# OPERATIONS MANAGEMENT

## EXPERIMENT NO -1

### Aim – Forecasting techniques using Qualitative Forecasting methods

**Shipment of welded tube by an aluminum producer are shown in table**

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tons | 2 | 3 | 6 | 10 | 8 | 7 | 12 | 14 | 15 | 18 | 19 |

**Compute a Forecast of year 12 using**

1) **Naive Method**
2) **Simple Moving Average – 3 Year Moving Average**
3) **Weighted Moving average – Weights 0.5, 0.3 , 0.2**
4) **Exponential Smoothing Forecast if,** $\alpha = 0.3$

**1) Naive Method**

| | | Naive Method |
|---|---|---|
| Year | Tons | Forecast |
| 1 | 2 | - |
| 2 | 3 | 2 |
| 3 | 6 | 3 |
| 4 | 10 | 6 |
| 5 | 8 | 10 |
| 6 | 7 | 8 |
| 7 | 12 | 7 |
| 8 | 14 | 12 |
| 9 | 15 | 14 |
| 10 | 18 | 15 |
| 11 | 19 | 18 |
| 12 | - | 19 |

## 2) Simple Moving Average – 3 Year Moving Average

| | | Simple Moving Average - 3 Year Moving Average |
|---|---|---|
| **Year** | **Tons** | **Forecast** |
| 1 | 2 | - |
| 2 | 3 | - |
| 3 | 6 | - |
| 4 | 10 | (2+3+6)/3 =3.67 |
| 5 | 8 | (3+6+10)/3=6.33 |
| 6 | 7 | (6+10+8)/3=8 |
| 7 | 12 | (10+8+7)/3=8.33 |
| 8 | 14 | (8+7+12)/3=9 |
| 9 | 15 | (7+12+14)/3=11 |
| 10 | 18 | (12+14+15)/3=13.67 |
| 11 | 19 | (14+15+18)/3=15.67 |
| 12 | - | (15+18+19)/3=17.33 |

$$\text{Moving Average, MA} = \frac{\sum X}{\text{Number of Periods}} = \frac{\sum X}{n}$$

Where,

X = Demand/Sales Value

## 3) Weighted Moving average – Weights 0.5, 0.3 , 0.2

Weighted Moving Average, WMA = $\sum$ (wt) * X

| | | Weighted Moving Average - Weights 0.5, 0.3 , 0.2 |
|---|---|---|
| **Year** | **Tons** | **Forecast** |
| 1 | 2 | - |
| 2 | 3 | - |
| 3 | 6 | - |
| 4 | 10 | ((2*0.5)+(3*0.3)+(6*0.2)) =3.1 |
| 5 | 8 | ((3*0.5)+(6*0.3)+(10*0.2))=5.3 |
| 6 | 7 | ((6*0.5)+(10*0.3)+(8*0.2))=7.6 |
| 7 | 12 | ((10*0.5)+(8*0.3)+(7*0.2))=8.8 |
| 8 | 14 | ((8*0.5)+(7*0.3)+(12*0.2))=8.5 |
| 9 | 15 | ((7*0.5)+(12*0.3)+(14*0.2))=9.9 |
| 10 | 18 | ((12*0.5)+(14*0.3)+(15*0.2))=13.2 |
| 11 | 19 | ((14*0.5)+(15*0.3)+(18*0.2))=15.1 |
| 12 | - | ((15*0.5)+(18*0.3)+(19*0.2))=16.7 |

**4) Exponential Smoothing Forecast if, $\alpha = 0.3$**

| | | Exponential Smoothing Forecast - $\alpha = 0.3$ |
|---|---|---|
| **Year** | **Actual Demand** | **Forecast Demand, $F_{t+1} = \alpha D_t + (1- \alpha) F_t$** |
| 1 | 2 | ((0.3 * 2)+(1-0.3)*2)=2 |
| 2 | 3 | ((0.3 * 2)+(1-0.3)*2)=2 |
| 3 | 6 | ((0.3 * 3)+(1-0.3)*2)=2.3 |
| 4 | 10 | ((0.3 * 6)+(1-0.3)*2.3)=3.41 |
| 5 | 8 | ((0.3 * 10)+(1-0.3)*3.41)=5.39 |
| 6 | 7 | ((0.3 * 8)+(1-0.3)*5.39)=6.17 |
| 7 | 12 | ((0.3 * 7)+(1-0.3)*6.17)=6.42 |
| 8 | 14 | ((0.3 * 12)+(1-0.3)*6.42)=8.09 |
| 9 | 15 | ((0.3 * 14)+(1-0.3)*8.09)=9.86 |
| 10 | 18 | ((0.3 * 15)+(1-0.3)*9.86)=11.4 |
| 11 | 19 | ((0.3 * 18)+(1-0.3)*11.4)=13.38 |
| 12 | - | ((0.3 * 19)+(1-0.3)*13.38)=15.07 |

