

# Probability Distributions & Simulation Summary

## 1. Introduction to Probability Distributions

Probability distributions describe how probabilities are distributed over values of a random variable. They are foundational for simulations in Operations Research and Statistics.

## 2. Discrete Distributions

- Binomial Distribution: Models the number of successes in a fixed number of independent Bernoulli trials.
  - Parameters:  $n$  (number of trials),  $p$  (probability of success)
- Poisson Distribution: Models the number of occurrences in a fixed interval of time or space.
  - Parameter:  $\lambda$  (rate of occurrence)
- Geometric & Hypergeometric Distributions: Used in sampling scenarios.

## 3. Continuous Distributions

- Normal Distribution: Bell-shaped curve, defined by mean ( $\mu$ ) and standard deviation ( $\sigma$ ).
- Exponential Distribution: Models time between Poisson events. Useful in queuing and reliability models.
- Uniform Distribution: Equal probability across interval  $[a, b]$ .

## 4. Simulating Random Variables

Python's `numpy.random` and `scipy.stats` libraries allow simulation of various distributions:

- Binomial: `np.random.binomial(n, p, size)`
- Poisson: `np.random.poisson(lam, size)`
- Normal: `np.random.normal(mu, sigma, size)`
- Exponential: `np.random.exponential(scale, size)`

## 5. Applications in Simulation

- Customer arrival modeling (Poisson)
- Service times in queues (Exponential)
- Inventory demand modeling (Normal, Uniform)
- Risk analysis (Monte Carlo with Normal or Lognormal)