UNIT – III

STATISTICAL PROCESS CONTROL (SPC)

What is SPC?

A process is stable when it performs with in the tolerance for the process parameters. When process performs outside tolerance, it means that there is an assignable cause for such variations. In such cases, root cause of variation can be found using statistical tools.

SPC provides a set of tools for building process capability in any organization. Capability is the ability to carry out a job correctly.

- SPC stands for Statistical Process Control
- SPC does not refer to a particular technique, algorithm, or procedure
- SPC is an optimization philosophy concerned with continuous process improvements, using a collection of (Statistical) tools for
    - a.) Data and process analysis
    - b.) Making inferences about process behaviour
    - c.) Decision making
- SPC is a key component of total quality initiatives
- Ultimately SPC seeks to improve profits by
    - Improving product quality
    - Improving productivity
    - Streamlining process
    - Reducing wastages
    - Reducing emission
    - Improve customer service, etc.

SEVEN TOOLS OF QUALITY

The seven quality control tools are very useful for ensuring process quality and thereby end product quality. We will now learn the following seven for process control.

1. PROCESS FLOW CHART.
2. CAUSE AND EFFECT DIAGRAM
3. CHECK SHEET
4. SCATTER DIAGRAM
5. PARETO CHART/ DIAGRAM
6. HISTOGRAM
7. CONTROL CHARTS

1. PROCESS FLOW CHARTS

Process flow char should indicate the various steps in the process which means, all the sub processes and their inputs and outputs ar documented in one diagram.

The diagram makes it easy to visualize the entire system, identify potential trouble spots and locate control activities.

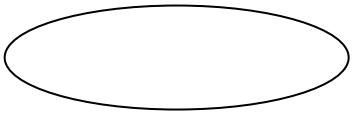
Improvements can be accomplished by changing, reducing combining or eliminating steps**.**

the various steps involved in formulating a process flow chart are given below.

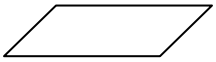
- Define the process.
- List the steps involved.
- Draw the diagram placing the process steps in boxes in the order of their sequence and link each other by arrows.
- Analyze the flow chart

The symbols used for drawing the process flow chart are given below.

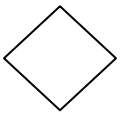
- Start/ End process.



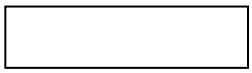
- Input/ output or information giving or taking.



- Inspection/ Decision making.



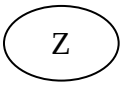
- Activities /operation / Tasks.



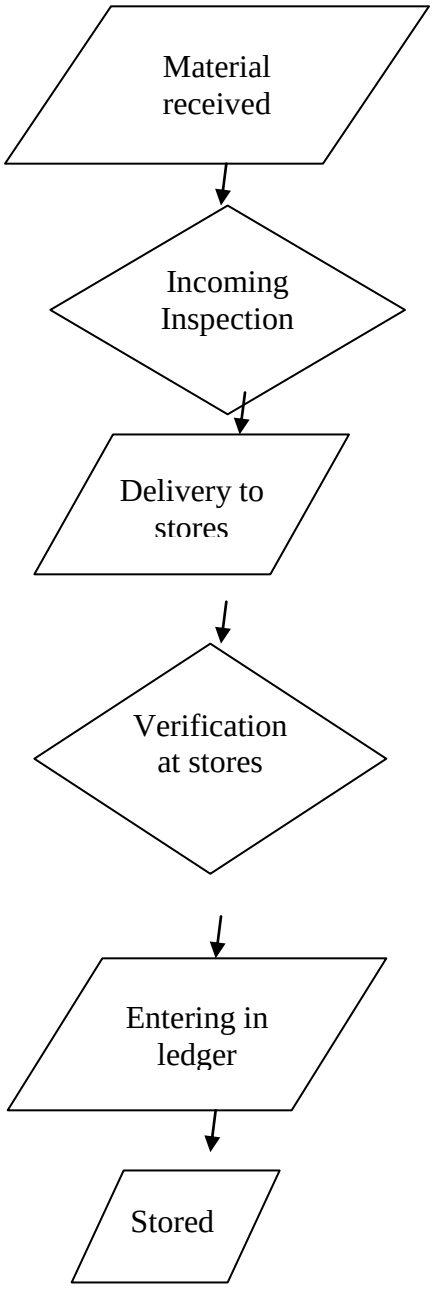
- Lines to connect portions of the chart.

- Arrows show the direction of flow.

- Circle with a letter inside to indicate the chart
  Is continued at another place with the same symbol.



Example of a process flow chart for material receipt.

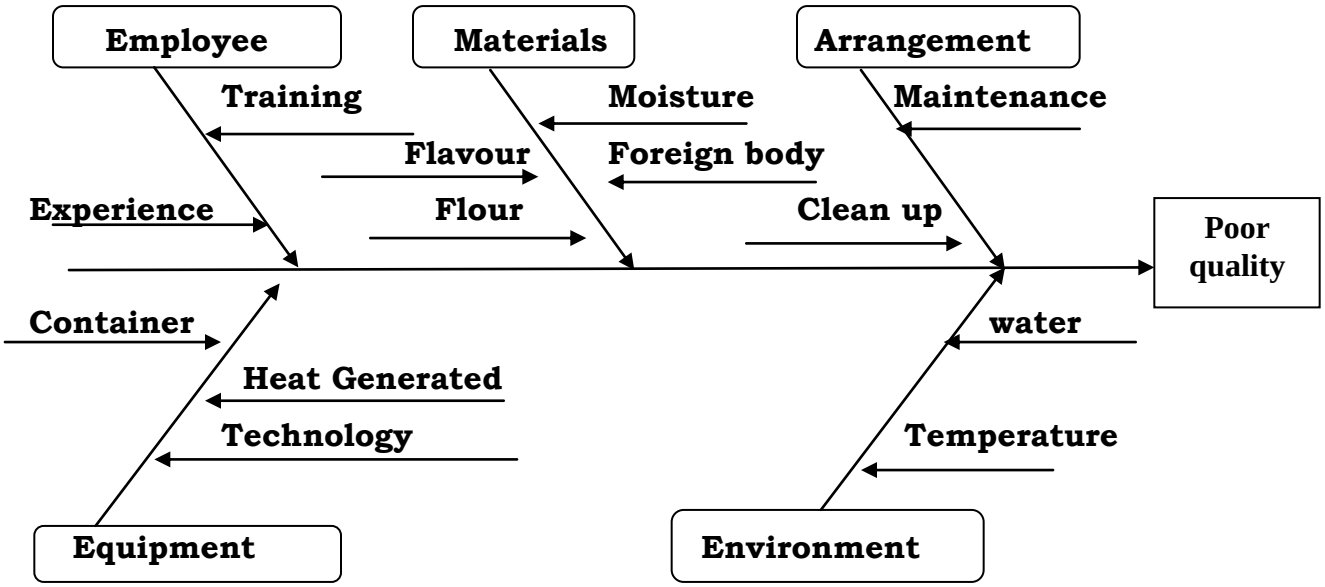


2. CAUSE AND EFFECT DIAGRAMS

It was developed by Dr. Kaoru Ishikawa in 1943mand is sometimes referred to as an Ishikawa diagram or a fishbone diagram because of its shape.