Exponential Smoothing Forecast, $F_{t+1} = \alpha D_t + (1- \alpha) F_t$

Where,

$F_{t+1}$ = Forecast for Next Period

$D_t$ = Actual Demand for present period

$F_t$ = Previously determined forecast for present period

$\alpha$ = Weighting factor, Smoothing constant

| | | **Naive Method** | **Simple Moving Average - 3 Year Moving Average** | **Weighted Moving Average - Weights 0.5, 0.3 , 0.2** | **Exponential Smoothing Forecast - α = 0.3** |
|---|---|---|---|---|---|
| **Year** | **Tons** | **Forecast Demand** | **Forecast Demand** | **Forecast Demand** | **Forecast Demand, Ft+1= α Dt + (1- α) Ft** |
| 1 | 2 | - | - | - | 2 |
| 2 | 3 | 2 | - | - | 2 |
| 3 | 6 | 3 | - | - | 2.3 |
| 4 | 10 | 6 | 3.67 | 3.1 | 3.41 |
| 5 | 8 | 10 | 6.33 | 5.3 | 5.39 |
| 6 | 7 | 8 | 8 | 7.6 | 6.17 |
| 7 | 12 | 7 | 8.33 | 8.8 | 6.42 |
| 8 | 14 | 12 | 9 | 8.5 | 8.09 |
| 9 | 15 | 14 | 11 | 9.9 | 9.86 |
| 10 | 18 | 15 | 13.67 | 13.2 | 11.4 |
| 11 | 19 | 18 | 15.67 | 15.1 | 13.38 |
| 12 | - | 19 | 17.33 | 16.7 | 15.07 |

# EXPERIMENT NO -2

**Aim - Setup the Master Production Schedule (MPS) Using Given Data**

**On hand = 24, Lot Size = 25, Demand time Fence = 6**

| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Forecast | 10 | 10 | 10 | 10 | 20 | 20 | |
| Customer Order(Booked) | 14 | 6 | 4 | 1 | | | |

**Solution:**

| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Forecast | 10 | 10 | 10 | 10 | 20 | 20 | |
| Customer Order(Booked) | 14 | 6 | 4 | 1 | | | |
| Projected Available Balance | 10 | 00 | 15 | 5 | 10 | 15 | |
| MPS | | | 25 | | 25 | 25 | |
| ATP | 4 | | 20 | | 25 | 25 | |

**MPS - Master Production Schedule**

**ATP –Available To Promise**

Projected Available Balance = Previously Available Balance + MPS – Current Period Requirements

ATP = (On Hand Inventory + MPS amount during this Period) – (Total of Booked orders till next MPS amount is available)

**Projected Balance for Period :**

Projected Available Balance= Previously Available Balance + MPS

**For Period 1 :**

P1=24 -14 = 10

**For Period 2 :**

P2 = 10-10 = 00

**For Period 3 :**

P3 = 00 – 10 = -10 , So, a Lot Size of 25 goes into MPS in week 3(Period 3) Resulting in a Balance of ( 00 + 25) -10 = 15

**For Period 4 :**

P4 = 15-10 = 5

**For Period 5 :**

P5 = 5- 20 = - 15, So, a Lot Size of 25 goes into MPS in week 5(Period 5) Resulting in a Balance of ( 5 + 25) -20 = 10

**For Period 6 :**

P6 = 10 – 20 =- 10, So, a Lot Size of 25 goes into MPS in week 6 (Period 6) Resulting in a Balance of ( 10 + 25) -20 = 15

**ATP –Available To Promise**

**For Period 1 :**

= (On Hand Inventory + MPS) – (Orders in Period 1 & 2)

= (24+0) – (14+6) = 4

**For Period 3 :**

= (On Hand Inventory + MPS of 3) – (Orders in Period 3 & 4)

= ( 00 + 25) – ( 4+1) = 20

**For Period 5 :**

= (On Hand Inventory + MPS of 5) – (Orders in Period 5)

= (00 + 25) – (00) = 25

**For Period 6 :**

= (On Hand Inventory + MPS of 6) – (Orders in Period 6)

= (00 + 25) – (00) = 25

# EXPERIMENT NO -3

**Aim - Setup the Man- Machine Chart Using Given Data**

**A workshop is engaged in printing patterns on plastic matt. The work is done according to customer orders. The shop has two identical printing equipment's that can print only one side of a matt at a time. The matt have dimension of 60 x 40 cm. A customer demand 3 matt's with identical patterns on both sides. The printing process is simple, the matt is placed in the machine and 30 minutes is allowed to print pattern. If the mat is kept in the machine less than 30 minutes then the colours fade. If it is kept more than 30 minutes, then the colours are too strong. The necessary operations and the required times are shown below**

