Chapter 2

- **Permutations**: ${}_nP_r = \frac{n!}{(n-r)!}, \quad \binom{n}{r} = \frac{n!}{r!(n-r)!}$
- **Additive rule**: $P(A \cup B) = P(A) + P(B) - P(A \cap B)$
- **Conditional probability**: $P(B|A) = \frac{P(A \cap B)}{P(A)},$
- **Independence**: $P(A|B) = P(A) \implies P(A \cup B) = P(A)P(B)$
- **Total probability**: $P(A) = \sum_{n=1}^{k} P(B_i \cap A) = \sum_{n=1}^{k} P(B_i)P(A|B_i)$
- **Bayes' Rule**: $\mathcal{P}$ of even in a partitioned Ω, $P(B_r|A) = \frac{P(B_r)P(A|B_r)}{\sum_{n=1}^{\infty} P(B_i)P(A|B_i)}$

Chapter 3

- **Probability mass function**: describes the probability that a discrete random variable is exactly equal to some value, i.e.,

$$p : R \to [0,1] \quad p(x) = \mathcal{P}(X = x) \impliedby p(x) \geq 0, \sum_i = p(x_i) = 1$$

- **Probability density function**: describes relative probabilities for a set of exclusive continuous events, i.e.,

$$\mathcal{P}(a \leq X \leq b) = \int_a^b f(x)\,dx \impliedby f(x) \geq 0, \forall x \in \mathbb{R}, \quad \int_{-\infty}^{\infty} f(x)\,dx = 1$$

- **Cumulative density function**: the sum of continuous probabilities up to a particular point (CDF can be > 1), i.e.,

$$f(x) = \int_{-\infty}^{x} f(u)\,du \implies \sum_{i=1}^{a} p(x_i)$$

Chapter 4

- **Expected value $E[X]$, $\bar{X}$**: a generalized weighted average, essentially the arithmetic mean of a large number of realizations of some random variable X.

$$\text{Discrete: } E[X] = \sum_x xf(x), \quad \text{Continuous: } E[X] = \int_{-\infty}^{\infty} xf(x)\,dx$$

  - Note: x can be a probability function.
  - Applying the mean value μ allows for expected variance, i.e., $\sigma^2 = E[(X-\mu)^2]$