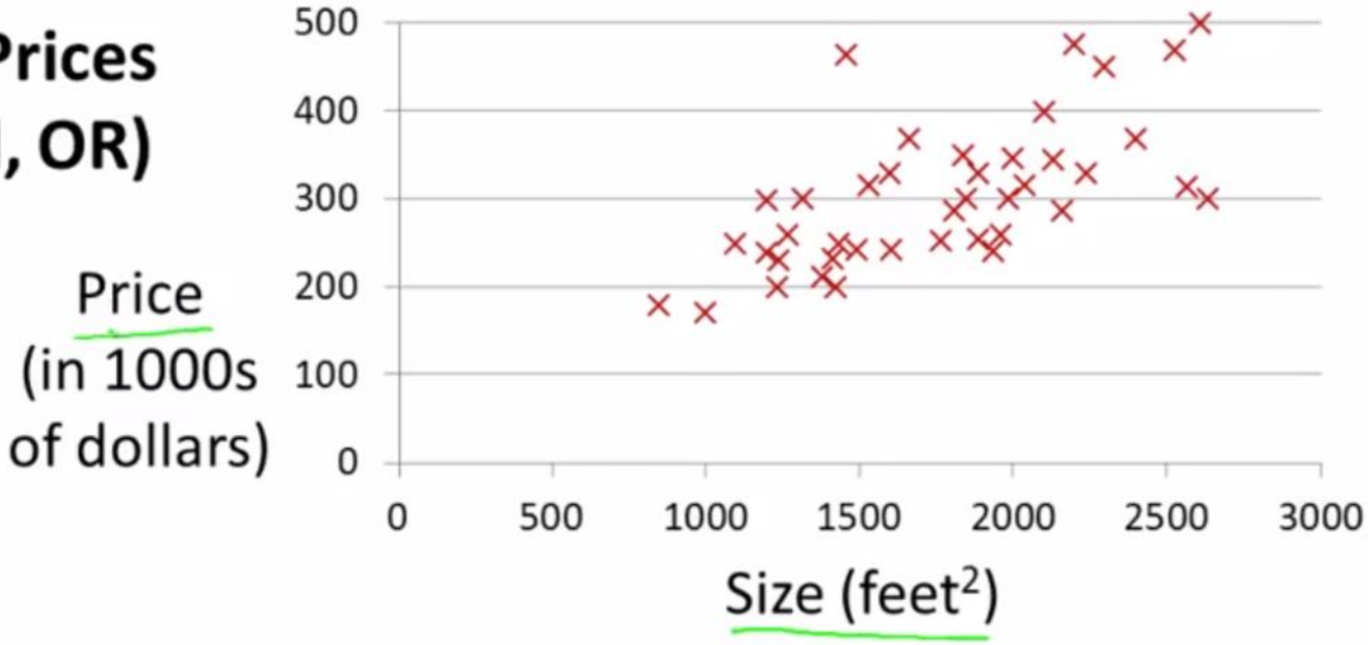
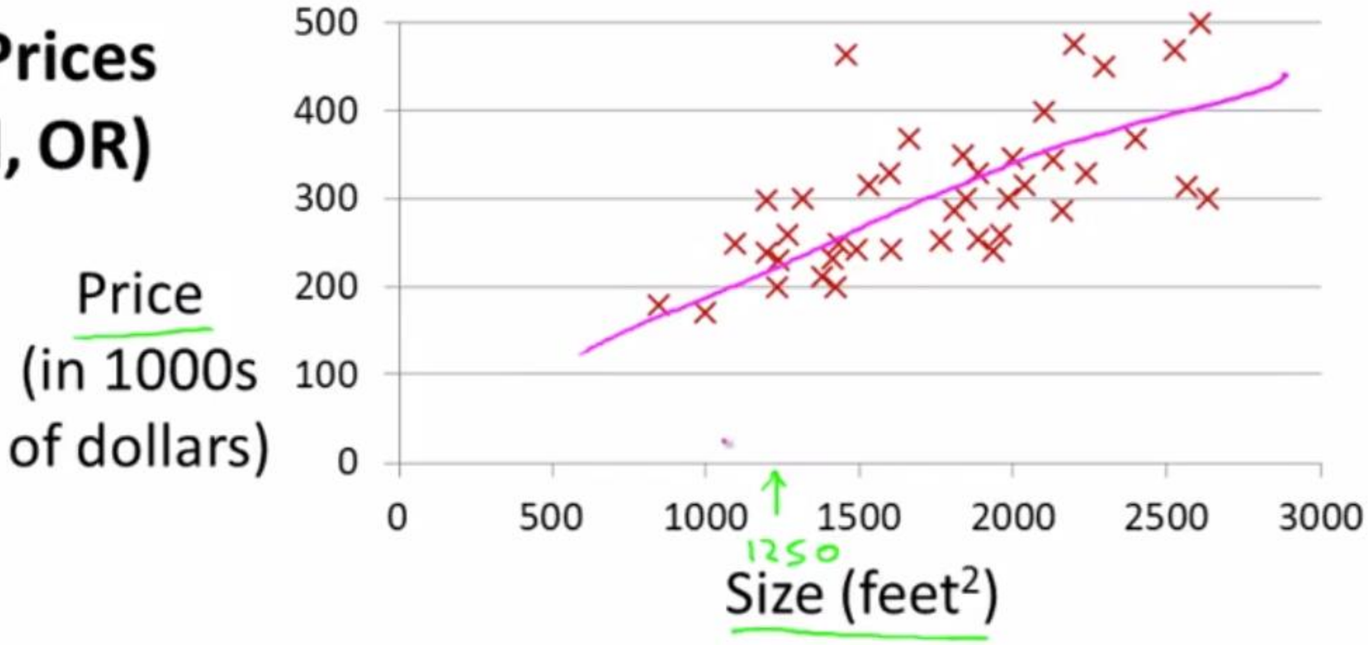
Model and Cost Function