1) **Placing one side of a matt -15 minutes**
2) **Printing either side - 30 minutes**
3) **Turning the matt - 5 minutes**
4) **Removing the matt - 15 minutes**

**By the help of Man - Machine chart show the best way for completing the printing of 3 matt's**

## MAN- MACHINE CHART

| TIME | EQUIPMENT -1 | EQUIPMENT -2 | MAN |
|---|---|---|---|
| 5 | GET READY | IDLE | PLACING, MATT-1, SIDE -1 |
| 10 | | | |
| 15 | | | |
| 20 | PRINTING, MATT-1, SIDE -1 | GET READY | PLACING, MATT-2, SIDE -1 |
| 25 | | | |
| 30 | | | |
| 35 | | PRINTING, MATT-2, SIDE -1 | IDLE |
| 40 | | | |
| 45 | | | |
| 50 | GET READY | | REMOVING MATT-1 |
| 55 | | | |
| 60 | | | |
| 65 | IDLE | GET READY | TURNING MATT -2 |
| 70 | GET READY | PRINTING, MATT-2, SIDE -2 | PLACING, MATT-3, SIDE -1 |
| 75 | | | |
| 80 | | | |
| 85 | PRINTING, MATT-3, SIDE -1 | | IDLE |
| 90 | | | |
| 95 | | | |
| 100 | | GET READY | REMOVING MATT-2 |
| 105 | | | |
| 110 | | | |
| 115 | GET READY | IDLE | TURNING MATT -3 |
| 120 | PRINTING, MATT-3, SIDE -2 | GET READY | PLACING, MATT-1, SIDE -2 |
| 125 | | | |
| 130 | | | |
| 135 | | PRINTING, MATT-1, SIDE -2 | IDLE |
| 140 | | | |
| 145 | | | |
| 150 | GET READY | | REMOVING MATT-3 |
| 155 | | | |
| 160 | | | |
| 165 | IDLE | GET READY | REMOVING MATT-1 |
| 170 | | | |
| 175 | | | |
| 180 | | | |

Utility of Man =( 130/175) *100=74.28%

Utility of Equipment 1 = (155/175 )*100=88.57%

Utility of Equipment 2 = (155/175) *100=88.57%

# EXPERIMENT NO -4

**Aim - Setup the Job Process Chart Using Given Data**

1. Job or component was brought from stores 10 meter away
2. The job was loaded on the machine 2 minutes
3. It was machined 5 minutes
4. The job was then send to inspection bench 12 meters
5. It has to wait for 15 minute for the Inspector to be free from previous job
6. The job was checked for accuracy 2 minutes
7. The job was then moved back to store 12 meter away from inspection bench and store in rack
8. The job has to placed in the rack for 0.2 min

## JOB PROCESS CHART

## (MATERIAL TYPE)

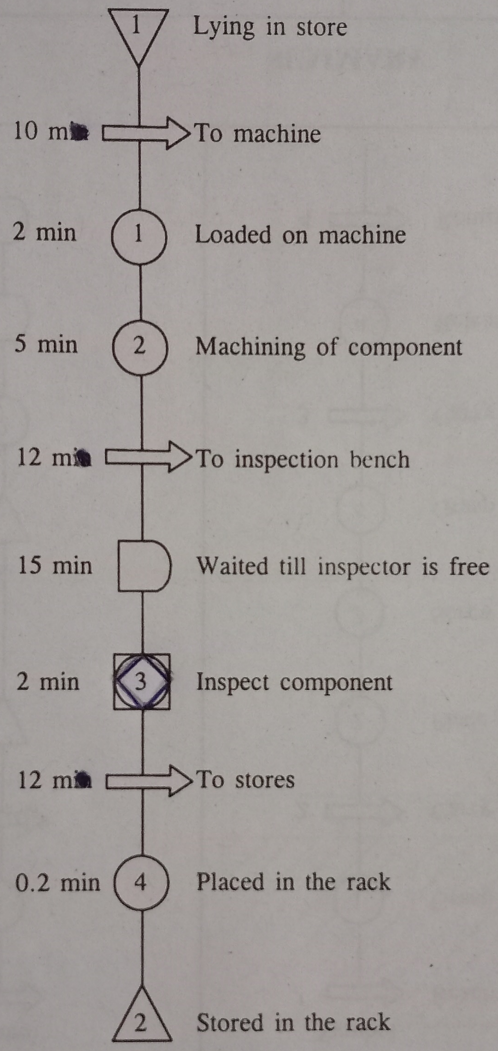
Task : Machining of the component

Chart begins : Component lying in the stores

Chart ends : The machined component lying in the stores

Charted by :.....