A cause and effect diagram is a picture composed of lines and symbols designed to represent a meaningful relationship between an effect and its causes.

This tool helps to organize problem-solving efforts by identifying all the factors that might have caused the problem. During brain storming sessions, this diagram is used to organize the ideas generated.



3. CHECK SHEET

Check sheets are a systematic way of recording data. It is also called a tally sheet. It is quite suitable for on line data collection and getting a quick review of the process.

A check sheet is a form in table format prepared for recording data. Thus the necessary information can be recorded by making a check mark on the page. Check sheets are used in following ways:

1. Check sheets for recording data and making surveys
    - Defective item check sheet
    - Defect factor check sheet
    - Defect position check sheet
    - Process distribution check sheet
2. Inspection and validation check sheet

Product name…

Product no… Process: publishing

DEFECTIVE ITEM CHECK SHEET

Defect	Day 1	Day 2	Day 3	Day 4	Total
A	~~IIII~~ II	~~IIII~~ I	II	I	16
B	III	~~IIII~~ I	I	II	12
C	IIII	~~III~~ ~~IIII~~ I	III	III	21
D	II	~~IIII~~ I	II	IIII	13
Total	16	29	8	9	62

A-spelling mistakes

B-grammar mistakes

C-mistakes in the page numbers

D-punctuation marks

4. SCATTER DIAGRAMS

Scatter diagram is a graph that shows the degree and direction of relationship between two variables. It can be useful in deciding whether there is a correlation between any two variables.

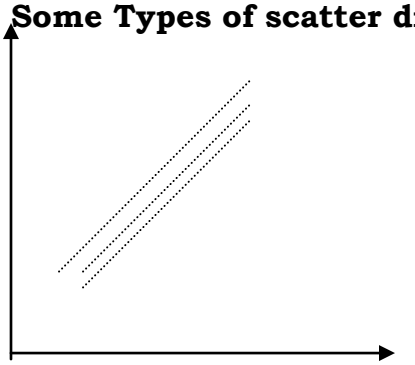
Relationship between the temperature and the number of errors committed per hour. High values of temperature correspond to high number of errors and vice versa. Higher values of speed correspond to low noise and vice versa.

The higher the correlation between the two variables, the lesser will be the scatter the points will tend to line up. On the other hand, if there were little or no relationship between two variables, the points would be completely scattered.

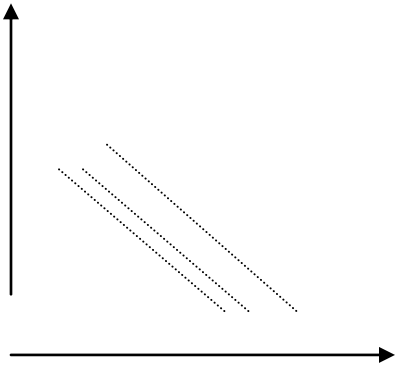
Uses of scatter diagram

- The purpose of scatter diagram is, therefore to display what happened to one variable to another variable is changed.
- This diagram is used to understand, why particular variations occur and how they can be controlled.

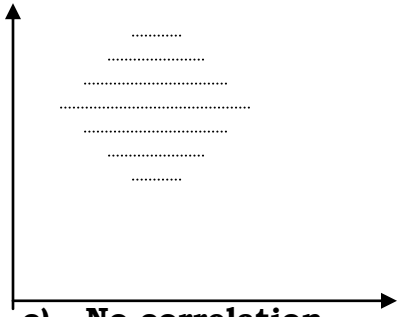
Some Types of scatter diagram



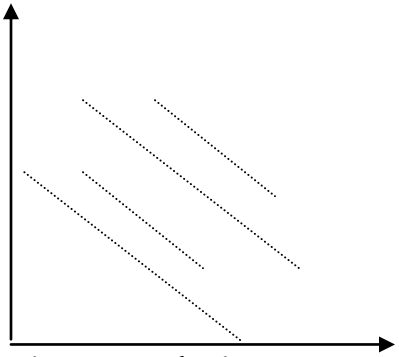
a) Positive correlation



b) Negative correlation



c) No correlation



d) Negative correlation may exist

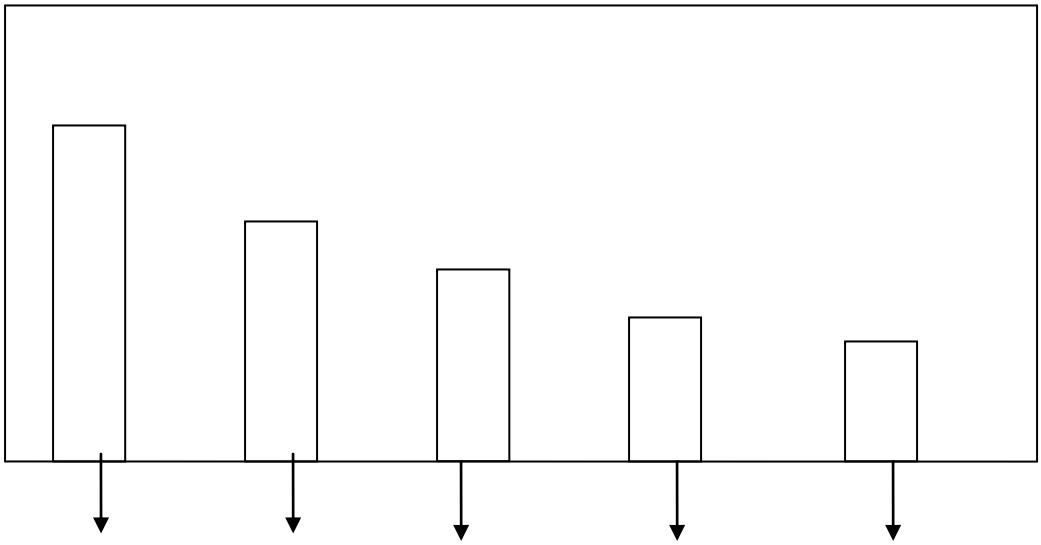
5. PARETO CHARTS AND ANALYSIS

- ❖ Alfredo Pareto (1848-1923) had gone in for conducting extensive studies to determine the distribution pattern.
- ❖ Pareto charts helps in prioritizing the problems, so that the company will have idea on which problem to be addressed first.
- ❖ The Pareto charts helpful in studying and improving the quality and efficiency. It also helps to preserve energy, reduce wastage, improve safety, reduce cost etc.