Model Representation

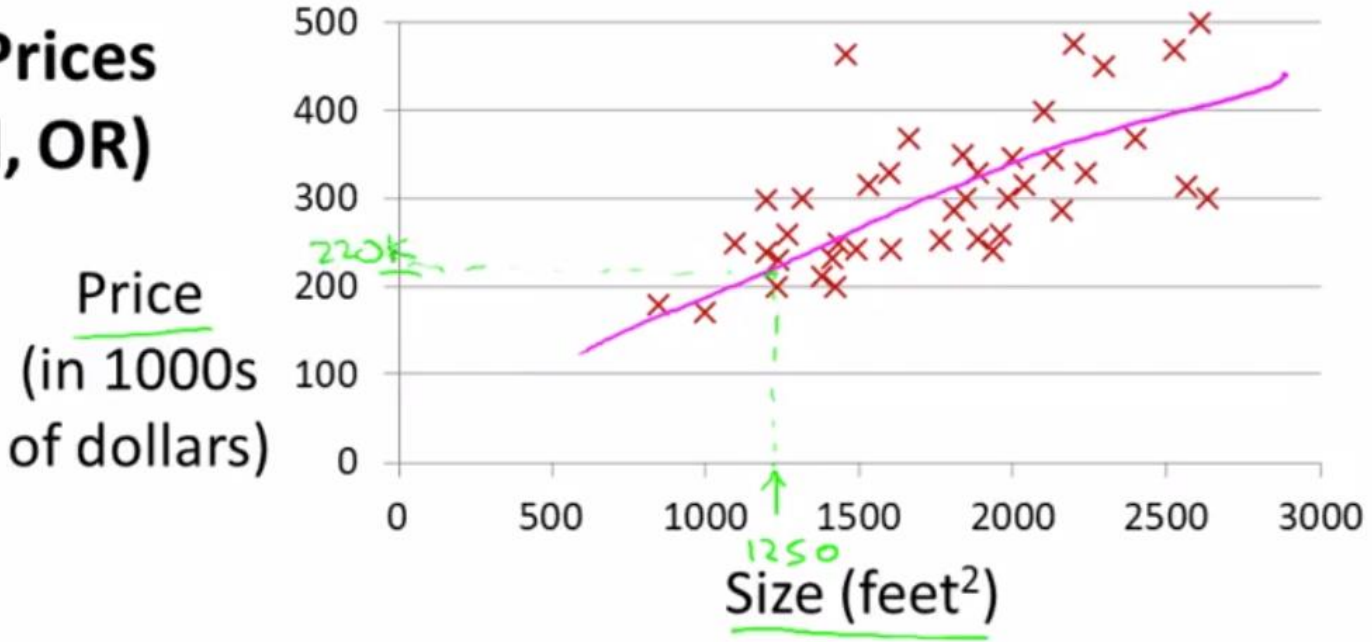
Housing Prices (Portland, OR)



Housing Prices (Portland, OR)



Housing Prices (Portland, OR)



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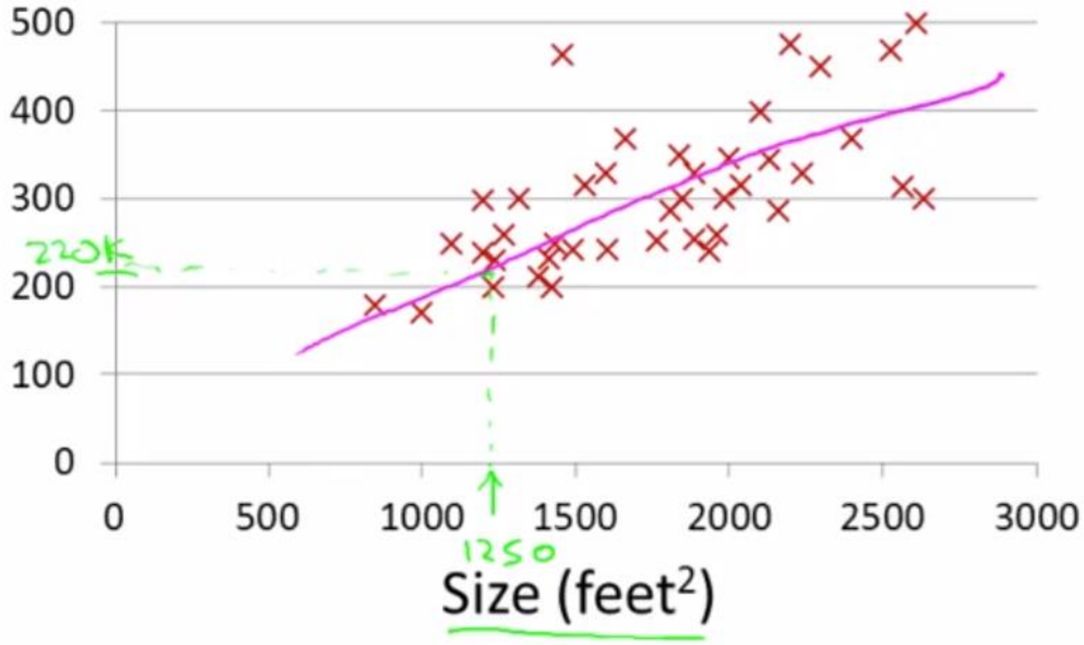
Housing Prices (Portland, OR)

Price
(in 1000s
of dollars)



Supervised Learning

Given the "right answer" for each example in the data.

Regression Problem

Predict real-valued output

Training set of housing prices (Portland, OR)

Size in feet^2 (x)	Price ($) in 1000's (y)
2104	460
1416	232
1534	315
852	178
…	…

Notation:

- **m** = Number of training examples
- **x**'s = "input" variable / features
- **y**'s = "output" variable / "target" variable

Training set of housing prices (Portland, OR)

Size in feet^2 (x)	Price ($) in 1000's (y)
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m = 47

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$m = 47$

Notation:

