Probability Formulas

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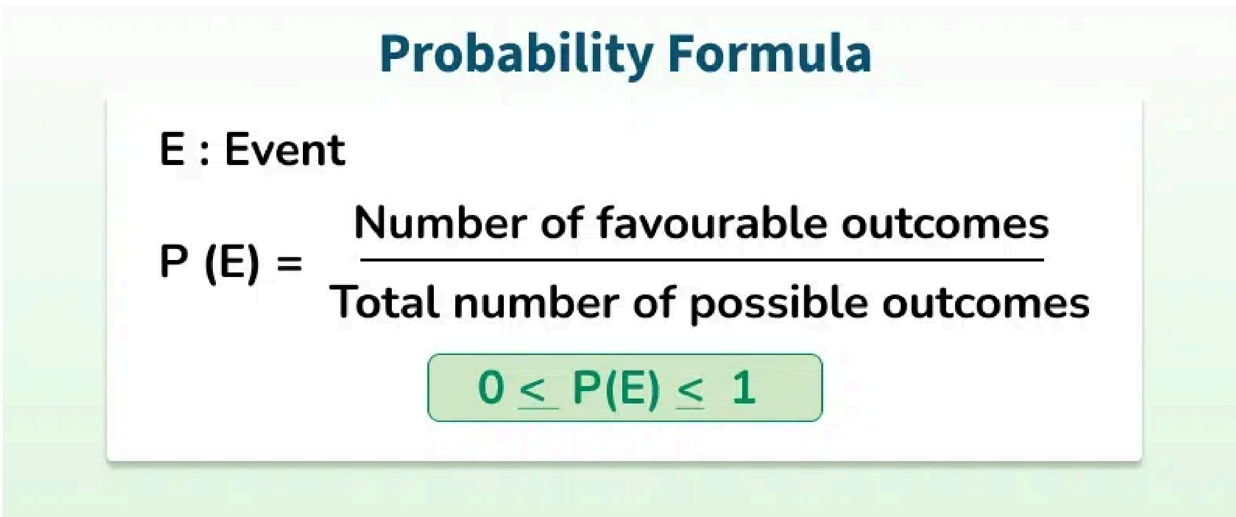
Probability Formulas are essential mathematical tools used in calculating the probability. Below is the main formula for probability.



Probability Formula

> ***Probability of an Event = (Count of favorable outcomes) / (Total number of possible outcomes for the event)***
>
> ***P(A) = n(E) / n(S)***
>
> ***0 ≤ P(A) ≤ 1***

Here, P(A) signifies the probability of an event A, where n(E) is the count of favorable outcomes, and n(S) is the total number of possible outcomes for the event.

When considering the **complementary event**, represented as P(A'), which denotes the non-occurrence of event A. Then the formula will be:

P(A') is the opposite of event A, indicating that either event P(A) occurs or its complement P(A') occurs.
Therefore, now we can say; P(A) + P(A') = 1

Learn,

- Basic Concepts of Probability
- Events in Probability
- Types of Events in Probability

Terms Related to Probability Formula

Some of the most common terms related to probability formulas are:

- **Experiment:** An Experiment is an action or procedure conducted to generate a particular outcome.

- **Sample Space:** The Sample Space includes the complete potential outcomes that come from an experiment. For example, when flipping a coin, the sample space includes {head, tail}.

- **Favorable Outcome:** A favorable outcome is the result that aligns with the intended or expected conclusion. In the case of rolling two dice, examples of favorable outcomes resulting in a sum of 4 are (1,3), (2,2), and (3,1).

- **Trial:** A trial denotes the execution of a random experiment.

- **Random Experiment:** A Random Experiment is characterized by a well-defined set of possible outcomes. An example of a random experiment is tossing a coin, where the result could be either heads or tails. That means the result would be uncertain.

- **Event:** An Event denotes the total outcomes that come from a random

- **Equally Likely Events:** Equally Likely Events have identical probabilities of occurrence. The outcome of one event does not impact the outcome of another.

- **Exhaustive Events:** An Exhaustive Event occurs when the set of all possible outcomes covers the complete sample space.

- **Mutually Exclusive Events:** Mutually Exclusive Events are those that cannot occur simultaneously. For example, when we toss the coin, the result will be either a head or a tail, but we cannot get both at the same time.