The 20% Rule

- ➢ 20% of the wealth in Italy was held by 20% of the production
- ➢ 20% of customers accounted for 80% of sales
- ➢ 20% of parts accounted for 80% of cost.. Etc.

The below Pareto chart gives an idea about the various factors that play an important role in determining quality of cake.



By using this chart we have found out that the most critical factor is the employee, so once the company goes in for employing proper employees then the quality of output increases.

The next factor that the company has to concentrate is the raw material that is used for production. Once these factors are concentrated then the desired results can be achieved.

6. HISTOGRAM DIAGRAMS

A histogram is a graph that displays the distribution of data. A histogram is also known as 'frequency distribution diagram'. It is constructed from the data collected in a frequency table. A frequency table is a chart that divides the range of data into several equal sections to compare the frequency of occurrence in each section.

Uses of histogram

A histogram is used to show clearly where the most frequently occurring values are located and the data is distributed. It is also a tool for determining the maximum results. It enables the analyst to quickly visualize the features of a complete set of data.

Construction of histogram

A histogram may be constructed using the following steps:

1. After the data collection, count the number of data values collected.
2. Determine the range of the data. Range=Highest value-lowest value.

Number of values	Number of classes	Number of values	Number of classes
Less than 50	5-7	100-250	7-12
50-100	6-10	Morethan 250	10-20

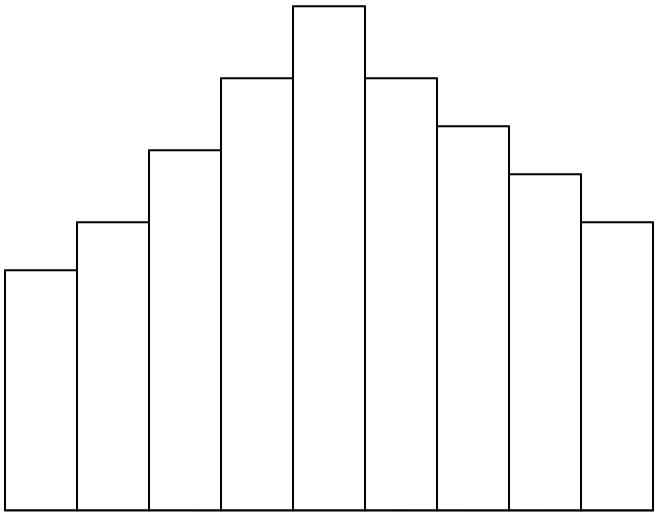
3. Divide the data values in groups or classes and count the number of values in each class. The following table shows the guidelines to divide the data values.

GUIDELINES TO FORM CLASSES

4. Now deter mine the width of the classes
   Width of the classes=range/Number of classes selected from the above table
5. Draw a frequency table for all values.
6. Construct a histogram based on the frequency table. For that, mark the class limits on the horizontal axis and the frequency on the vertical axis.
7. Finally write the title and number of values on the diagram.

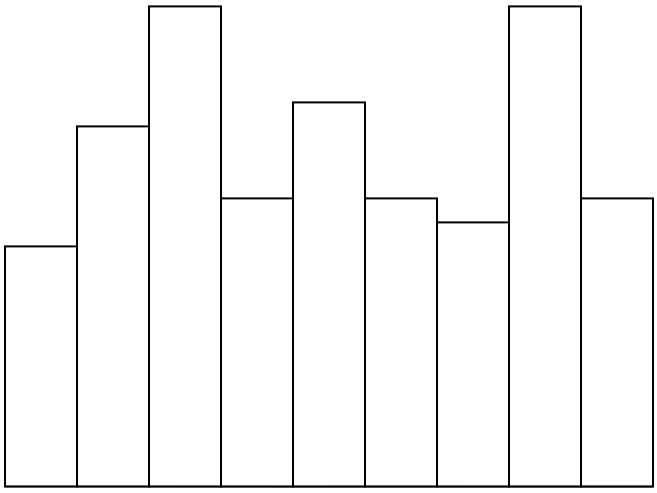
Types of histograms and their interpretations

The following patterns are very useful in the analysis of data.



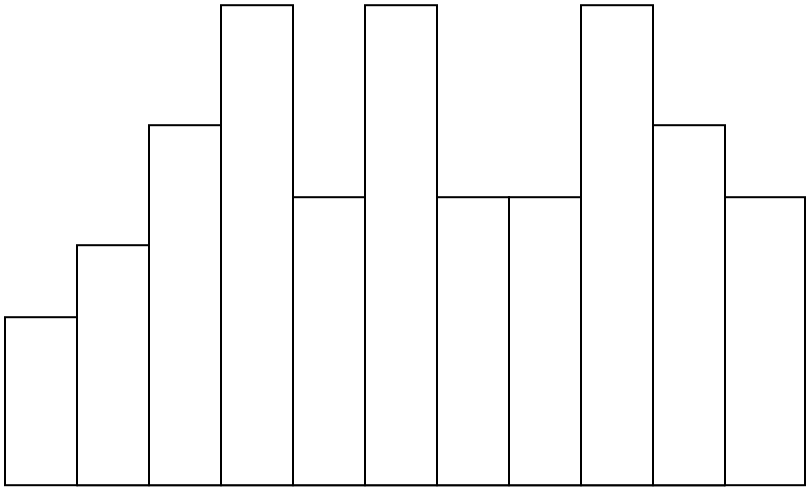
(a) Bell-shaped histogram

Bell-shaped	Symmetrical shape with a peak in middle representing a normal distribution.



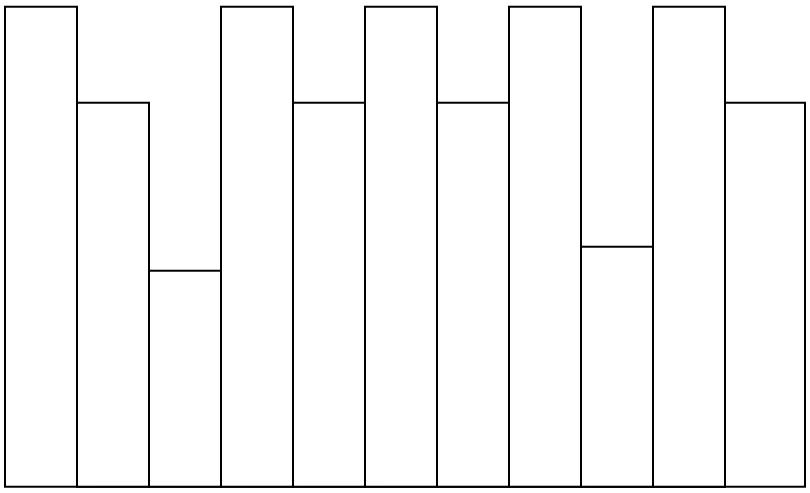
(b) Double-peaked histogram

Double-peaked	Two normal distribution with two peaks in middle indicating more than one distribution at work.