- **m** = Number of training examples
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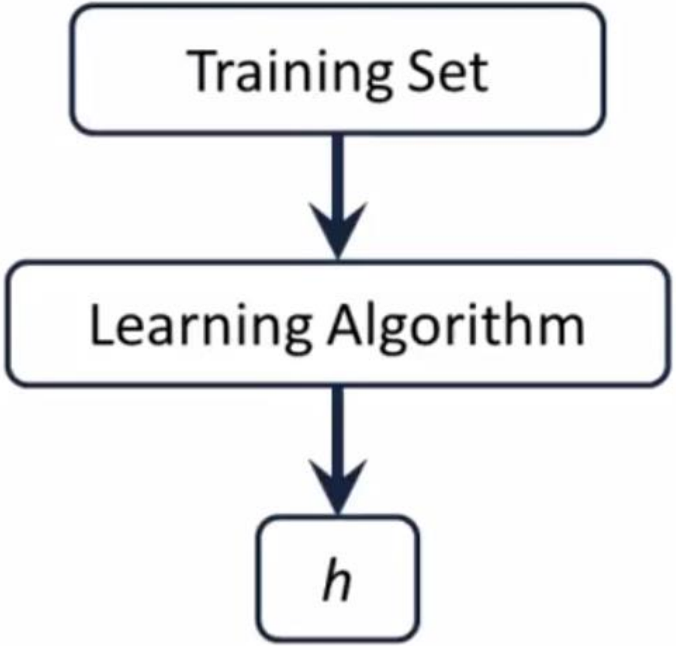
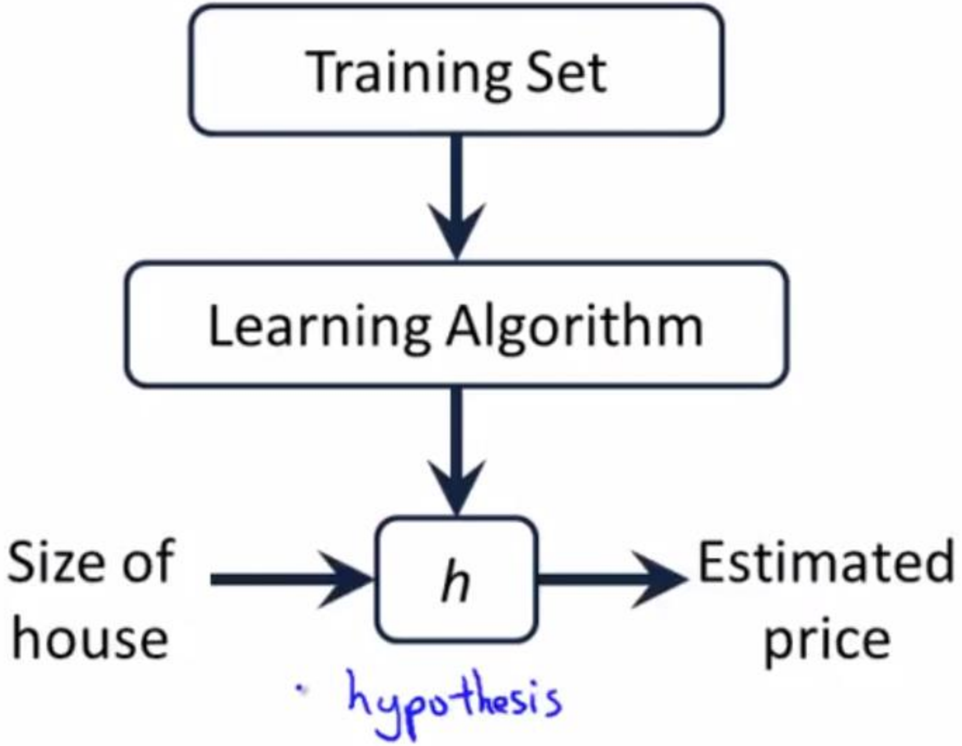
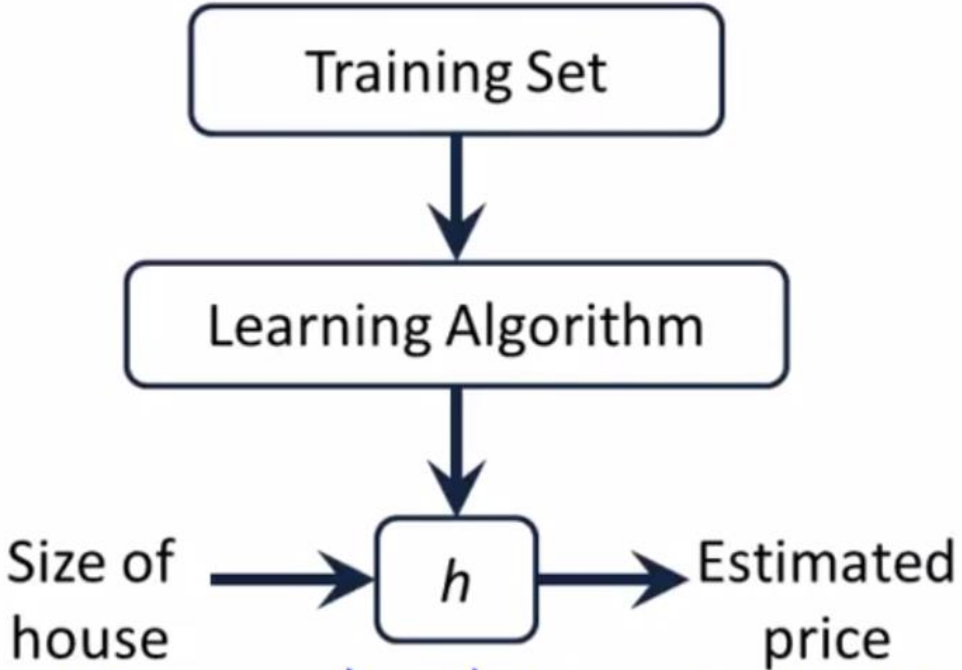
- **y**'s = "output" variable / "target" variable

