Gradient Descent in Practice II: Learning Rate

Multivariate Linear Regression

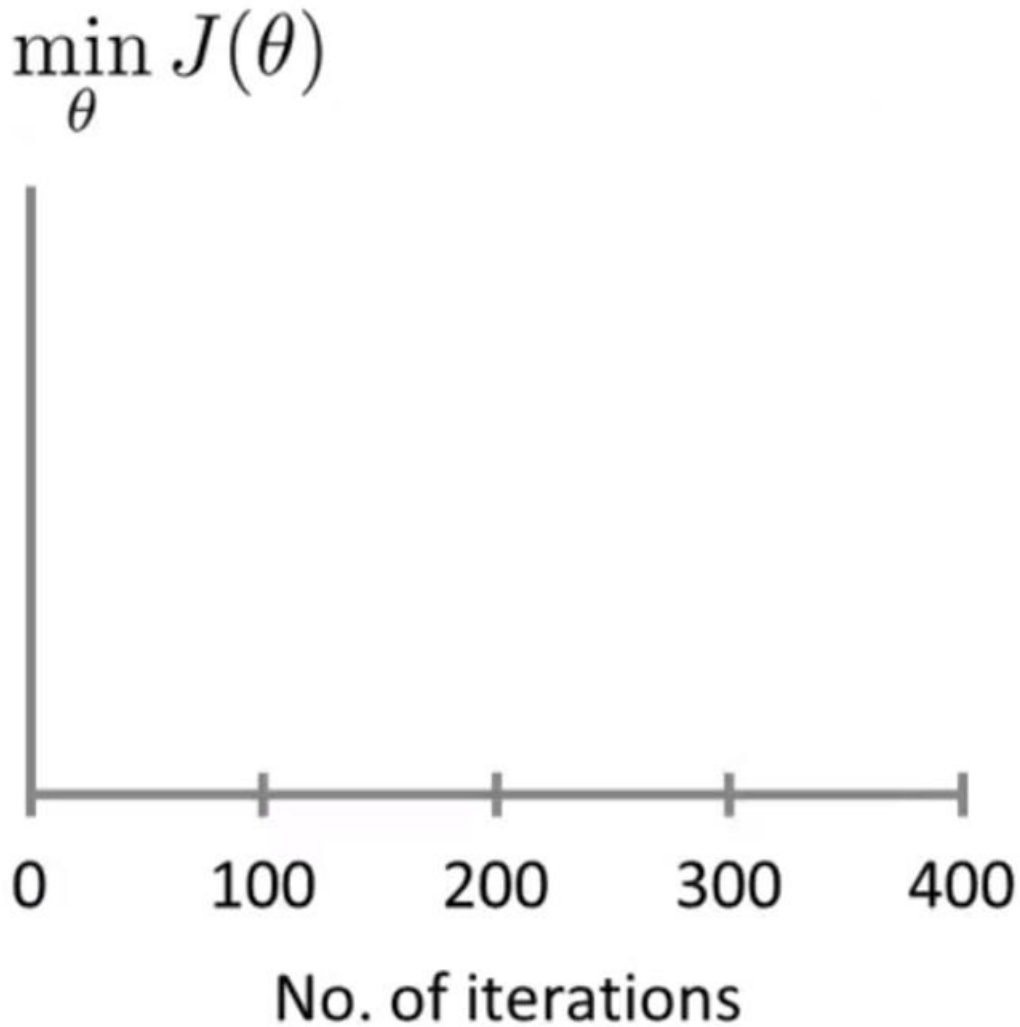
Linear Regression with Multiple Variables

Gradient descent

$$\theta_j := \theta_j - \alpha \frac{\partial}{\partial \theta_j} J(\theta)$$

- "Debugging": How to make sure gradient descent is working correctly.
- How to choose learning rate α.

Making sure gradient descent is working correctly.