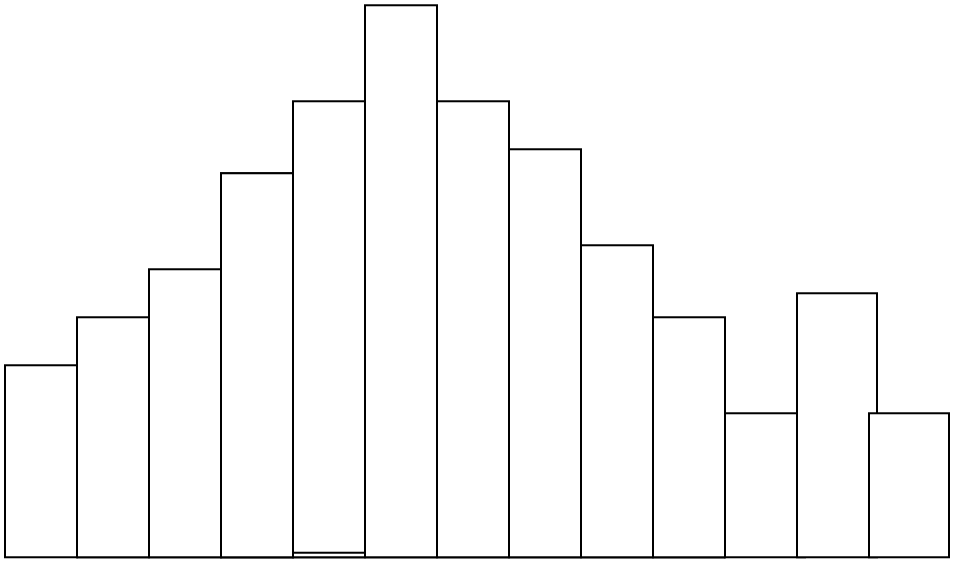
© Plateau

Plateau	Flat top, no distinct peak and tails indicating more than one distribution at work



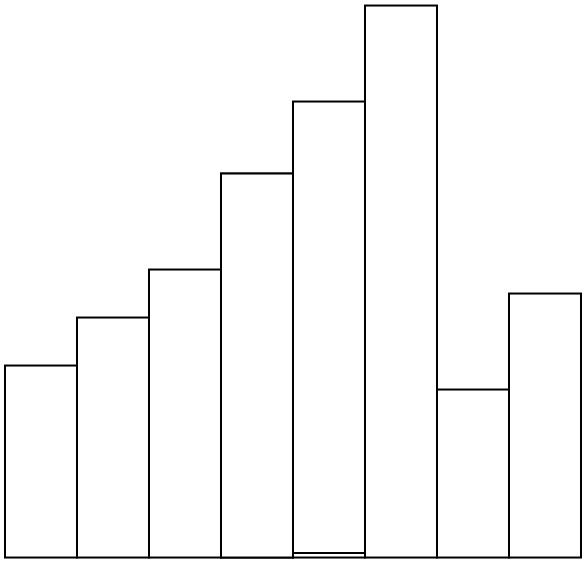
(d) Comb

Comb	Alternative peaks showing possible errors in data collection and analysis



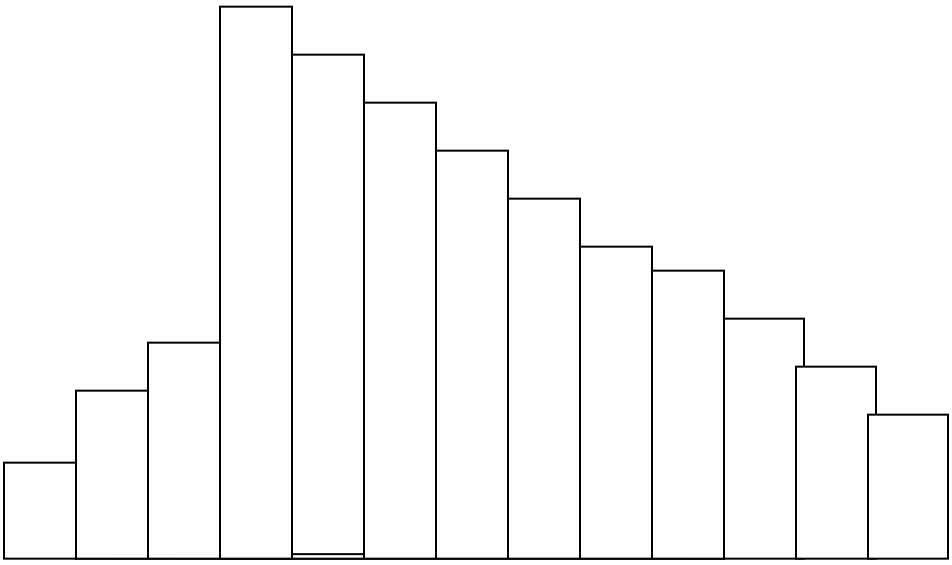
(e) Isolated peak

Isolated peak	Two normal distributions suggesting two processes taking place at the same time.



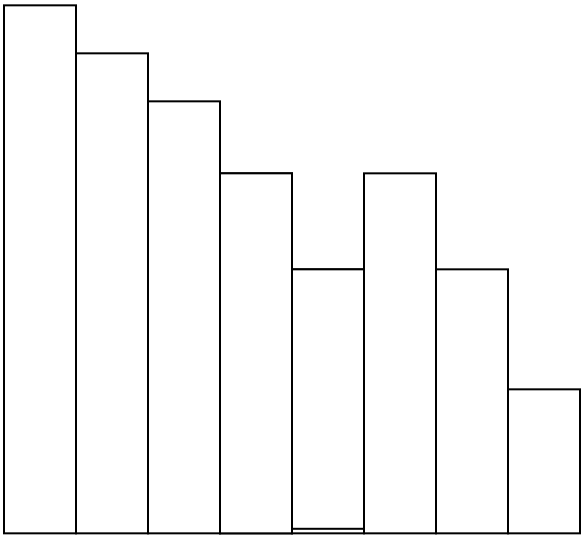
(f) Edged peak

Edged peak	A normal distribution curve with a large peak at one end indicating errors in data recording.



(g) Skewed

Skewed	An asymmetrical shape positively or negatively skewed-usually reflecting limits in the specification on one side.

