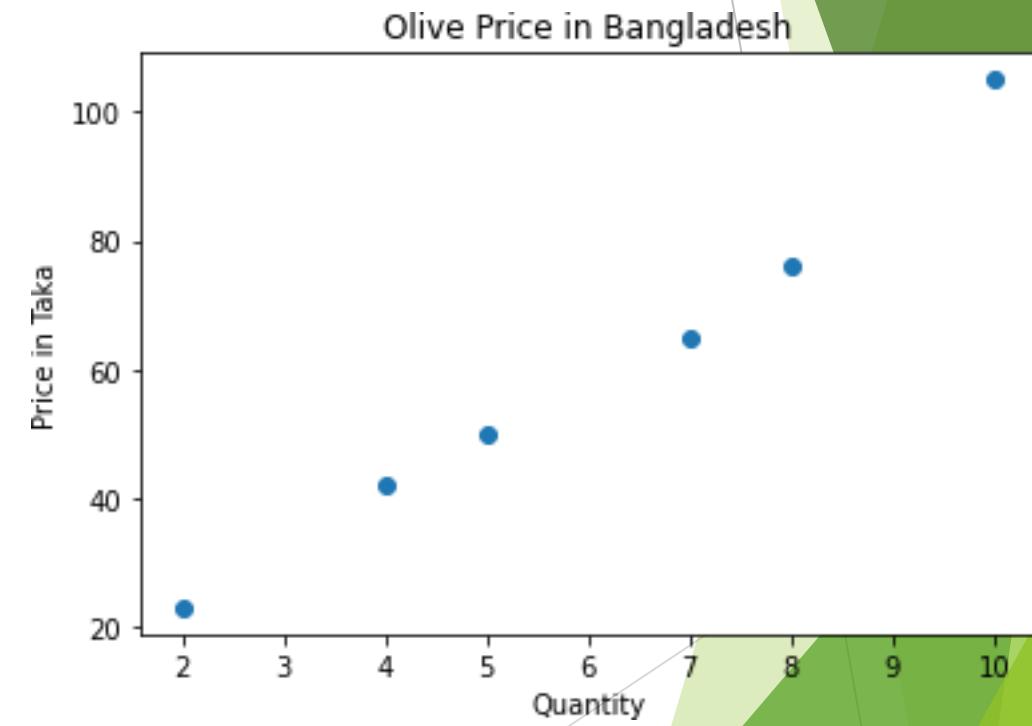
Mean Values

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

6.0

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

60.16666666666666



All about Linear Regression

	x	y
0	5	50
1	7	65
2	4	42
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5	10	105

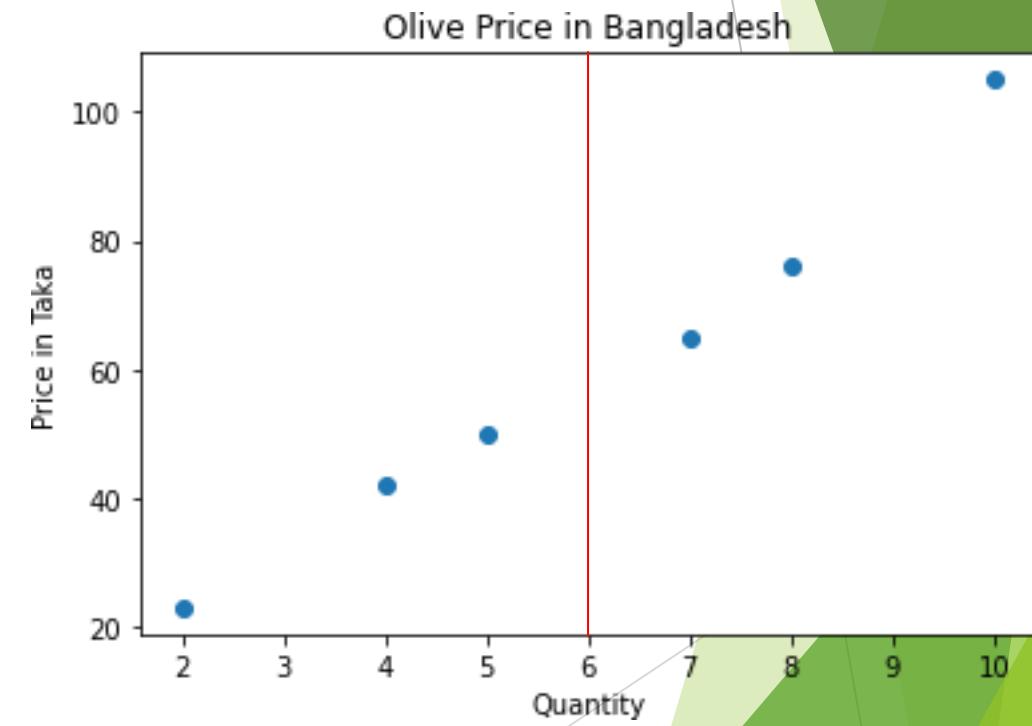
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All about Linear Regression