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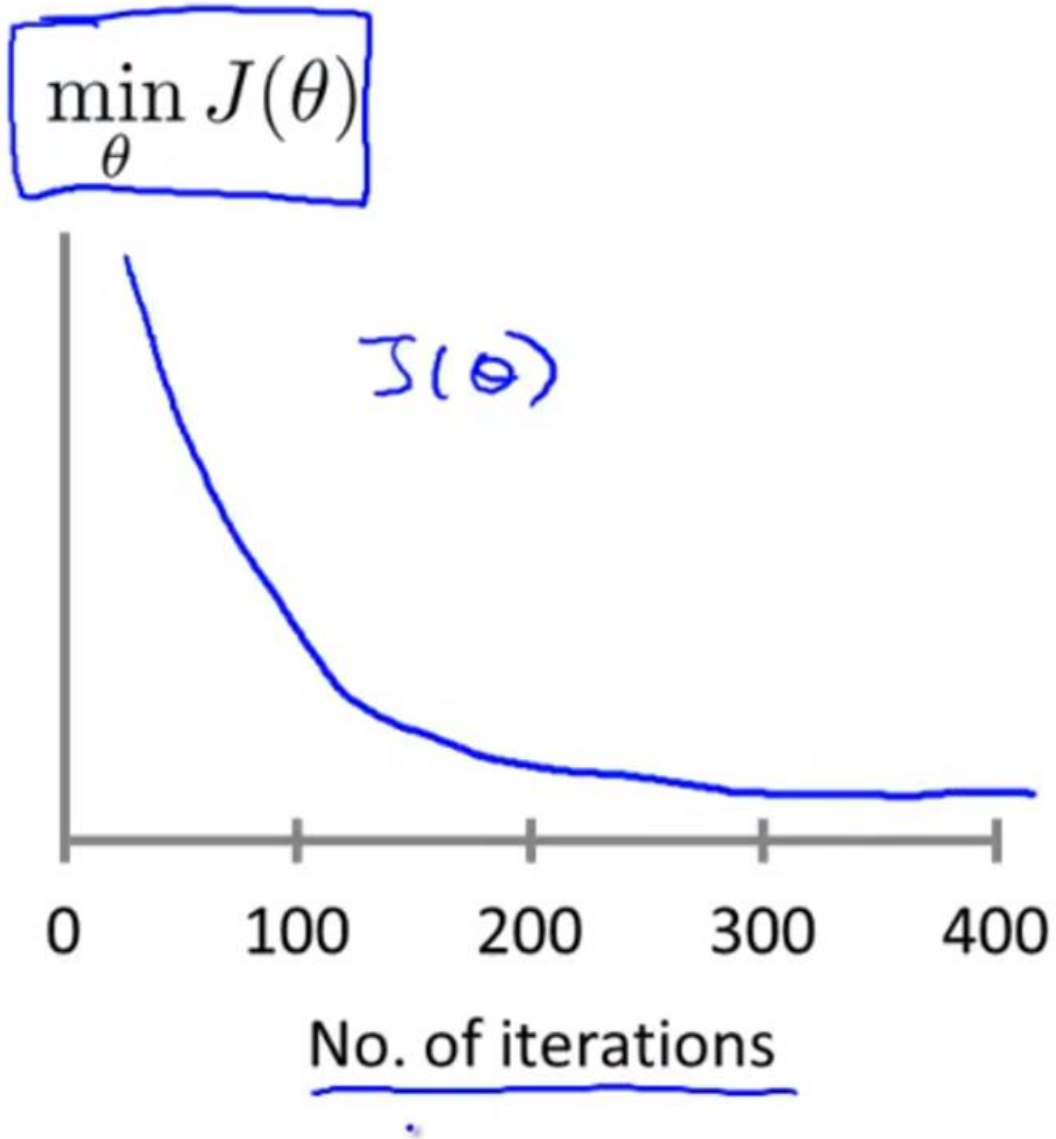

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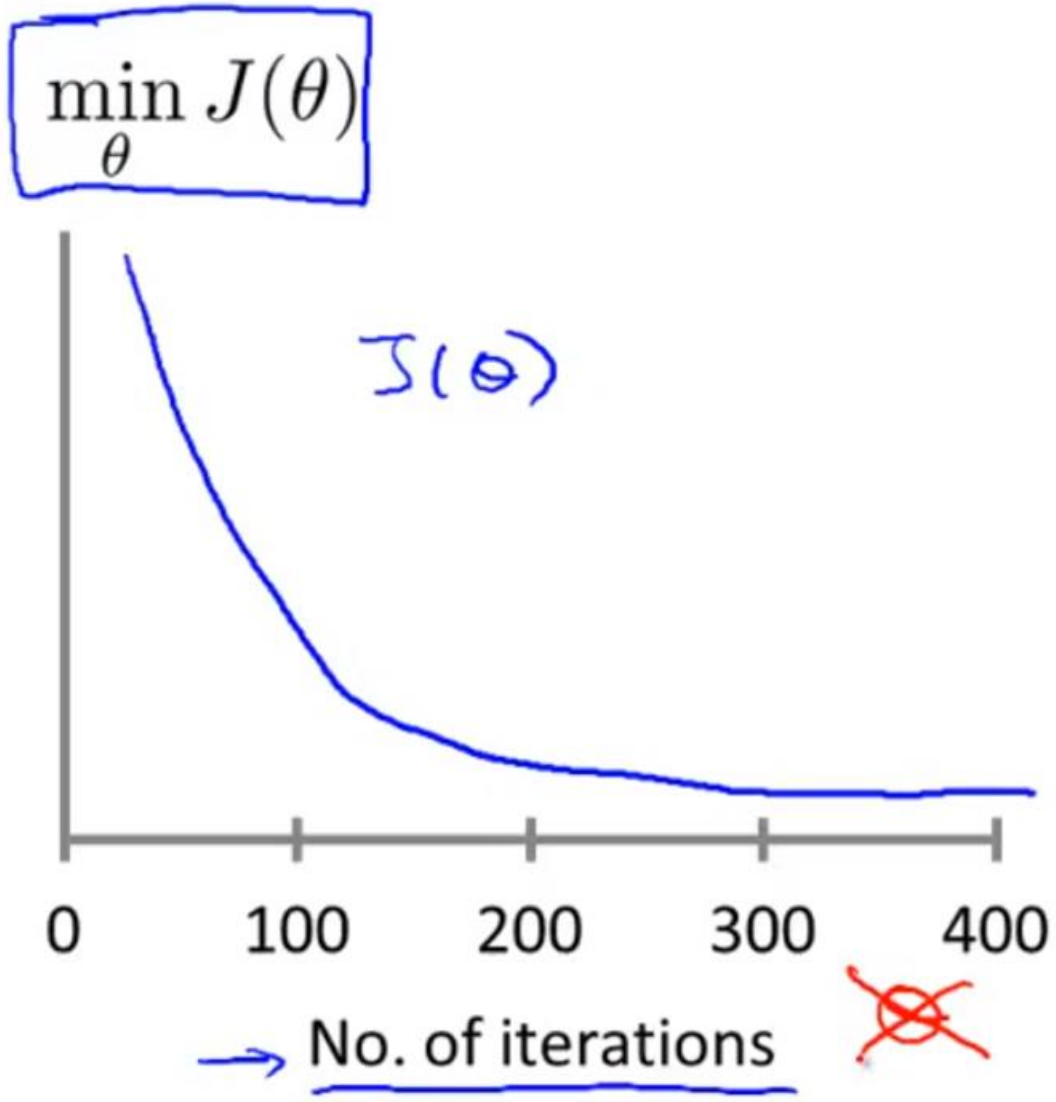

