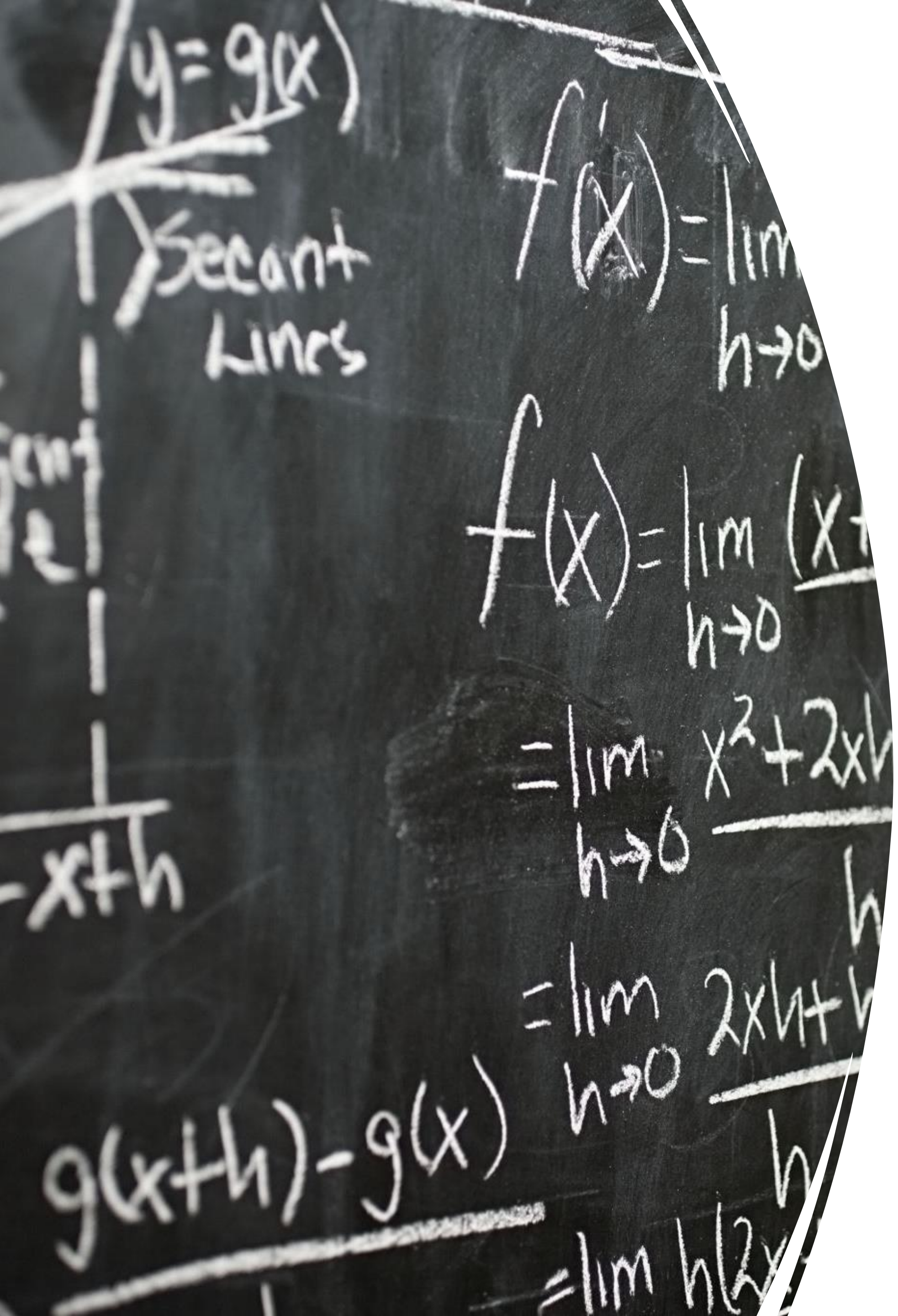
- **Bayes Theorem Algorithm**

Dr. Jagendra Singh



BAYES THEOREM

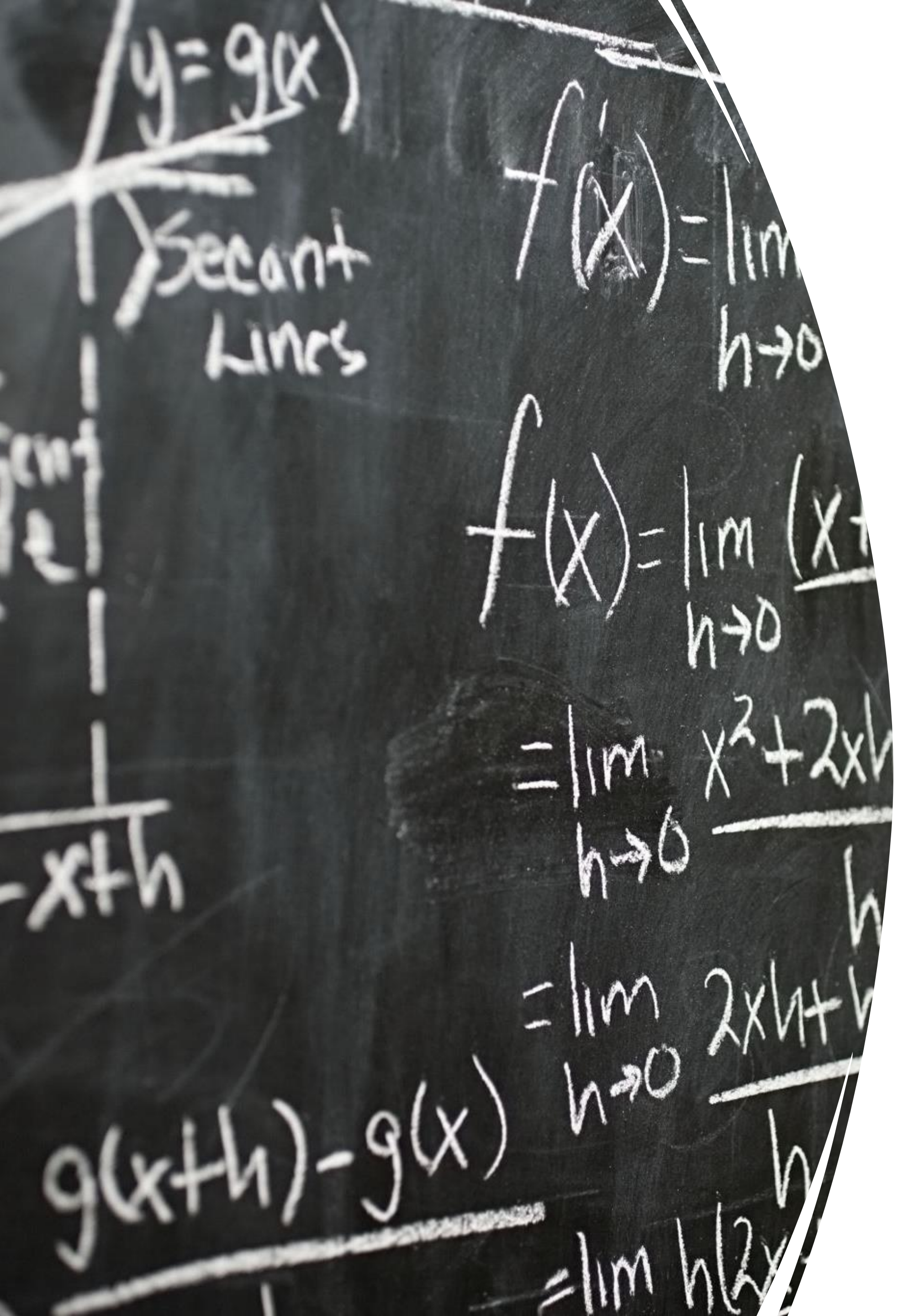
- An important concept of Bayes theorem named **Bayesian method** is used to calculate conditional probability in Machine Learning application that includes classification tasks.
- Further, a simplified version of Bayes theorem (Naïve Bayes classification) is also used to reduce computation time and average cost of the projects.
- Bayes theorem is also known with some other name such as **Bayes rule or Bayes Law.**

BAYES THEOREM

Bayes theorem helps to determine the probability of an event with random knowledge.

