

# MODELING AND SIMULATION

## Motivation

**Prerequisites:** EEE208/EEE0208 Probability and Random Variables

### Textbooks:

- 1) Fikri Öztürk, Levent Özbek, “Matematiksel Modelleme ve Simülasyon”, 2004.
- 2) Averill M. Law, “Simulation Modeling and Analysis”, McGraw-Hill, New York, 2015.
- 3) D. P. Bertsekas, J. N. Tsitsiklis, “Introduction to Probability”, 2<sup>nd</sup> Ed., Athena Science 2008.

### References:

- 1) Gentle, J. E., 2003 “Random Number Generation and Monte Carlo Methods”

# Information and Policies

- Report writing
- IEEE Manuscript Templates
- MathType equation editor
- Level of MATLAB knowledge
- Are you a hard-working student?
- Cheating & Plagiarism Policy
- Grading weights are as follows: midterm (30%) and final (80%)
- Midterm: Homeworks, Final: Project

# Course Contents

- Experiment, model and simulation
- Mathematical modeling
  - Mathematical models
  - Probabilistic models
- Probabilistic Modeling
  - Describing uncertainty
  - Noise
  - Probabilistic models
    - Thermal noise, AWGN
  - Probabilistic inference

# Course Contents (Continued)

- Newton's laws of motion
- Simulation examples
- Random number generators
- Inverse Transform Sampling
- Randomness tests
- Monte Carlo methods
  - Area of a Disk
  - Estimating Sinusoidal Frequency
- Performance Evaluation in Monte Carlo Simulations
- Model Parameter Estimation