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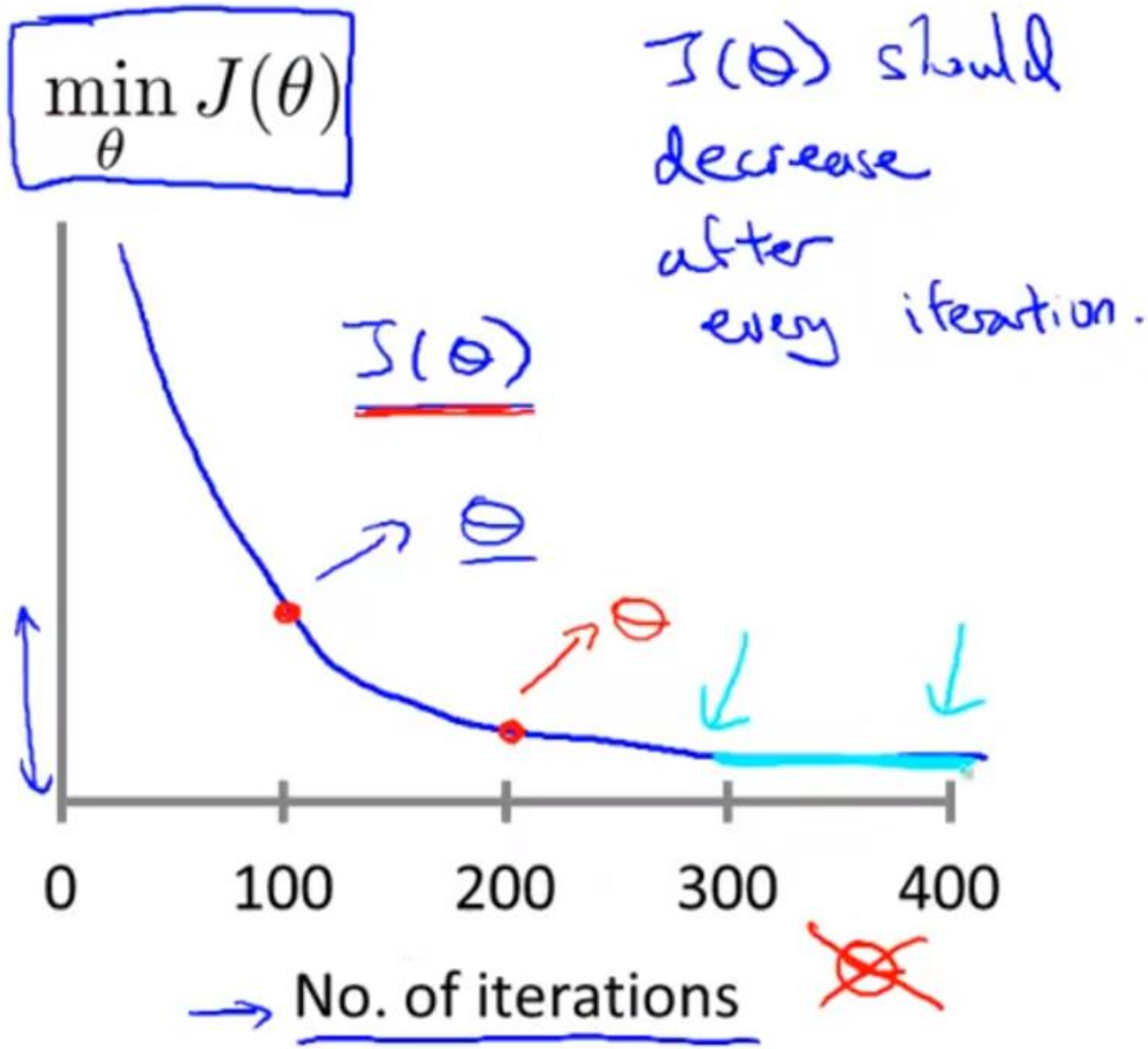