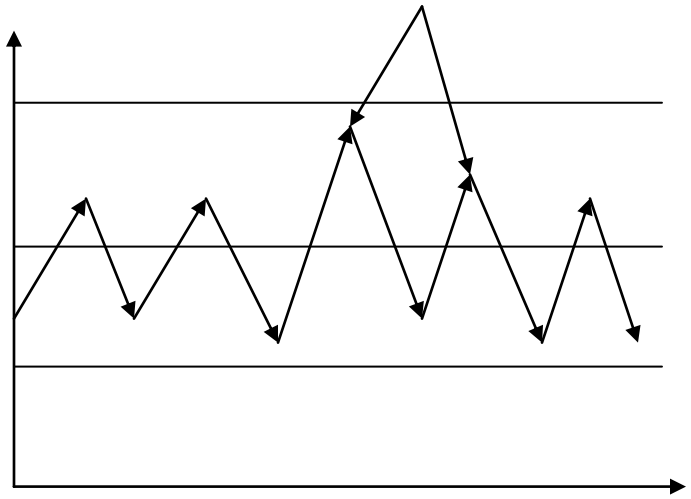


(h) Truncated

Truncated	An asymmetrical shape with a peak at the end. Usually being a part of a normal distribution with part of it having been removed.

7. CONTROL CHARTS

A control charts is used to monitor a process to see if the process output is random. It helps to detect the presence of controllable causes of variation. It can also indicate when a problem occurred and give insight into what might have caused the problem.



- A control chart invented by WALTER A.SHEWRAT is the most widely used tool in statistical process control (SPC).
- A control chart is a graph that displays data taken over time and variations of this data.
- The control chart is based on a series of random samples taken at regular intervals.
- The chart consists of three horizontal lines that remain constant over time: a centerline, a lower control limit (LCL), and on upper control limit (UCL).
- The center is usually set at normal design value. The UCL and LCL are generally set at +_3 standard deviations of the sample means.

If a sample drawn from the process lies inside these (UCL and LCL) limits, it means the process is in control. On the other hand, if the sample lies outside these limits, then the process is said to be out of control. So appropriate corrective action is necessary to eliminate the condition.

Types of control charts:

The two basic control charts are:

(a) Control charts for variable-

Variable control charts are used to monitor those quality characteristics of a process that are measurable. Some of the examples are measuring the data such as time, length, temperature, weight, pressure etc.

Even though $\overline{X}$ and R charts are the two charts frequently used to find out the variation in any quality characteristics.

b) Control charts for attributes-

Another way of measuring these quality characteristics is by counting the number of defects (non conformities) in a particular unit. For example counting the number of defects of scratches or small crack in a unit etc, number of bubbles in a glass bottle. etc.,

This type of quality characteristics are called as attributes. The attribute that we are going to study we take only one of the two alternatives. That are possible (i.e.) either they conform or they do not conform, either it is present or it is absent. .

Uses of control charts

The purpose of a control chart is to identify when the processes has gone out of statistical control, thus signaling the need for some corrective action to be taken.

PROCESS CAPABILITY

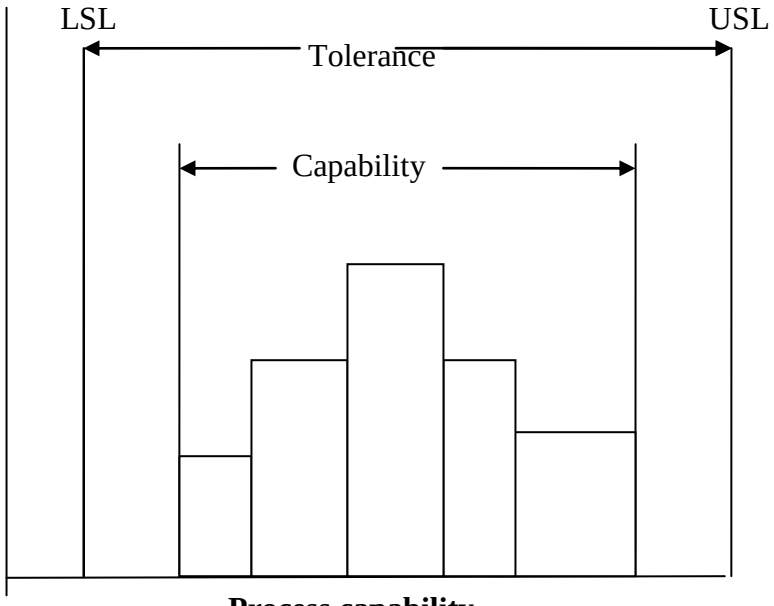
Process capability is a tool that helps to determine the ability of a process to meet specification limit.

The process capability of process is defined as the spread of the output of that process around its central value. A process is said to be highly capable when all the outputs from the process lie closer to the central value.

Process capability compares the output of an in-control process to the specification limits by using capability indices. The comparison is made by forming the ratio of the spread between the process specifications (the specification "width") to the spread of the process values, as measured by process standard deviation units (the process "width")

Once a process is said to be statistically controlled then all the outputs of the process will lie between - 3σ to + 3σ. Which means that then the process capability of the process would become 6σ?

Formulas of process capability is = 6σ = $\sigma = \acute{R}/d_2$



Process capability

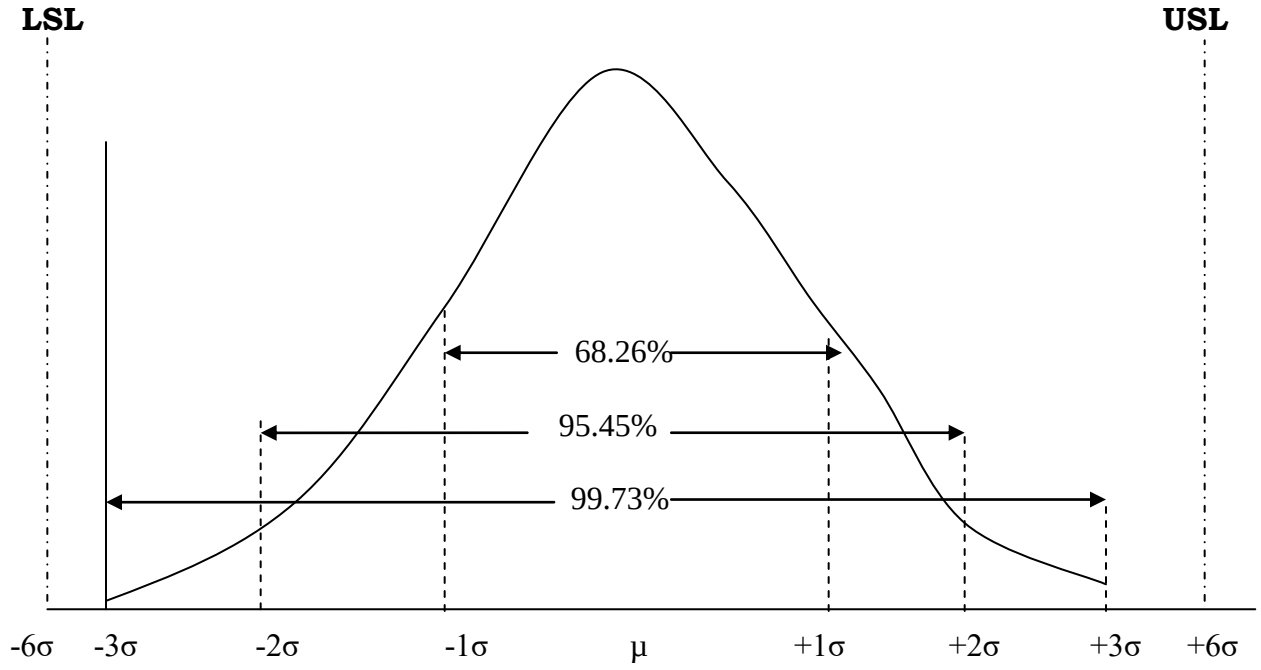
SIX SIGMA

This particular concept originated from Motorola.

