



Multinomial Distribution: Definition, Examples

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The **multinomial distribution** is used to find probabilities in experiments where there are more than two outcomes.

Binomial vs. Multinomial Experiments

The first type of experiment introduced in [elementary statistics](#) is usually the [binomial experiment](#), which has the following properties:

- Fixed number of n trials.
- Each trial is an [independent event](#).
- Only two outcomes are possible (Success and Failure).
- Probability of success (p) for each trial is constant.
- A [random variable](#) Y = the number of successes.

A multinomial experiment is almost identical with one main difference: a binomial experiment can have two outcomes, while a multinomial experiment can have multiple outcomes.

Example: You roll a die ten times to see what number you roll. There are 6 possibilities (1, 2, 3, 4, 5, 6), so this is a multinomial experiment. If you rolled the die ten times to see how many times you roll a three, that would be a [binomial experiment](#) (3 = success, 1, 2, 4, 5, 6 = failure).

A binomial experiment will have a [binomial distribution](#). A multinomial experiment will have a multinomial distribution.

Multinomial Distribution Example

Three card players play a series of matches. The probability that player A will win any game is 20%, the probability that player B will win is 30%, and the probability player C will win is 50%. If they play 6 games, what is the probability that player A will win 1 game, player B will win 2 games, and player C will win 3?

Use the following formula to calculate the odds (*Need help?* [Check out our tutoring page!](#)):

$$P = \frac{n!}{(n_1!)(n_2!)...(n_x!)} P_1^{n_1} P_2^{n_2} ... P_x^{n_x}$$

where:

- n = number of events
- n_1 = number of outcomes, event 1
- n_2 = number of outcomes, event 2
- n_3 = number of outcomes, event x
- p_1 = probability event 1 happens
- p_2 = probability event 2 happens
- p_x = probability event x happens

Using the data from the question, we get:

- $n = 12$ (6 games total).
- $n_1 = 1$ (Player A wins).
- $n_2 = 2$ (Player B wins).
- $n_3 = 3$ (Player C wins).
- $p_1 = 0.20$ (probability that Player A wins).
- $p_2 = 0.30$ (probability that Player B wins).
- $p_3 = 0.50$ (probability that Player C wins).

Putting this into the formula, we get:

$$\Pr(A = 1, B = 2, C = 3) = \frac{6!}{1!2!3!} (0.2^1)(0.3^2)(0.5^3) = 0.135$$

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References

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Papoulis, A. [Probability, Random Variables, and Stochastic Processes, 2nd ed.](#) New York: McGraw-Hill, 1984.

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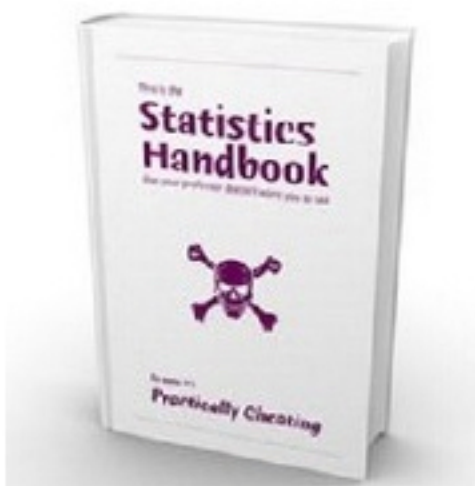
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