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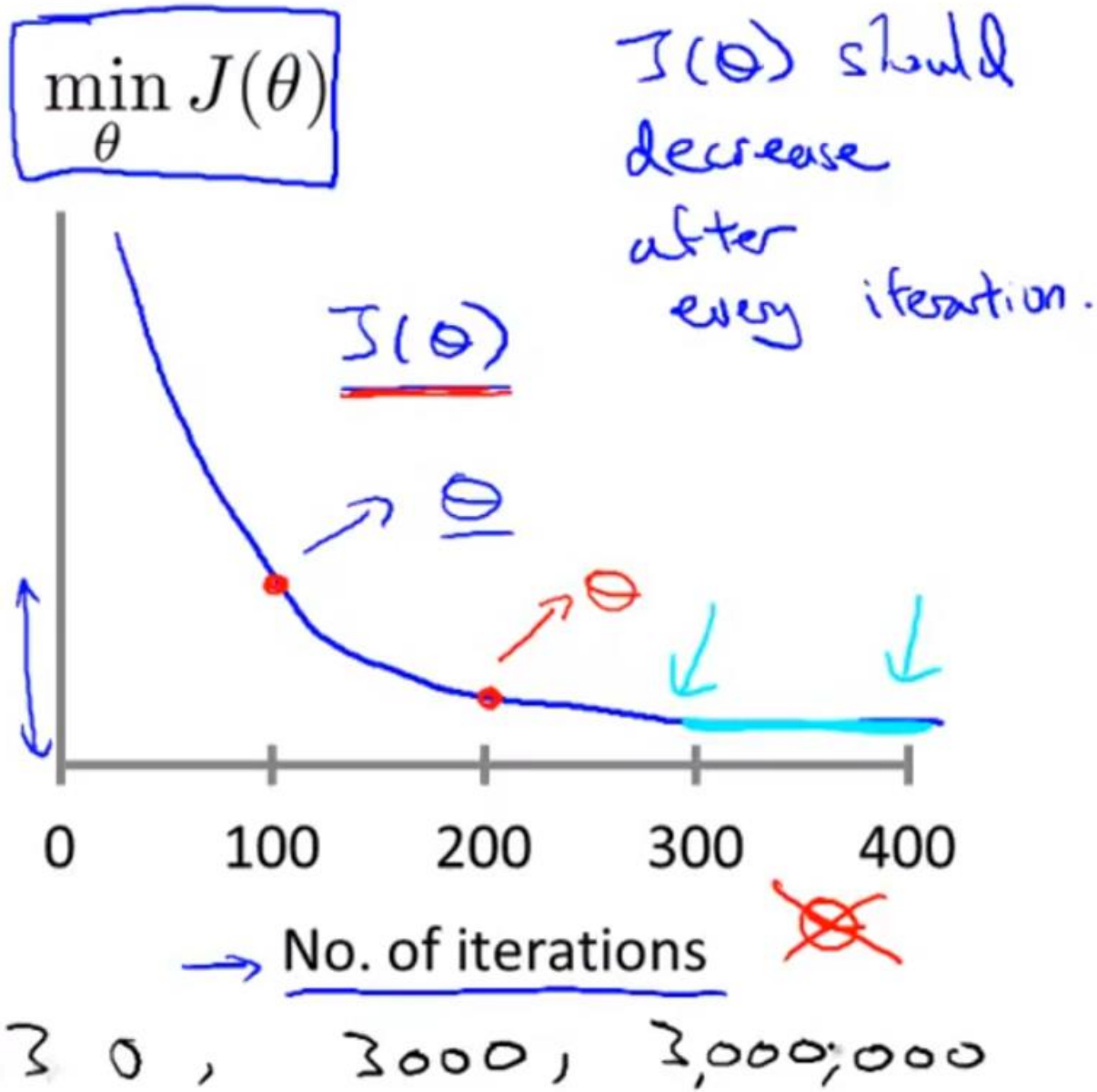

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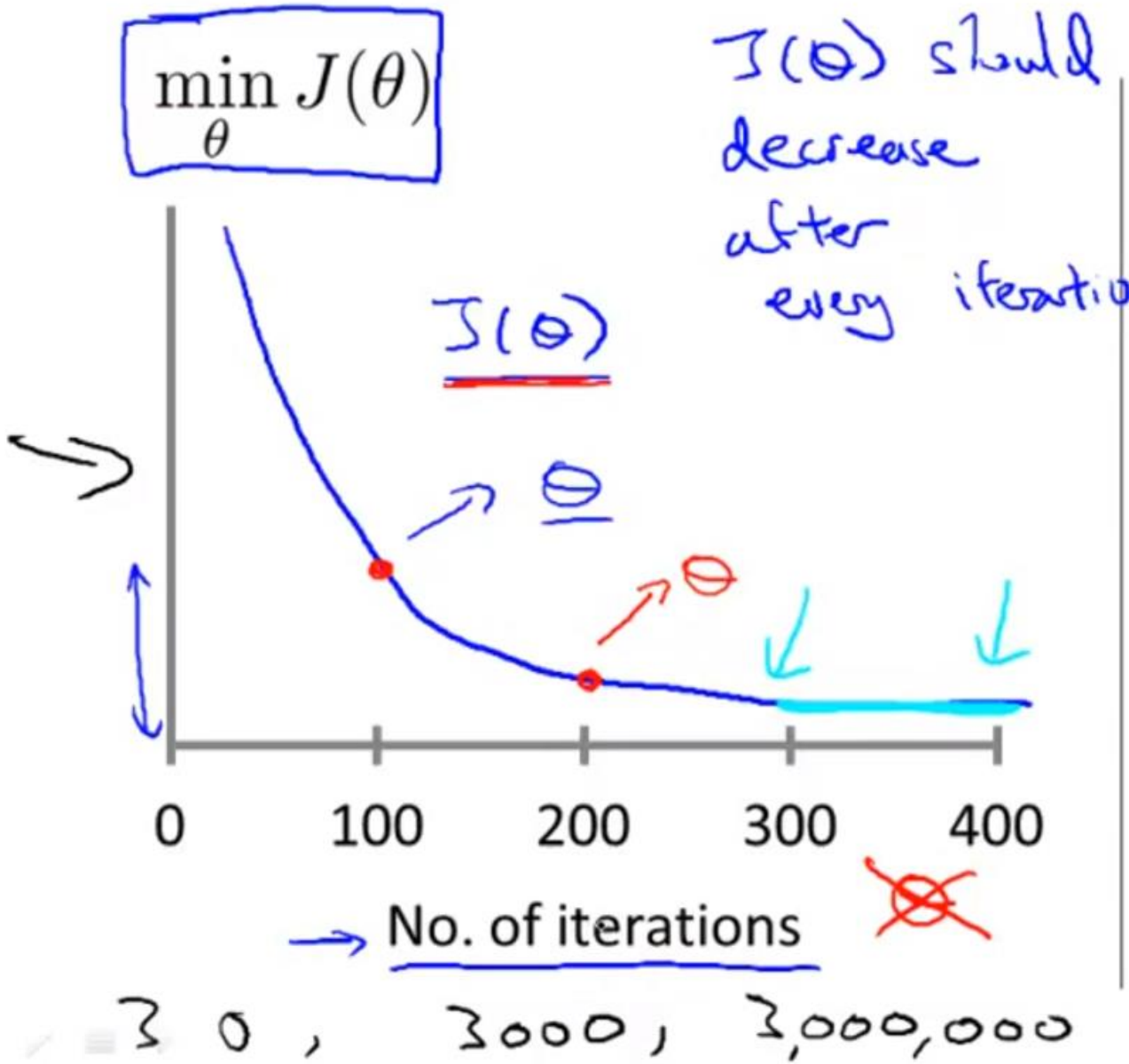

Example automatic convergence test:

Declare convergence if $J(\theta)$ decreases by less than 10^{-3} in one iteration.