Six sigma is highly disciplined process that helps the enterprises to focus on developing and delivering new perfect products and services. Six sigma is a corporate quality programmes that emphasis on identifying and avoiding variation.

Six-sigma strategy can be used in an organization to achieve incredible levels of efficiency. The defects can be brought down to a level pf 3.4 parts per million. This level is with a shift of 1.5σ. If the process can be cantered properly the value can be still smaller (i.e. two defects per billion).

The objective of the six-sigma quality is to reduce process output variation so that ± six standard deviations lie between the mean and the nearest specification limit.



THE NEW SEVEN MANAGEMENT AND PLANNING TOOLS

The advanced tools that are used to manage cross functionality include the seven new QC tools also known as the **"Seven Management and Planning Tools" or 7 MP Tools in the US.**

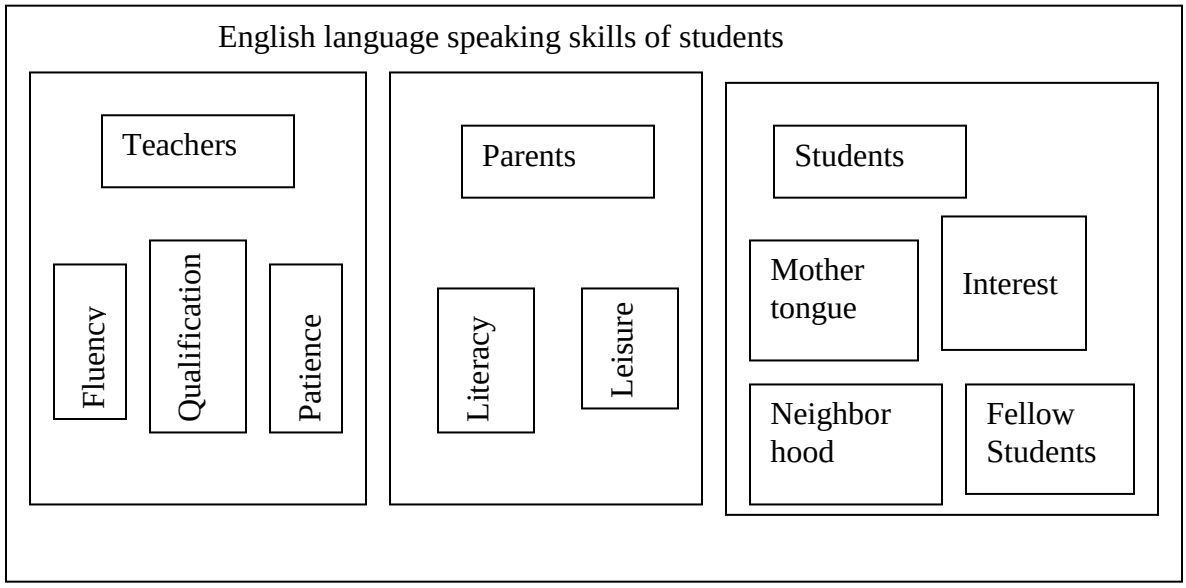
1. Identify a system owner and team members for each critical system.
2. Describe the system under study
3. Identify all subsystems that contribute to the critical system
4. Define the interdependencies of the subsystems
5. Prioritize the subsystems as to their contribution to the critical system
6. Develop a detailed "as is" description of the critical system. This includes identifying the interfaces between all system components as well as expanding the level of detail for major contributing subsystems.
7. Identify obvious system deficiencies
8. Identify possible causes of system deficiencies
9. Establish "basic line" measures for the system and major subsystems
10. Assess the performance of the system and major subsystems
11. Develop a "should be" description of the system and subsystems
12. Recommended changes to improve system and subsystem performance.

THE NEW SEVEN MANAGEMENT AND PLANNING TOOLS ARE:

1. Affinity Diagram.
2. Inter Relationship Diagram.
3. Tree Diagram.
4. Matrix Diagram
5. Prioritization Matrix
6. Process Decision Programme Chart.
7. Arrow Diagram / Activity Network Diagram

1. AFFINITY DIAGRAMS

In affinity diagrams large volumes of data is gathered and organized. Ideas, opinions, and facts relating to a problem are grouped. A sequence or pattern formation is the main aim. This is mainly used in addressing issues such as customer dissatisfaction etc. affinity diagram are tools for verbal data. Its applications are to organize into groups a large number of ideas, opinions about a particular topic.

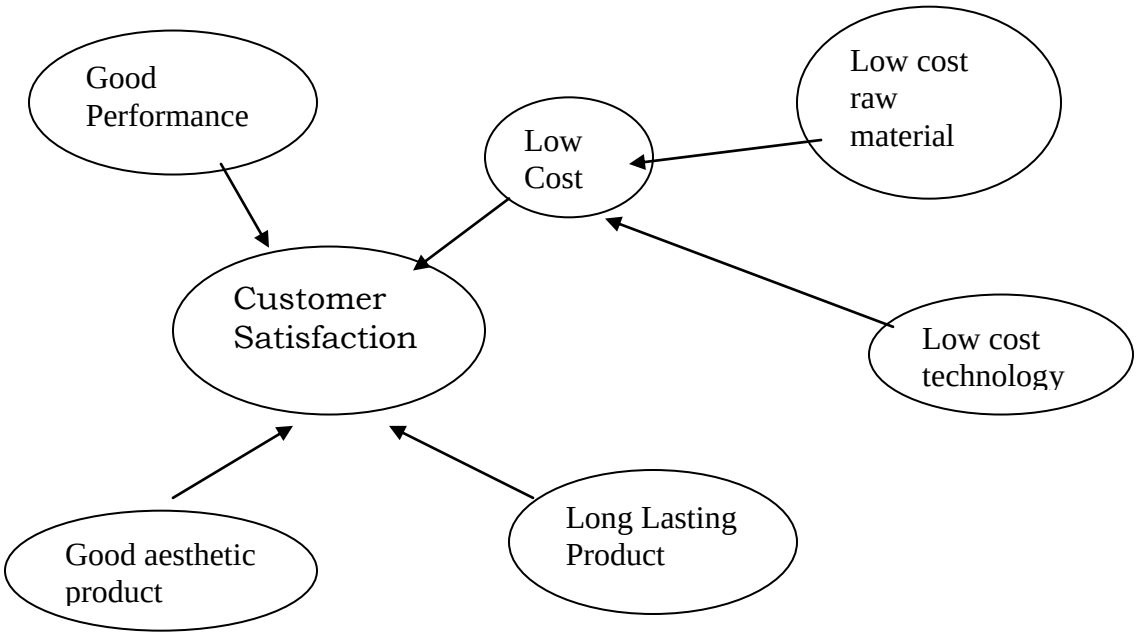


Example of an affinity diagram drawn to improve the English language speaking skills of students.

