Lecture 1

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1 Uncertainties

- Lack of modeling
- Limited measurements
- $V_1 - V_2 = I_{12}R_{12}$
- $mx + dx + kx = 0$

Probability is the **systematic** way to deal with uncertainties.

2 Coin Flips

- 2 outcomes, H or T
- Fair coin: $P(H) = P(T) = 0.5$
- Biased coin: $P(H) = 0.3, P(T) = 0.7$
- $P(H) + P(T) = 1$

Example 2.1.

$$\begin{aligned} P(HH) &= P(H)P(H) \\ &= 0.3 \times 0.3 \\ &= 0.09 \end{aligned}$$

Example 2.2.

$$\begin{aligned} P(HT) &= P(H)P(T) \\ &= 0.3 \times 0.7 \\ &= 0.21 \end{aligned}$$

Example 2.3.

$$\begin{aligned} P(HT \text{ or } TH) &= P(HT) + P(TH) \\ &= 0.42 \end{aligned}$$

Example 2.4. How to make a fair coin flip using a biased coin: flip a coin twice, A wins if HT, B wins if TH, else reflip.

3 Sample Space

- Coin flip: $\{H, T\}$
- Dice throw: $\{1, 2, 3, 4, 5, 6\}$
- 2 coin flips: $\{HH, HT, TH, TT\}$
- Temperature: $\{t \in \mathbb{R} | -30 \leq t \leq 30\}$

4 Event

- An **event** is a subset of S
- $\{1, 2, 3, 4, 5, 6\}$ is the sample space for a die
- each element is an event
- even results is also an event $\{2, 4, 6\}$
- Negative temperature: $\{t \in \mathbb{R} | -30 \leq t < 0\} \subset \{t \in \mathbb{R} | -30 \leq t \leq 30\}$

Definition 4.1. The **complement** of an event A is defined as

$$A' = \{s \in S | s \notin A\}$$

- The complement of H is T
- Die: the complement of $\{1, 2\}$ is $\{3, 4, 5, 6\}$
- $S = \{(x, y)|x^2+y^2 \leq 1\}, A = \{(x, y)|(x, y) \in S, x \geq 0\}, A' = \{(x, y)|(x, y) \in S, x < 0\}$

5 Intersection

- Die: even $\cap\{n \leq 3\} = \{2\}$
- $\{H\} \cap \{T\} = \emptyset$
- A and B are mutually exclusive iff $A \cap B = \emptyset$
- $A \cap A' = \emptyset$

6 Union

- Everything in A or B
- $A \cup B$
- even $\cap\{n \leq 3\} = \{1, 2, 3, 4, 6\}$
- $A \cup A' = S$