Epsilon

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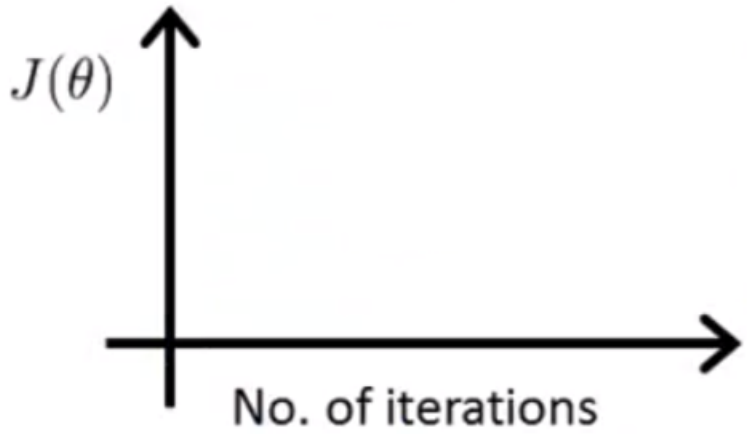

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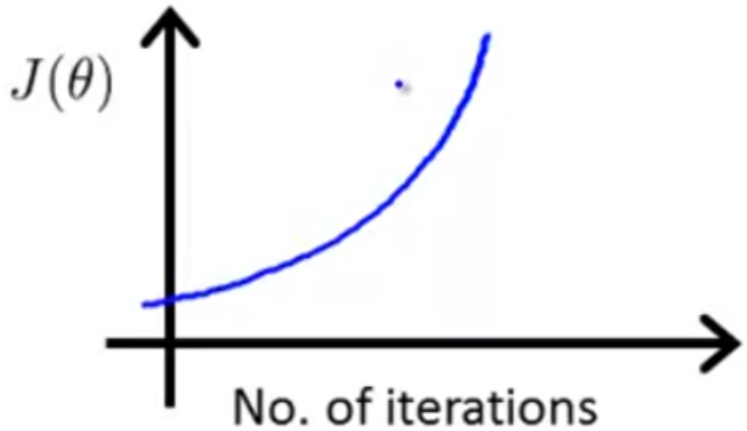

Gradient descent not working.

Use smaller α.

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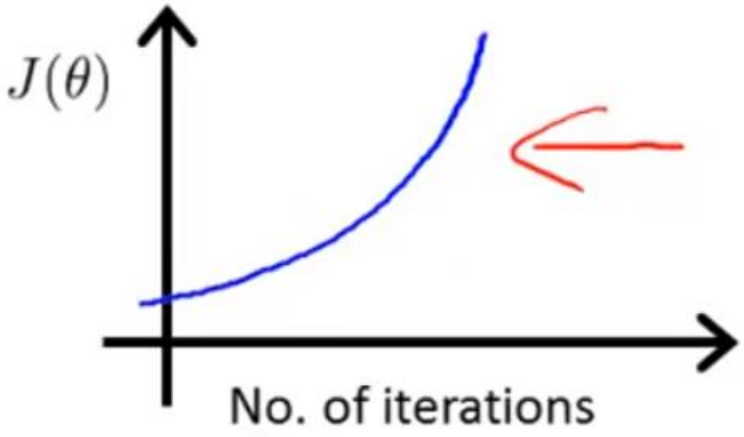

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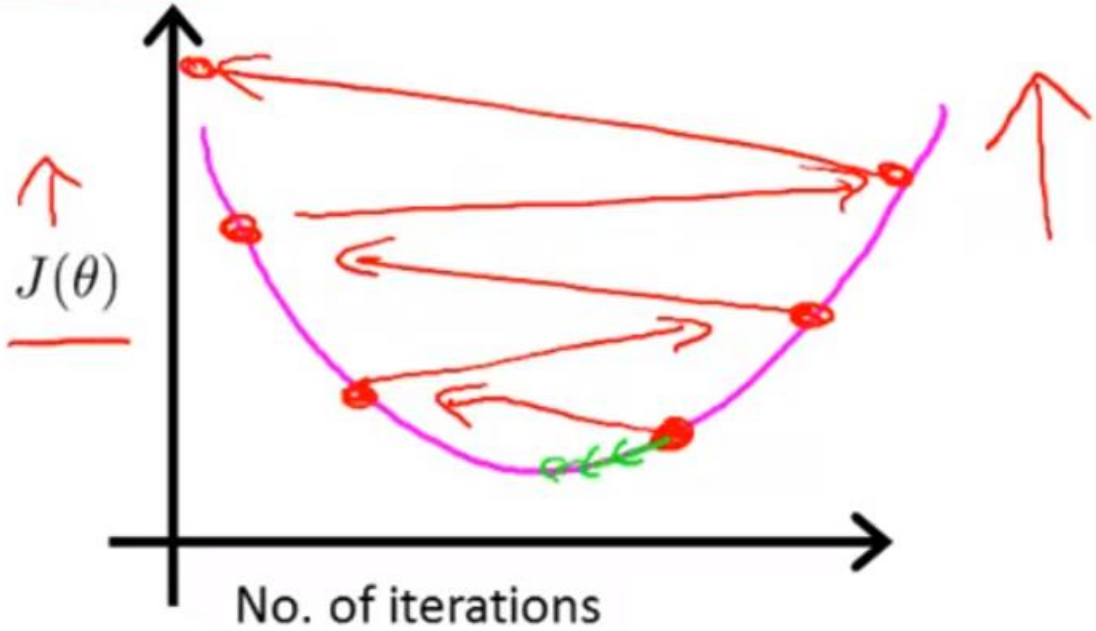