2. INTER RELATIONSHIP DIAGRAM

The relationship between causative factors and then main issue is established. This tool helps us in identifying the relationship between different factors, which cause a problem or issue.

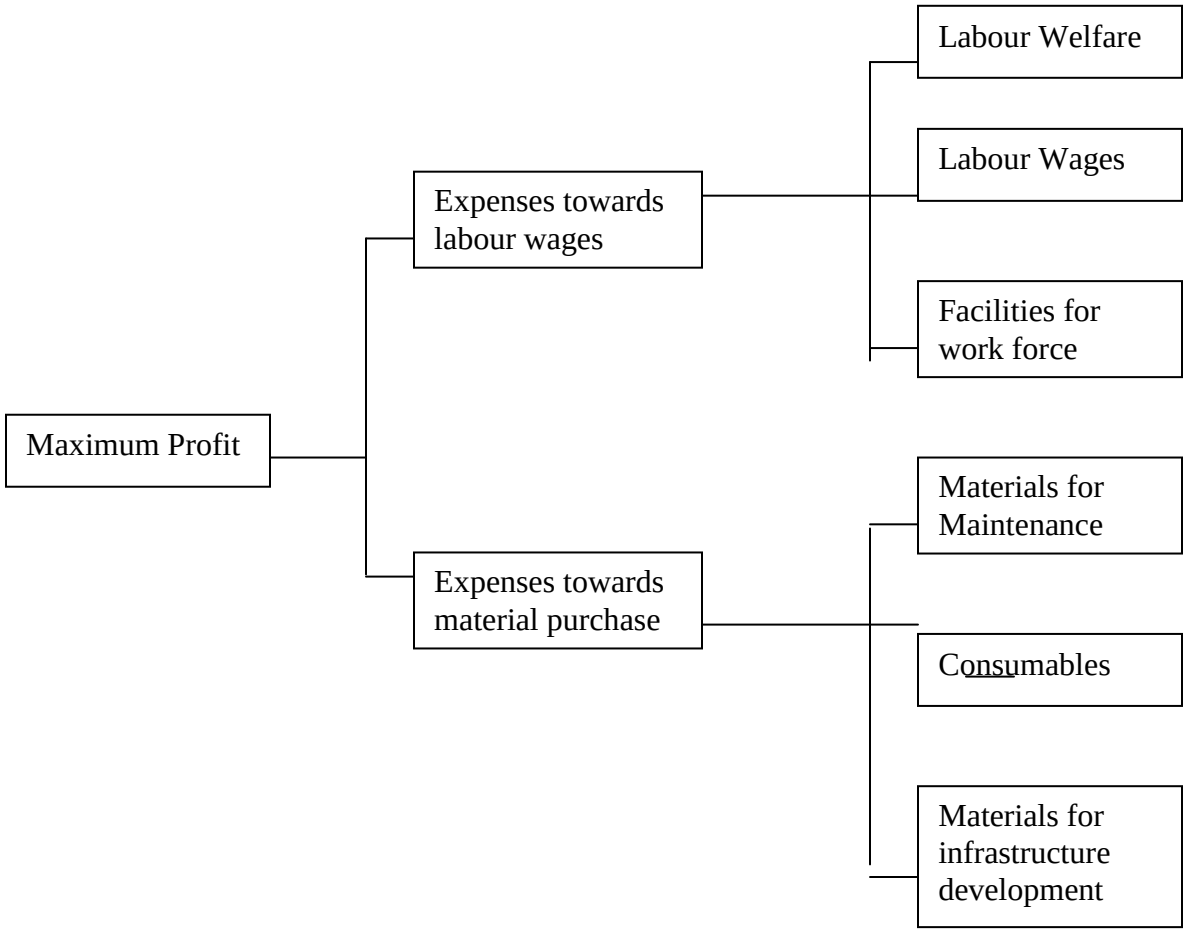
It also helps in determining the interrelationship between these factors. This tool is used to identify the major causes, which help in solving a problem on the basis of logical analysis and linkage of causes associated with the problem.



Example of a relationship diagram drawn to improve customer satisfaction.

3. TREE DIAGRAM

Tree diagram is listed as a tool for non- numerical data. It is used to show the relationship between an issue and its component elements. Therefore a tree diagram breaks down the issue into its component elements. This is a tool for operational planning after initial diagnosis of issues.



Example of a tree diagram constructed to analyze the monthly outgoings in a company

4. MATRIX DIAGRAM

A matrix diagram consists of a set of columns and rows. The intersections of these rows and columns are checked for determining the nature and strength of the problem. These help us to arrive at the key ideas and determining the relationship and an effective way of perusing the problem.

This method is very much help full in accelerating the problem solving process through multidimensional thinking. This is achieved by indicating the existence of relationship as well as the strength of relationship between two or more sets of factors. There are basically % types of matrix diagrams.

1. L – Shaped matrix (2 variables are used)
2. T – Shaped matrix (3 variables are used)
3. Y- Shaped matrix (3 variables are used)
4. X - Shaped matrix (4 variables are used)
5. C- Shaped matrix (3 variables are used)

Cause / Effect Category	Error in testing	Error in Report	Crossed PDS
Employee training	O	O	
Employee motivation	Δ	Δ	©
Machinery			Δ
Methods	©		Δ
Supervisor	©	Δ	

5. MATRIX DATA ANALYSIS

The matrix data analysis is useful to prioritize the actions to be taken. This can be used to analyze the causes of non-conformities and identify the top most causes.

This technique is very simple. Each one of the significant customers were requested to rank their level of satisfaction against the following four parameters.

For example

.