Probability of an Event

In Probability theory, an event represents a set of possible outcomes derived from an experiment. It often forms a subset of the overall sample space. If we represent the probability of an event E as P(E), the following principles apply:

The probability P(E) lies between 0 and 1.

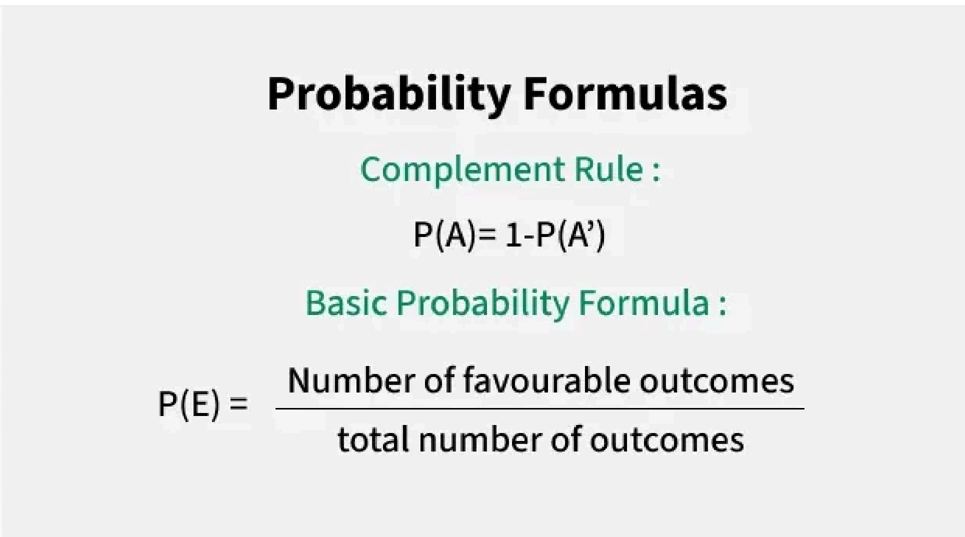
- For an impossible event (E), P(E) = 0.
- For a certain event (E), P(E) = 1.

The sum of the probabilities of all possible outcomes in a random experiment is equal to 1.

> ***Example :*** *In a rolling die experiment*
>
> *Possible Outcomes : { 1, 2, 3, 4, 5, 6 }*
> *then , P(1) + P(2) + P(3) + P(4) + P(5) + P(6) = 1*

The different Probability Formulas are discussed below:

For a particular event E, probability formula will be P(E) = n(E) / n(S)
Here, n(E) represents the number of outcomes favorable to event E, and n(S) denotes the total count of outcomes within the sample space.



1 / 4

Classical Probability Formula

> ***P(A) = Number of Favorable Outcomes/Total Number of Possible Outcomes***

When we deal with an event that is the union of two separate events, for example, A and B, the probability of the union will be:

Joint Probability Formula

It represents the common elements that constitute the distinct subsets of both events A and B. The formula can be expressed as:

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

- $P(A \cap B)$ is the **joint probability**, meaning the probability that **both** events A and B occur.
- $P(A|B)$ is the **conditional probability** of A given that B has already occurred.
- $P(B|A)$ is the **conditional probability** of B given that A has already occurred.
- $P(A)$ and $P(B)$ are the probabilities of events A and B occurring individually.

Addition Rule for Mutually Exclusive Events

If events A and B are mutually exclusive, that means they cannot happen at the same time; the probability of either event occurring is equal to the sum of their respective probabilities. Then:

$P(A \cap B)=0$

Thus, the **Addition Rule** for mutually exclusive events becomes:

$$P(A \cup B) = P(A) + P(B)$$

Complementary Rule Formula

If A is an event, then the probability of not A is expressed by the complementary rule:

$$P(\text{not } A) = 1 - P(A) \text{ or } P(A') = 1 - P(A)$$

- $P(A)$ is the probability that event A occurs.
- $P(A')$ is the probability that event A **does not** occur.
- Since an event either happens or it doesn't, their probabilities must add up to 1.