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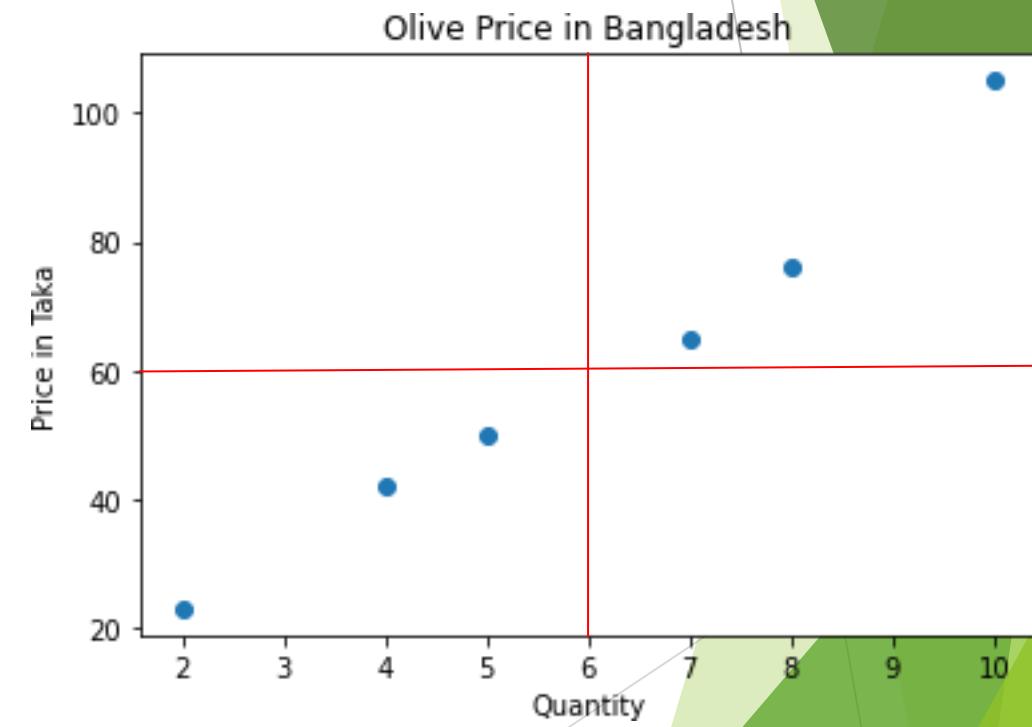
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All about Linear Regression

Formula of Linear Regression

$$Y = MX + C$$
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$$M = \frac{\bar{X} \cdot \bar{Y} - \bar{X}\bar{Y}}{(\bar{X})^2 - \bar{X}^2}$$
$$\bar{X} = \text{Mean } X$$
$$\bar{Y} = \text{Mean } Y$$

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

Calculation Table for Single Variable Linear Regression

All about Linear Regression

Formula of Linear Regression

$$Y = MX + C$$
$$C = \bar{Y} - M\bar{X}$$
$$M = \frac{\bar{X} \cdot \bar{Y} - \bar{X}\bar{Y}}{(\bar{X})^2 - \bar{X}^2}$$
$$\bar{X} = \text{Mean } X$$
$$\bar{Y} = \text{Mean } Y$$



Final Calculations

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

$$M = 9.782$$

$$C = 60.17 - (9.782 * 6)$$

$$C = 1.48$$

$$Y = (9.782 * X) + 1.48$$

$$\text{Predict, } y = (9.782 * 7) + 1.48$$

$$\text{Ans} = 69.95$$

All about Linear Regression

All about Linear Regression

	A	B	C	D	E	F	G	H	I	J
1	x	y	xy	x2	Ȑx	Ȑy	(xy) bar	(Ȑx)2	(x2) bar	Final Calculations
2	5	50	250	25						$M = ((6*60.17)-429.5) / (36-43)$
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						$C = 1.48$
6	2	23	46	4	Avg=6	Avg=60.17	Avg=429.5	36	Avg=43	$Y = (9.782 * X) + 1.48$
7	10	105	1050	100	Average	Average	Average		Average	Predict, $y = (9.782 * 7) + 1.48$
8	7	69.95		49						Ans = 69.95
9										

Formula of Linear Regression

$$Y = Mx + C$$
$$C = \bar{Y} - M\bar{X}$$
$$M = \frac{\bar{X}\bar{Y} - \bar{XY}}{(\bar{X})^2 - \bar{X}^2}$$
$$\bar{X} = \text{Mean } X$$
$$\bar{Y} = \text{Mean } Y$$

