1. Need of Statistics in Data Science and Big Data Analytics

- **Statistics** plays a critical role in **Data Science** and **Big Data Analytics** by providing methods to summarize, analyze, and interpret large datasets. It helps in making decisions, predictions, and uncovering trends in the data.
- **Role in Data Science**: Data science often involves working with vast amounts of data, and statistics helps in analyzing the data, making predictions, and drawing meaningful conclusions from patterns. For example, using statistical techniques to build predictive models, such as forecasting sales trends or predicting customer behavior.
    - **Example**: A retailer may use statistical methods to understand which products are most likely to be purchased together, helping with inventory management and promotions.
- **Role in Big Data Analytics**: Big data typically involves large and complex datasets that traditional methods can't handle. Statistical methods help in efficiently analyzing this data to extract insights.
    - **Example**: In healthcare, using statistical analysis to detect patterns in the large-scale medical data of thousands of patients can help identify factors that contribute to diseases like diabetes or heart disease.

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2. Measures of Central Tendency: Mean, Median, Mode, Mid-range

- **Central Tendency** refers to the central point of a data distribution and provides a summary of the data.
    - **Mean**: The average of all data points, calculated by summing all values and dividing by the number of values.
        - **Example**: If the data points are 2, 3, 5, 7, and 10, the mean is $\frac{2+3+5+7+10}{5} = 5.4$.
    - **Median**: The middle value when the data is arranged in ascending or descending order. If the data set has an even number of values, the median is the average of the two middle values.
        - **Example**: In the data set 2, 3, 5, 7, 10, the median is 5 (the middle value). For the data 2, 3, 5, 7, 10, 12, the median is $\frac{5+7}{2} = 6$.
    - **Mode**: The value that appears most frequently in the data set. If no value repeats, there is no mode.

        - **Example**: In the data set 2, 3, 3, 5, 7, the mode is 3 because it appears twice.

- **Mid-range**: The average of the maximum and minimum values in a dataset. It's calculated as $\frac{\text{Max Value}+\text{Min Value}}{2}$.
    - **Example**: For the data set 2, 3, 5, 7, 10, the mid-range is $\frac{10+2}{2} = 6$.

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3. Measures of Dispersion: Range, Variance, Mean Deviation, Standard Deviation

- **Measures of Dispersion** show how spread out the data is, indicating the degree of variability in the dataset.
    - **Range**: The difference between the maximum and minimum values in the data set.
        - **Example**: For the data 2, 5, 7, 10, the range is 10−2=810 - 2 = 810−2=8.
    - **Variance**: Measures how far each data point is from the mean and averages those squared differences. The formula for variance is:

$$\text{Variance} = \frac{\sum (X_i - \mu)^2}{N}$$

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        - **Example**: For data 2, 3, 5, 7, 10, the mean is 5.4. The variance would be the average of the squared differences between each data point and the mean.
    - **Mean Deviation**: The average of the absolute differences between each data point and the mean.
        - **Example**: For the data 2, 3, 5, 7, 10, the mean deviation is the average of the absolute differences from the mean (5.4).
    - **Standard Deviation**: The square root of the variance, providing a measure of how spread out the data is. It's in the same unit as the original data, making it easier to interpret.
        - **Example**: In the data 2, 3, 5, 7, 10, the standard deviation is the square root of the variance, which provides an idea of the data's spread around the mean.

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4. Bayes' Theorem

- **Bayes' Theorem** provides a way to update the probability of a hypothesis based on new evidence. It's foundational in **probability theory** and **machine learning**.
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    - Formula:

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

      Where:

      - $P(A|B)$ is the probability of event A occurring given that B has occurred.
      - $P(B|A)$ is the probability of event B given A.
      - $P(A)$ and $P(B)$ are the probabilities of A and B independently.
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    - **Example**: In medical diagnostics, Bayes' Theorem can be used to update the probability that a patient has a disease after receiving test results. If a test is 95% accurate, and a person shows symptoms of the disease, Bayes' Theorem helps calculate the likelihood of the disease given the test result.

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5. Basics and Need of Hypothesis and Hypothesis Testing

- **Hypothesis**: A hypothesis is a statement or assumption about a population parameter, often based on observations or prior knowledge. It's a claim about the relationship between variables.
- **Need**: Hypothesis testing helps in making decisions or inferences about population parameters based on sample data. It allows us to assess whether a statement about a population is likely to be true.
- **Example**: A company may hypothesize that a new marketing campaign will increase sales. Hypothesis testing helps assess whether the increase in sales is statistically significant or just due to random variation.

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6. Pearson Correlation

- **Pearson Correlation** measures the strength and direction of the linear relationship between two variables. It's a number between -1 and 1.
    - Formula:

      $$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}}$$

      Where:
        - r is the Pearson correlation coefficient.
        - X_i and Y_i are individual data points from two variables X and Y.
    - **Example**: In a study examining hours studied vs. exam scores, a high positive correlation (near 1) suggests that more hours studied is associated with higher exam scores.
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7. Sample Hypothesis Testing

- **Sample Hypothesis Testing** involves testing a hypothesis about a population using a sample from that population. It's used to infer whether there's enough evidence to support the hypothesis.
- **Example**: A university may want to test if the average GPA of students in a program is higher than 3.5. A sample of students' GPAs is taken, and hypothesis testing helps determine if the sample mean is significantly different from 3.5.

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8. Chi-Square Tests

- **Chi-Square Test** is used to determine if there's a significant association between categorical variables.
    - **Example**: A retailer might want to know if there's a relationship between gender and product preference. The Chi-Square test can help determine whether the observed distribution of preferences differs

significantly from what would be expected if there were no relationship.

- no relationship.
  - **Formula:**

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where O_i is the observed frequency and E_i is the expected frequency.

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9. t-test

- The **t-test** is used to determine whether there is a significant difference between the means of two groups.
  - **One-Sample t-test**: Compares the mean of a single sample to a known value.
  - **Independent t-test**: Compares the means of two independent groups.
  - **Paired t-test**: Compares the means from the same group at different times (e.g., before and after an intervention).
- **Example**: A company wants to test if a new drug improves blood pressure more than an existing drug. A t-test would help determine if the difference in means between the two groups is statistically significant.