(x, y) - one training example

$(x^{(i)}, y^{(i)})$ - i^{th} training example


Training Set
Learning Algorithm
h


Training Set
Learning Algorithm
Size of house
h
Estimated price
hypothesis

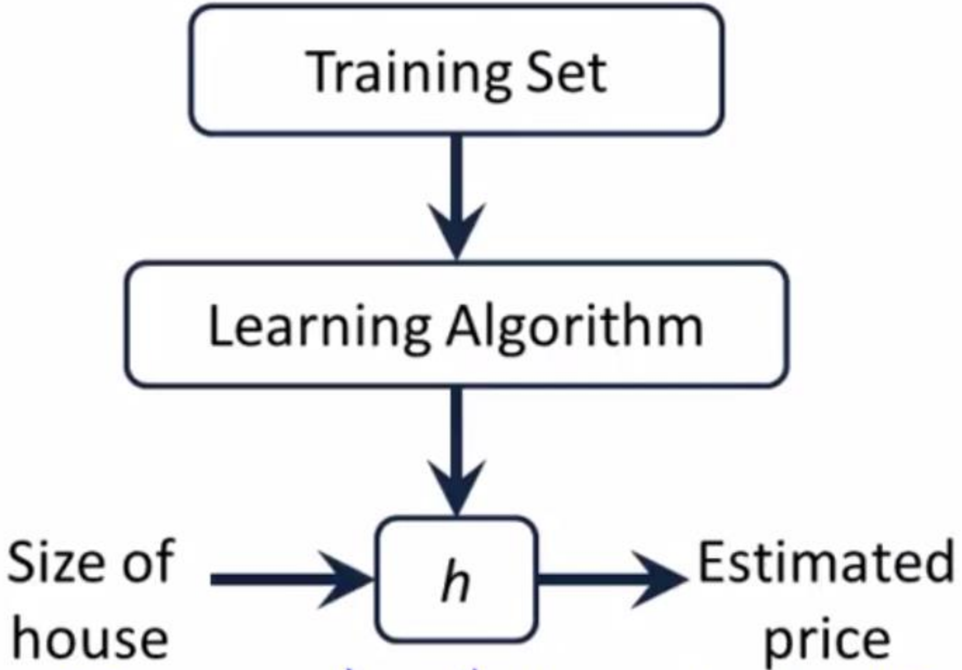


x

hypothesis

(estimated value of y)

h maps from x's to y's.



x

hypothesis

(estimated value of y)

h maps from x's to y's.

How do we represent *h* ?

$$h_\theta(x) = \theta_0 + \theta_1 x$$

Shorthand: $h(x)$

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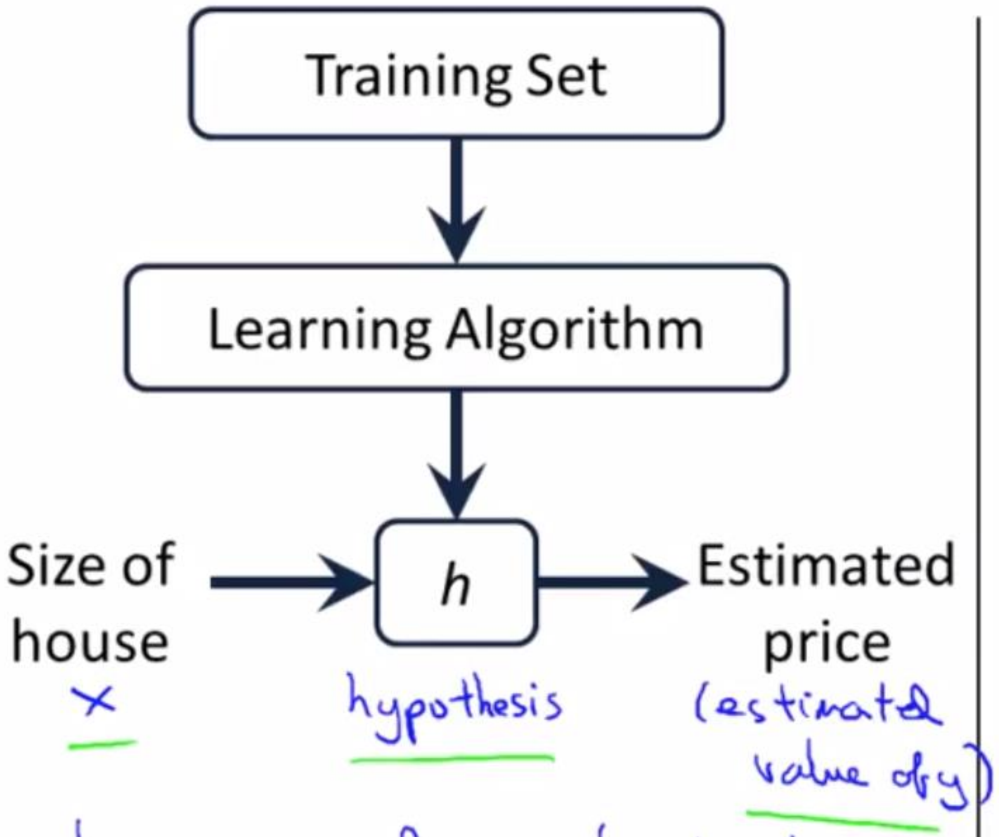

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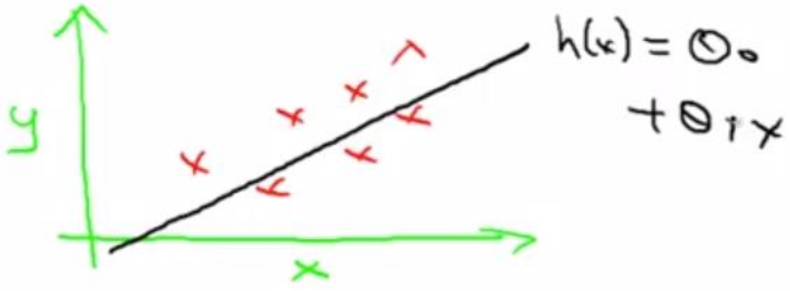

