UNIT -1

SIX SIGMA PRINCIPLES

Six Sigma Statistics:

1. Basic Six Sigma Statistics:

These are the fundamental statistical tools used in Six Sigma to measure and analyze process performance:

Mean (μ):

- The **average** of a data set. It gives a central value and is used to understand the general trend of a process.

Standard Deviation (σ):

- A measure of the **spread** or **dispersion** of data around the mean. In Six Sigma, we aim to reduce the standard deviation to achieve more consistent and predictable processes.

Variance:

- The square of the standard deviation. It is another measure of spread that indicates how much individual data points differ from the mean.

Range:

- The difference between the highest and lowest values in a dataset. It provides a simple, quick snapshot of data variability.

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2. Defects and Defects Per Million Opportunities (DPMO):

Six Sigma is all about reducing defects. To measure defect levels and improvement, we use **DPMO**, which represents how many defects occur per million opportunities.

- **Formula for DPMO**:

DPMO=(DefectsOpportunities×Units)×1,000,000\text{DPMO} = \left(\frac{\text{Defects}}{\text{Opportunities} \times \text{Units}} \right) \times 1,000,000DPMO=(Opportunities×UnitsDefects)×1,000,000

- **Example**: If 2 defects occur in 500 products, with 3 opportunities per product, the DPMO would be:

  DPMO=(2500×3)×1,000,000=1,333\text{DPMO} = \left(\frac{2}{500 \times 3} \right) \times 1,000,000 = 1,333DPMO=(500×32)×1,000,000=1,333

The goal is to reduce DPMO to as close to zero as possible.

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3. Sigma Levels:

The **sigma level** measures process performance. It reflects how well a process is performing in terms of defects. The higher the sigma level, the fewer defects there are.

- **Six Sigma** represents a process that is **99.99966% defect-free** (3.4 defects per million opportunities).
- **A 1-sigma process** has a much higher defect rate (about 690,000 defects per million opportunities).

The standard sigma scale is as follows:

- **1 Sigma** = 690,000 defects per million
- **2 Sigma** = 308,000 defects per million
- **3 Sigma** = 66,800 defects per million
- **4 Sigma** = 6,210 defects per million
- **5 Sigma** = 233 defects per million
- **6 Sigma** = 3.4 defects per million

Six Sigma level is the ultimate goal, where the process is **almost perfect**, with minimal defects.

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4. Control Charts:

Control charts are used to monitor process variation over time, helping identify trends, shifts, or abnormal variations. Common types of control charts include:

- **X-bar Chart**: Measures the average of a sample over time.
- **R-chart**: Measures the range (variation) within a sample.
- **P-chart**: Used for **proportional data** (defect rate) to monitor the percentage of defective items.
- **C-chart**: Used for **count data** (defect counts per unit) to monitor the number of defects.

Control charts help ensure the process is stable and predictable, which is a key requirement for Six Sigma.

5. Process Capability (Cp, Cpk):

Process capability measures how well a process can produce output within specification limits. It tells you whether the process is capable of meeting customer requirements and specifications.

- **Cp (Process Capability Index)**:

  Cp=USL−LSL6σCp = \frac{USL - LSL}{6\sigma}Cp=6σUSL−LSL

  Where:

  - **USL** = Upper Specification Limit
  - **LSL** = Lower Specification Limit
  - **σ** = Standard deviation

  Cp measures how much room is available between the specification limits relative to the process spread. A Cp value of 1 means the process is just capable of meeting the specifications.

- **Cpk (Process Capability Index with Centering)**:

  Cpk=min(USL−μ3σ,μ−LSL3σ)Cpk = \min \left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma} \right)Cpk=min(3σUSL−μ,3σμ−LSL)

  Where:

  - **μ** = Mean of the process

  Cpk accounts for the process's centering (whether the mean is at the center of the specification limits). A Cpk value greater than 1.33 is typically considered acceptable in Six Sigma.

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6. Z-scores:

A **Z-score** indicates how many standard deviations a data point is from the mean. In Six Sigma, Z-scores are used to measure how far a process is from perfection (i.e., the target).

- **Formula for Z-score**: Z=X−μσZ = \frac{X - \mu}{\sigma}Z=σX−μ Where:
  - **X** = Data point
  - **μ** = Mean
  - **σ** = Standard deviation

For example, a Z-score of **6** corresponds to a **Six Sigma** level (very few defects).

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7. Hypothesis Testing:

Six Sigma also uses **hypothesis testing** to make data-driven decisions. It helps test assumptions about a population based on sample data. Common hypothesis tests include:

- **t-test**: Used to compare the means of two groups.
- **ANOVA (Analysis of Variance)**: Used to compare means across more than two groups.
- **Chi-square test**: Used for categorical data to determine if there is a significant association between variables.

These statistical tests allow Six Sigma practitioners to make decisions about process improvements and whether changes result in meaningful improvements.

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8. Regression Analysis:

Regression analysis helps identify relationships between variables and predict future performance. It's especially useful in analyzing how different process inputs (independent variables) affect outputs (dependent variables).

- **Simple Linear Regression**: Models the relationship between two variables (one independent and one dependent).
- **Multiple Regression**: Models the relationship between multiple independent variables and one dependent variable.

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9. Pareto Analysis:

Pareto analysis, based on the **80/20 rule**, helps prioritize which issues to address first by focusing on the most significant problems. This can be done by plotting a **Pareto chart**, where data is displayed in descending order of frequency, helping you identify which issues contribute most to the overall problem.