All about Linear Regression

Data Set

	x	y
0	5	50
1	7	65
2	4	42
3	8	76
4	2	23
5	10	105

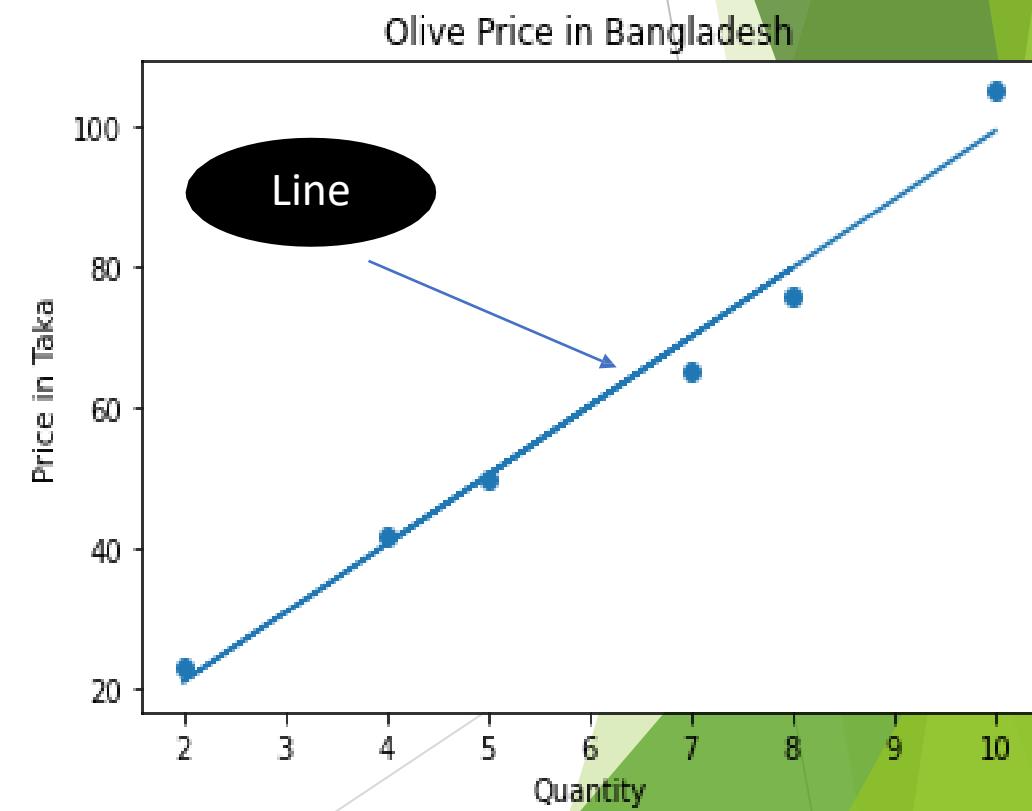
Value of M & C

reg.coef_

array([9.78571429])

reg.intercept_

1.4523809523809703



All about Linear Regression

Data Set

	x	y
0	5	50
1	7	65
2	4	42
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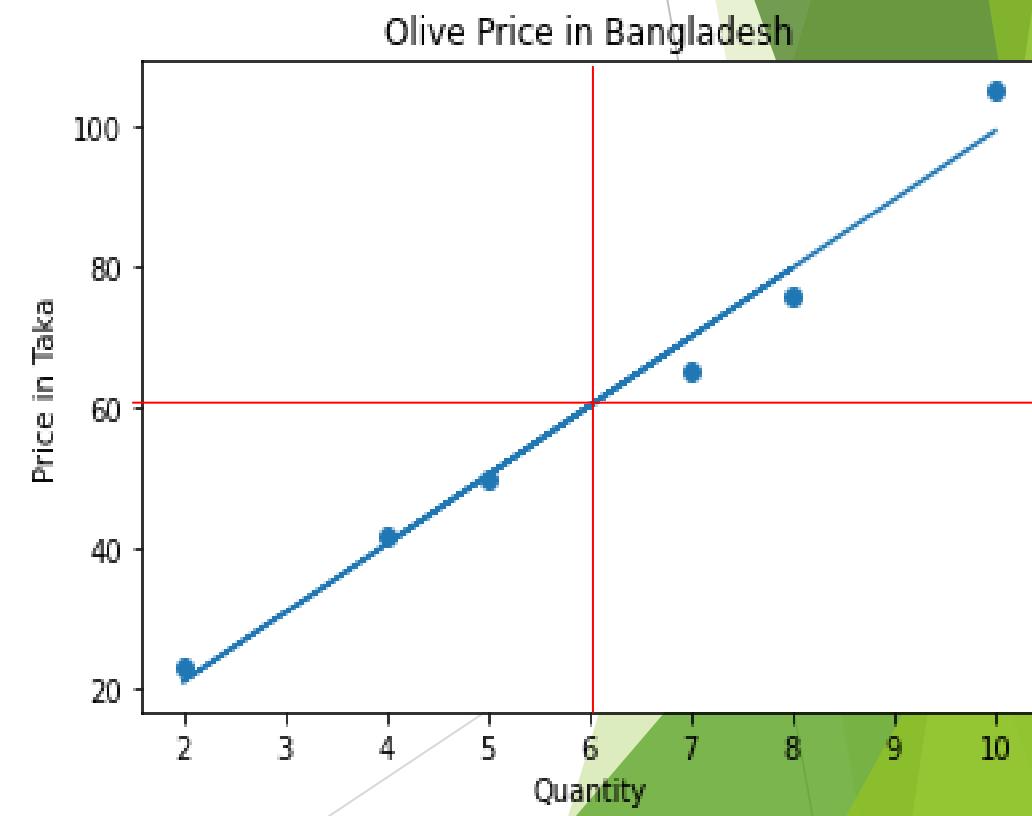
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```