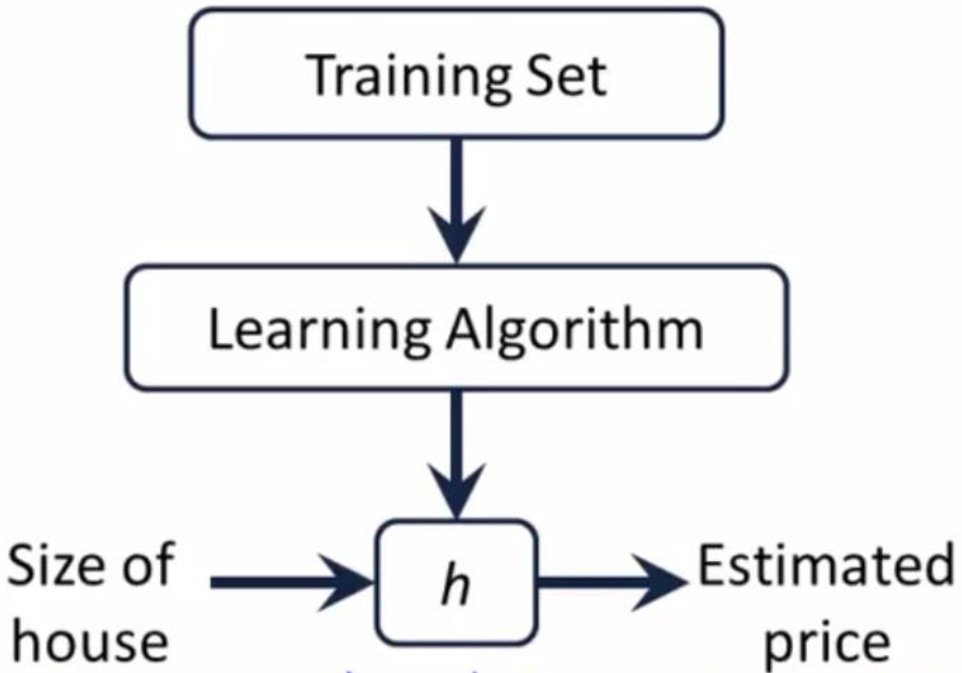

x

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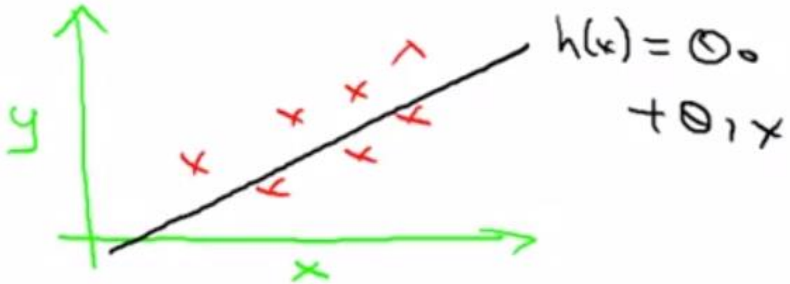

Linear regression with one variable. (x)

Univariate linear regression.

└ one variable

Cost Function: How to choose θs?

Training Set

Size in feet^2 (x)	Price ($) in 1000's (y)
2104	460
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Hypothesis: $h_\theta(x) = \theta_0 + \theta_1 x$

Training Set

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...	...

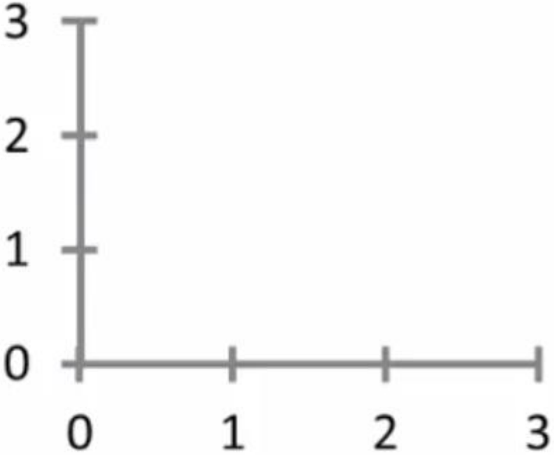
m = 47

Hypothesis: $h_\theta(x) = \theta_0 + \theta_1 x$

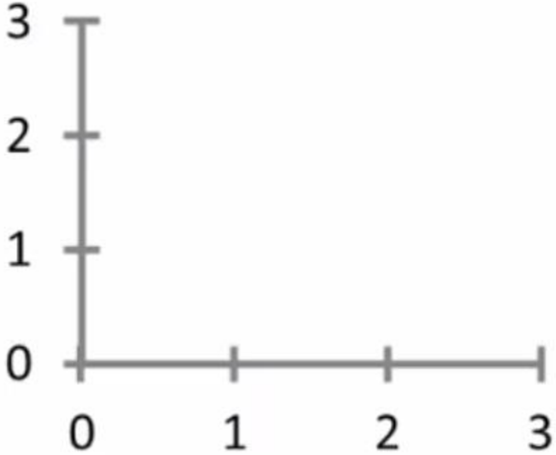
θ_i's: Parameters

How to choose θ_i's ?

