

## The Outlines of ECE 302 — Prof. Wang's section

1. Probability is a weight assignment.
  - Frequency vs. belief
2. If a probabilistic model is reasonable to the real phenomenon, we can use it to derive some useful conclusions.
3. The main theme of our probabilistic methods is “counting.”
  - Counting sometimes may be hard.
  - **Set operations** to help us count the weights. (Outcomes vs. events vs. sample space.)
  - A reasonable weight assignment needs to satisfy several properties.
  - We assign weights by **probability mass functions** and **probability density functions**.
4. **Conditional probability:** Zoom-in and renormalization
  - Help us make a decision when focusing on the occurrence of some particular event.
  - Help us construct new weight assignments.
5. **Independence:** When the conditional probability is the same as the original probability. (It is not about whether two events are physically related.)
6. **Random variables:** Experiments with outputs being “numbers”
  - Most of the experiments indeed output numbers.
  - **Expectation:** Weighted average.
  - **Variance**
  - Important discrete random variables: Bernoulli, binomial, geometric, Poisson random variables.
  - Important continuous random variables: uniform, exponential, Gaussian, Laplacian, Rayleigh.
  - These random variables model the real phenomena to a very close degree.
7. **Cumulative distribution function**

- A unifying method to specify random variables. (Conversion between the pmf, pdf, and cdf)
  - Can be used to compute probability very efficiently.
  - Characterizing random variables of mixed type.
  - Find the pmf/pdf of new random variables.
8. Other unifying ways to describe a random variable:
- The **generalized probability density function**
  - The **characteristic function**
  - The **moment generating function**
  - The **probability generating function**
9. All the concepts can be combined together:
- Conditional pdf, conditional pmf, conditional cdf, conditional generalized pdf, **conditional expectation**.
10. Functions of random variables:
- Quantization,
  - Linear operations,
    - **Standard Gaussian random variable**
  - Other functions:  $\max(X, X^2)$ , etc.
  - Computing the pmf, pdf, cdf of  $Y$  being a function of an existing random variable  $X$ .
11. What if we do not have the complete knowledge of the weight assignment?
- The **union bound**,
  - The **Markov inequality** and the **Chebyshev inequality** and the **Chernoff bound**.