All about Linear Regression

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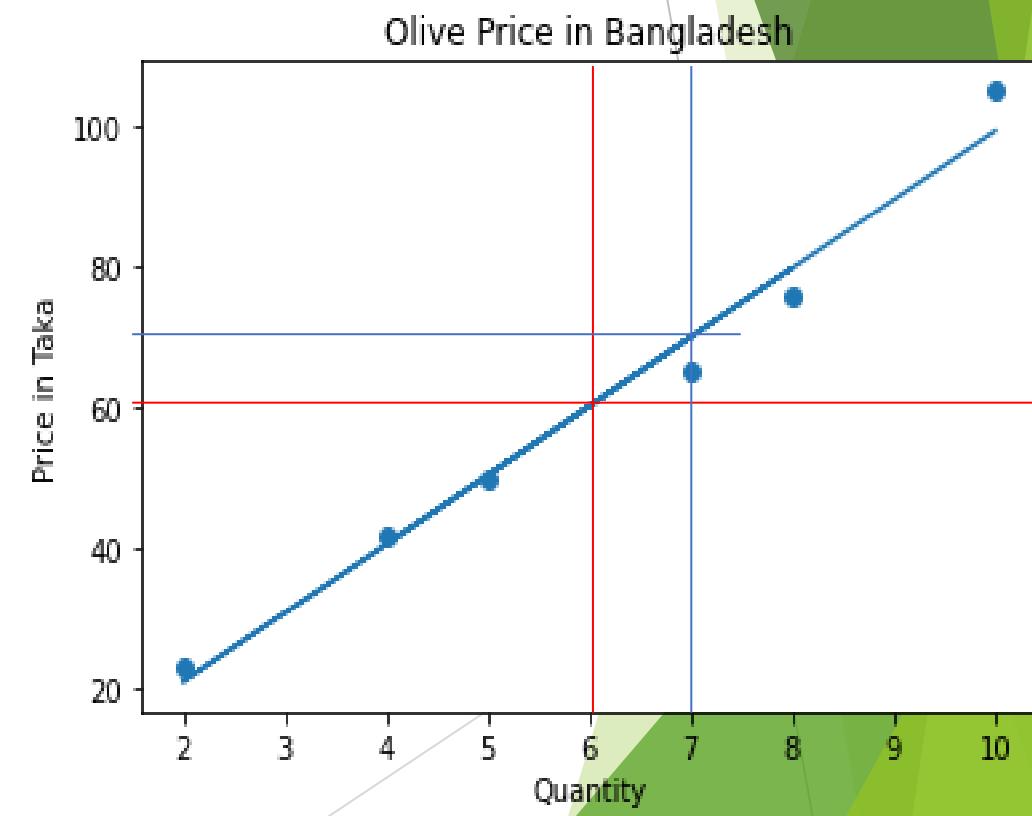
Value of M & C