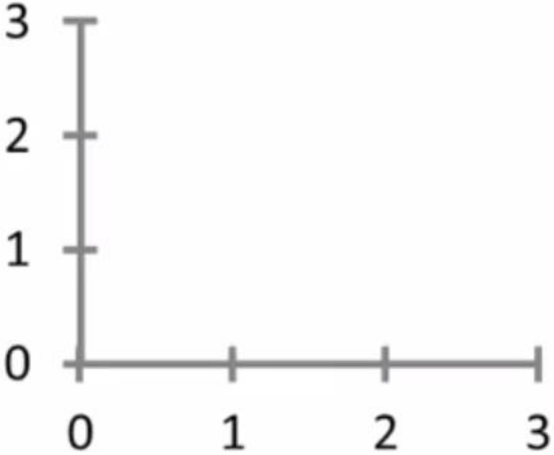
$$h_\theta(x) = \theta_0 + \theta_1 x$$



$\theta_0 = 1.5$
$\theta_1 = 0$

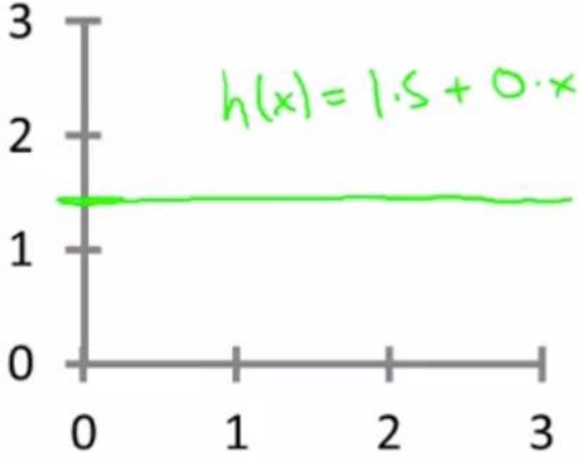


$\theta_0 = 0$
$\theta_1 = 0.5$

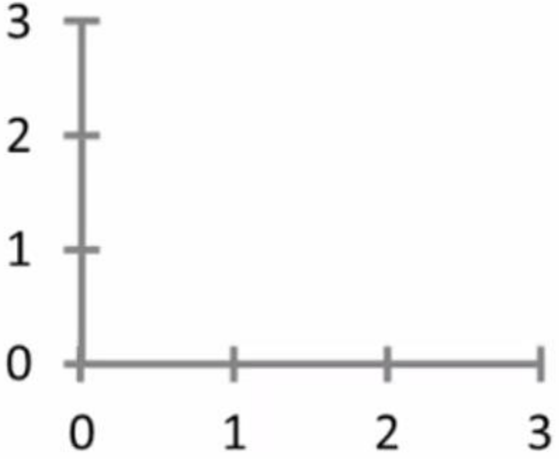


$\theta_0 = 1$
$\theta_1 = 0.5$

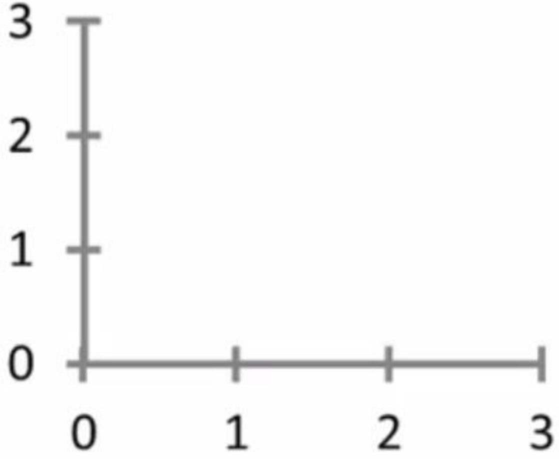
$$h_\theta(x) = \theta_0 + \theta_1 x$$



$\theta_0 = 1.5$
$\theta_1 = 0$

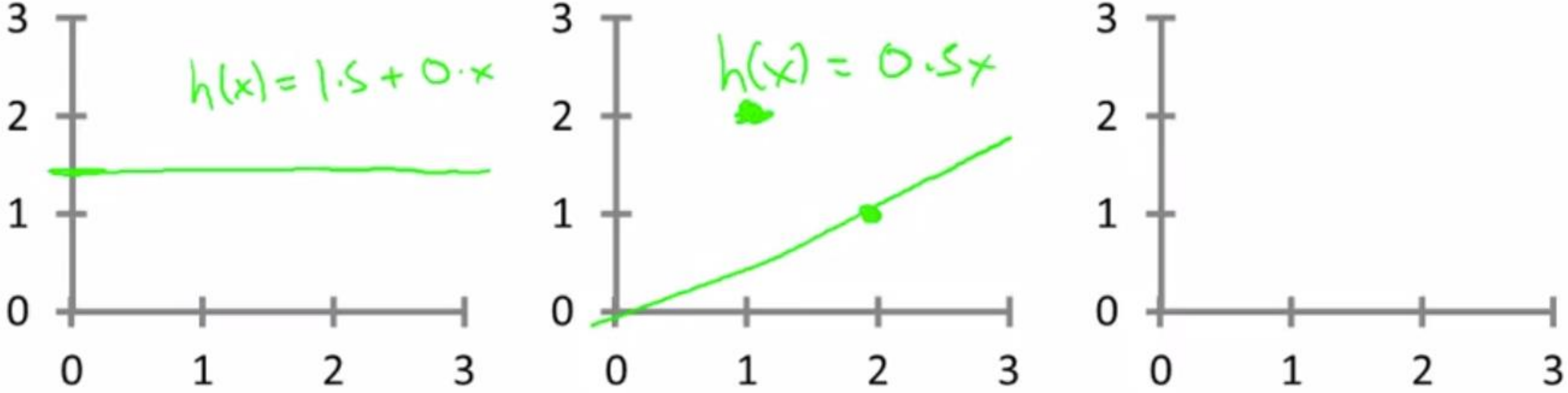


$\theta_0 = 0$
$\theta_1 = 0.5$



$\theta_0 = 1$
$\theta_1 = 0.5$

$$h_\theta(x) = \theta_0 + \theta_1 x$$



$\theta_0 = 1.5$
$\theta_1 = 0$

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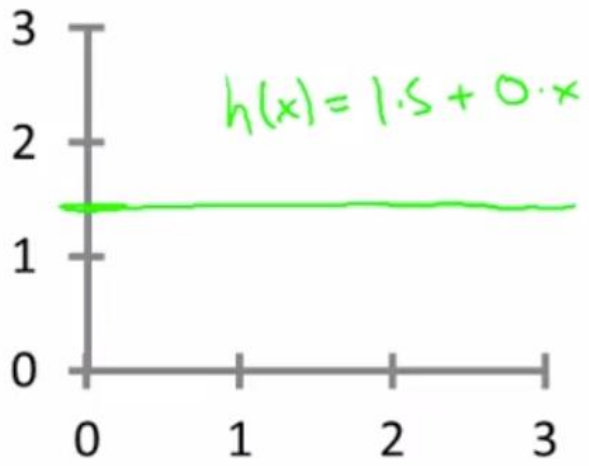
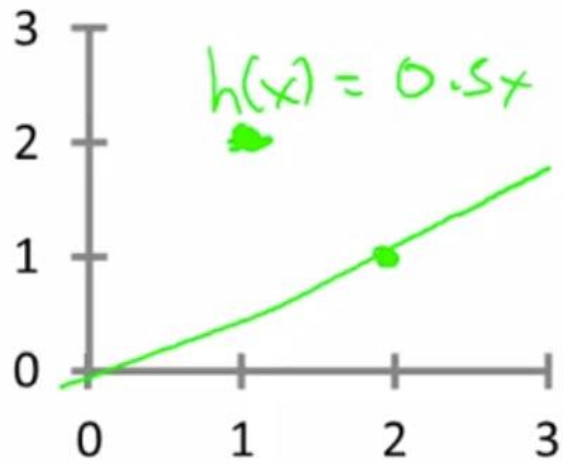
$\theta_0 = 1$
$\theta_1 = 0.5$

