Probability Distributions

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| **Distribution** | **Definition** | **Example** | **Equation/Key Parameters** | **Use Case** |
| Bernoulli | Models a single trial with two outcomes (1 = Success, 0 = Failure). | Flipping a coin once: Heads = Success (1), Tails = Failure (0).  A light bulb either works (1) or does not work (0). | P(X=1) = p, P(X=0) = 1-p (0 ≤ p ≤ 1) | Binary events like Yes/No, On/Off. |
| Binomial | Models number of successes in n independent trials. | Tossing a coin 10 times and counting Heads.  Out of 10 tossed coins, how many show Heads? | P(X=k) = C(n, k) \* p^k \* (1-p)^(n-k) | Predicting defective items in batches. |
| Poisson | Models number of events in a fixed interval. | Number of customer calls received in an hour.  Number of emails received per hour, where average = 5 emails. | P(X=k) = (λ^k \* e^(-λ)) / k! | Rare events like accidents or system failures. |
| Geometric | Models number of trials until first success. | Rolling a die until you get a 6. | P(X=k) = (1-p)^(k-1) \* p | Finding first success in repeated trials. |
| Normal | Bell-shaped curve; most values are near the mean. | Heights of people or exam scores.  Height of students in a classroom. | f(x) = (1 / sqrt(2πσ²)) \* e^(-(x-μ)² / 2σ²) | Modeling natural phenomena. |
| Uniform | All outcomes in a range are equally likely. | Rolling a fair 6-sided die (each number has an equal chance). | f(x) = 1 / (b-a), a ≤ x ≤ b | Random sampling or lotteries. |
| Exponential | Models time until the next event happens. | Time between arrivals of customers at a bank.  Time between calls at a customer service center. | f(x) = λ \* e^(-λx), x ≥ 0 | Queuing systems, reliability analysis. |
| Beta | Models probabilities that fall between 0 and | Probability of a website visitor clicking on an ad.  Probability of conversion rates (e.g., click-through rate of an ad) | f(x) = (x^(α-1) \* (1-x)^(β-1)) / B(α, β) | Bayesian statistics and probability modeling. |