Some probability formulas based on complementary rules are as follows:

- $P(A \cap A') = 0$
- $P(A' \cap B) = P(B) - P(A \cap B)$
- $P(A \cap B') = P(A) - P(A \cap B)$
- $P(A \cup B) = P(A \cap B') + P(A' \cap B) + P(A \cap B)$
- ***$P(A \cap B) + P(A' \cap B') = 1$ (Not always true)***

Conditional Rule Formula

In the case, where the occurrence of event A is already known, the probability of event B is going to occur, referred to as conditional probability. It can be calculated using the formula:

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

P (B/A): Probability of event B when event A has already occurred.

Relative Frequency Formula

The relative frequency formula is based on frequencies observed in real-world data. This formula is given as

P(A) = Number of Times Event A Occurs/Total Number of Trials or Observations

Probability Formula with the Multiplication Rule

- ***P(A ∩ B) = P(A)·P(B) (in case of independent events)***
- ***P(A ∩ B) = P(A)·P(B|A) (in case of dependent events)***

Disjoint Event

Two events **A** and **B** are **disjoint** (or **mutually exclusive**) if **they cannot happen at the same time**. This means their intersection is empty:

P(A∩B) = 0

Bayes' Theorem

Bayes' Theorem calculates the probability of event A given the occurrence of event B. The **Bayes Theorem** Formula is given as

P(A|B)= P(B|A) × P(A)/ P(B)

- P(A|B) = Probability of **A happening given that B has occurred** (**posterior probability**).
- P(B|A) = Probability of **B happening given that A has occurred**.
- P(A) = Probability of **A happening** (**prior probability**).
- P(B) = Probability of **B happening** (total probability of evidence).

Dependent Probability Formula

When two events **depend** on each other, the probability of one event affects the probability of the other. The formula for **dependent probability** is:

P(B and A) = P(A) × P(B | A)

- P(A∩B) = Probability of **both A and B occurring**.

Independent Probability Formula

Two events **A** and **B** are **independent** if the occurrence of one does **not affect** the probability of the other.
For **independent events**, the probability of both occurring is:

P(A and B) = P(A) × P(B)

Binominal Probability Formula

The Binomial Probability Formula is given as

P(x) = $^nC_k \cdot p^x(1-p)^{n-x}$

P(x) = $[\frac{n!}{x!(n-x)!}] \cdot p^x(1-p)^{n-x}$

Where,
n = Total number of events
x = Total number of successful events.
p = Success Probability in a single trial.
^nC_r *= [n!/r!(n−r)]!*
1 – p = Probability of failure.

Learn Binomial Distribution

Normal Probability Formula

The Normal probability formula is given by:

P(x) = $(1/\sqrt{2\pi})e^{(-x^2/2)}$

Learn Normal Distribution

Experimental Probability formula

Probability P(x) = Number of times an event occurs / Total number of trials.

Theoretical Probability Formula

The Theoretical Probability Formula is,

P(x) = Number of Favorable outcomes/ Number of Possible outcomes.

Standard Deviation Probability Formula

The Standard Deviation Probability Formula is given as

P(x) = $(1/\sigma\sqrt{2\Pi})e^{-(x-\mu)^2/2\sigma^2}$

Bernoulli Probability Formula

A random variable X will have a Bernoulli Distribution with probability p; the formula is,

P(X = x) = p^x (1 – p)$^{1-x}$, for x = 0, 1 and P(X = x) = 0 for other values of x

Here, 0 is failure and 1 is the success.

Probability Formula for Class 10

In Class 10, we have to study basic probability, such as the probability of tossing a coin, tossing 2 coins, tossing 3 coins, throwing a die, throwing two dies, probability of drawing a card from well well-shuffled deck. All these questions can be solved with only one formula. The Probability Formula Class 10 is given as

n(E) is number of trials in which Event Occurred
n(S) is number of Sample Space

Probability Formula for Class 12

The various formula used in Probability Class 12 is tabulated below:

Various Probability Formulas	
Experimental or Empirical Probability Formula	P(E) = Number of times an event occurs / Total number of trials.
Classical or Theoretical Probability Formula	P(E) = Number of Favorable Outcomes/Total Number of Possible Outcomes
Addition Probability Formula	$P(A \cup B) = P(A) + P(B) – P(A \cap B)$
Joint Probability Formula	$P (A \cap B) = P (A).P (B)$
Addition Rule for Mutually Exclusive Events	P(A or B) = P(A) + P(B)
Complementary Rule Formula	P(not A) = 1 – P(A) or P(A’) = 1 – P(A). P(A) + P(A') = 1
Conditional Rule Formula	$P(B\|A) = P(A \cap B)/P(A)$
	P(A) = Number of Times Event A