	Excellent	**Very good**	**Good**	**Average**	**Poor**
Quality of testing/ calibration carried out	***	***		***	***
Quality of reports	***	***			
Quality of customer service rendered	***	***	***		***
Promptness of service rendered		***		***	

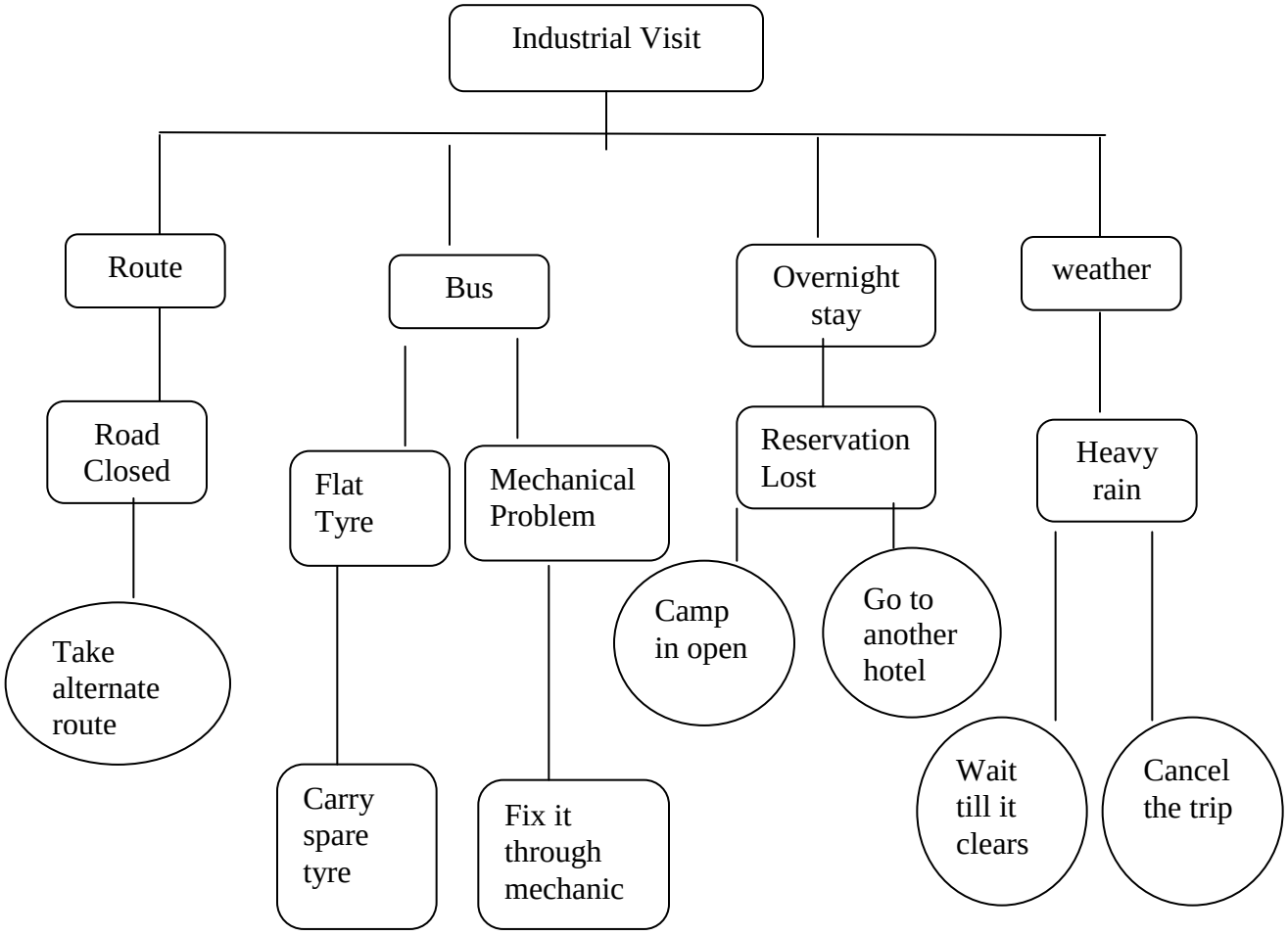
From the above example the matrix is helps in ranking the problems of issues by chosen criteria that are important to the organization. Then, one can say clearly which problem is the most important one and to be solved first.

The prioritization matrix is a useful technique for arriving at priorities when there are a number of actions to be taken.

6. PROCESS DECISION PROGRAMME CHART

This method helps one in getting prepared for any unexpected problems that may occur while carrying out certain activities. It is very much useful when one is unaware about either the product or the process and also when one is not clear with the type of environment in which the activity has to be carried out.

The process decision program charts application can be explained with the following example. Let us take the students are going for an industrial visit to Chennai for 3 days. This chart helps in finding out what could go wrong during the trip and how to fix the problem.



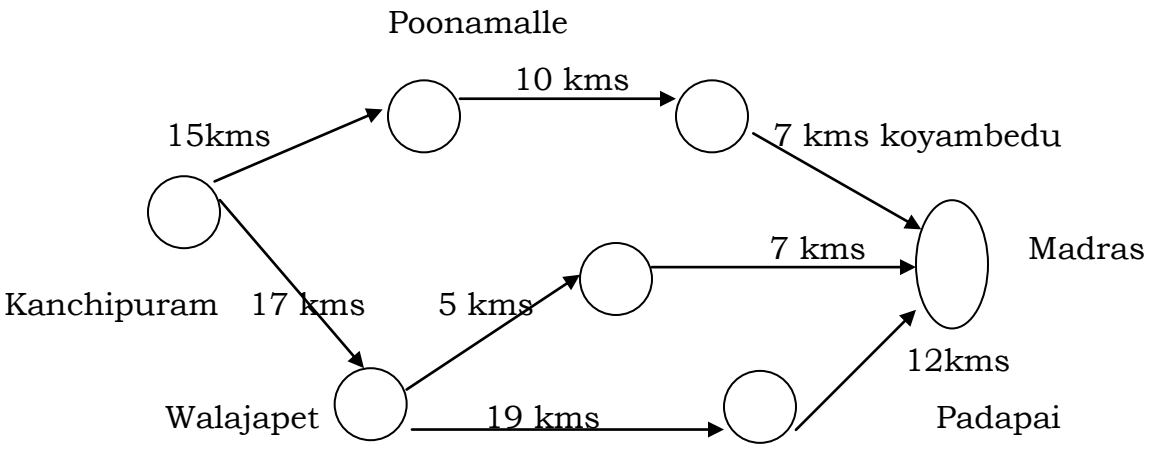
The above chart gives the problems than one can come across and the alternate solutions for the problems.

7. ARROW DIAGRAM

This method is helpful in scheduling the activities so that any project can be completed in the best possible way. It will provide a time sequential action plan for all the tasks that are to be carried out in a project.

The other name by which the activity network diagram can be called Program Evaluation Review Technique (PERT) , Critical Path Method (CPM) Activity Network Diagram, Activity on node

The total work or task is sub- broken down to sub tasks or activities. The sub tasks and the total work is linked by arrows and a diagram is constructed to depict the activities.



Example of Arrow diagram for travel between Kanchipuram and Madras