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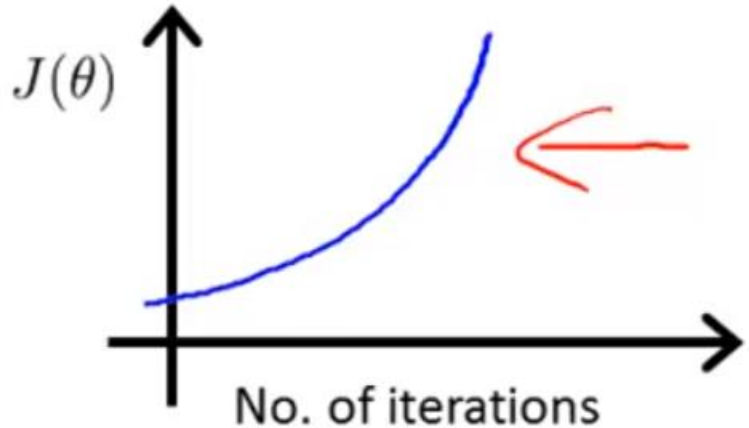

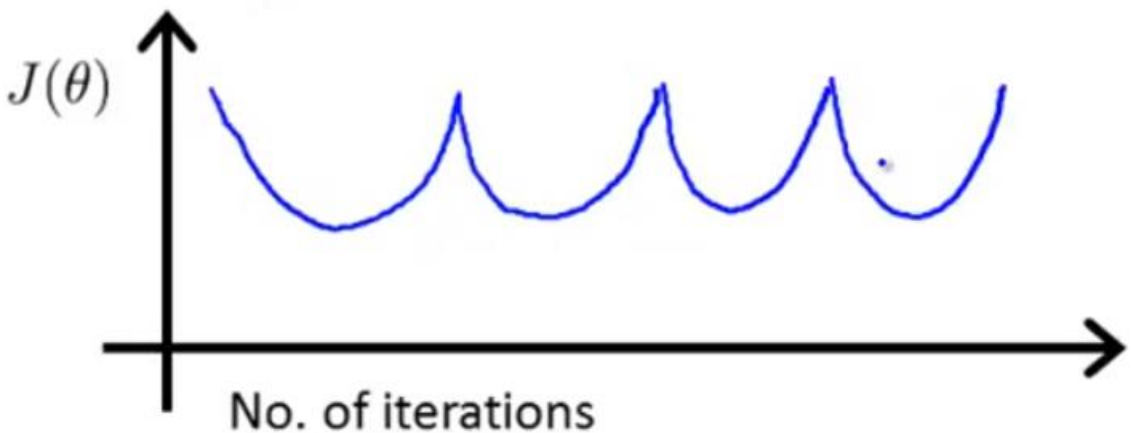

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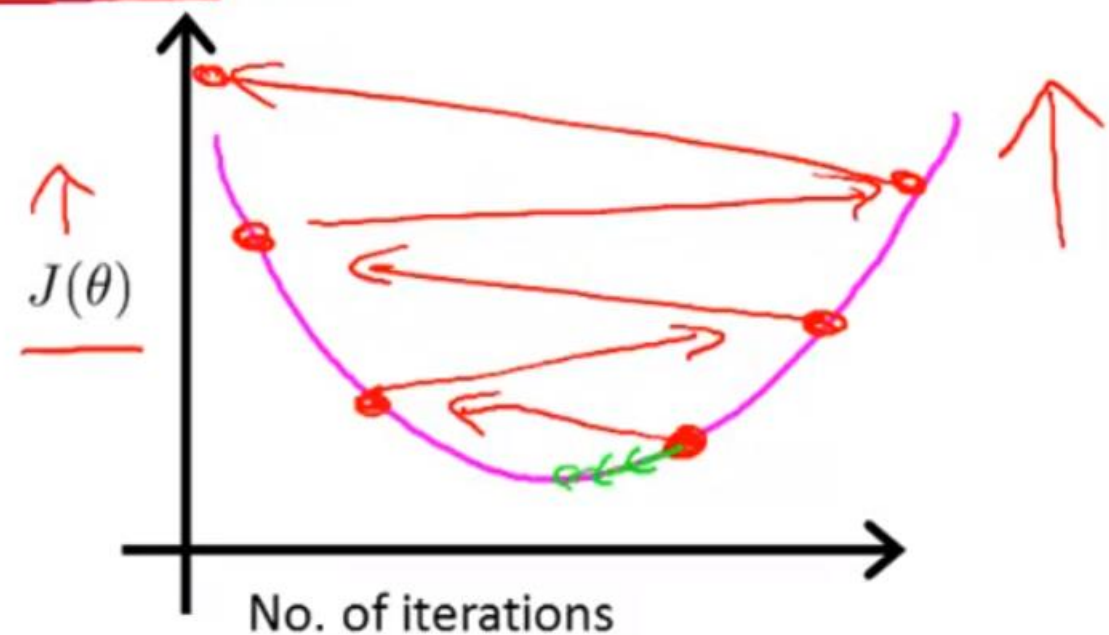

