Logistics Regression

WHAT IS LOGISTIC REGRESSION?

- Logistic regression is a type of supervised machine learning used to predict the probability of a target variable.
- It is used to estimate the relationship between a dependent (target) variable and one or more independent variables.
- The output of the dependent variable is represented in discrete values such as 0 and 1.

- The logistic regression equation can be represented as:

- **$logit(p) = ln(p/(1-p)) = b0+b1X1+b2X2+b3X3....+bkXk$**

  - Where;
  - p= probability of the occurrence of the feature
  - x1,x2,..xk= set of input features of x
  - b1,b2...bk= parameter values to be estimated in the logistic regression formula

TYPES OF LOGISTIC REGRESSION

- **Binary Logistic Regression Model**
  - This is one of the most widely-used logistic regression models, used to predict and categorize data into either of the two classes.
- **Multinomial Logistic Regression Model**
  - The multinomial logistic regression model is used to classify the target variable into multiple classes, irrespective of any quantitative significance.
- **Ordinal Logistic Regression Model**
  - The ordinal logistic regression model is used to classify the target variable into classes and also in order. For example, a pupil's performance in an examination can be classified as poor, good, and excellent in a hierarchical order.

HOW DOES LOGISTIC REGRESSION WORK?

- The Sigmoid function (logistic regression model) is used to map the predicted predictions to probabilities.
- The Sigmoid function represents an 'S' shaped curve when plotted on a map. The graph plots the predicted values between 0 and 1.
- The values are then plotted towards the margins at the top and the bottom of the Y-axis, with the labels as 0 and 1.
- Based on these values, the target variable can be classified in either of the classes.

Sigmoid Function

- Sigmoid function is defined as the inverse of logit function. Which means for a probability value P we have:

$$P = sigmoid\big(logit(P)\big)$$

Sigmoid performs the inverse of logit which means it maps any arbitrary real number into the range of (0, 1). The function is defined as:

$$sigmoid(z) = \frac{1}{1 + e^{-z}}$$
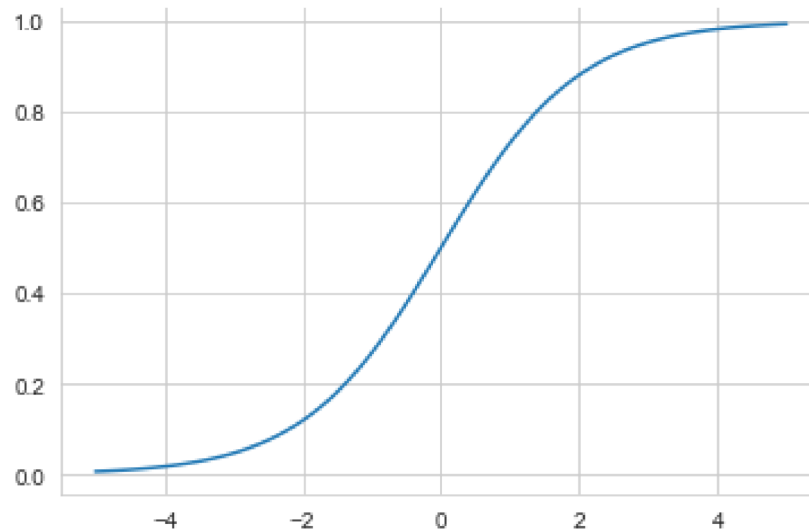
Example

- Consider an example where we are interested to find the effect of studying hours per day over the result in examination and predict that a student will pass or fail for given study hours. We have sample data about six students for their grades and total study hours per day.

Table-1	
Study Hours per day	Grades
6	1(Pass)
5	0(Fail)
4	0(Fail)
7	1(Pass)
8	1(Pass)
2	0(Fail)

Figure-1: Scatter Graph
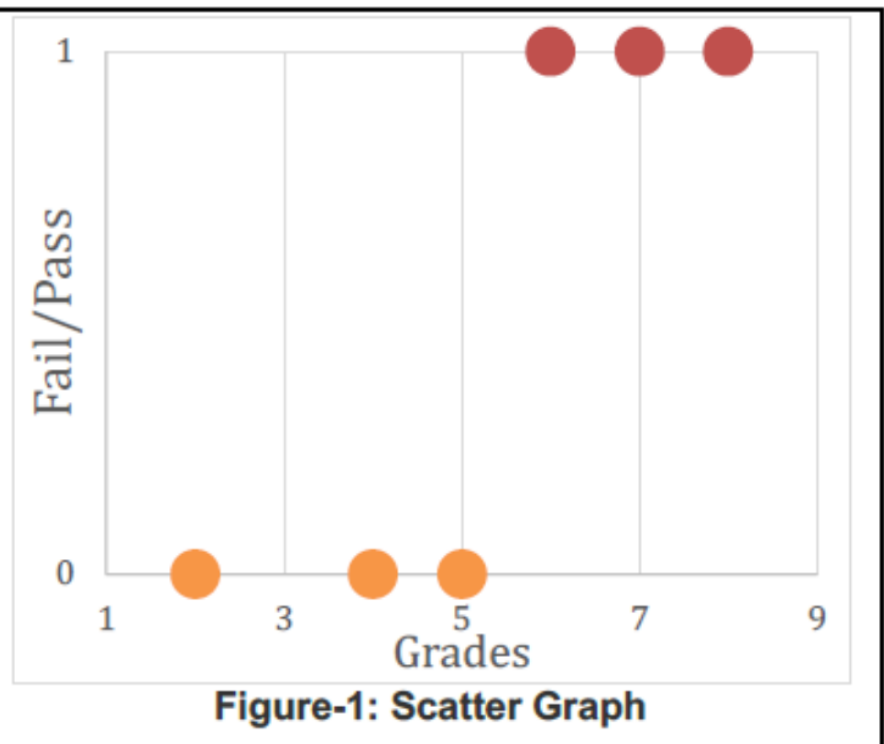
- The equation for the Sigmoid function is given as:
  - $y = 1/(1+e^{\wedge}x)$, where
  - $e^{\wedge}x$= the exponential constant with a value of 2.718.

- This equation gives the value of y(predicted value) close to zero if x is a considerable negative value.

- Similarly, if the value of x is a large positive value, the value of y is predicted close to one.

- A decision boundary can be set to predict the class to which the data belongs. Based on the set value, the estimated values can be classified into classes.

- For instance, let us take the example of classifying emails as spam or not. If the predicted value(p) is less than 0.5, then the email is classified spam and vice versa.