# Studying a System

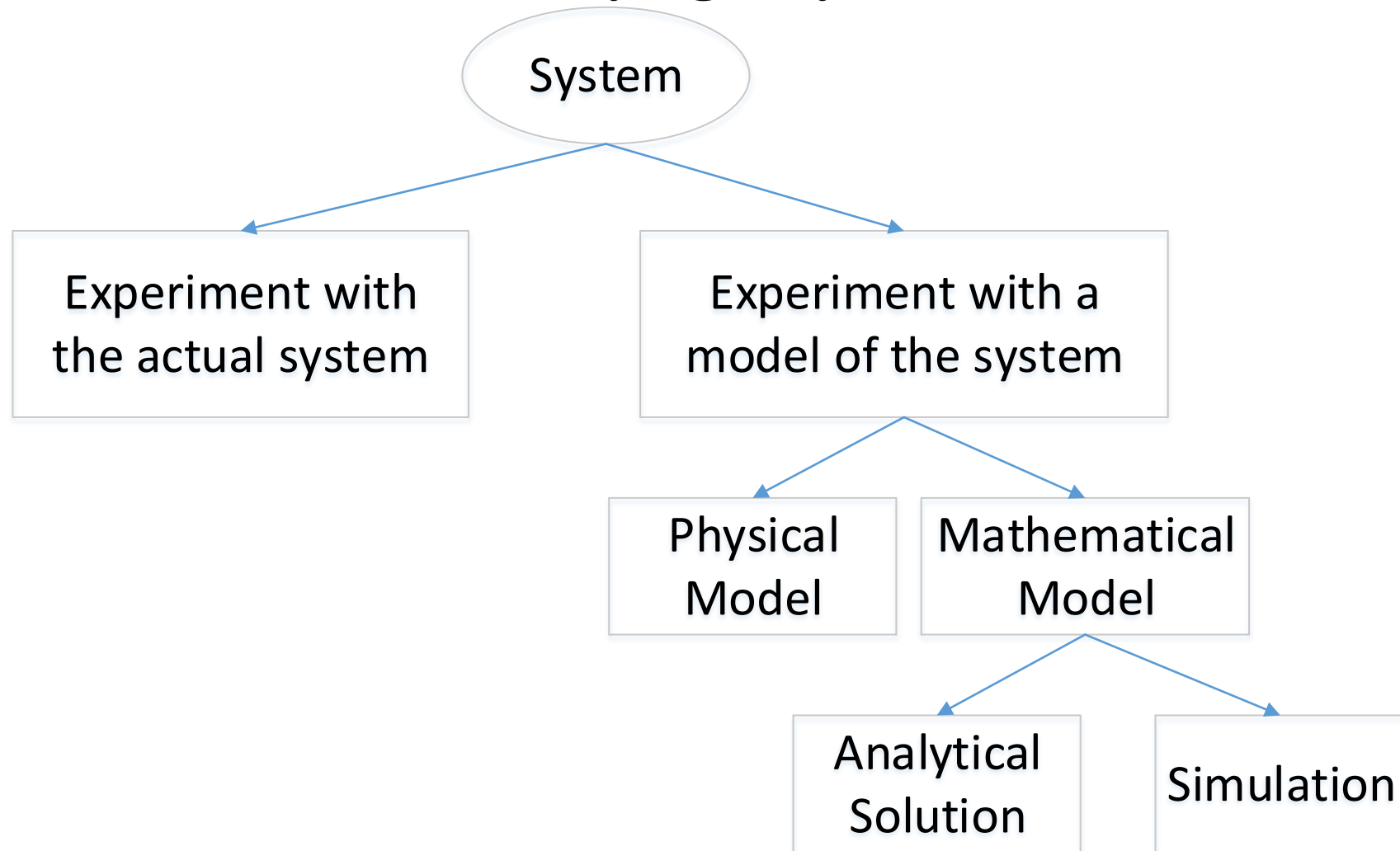


Figure: Studying a system (Law, A.M, 2015)

# Studying a System

## Experiment with

- the actual system (not cost-effective)
- a model of the system

## Physical Models

- can be used for a limited number of systems

## Mathematical Models

- logical and quantitative relationships
- Methods: Algebra, calculus, probability theory
- Real-world systems modeled realistically are generally too complex.
  - Analytical solution is not available most of the time.
- Simulation is a solution

# Experiment, Model and Simulation

## ○ Free Fall Motion

### ▪ Experiment:

- Today: Technology, see the video

- In the past: “The Universe of Galileo and Newton” by

William Bixby

## ○ Experiment, Model and Simulation concepts

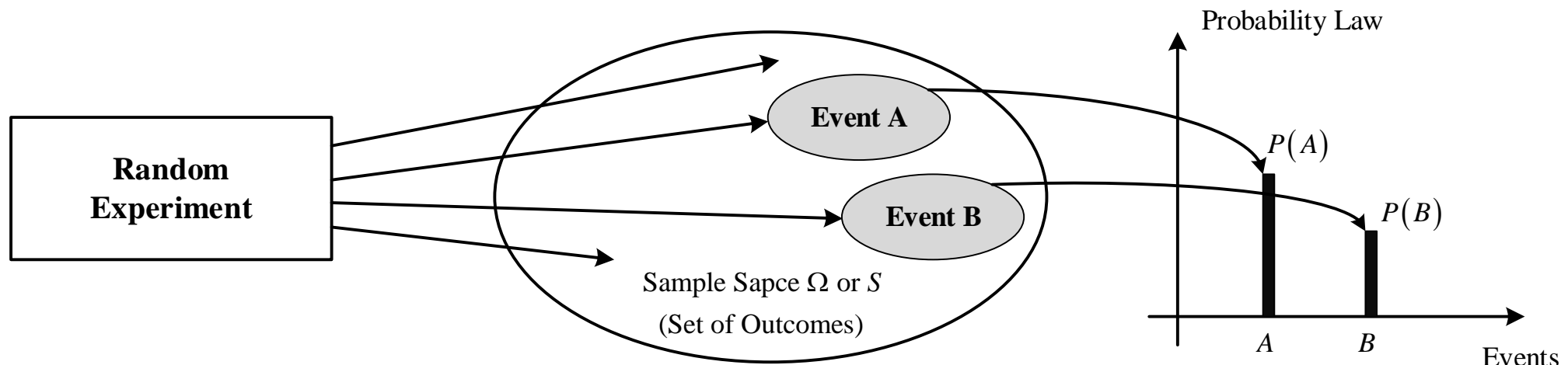
### ▪ Experiment – Simulation:

- Some examples: Designing earthquake-resistant buildings, designing a rocket

# PROBABILISTIC MODELS

Elements of a Probabilistic Model:

- The sample space  $\Omega$
- **The probability law**  
assigns nonnegative numbers to events



Textbook: D. P. Bertsekas, J. N. Tsitsiklis, "Introduction to Probability", 2nd Ed., Athena Science 2008.

Textbooks: Fikri Öztürk, Levent Özbek, "Matematiksel Modelleme ve Simülasyon", 2004.  
Averill M. Law, "Simulation Modeling and Analysis", McGraw-Hill, 2015.



# PROBABILISTIC MODELS

## Sample Spaces and Events

- Random Experiment
- Trial
- Outcome
- Sample Space  $S$
- Event
- Sure Event
- Impossible Event

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