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MULTIPLICATION RULE OF PROBABILITY

The multiplication rule of probability explains the condition between two events. For two events A and B associated with a sample space S, the set A∩B denotes the events in which both event A and event B have occurred. Hence, (A∩B) denotes the simultaneous occurrence of the events A and B. The event A∩B can be written as AB. The probability of event AB is obtained by using the properties of conditional probability.

Multiplication Rule of Probability Statement and proof

We know that the conditional probability of event A given that B has occurred is denoted by P(A|B) and is given by:

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

Where, $P(B) \neq 0$

$P(A \cap B) = P(B) \times P(A|B)$ ……..(1)

$$P(B|A) = \frac{P(B \cap A)}{P(A)}$$

Where, $P(A) \neq 0$.

$P(B \cap A) = P(A) \times P(B|A)$

Since, $P(A \cap B) = P(B \cap A)$

$P(A \cap B) = P(A) \times P(B|A)$ ……(2)

From (1) and (2), we get:

$P(A \cap B) = P(B) \times P(A|B) = P(A) \times P(B|A)$ where,

$P(A) \neq 0$, $P(B) \neq 0$.

The above result is known as multiplication rule of probability.

For independent events A and B, $P(B|A) = P(B)$. The equation (2) can be modified into,

$P(A \cap B) = P(B) \times P(A)$

Multiplication Theorem in Probability

We have already learned the multiplication rules we follow in probability, such as;

$P(A \cap B) = P(A) \times P(B|A)$; if $P(A) \neq 0$

$P(A \cap B) = P(B) \times P(A|B)$; if $P(B) \neq 0$

Let us learn here the multiplication theorems for independent events A and B.

If A and B are two independent events for a random experiment, then the probability of simultaneous occurrence of two independent events will be equal to product of their probabilities. Hence,

$P(A \cap B) = P(A).P(B)$

Now, from multiplication rule we know;

$P(A \cap B) = P(A) \times P(B|A)$

Since A and B are independent, therefore;

$P(B|A) = P(B)$

Therefore, again we get;

$P(A \cap B) = P(A).P(B)$

Hence, proved.

Example: An urn contains 20 red and 10 blue balls. Two balls are drawn from a bag one after the other without replacement. What is the probability that both the balls drawn are red?

Solution: Let A and B denote the events that first and second ball drawn are red balls. We have to find $P(A \cap B)$ or P(AB).

P(A) = P(red balls in first draw) = 20/30

Now, only 19 red balls and 10 blue balls are left in the bag. Probability of drawing a red ball in second draw too is an example of conditional probability where drawing of second ball depends on the drawing of first ball.

Hence Conditional probability of B on A will be,

P(B|A) = 19/29

By multiplication rule of probability,

$P(A \cap B) = P(A) \times P(B|A)$

$P(A \cap B) = \frac{20}{30} \times \frac{19}{29} = \frac{38}{87}$