**Polynomial distribution**

A multinomial distribution is the probability distribution of the outcomes from a multinomial experiment.

**Multinomial Experiment has the following properties:**

1. The experiment consists of n repeated trials.

Each trial has a discrete number of possible outcomes.

3) On any given trial, the probability that a particular outcome will occur is constant.

4) The trials are independent; that is, the outcome on one trial does not affect the outcome on other trials.

Consider the following statistical experiment. You toss two dice three times, and record the outcome on each toss. This is a multinomial experiment because:

**The experiment consists of repeated trials. We toss the dice three times.**

Each trial can result in a discrete number of outcomes - 2 through 12.

The probability of any outcome is constant; it does not change from one toss to the next.

The trials are independent; that is, getting a particular outcome on one trial does not affect the outcome on other trials**.**

**Note: A binomial experiment is a special case of a multinomial experiment. Here is the main difference. With a binomial experiment, each trial can result in two - and only two - possible outcomes. With a multinomial experiment, each trial can have two or more possible outcomes.**

**Multinomial Formula.**

Suppose a multinomial experiment consists of n trials, and each trial can result in any of k possible outcomes: E1, E2, . . . , Ek. Suppose, further, that each possible outcome can occur with probabilities p1, p2, . . . , pk. Then, the probability (P) that E1 occurs n1 times, E2 occurs n2 times, . . . , and Ek occurs nk times is:

P = [ n! / ( n1! \* n2! \* ... nk! ) ] \* ( p1n1 \* p2n2 \* . . . \* pknk )

where n = n1 + n2 + . . . + nk.

Example problem:

Suppose we have a bowl with 10 marbles - 2 red marbles, 3 green marbles, and 5 blue marbles. We randomly select 4 marbles from the bowl, with replacement. What is the probability of selecting 2 green marbles and 2 blue marbles?

Solution: To solve this problem, we apply the multinomial formula. We know the following:

The experiment consists of 4 trials, so n = 4.

The 4 trials produce 0 red marbles, 2 green marbles, and 2 blue marbles; so nred = 0, ngreen = 2, and nblue = 2.

On any particular trial, the probability of drawing a red, green, or blue marble is 0.2, 0.3, and 0.5, respectively. Thus, pred = 0.2, pgreen = 0.3, and pblue = 0.5

We plug these inputs into the multinomial formula, as shown below:

P = [ n! / ( n1! \* n2! \* ... nk! ) ] \* ( p1n1 \* p2n2 \* . . . \* pknk )

P = [ 4! / ( 0! \* 2! \* 2! ) ] \* [ (0.2)0 \* (0.3)2 \* (0.5)2 ]

P = 0.135

Thus, if we draw 4 marbles with replacement from the bowl, the probability of drawing 0 red marbles, 2 green marbles, and 2 blue marbles is 0.135.