Geometric Distribution | Formula, Mean and Examples

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Geometric distribution is a probability distribution that defines the number of trials required to get the first success in a series of independent and identically distributed **Bernoulli trials,** where each trial has **two possible outcomes: success or failure.** The trials are conducted **until the first success is observed,** and the **probability of success in each trial is constant.**

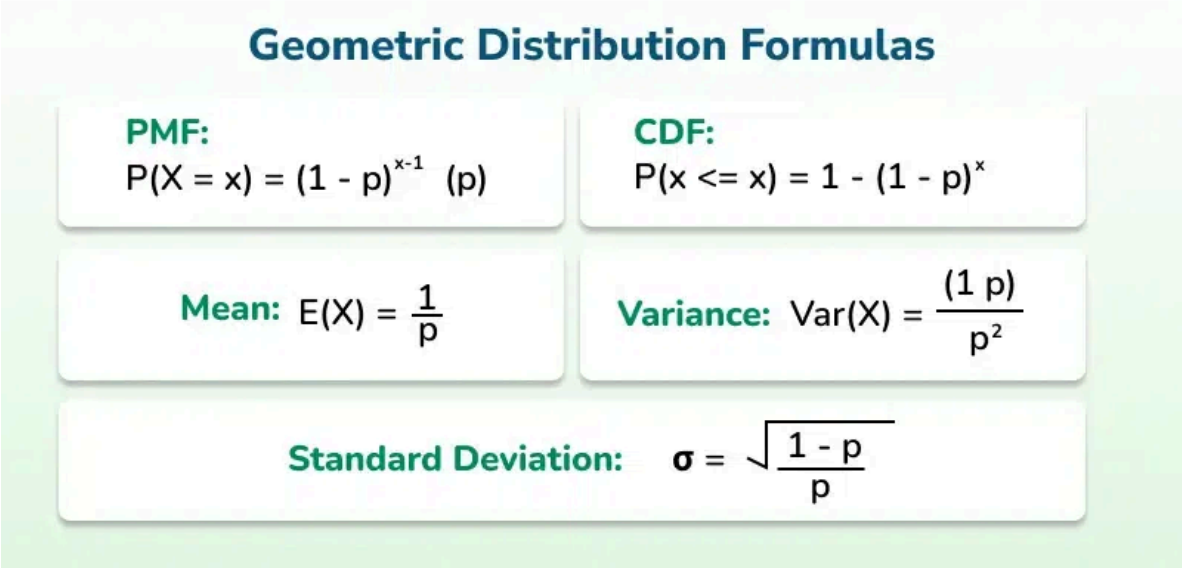
The geometric distribution is commonly used in various real-life circumstances. In the financial industry, it is used to estimate the financial rewards of making a given decision in a cost-benefit analysis.

Geometric distributions are probability distributions that are based on three key assumptions.

- Trials are independent
- Each trial has one of two outcomes: success or failure
- For each trial, the probability of success, p, is constant across trials.

Geometric Distribution Formulas

The geometric distribution is characterized by two important functions: the **Probability Mass Function (PMF)** and the **Cumulative Distribution Function (CDF)**. These formulas help calculate the likelihood of achieving the first success after a certain number of trials. Below are the key formulas associated with the geometric distribution:



Geometric Distribution Formulas

Geometric Distribution PMF

The likelihood that a discrete random variable, X, will be exactly identical to some value, x, is determined by the probability mass function.

$$P(X = x) = (1 - p)^{x-1}p$$

where, $0 < p \leq 1$.

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The probability that a random variable, X, will assume a value that is less than or equal to x can be described as the cumulative distribution function of a random variable, X, that is assessed at a point, x. The distribution function is another name for it.

$$P(X \leq x) = 1 - (1 - p)^x$$

Mean of Geometric Distribution

The geometric distribution's mean is also the geometric distribution's expected value. The weighted average of all values of a random variable, X, is the expected value of X.

$$E[X] = 1 / p$$

Variance of Geometric Distribution

Variance is a measure of dispersion that examines how far data in a distribution is spread out about the mean.

$$Var[X] = (1 - p) / p^2$$

Standard Deviation of Geometric Distribution

The square root of the variance can be used to calculate the standard deviation. The standard deviation also indicates how far the distribution deviates from the mean.

$$S.D. = \sqrt{VAR[X]}$$
$$S.D. = \sqrt{1 - p / p}$$

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Sample Problems on Geometric Distribution

Problem 1: If a patient is waiting for a suitable blood donor and the probability that the selected donor will be a match is 0.2, then find the expected number of donors who will be tested till a match is found, including the matched donor.

Solution:

Given,
$p = 0.2$
$E[X] = 1 / p$
$= 1 / 0.2$
$= 5$

The expected number of donors who will be tested till a match is found is ***5***

Problem 2: Suppose you are playing a game of darts. The probability of success is 0.4. What is the probability that you will hit the bullseye on the third try?

Solution:

Given,
$p = 0.4$
$P(X = x) = (1 - p)^{x - 1}p$
$P(X = 3) = (1 - 0.4)^{3 - 1}(0.4)$
$P(X = 3) = (0.6)^2(0.4)$
$= 0.144$

The probability that you will hit the bullseye on the third try is ***0.144***

Problem 3: A light bulb manufacturing factory finds 3 in every 60 light bulbs defective. What is the probability that the first defective light bulb with be found when the 6th one is tested?

Solution:

Given,

$P(X = 6) = (0.95)^5(0.05)$
$P(X = 6) = 0.0386$

The probability that the first defective light bulb is found on the 6th trial is ***0.0368***

Problem 4: Find the probability density of the geometric distribution if the value of p is 0.42; x = 1,2,3, and also calculate the mean and variance.

Solution:

Given that p = 0.42 and the value of x = 1, 2, 3

The formula of probability density of geometric distribution is

$P(x) = p\ (1 - p)^{x-1}; x = 1, 2, 3$
$P(x) = 0;$ *otherwise*
$P(x) = 0.42\ (1 - 0.42)$
$P(x) = 0;$ *Otherwise*

$Mean = 1/p$
$= 1/0.42$
$= 2.380$

$Variance = 1 - p/p^2$
$= 1 - 0.42/(0.42)^2$
$=$ ***3.287***

Problem 5: If the probability of breaking the pot in the pool is 0.4, find the number of breaks before success and the corresponding variance and standard deviation.

Solution:

Here,
$X \sim geo(0.4)$

Hence,
$e(x) = 1/0.4 = 2.5$
$Var(x) = 0.6/0.4^2$
$= 3.75$

Hence, standard deviation (σ*) =* ***1.94***

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