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All about Linear Regression

Data Set

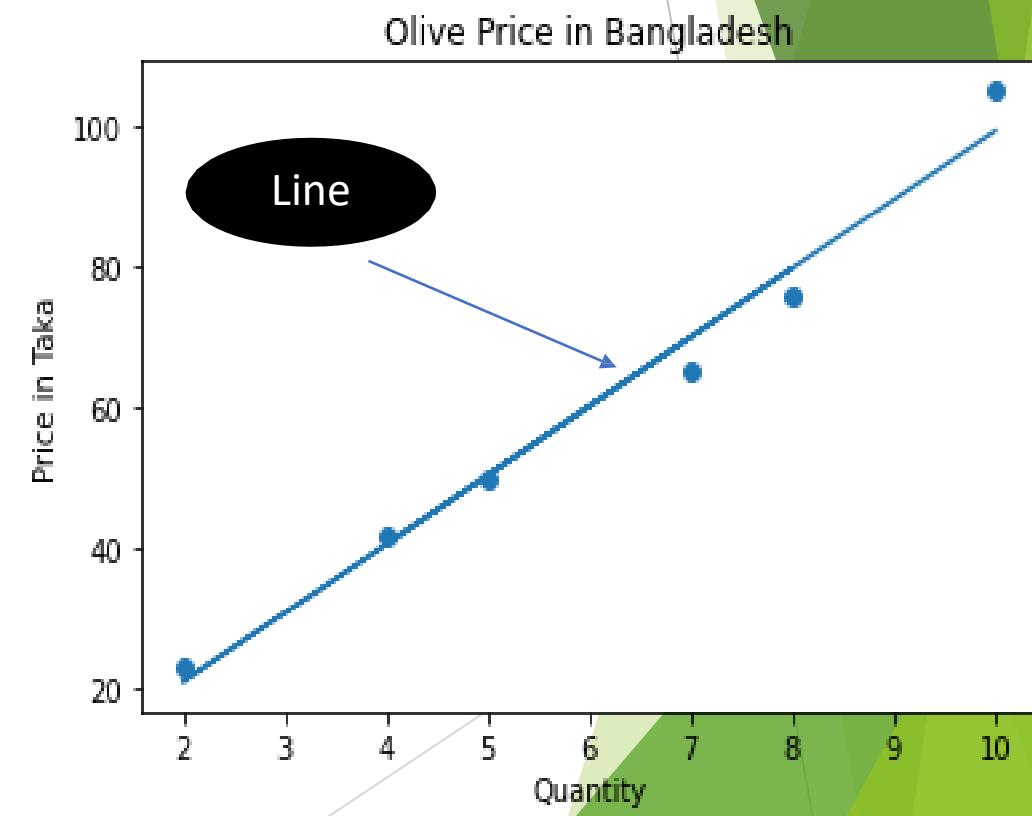
	x	y
0	5	50
1	7	65
2	4	42
3	8	76
4	2	23
5	10	105

Predict New Value

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

```
pred
```

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



All about Linear Regression

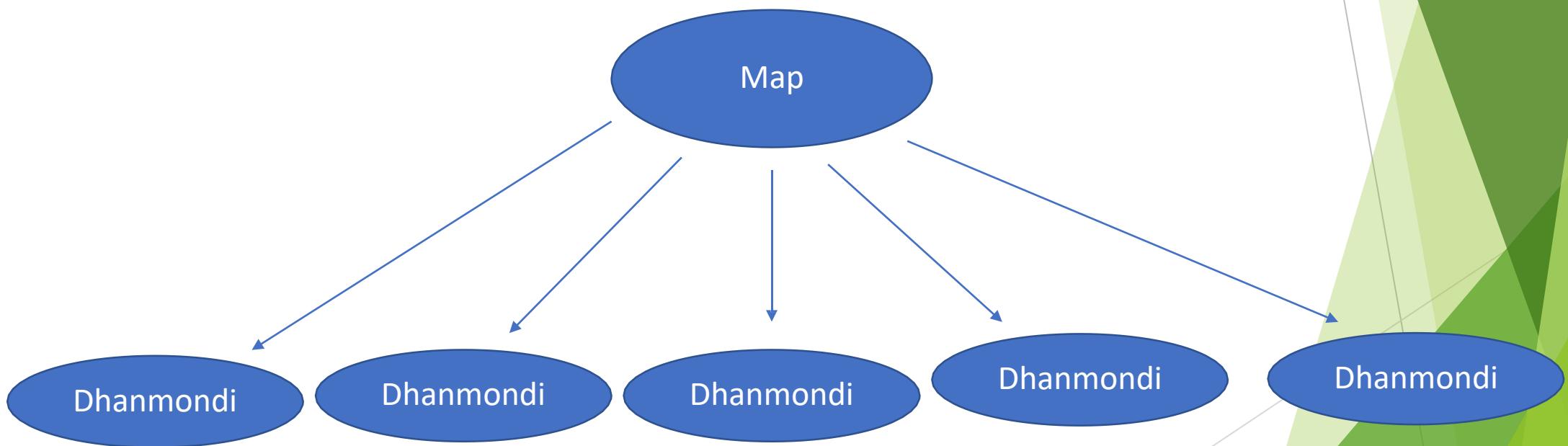
Let's Implement Linear Regression with Python