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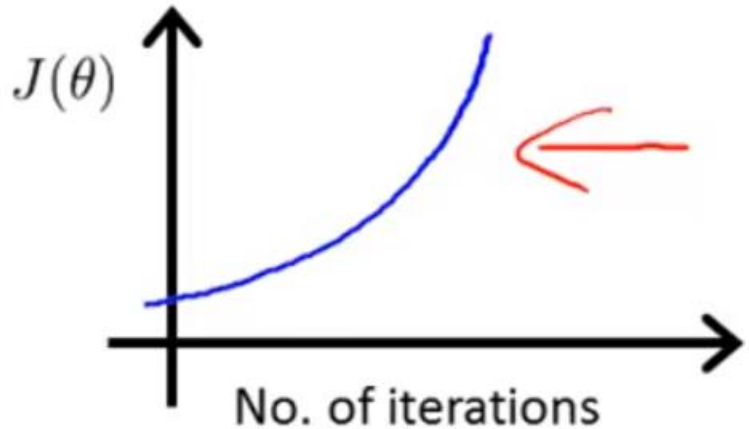

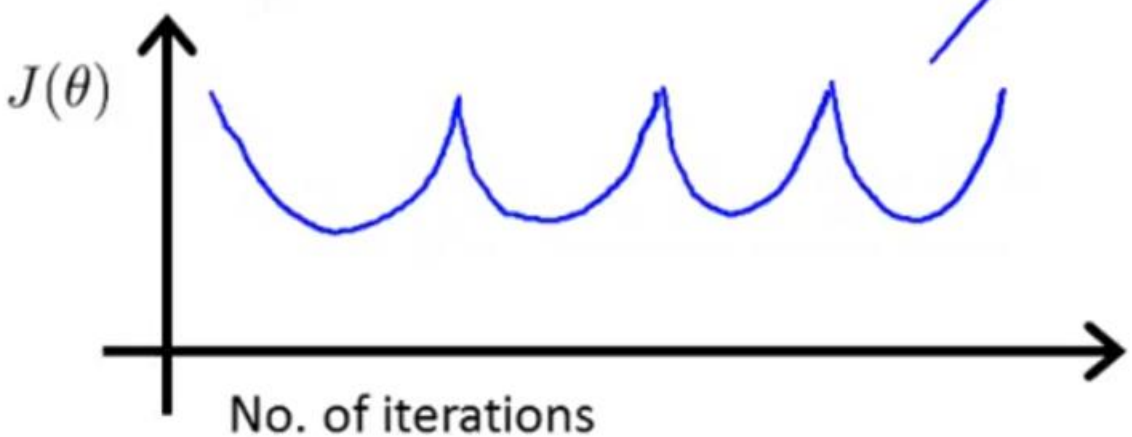

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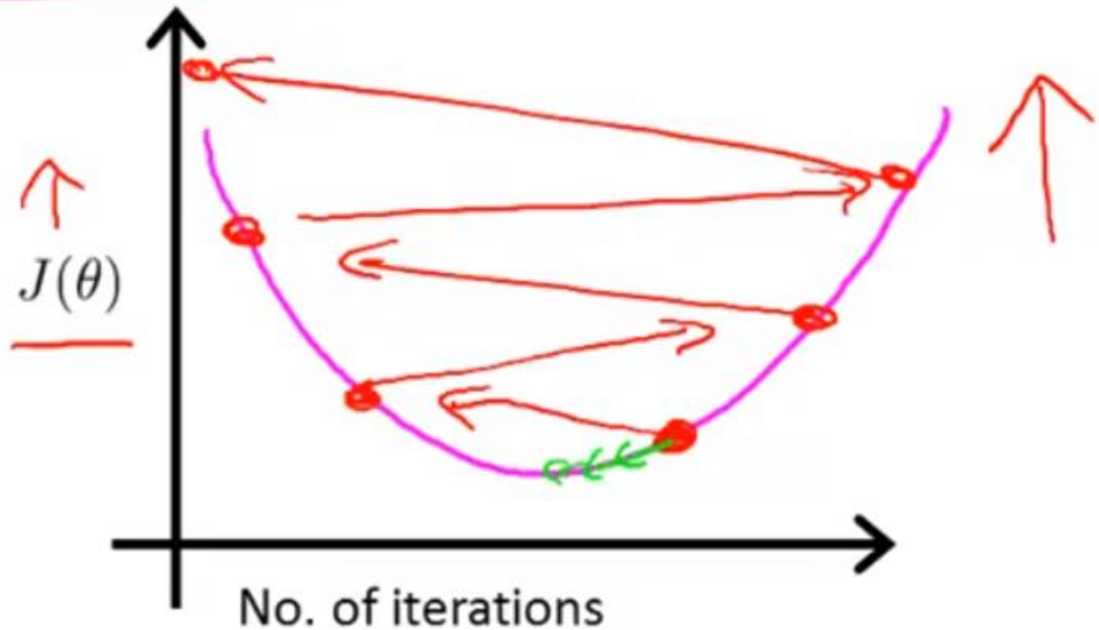