$$h_\theta(x) = \theta_0 + \theta_1 x$$



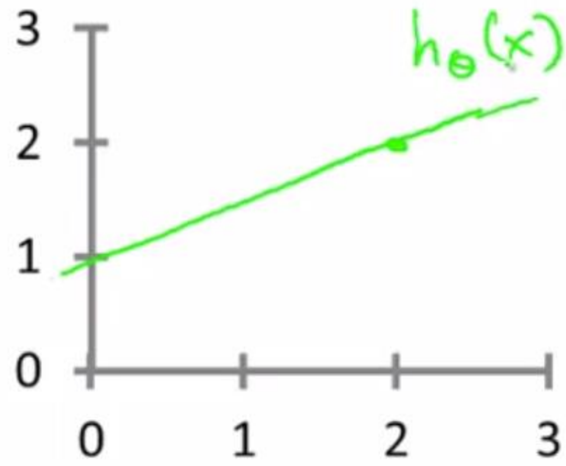
$\theta_0 = 1.5$

$\theta_1 = 0$



$\theta_0 = 0$

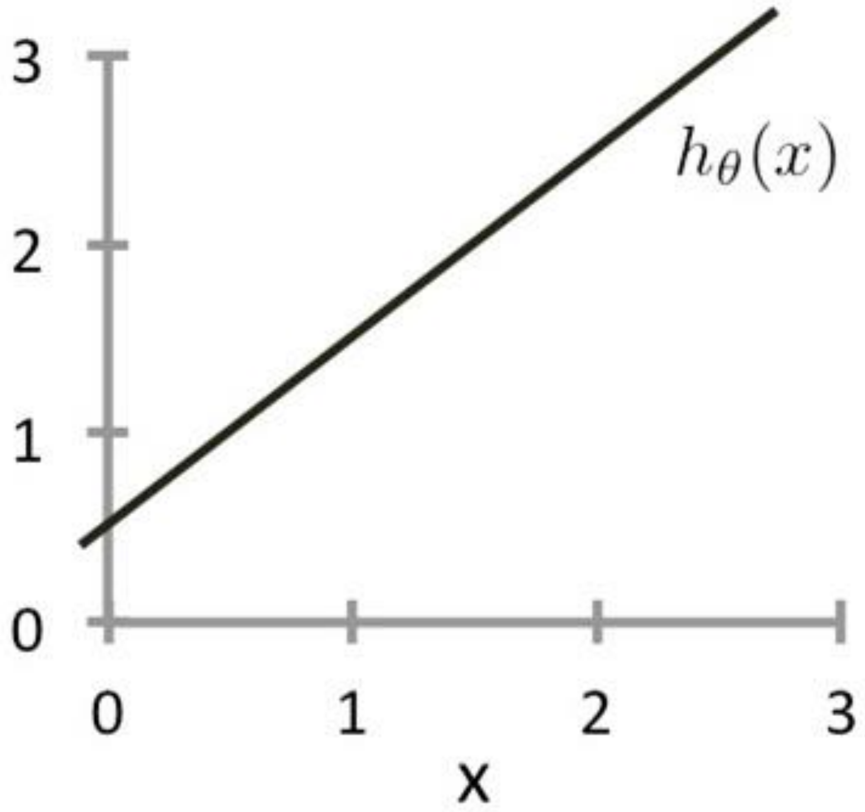
$\theta_1 = 0.5$

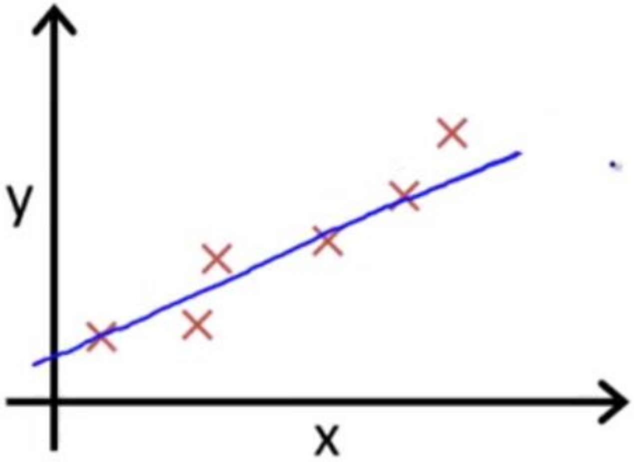


$\theta_0 = 1$

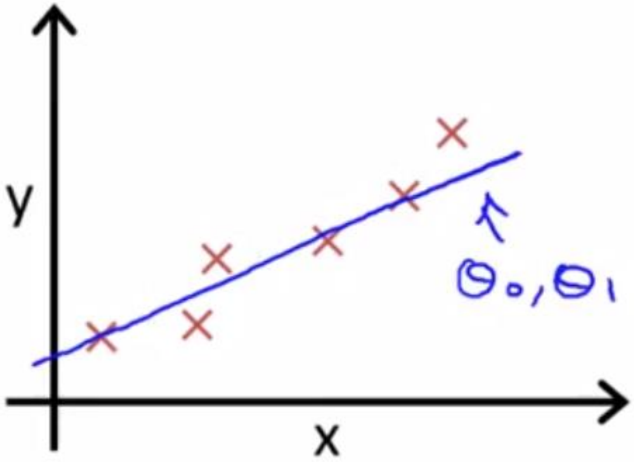
$\theta_1 = 0.5$

Consider the plot below of $h_\theta(x) = \theta_0 + \theta_1 x$. What are θ_0 and θ_1?

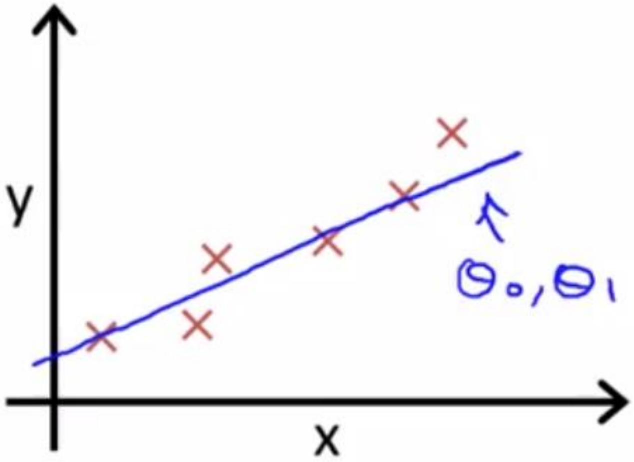




How to find a good fit?