Linear Regression using Gradient Descent

All about Linear Regression

Cost Function

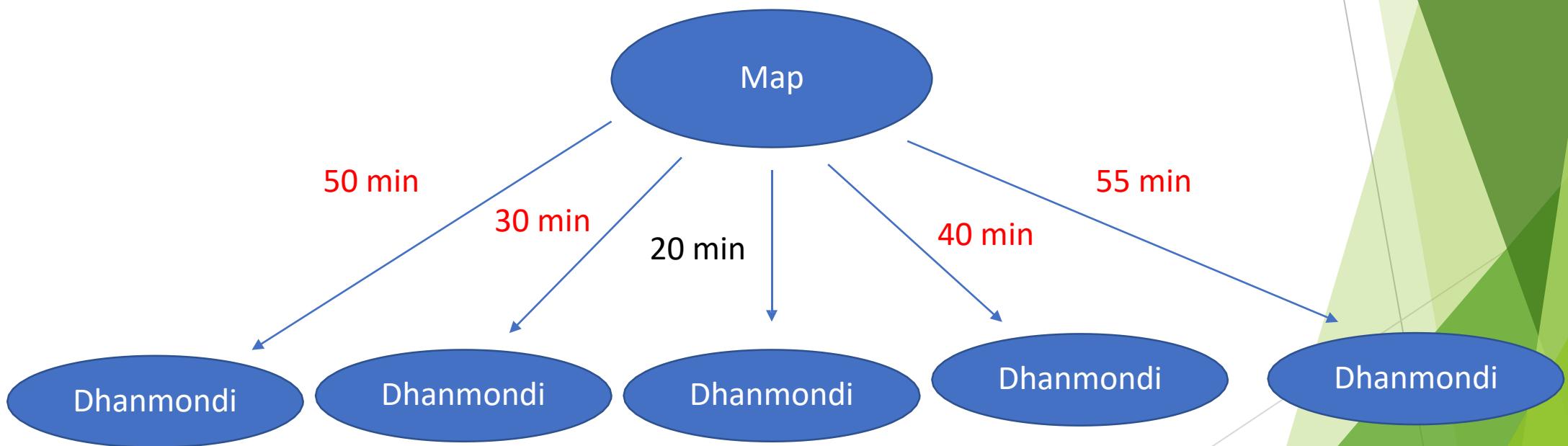
The cost function is a function, which associates a cost with a decision.



All about Linear Regression

Cost Function

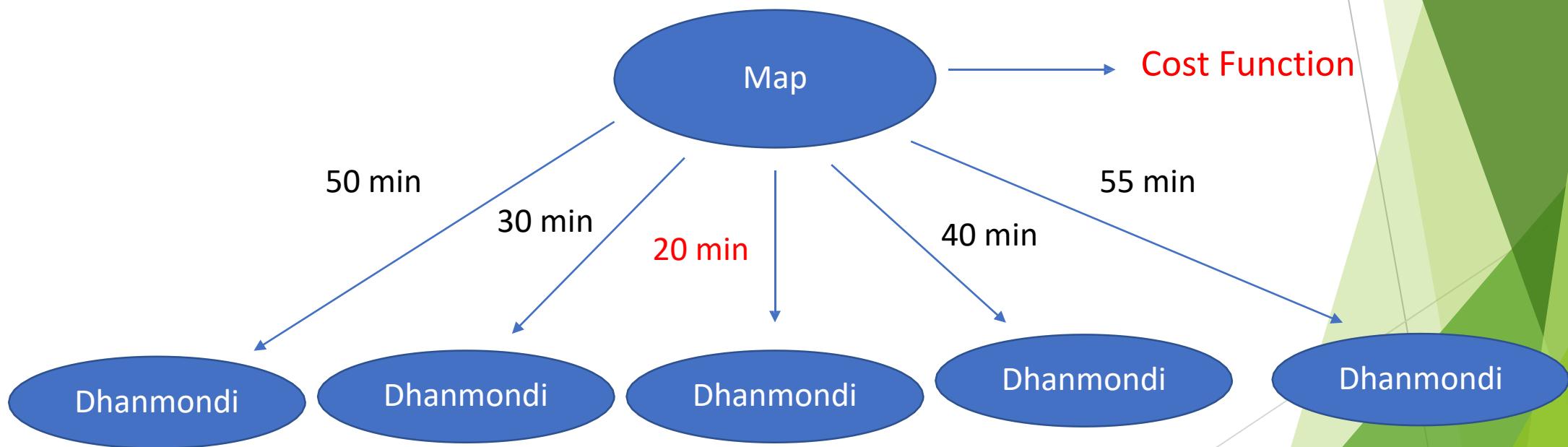
The cost function is a function, which associates a cost with a decision



All about Linear Regression

Cost Function

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



All about Linear Regression

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

$$\text{Predicted Price (Y)} = m * \text{area} + c$$

$$\text{L1 Loss (error)} = (1/n) * |(y_i - \hat{y}_i)|$$

y_i = Area for each row

\hat{y}_i = Predicted Value

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

	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				

All about Linear Regression

► Cost Function

- The cost function is a function, which 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