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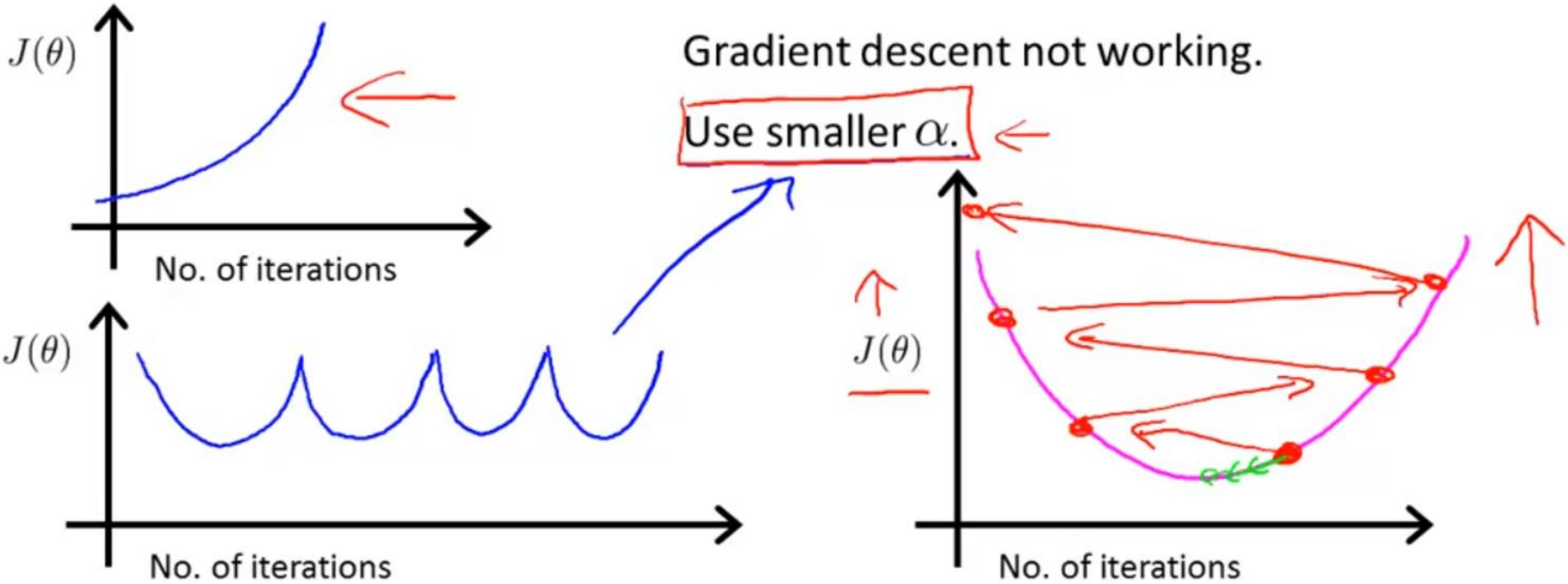
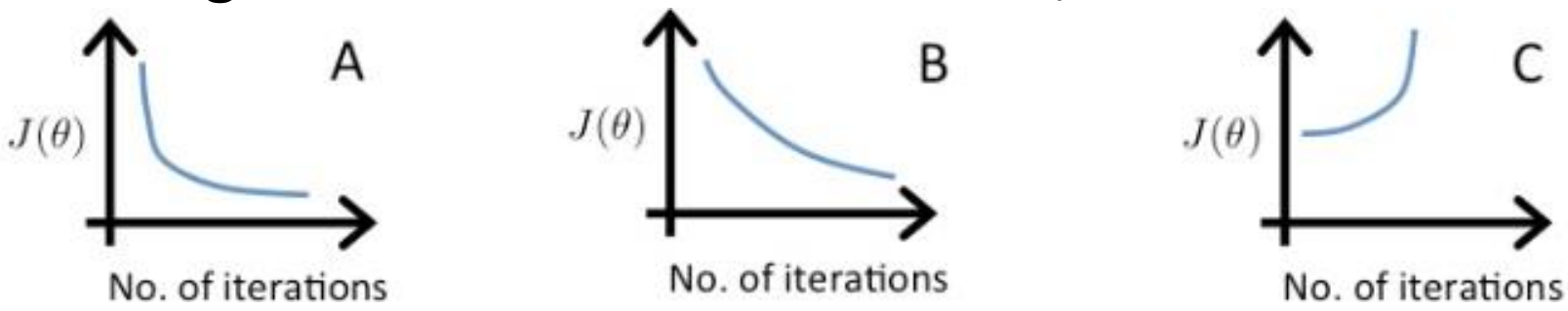


- For sufficiently small α, $J(\theta)$ should decrease on every iteration.
- But if α is too small, gradient descent can be slow to converge.

Exercise

- Suppose a friend ran gradient descent three times, with
- α=0.01,
- α=0.1,
- α=1,



- and got the following three plots (labeled A, B, and C):
- Which plots corresponds to which values of α?

	A	B	C
A	0.01	0.1	1
B	0.1	0.01	1
C	1	0.1	0.01
D	1	0.01	0.1

Summary:

- If α is too small: slow convergence.
- If α is too large: $J(\theta)$ may not decrease on every iteration; may not converge.

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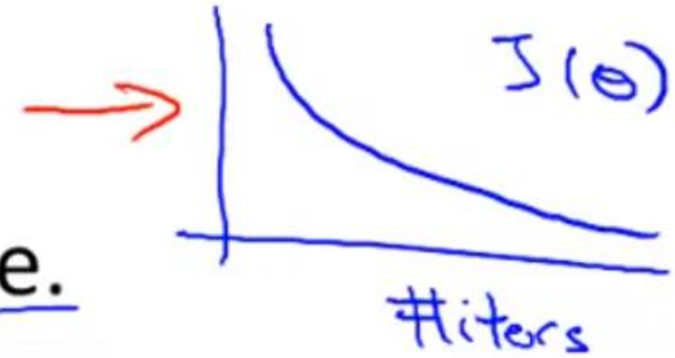
To choose α, try

$$\ldots, 0.001, \quad , 0.01, \quad , 0.1, \quad , 1, \ldots$$

Summary:



- If α is too small: slow convergence.
- If α is too large: $J(\theta)$ may not decrease on every iteration; may not converge. (Slow converge also possible.)

To choose α, try

$$\ldots, 0.001, 0.003, 0.01, 0.03, 0.1, 0.3, 1, \ldots$$