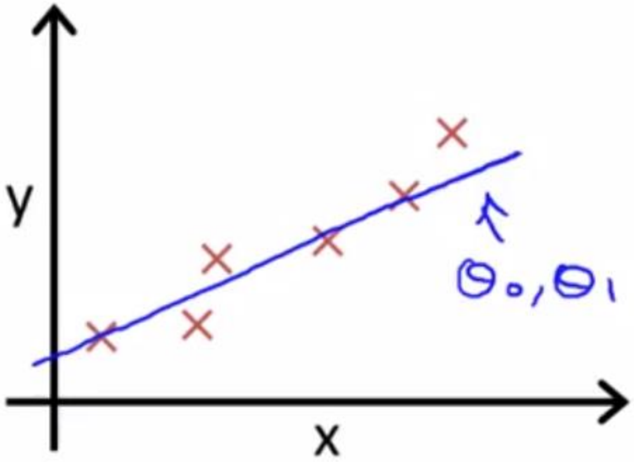
Idea: Choose θ_0, θ_1 so that
$h_\theta(x)$ is close to y for our
training examples (x, y)



$$\underset{\theta_0 \theta_1}{\text{minimize}} \quad h_\theta(x) - y$$

Idea: Choose θ_0, θ_1 so that $h_\theta(x)$ is close to y for our training examples (x, y)

x, y



minimize θ_0, θ_1 $\quad (h_\theta(x) - y)^2$

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x, y

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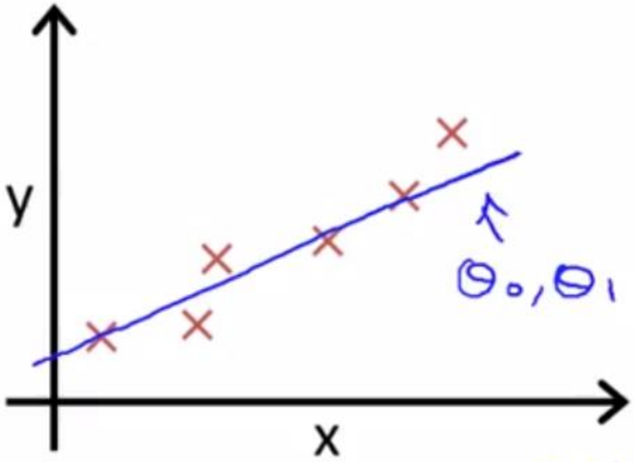


training examples

$$\underset{\theta_0 \theta_1}{\text{minimize}} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)}\right)^2$$

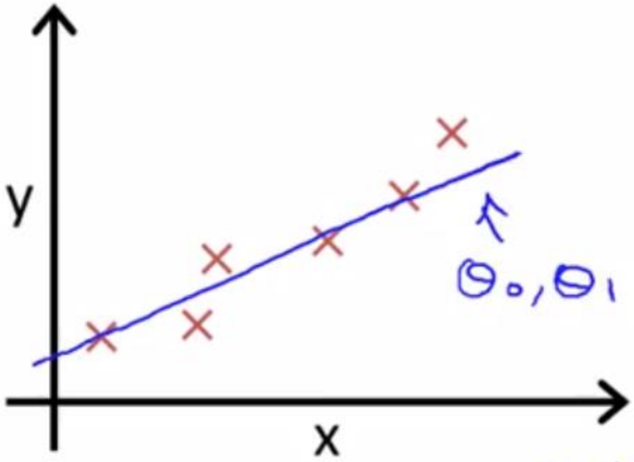
$(x^{(i)}, y^{(i)})$

Idea: Choose θ_0, θ_1 so that
$h_\theta(x)$ is close to y for our
training examples (x, y)

x, y

training examples

$$\underset{\theta_0, \theta_1}{\text{minimize}} \ \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)} \right)^2$$

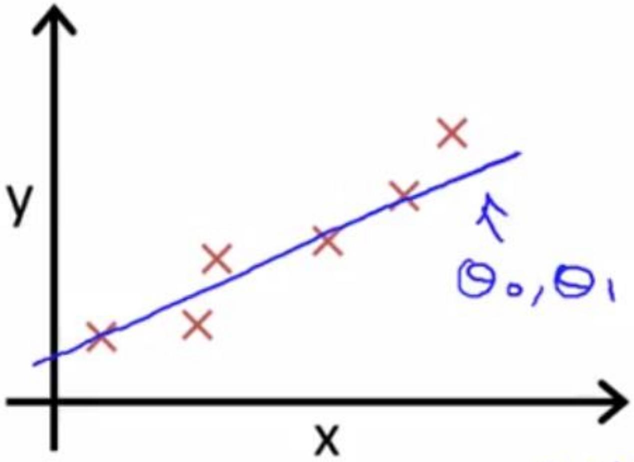


θ_0, θ_1

$(x^{(i)}, y^{(i)})$

Idea: Choose θ_0, θ_1 so that
$h_\theta(x)$ is close to y for our
training examples (x, y)

x, y



θ_0, θ_1

$(x^{(i)}, y^{(i)})$

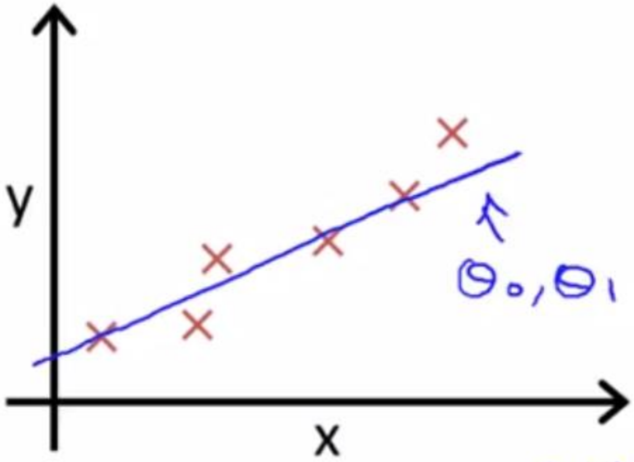
\# training examples

$$\boxed{\underset{\theta_0 \theta_1}{\text{minimize}}} \; \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)} \right)^2$$

$$h_\theta(x^{(i)}) = \theta_0 + \theta_1 x^{(i)}$$

Idea: Choose θ_0, θ_1 so that $h_\theta(x)$ is close to y for our training examples (x, y)

x, y



θ_0, θ_1

training examples

$$\boxed{\underset{\theta_0 \theta_1}{\text{minimize}}} \; \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)} \right)^2$$

$$h_\theta(x^{(i)}) = \theta_0 + \theta_1 x^{(i)}$$

$(x^{(i)}, y^{(i)})$

$$J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)} \right)^2$$

Idea: Choose θ_0, θ_1 so that
$h_\theta(x)$ is close to y for our
training examples (x, y)

$$\underset{\theta_0, \theta_1}{\text{minimize}} \; \underbrace{J(\theta_0, \theta_1)}_{\text{Cost function}}$$

x, y

Squared error function