It is used to calculate the probability of occurring one event while other one already occurred.

It is a best method to relate the condition probability and marginal probability.



WHAT IS BAYES THEOREM?

- ✓ Bayes theorem is one of the most popular machine learning concepts that helps to calculate the probability of occurring one event with uncertain knowledge while other one has already occurred.
- ✓ Bayes' theorem can be derived using product rule and conditional probability of event X with known event Y:
- ◦ According to the product rule we can express as the probability of event X with known event Y as follows;

P(X ? Y)= P(X|Y) P(Y) (1)

WHAT IS BAYES THEOREM?

- Further, the probability of event Y with known event X:

  - P(X ? Y)= P(Y|X) P(X)   (2)

✓ Mathematically, Bayes theorem can be expressed by combining both equations on right hand side. We will get:

$$\boxed{P(X|Y) = \frac{P(Y|X).P(X)}{P(Y)}}$$

WHAT IS BAYES THEOREM?

Bayes' Theorem Formula

The formula to calculate a posterior probability of A occurring given that B occurred:

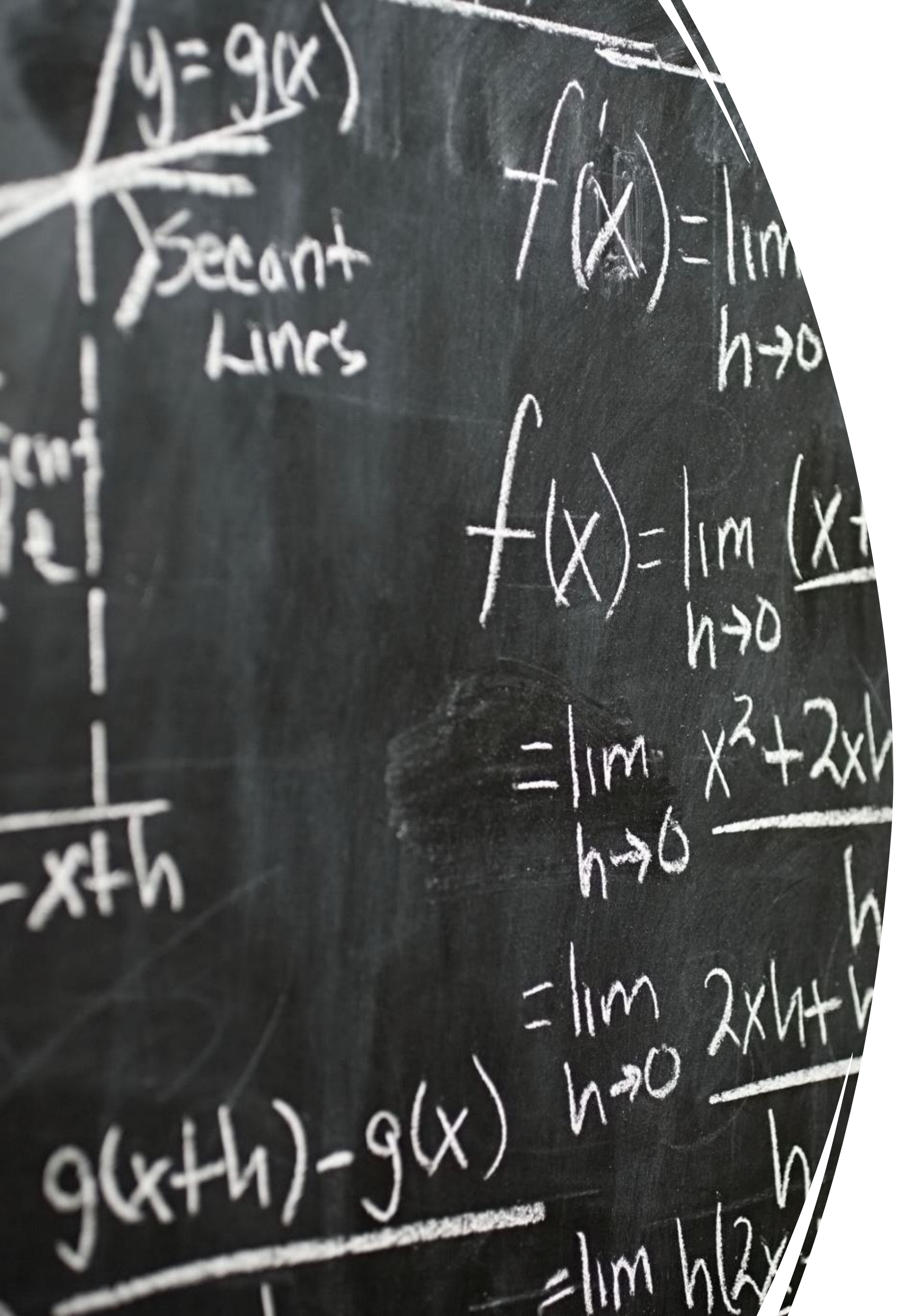
$$P(A \mid B) = \frac{P(A \cap B)}{P(B)} = \frac{P(A) \times P(B \mid A)}{P(B)}$$

