

## Logistic Regression in Machine Learning

Logistic Regression is a supervised machine learning algorithm used for classification problems. Unlike linear regression which predicts continuous values it predicts the probability that an input belongs to a specific class. It is used for binary classification where the output can be one of two possible categories such as Yes/No, True/False or 0/1. It uses sigmoid function to convert inputs into a probability value between 0 and 1.

### Types of Logistic Regression

1. Binomial Logistic Regression
  - Used when the output has two categories (e.g., Yes/No, 0/1).
  - Example: Predicting if a student will pass or fail.
2. Multinomial Logistic Regression
  - Used when the output has three or more categories with no order.
  - Example: Classifying an animal as a cat, dog, or sheep.
3. Ordinal Logistic Regression
  - Used when the output has ordered categories.
  - Example: Rating a product as low, medium, or high.

### Assumptions of Logistic Regression

- Independent Observations: Each data point must be independent of others.
- Binary Output: The dependent variable should be binary (0 or 1) unless using multinomial/ordinal versions.
- Linearity in Log-Odds: Predictors should have a linear relationship with the log odds of the outcome.
- No Extreme Outliers: Outliers can affect model accuracy.
- Large Sample Size: A bigger dataset ensures more reliable results.

## How Does Logistic Regression Work?

Logistic Regression is a supervised machine learning algorithm used for classification, especially when the output is binary (e.g., yes/no, 0/1).

### Step-by-Step Working:

1. **Takes Input Features (X):**

Like age, income, or exam score — values that affect the prediction.

2. **Applies a Linear Equation:**

$$z = \theta_0 + \theta_1 x_1 + \theta_2 x_2 + \cdots + \theta_n x_n$$

3. **Applies the Sigmoid Function:**

The linear output  $z$  is passed through the sigmoid function to convert it into a probability between 0 and 1:

$$\text{Sigmoid}(z) = \frac{1}{1 + e^{-z}}$$

4. **Makes Prediction:**

- If the result is  $> 0.5$ , it predicts class 1 (e.g., "yes")
- If the result is  $\leq 0.5$ , it predicts class 0 (e.g., "no")

Example:

Let's say you're predicting if a person will buy a product:

- Inputs: Age = 30, Salary = \$50,000
- Model calculates a score  $\rightarrow$  passes it through the sigmoid function
- If the probability = 0.85  $\rightarrow$  predicts "Will Buy"