Various Probability Formulas	
Disjoint Event	$P(A \cap B) = 0$
Bayes' Theorem	$P(A\|B) = P(B\|A) \times P(A)/ P(B)$
Dependent Probability Formula	$P(B \text{ and } A) = P(A) \times P(B \mid A)$
Independent Probability Formula	$P(A \text{ and } B) = P(A) \times P(B)$
Binominal Probability Formula	$P(x) = {}^nC_x \cdot p^x (1 - p)^{n-x}$ or $P(r) = [n!/r!(n-r)!] \cdot p^r (1 - p)^{n-r}$
Normal Probability Formula	$P(x) = (1/\sqrt{2\Pi})\ e^{(-x2/2)}$
Standard Deviation Probability Formula	$P(x) = (1/\sigma\sqrt{2\Pi})\ e^{-(x-\mu)^2/2\sigma^2}$
Bernoulli Probability Formula	$P(X = x) = p^x (1 - p)^{1-x}$, for $x = 0, 1$ and $P(X = x) = 0$ for other values of x.

Also, Check:

Probability Topics	
[Coin Toss Probability]	[Card Probability]
[Tricks to Solve Probability Questions]	[Interesting Facts on Probability]

Probability Topics	
Probability Quiz	Real-Life Applications of Probability

Solved Examples on Probability Formulas

Example 1: Select a card at random from a standard deck. What is the probability of drawing a card with a feminine face?

Solution:

In a standard deck containing 52 cards: Total possible outcomes = 52

Event A = drawing a card with a feminine face
The number of favorable events (considering only queens as feminine faces) = 4
Therefore, the probability P(A) is calculated using the formula:

P(A) = Number of Favorable Outcomes ÷ Total Number of Outcomes

P(A) = 4/52
P(A) = 1/13.

Example 2: If the Probability of event E, denoted as P(E) = 0.35, what is the probability of the complement event 'not E'?

Solution:

Given that P(E) = 0.35, we can use the complementary probability formula:
P(E) + P(not E) = 1

Substituting the known value:

P(not E) = 1 - P(E)
P(not E) = 1 - 0.35

Hence, P(not E) = 0.65

Example 3: Dangerous fires are very rare, around 1% but the smoke is

Probability of dangerous Fire when there is smoke by using Bayes theorem:

P(Fire) = 0.01
P(Smoke) = 0.20
P(Fire|Smoke) = 0.80
P(Fire|Smoke) = {P(Fire)P(Smoke Fire)}/P(Smoke)

We can substitute these values:

P(Fire | Smoke)=(0.01 × 0.80)/ 0.20
P(Fire | Smoke)=0.008/0.20
P(Fire | Smoke)= 0.04 = 4%.

Example 4: Within a bag, there are 2 green bulbs, 4 orange bulbs, and 6 white bulbs. When a bulb is randomly chosen from the bag, what is the probability of picking either a green bulb or a white bulb?
Solution:

We are given a bag containing:

- ***2 Green bulbs***
- ***4 Orange bulbs***
- ***6 White bulbs***
- ***Total bulbs = 2 + 4 + 6 = 12***

*We need to find the probability of picking **either a green or a white bulb**.*
E = picking either a green bulb or a white bulb
P(E) = (Number of green bulbs + Number of white bulbs) / Total number of bulbs
P(E) = (2+6)/12
P(E) = 8/12
P(E) = 2/3.

Practice Questions on the Probability Formulas

Question 1. From a collection of marbles in a bag—8 red, 9 blue, and 6

Question 2. In a drawer containing 6 black pens, 4 blue pens, and 7 red pens, a pen is drawn at random. What is the probability that the pen is either black or blue?

Question 3. Drawing one card from a thoroughly shuffled deck of 52 cards, determine the probability that the card will:

- Be a king.
- Not to be a king.

Question 4. According to a survey, 70% of individuals enjoy chocolate, and among those chocolate enthusiasts, 60% also have a liking for vanilla. What is the probability that an individual likes vanilla, given their fondness for chocolate?

Question 5. Determine the probability of rolling an odd number when a six-sided die is rolled.

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