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

MAE = mean absolute error

y_i = prediction

x_i = true value

n = total number of data points

The form of the function is shown

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

MSE = mean squared error

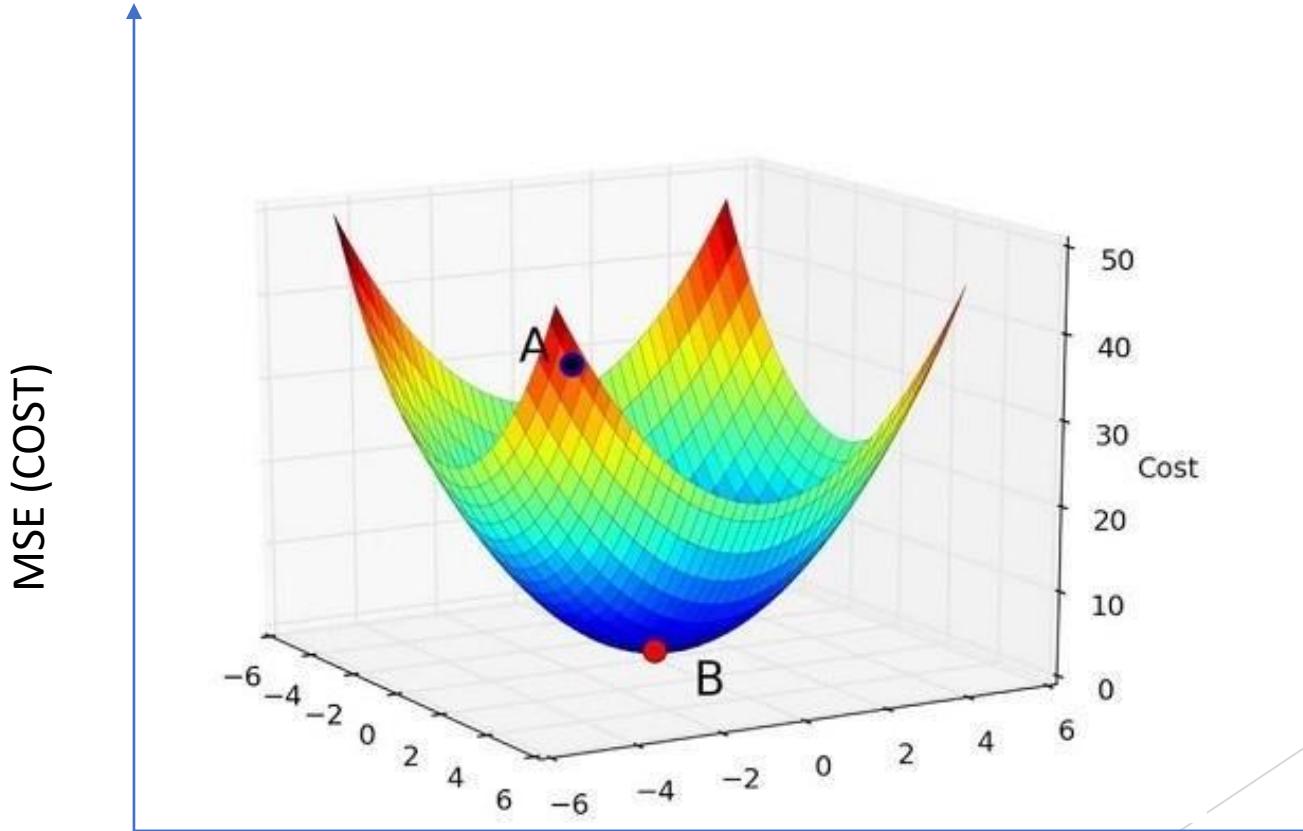
n = number of data points

Y_i = observed values

\hat{Y}_i = predicted values

All about Linear Regression

Minimizing the cost function: Optimizer
Gradient Descent

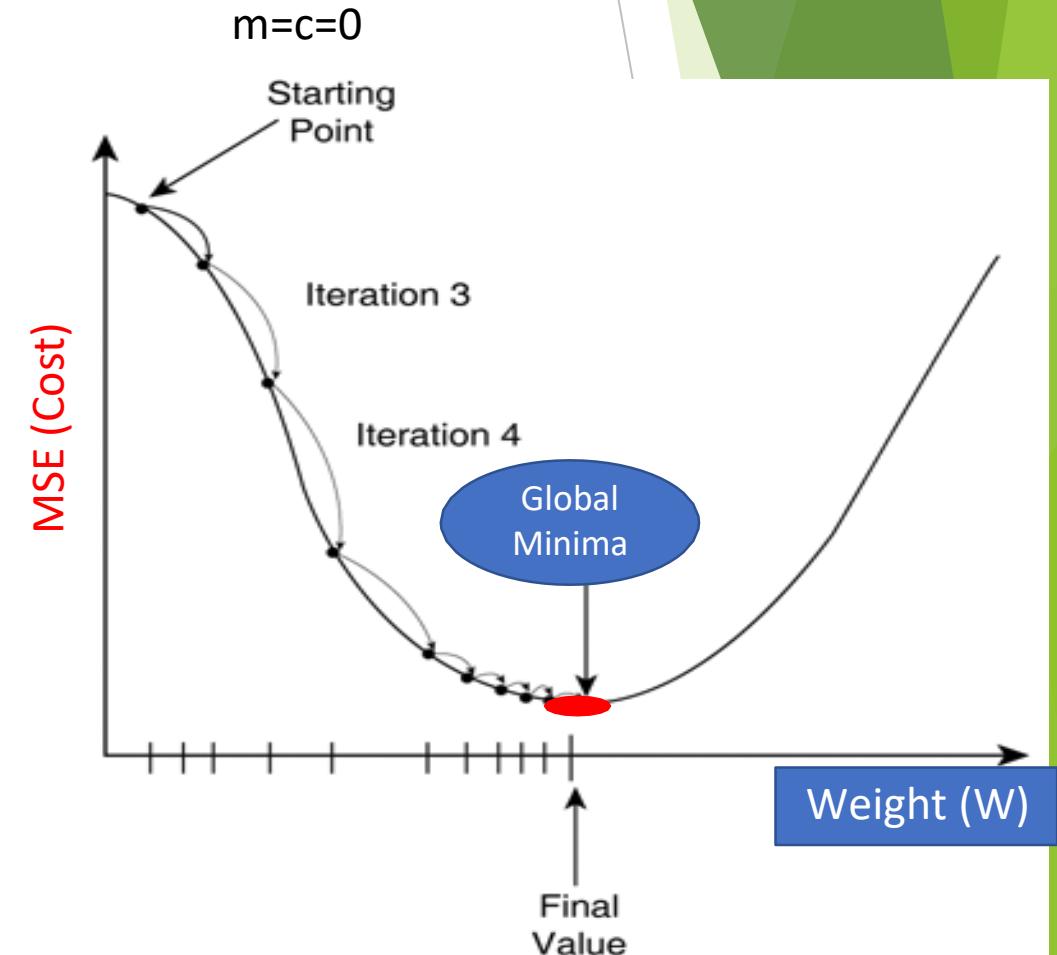


All about Linear Regression

Minimizing the cost function: Optimizer
Gradient Descent

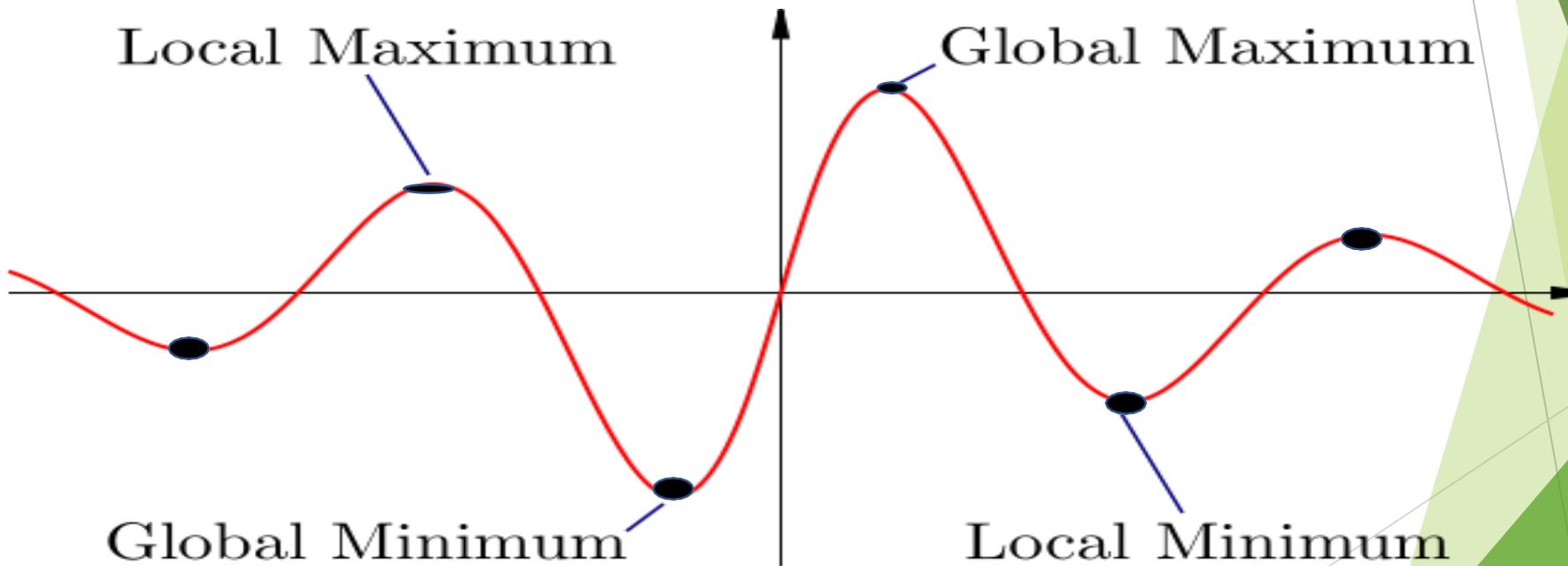
Gradient descent is an efficient optimization algorithm that attempts to find a local or global minima of a function. At this point the model has optimized the weights such that they minimize the cost function. Gradient descent enables a model to learn the gradient or direction that the model should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

$$\text{Weight}_{\text{new}} = \text{Weight}_{\text{old}} - \eta \frac{\partial \text{Loss}}{\partial \text{Weight}_{\text{old}}}$$



All about Linear Regression

Minimizing the cost function:
Gradient Descent



All about Linear Regression

Let's Implement Linear Regression with Python