where:

$A, B = \text{Events}$

$P(B \mid A) = \text{The probability of B occurring given that A is true}$

$P(A)$ and $P(B)$ = The probabilities of A occurring and B occurring independently of each other

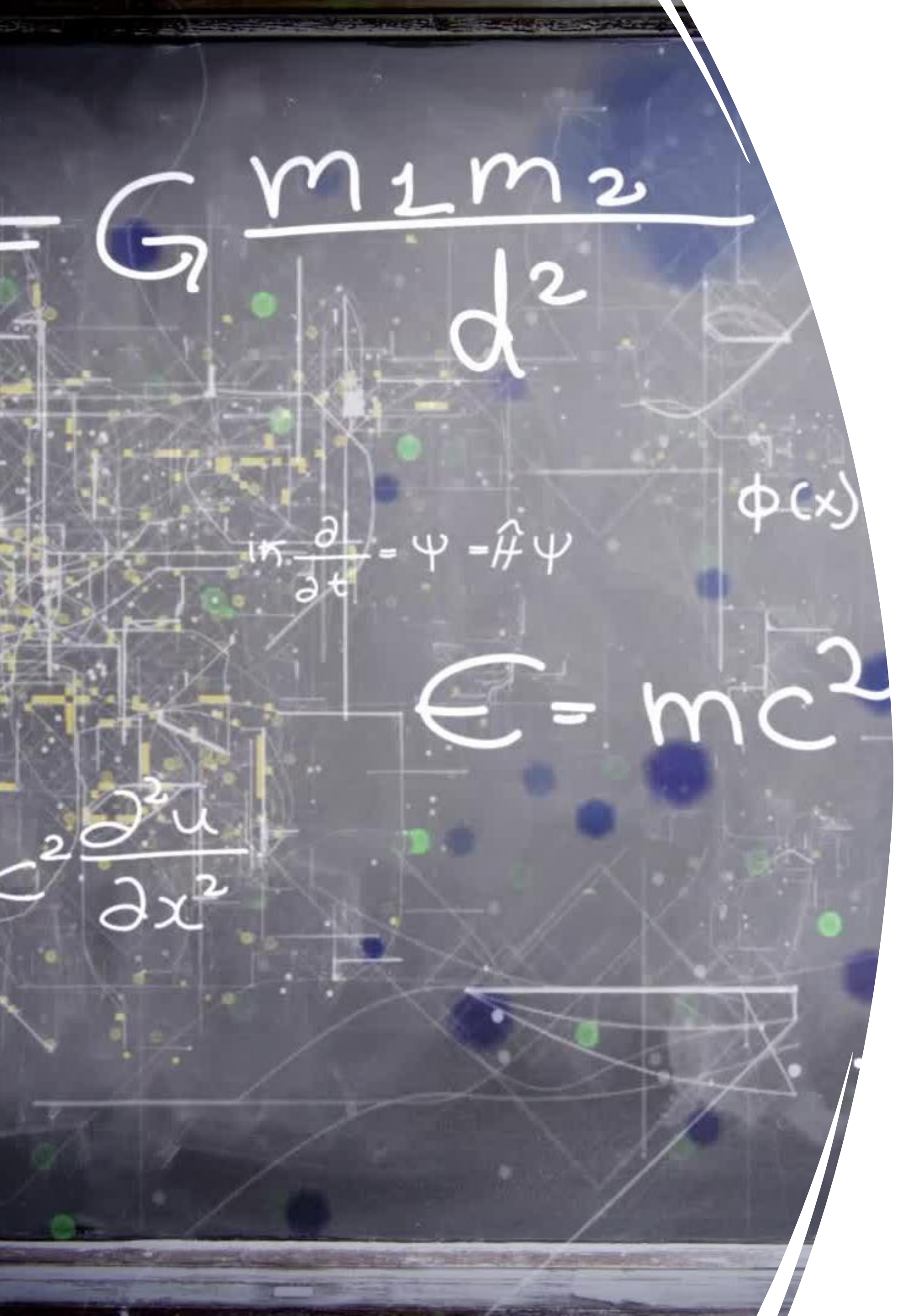


WHAT IS BAYES THEOREM?

- ✓ Here, both events X and Y are independent events which means probability of outcome of both events does not depends one another.
- ✓ The above equation is called as Bayes Rule or Bayes Theorem.

WHERE

- P(X|Y) is called as **posterior**, which we need to calculate. It is defined as updated probability after considering the evidence.
- P(Y|X) is called the **likelihood**. It is the probability of evidence when hypothesis is true.
- P(X) is called the **prior probability**, probability of hypothesis before considering the evidence
- P(Y) is called **marginal probability**. It is defined as the probability of evidence under any consideration.



BAYES THEOREM

- Hence, Bayes Theorem can be written as:
- **posterior = (likelihood * prior) / evidence**

PROBABILITY TERMS

Sample Space

- During an experiment what we get as a result is called as possible outcomes and the set of all possible outcome of an event is known as sample space. For example, if we are rolling a dice, sample space will be:
  - S1 = {1, 2, 3, 4, 5, 6}
- Similarly, if our experiment is related to toss a coin and recording its outcomes, then sample space will be:
  - S2 = {Head, Tail}

PROBABILITY TERMS

Event

- Event is defined as subset of sample space in an experiment. Further, it is also called as set of outcomes.
- Assume in our experiment of rolling a dice, there are two event A and B such that;
- A = Event when an even number is obtained = {2, 4, 6}
- B = Event when a number is greater than 4 = {5, 6}

PROBABILITY TERMS

Event

- Probability of the event A "P(A)"= Number of favourable outcomes / Total number of possible outcomes
  P(E) = 3/6 =1/2 =0.5
- Similarly, Probability of the event B "P(B)"= Number of favourable outcomes / Total number of possible outcomes
  =2/6
  =1/3
  =0.333
- Union of event A and B:
  $A \cup B = \{2, 4, 5, 6\}$

PROBABILITY TERMS

Independent Event

- Two events are said to be independent when occurrence of one event does not affect the occurrence of another event.
- In simple words we can say that the probability of outcome of both events does not depends one another.
- Mathematically, two events A and B are said to be independent if:
  - $P(A \cap B) = P(AB) = P(A)*P(B)$

PROBABILITY TERMS

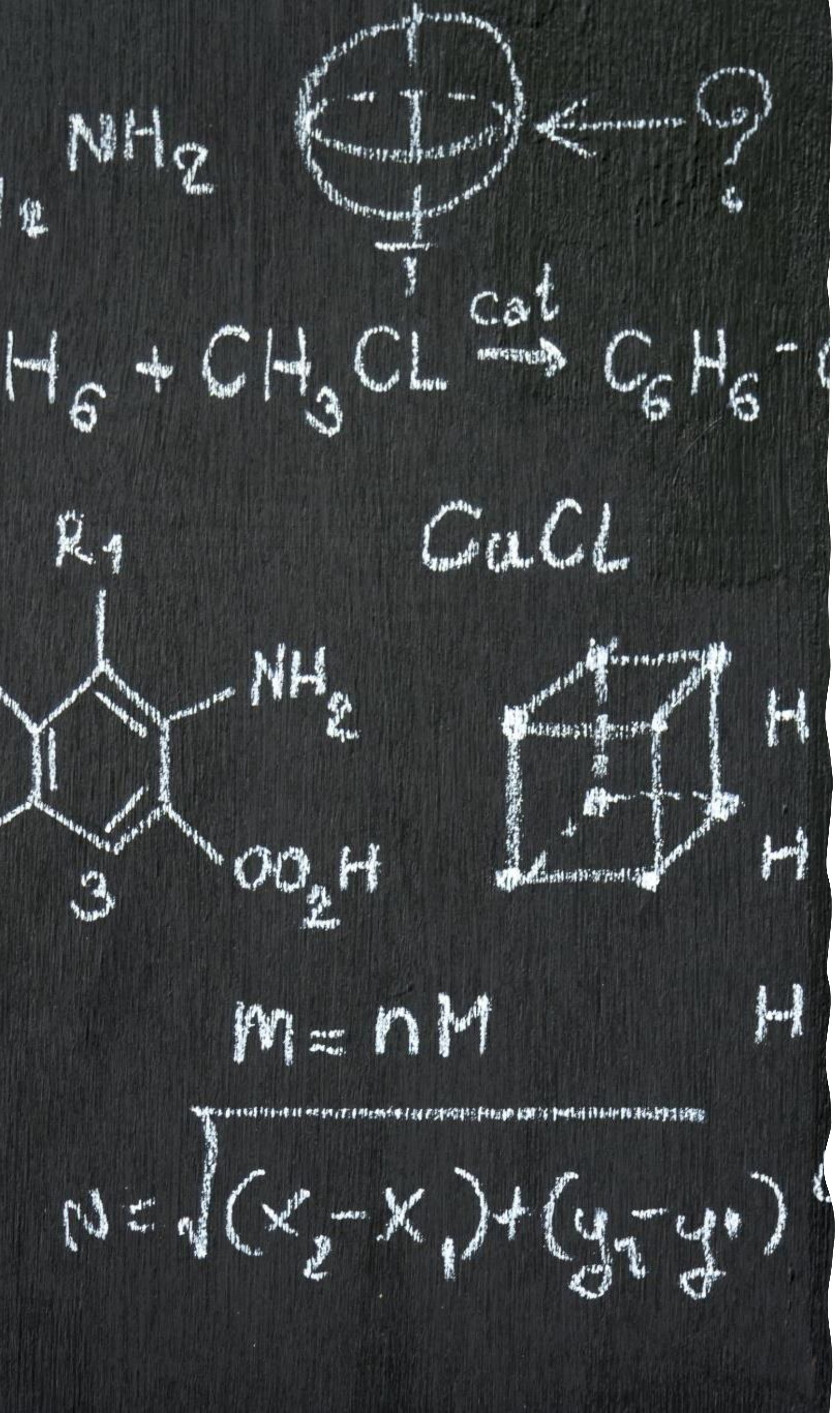
Conditional Probability

- Conditional probability is defined as the probability of an event A, given that another event B has already occurred (i.e. A conditional B). This is represented by P(A|B) and we can define it as:
  - $P(A|B) = P(A \cap B) / P(B)$

PROBABILITY TERMS

Marginal Probability

- Marginal probability is defined as the probability of an event A occurring independent of any other event B. Further, it is considered as the probability of evidence under any consideration.
  - $P(A) = P(A|B)*P(B) + P(A|\sim B)*P(\sim B)$
- Here ~B represents the event that B does not occur.



HOW TO APPLY BAYES THEOREM OR IN MACHINE LEARNING?

- Bayes theorem helps us to calculate the single term P(B|A) in terms of P(A|B), P(B), and P(A).
- This rule is very helpful in such scenarios where we have a good probability of P(A|B), P(B), and P(A) and need to determine the fourth term.
- Naïve Bayes classifier is one of the simplest applications of Bayes theorem which is used in classification algorithms to isolate data as per accuracy, speed and classes.

THANK YOU