Date of charting :.....




### SUMMARY

| Symbol | Frequency | Time | Distance |
|---|---|---|---|
| ○ | 4 | 9.2 min | - |
| ⇨ | 3 | - | 34 m |
| □ | 1 | 2 min | - |
| D | 1 | 15 min | - |
| ▽ | 2 | - | - |

# EXPERIMENT NO -5

**Aim - Solve the Economic Order Quantity (EOQ) Problems**

## Formulas used

### Economic Order Quantity (EOQ)

$$Q = \sqrt{\frac{2DS}{H}}$$

**Where,**

Q = Economic Order Quantity (EOQ)

D = Demand Rate (Quantity Sold Per Year)

S = Ordered Cost or Set Up Cost Per Order

H = Holding Costs( Per Year, Per Unit)

### Total Annual Cost ( TC)

$$TC = \left(\frac{D}{Q}\right) * S + \left(\frac{Q}{2}\right) * H$$

$$\text{Number of orders} = \frac{\text{Annual Demand}}{\text{EOQ}} = \frac{D}{Q}$$

$$\text{Number of orders} = \frac{\text{Annual Demand}}{\text{EBQ}} = \frac{D}{Q^*}$$

Economic Batch Quantity (EBQ) = Q*

**(1) A company has got a demand for its particular part at 10,000 units per year. The cost per unit is Rs 2 and it costs Rs 36 to place an order and to process the delivery. The inventory carrying cost can be estimated at 9% of average inventory investment. Calculate**

**(i) Economic Order Quantity (EOQ)**

**(ii) Optimum number of orders to be placed per annum**

**(iii) Minimum total cost of inventory per annum**

## Solution -

Annual Demand, D = 10000 units/annum

Order Cost, S = Rs 36/order

Cost per unit =Rs 2unit

Inventory carrying cost , H = 9% = Rs 2 * (9/100) = 0.18 Rs

**(i)** Economic Order Quantity (EOQ)

$$Q = \sqrt{\frac{2DS}{H}}$$

Q = (√2*D*S)/(√H) =(√2*10000*36)/(√0.18) = 2000 units

(ii) Optimum number of orders

$$\text{Number of orders} = \frac{\text{Annual Demand}}{\text{EOQ}} = \frac{D}{Q} = \frac{10000}{2000} = 5$$

(iii) Minimum total cost of inventory per annum

= inventory carrying cost

= Rs 2 * (9/100)*2000 = Rs 360 / annum

**(2) ABC company produces a cable at rate of 5000 meters/hr. The cable is used at the rate of 2500 meters/hr. The cost of the cable is Rs 5 per meter. The inventory carrying cost of 25 % and setup costs are Rs 4050 per setup. Determine the optimal number of cycles required in a year for the manufacture of this cable.**

**Solution**

Production Rate, p = 5000 m/hr

Demand Rate, d = 2500 m/hr

Price per unit = Rs 5 /meter

H = Rs 5 *(25/100) = 5 *0.25 =1.25 Rs

Set up cost = 4050 per order

D = 2500*8 hr/day*365 Days = 73,00,000 units/annum

$$Q^* = \sqrt{\frac{2DS}{H\ (1-(d/p))}}$$

Q* =(√2*D*S)/(√H(1-(d/p)) =(√2*7300000*4050)/(√1.25(1-(2500/5000))

Q* =243166.60/0.790 =307805 units

Optimum number of cycles per annum =

$$\text{Number of orders} = \frac{\text{Annual Demand}}{\text{EBQ}} = \frac{D}{Q^*} = \frac{7300000}{307805} = 23.71 = 24$$

**(3) A company consumes 12000 units of a particular item. The company has a production capacity of 60 units/day. The cost of each unit produced by the company is Rs 8. The setup and tooling up cost is Rs 96 per setup. The carrying charges are 15 % of cost per unit.**

**Determine**

**(i) Economic Quantity to be manufactured in each batch.**

**(ii) How frequency should the production runs be made**

**(iii) Determine the Production period.**

**Assume 300 Working days per annum**

**Solution-**

D = 12000 units/day

P= 60 per day

S= Rs 96 per order

Consumption rate, d=12000/300 = 40 per day

H = Rs 8*(15/100) = Rs 1.2.

(i) EBQ

$$Q^* = \sqrt{\frac{2DS}{H\ (1-(d/p))}}$$

Q* = =(√2*D*S)/(√H(1-(d/p))

=(√2*12000*96)/(√1.2(1-(40/60))

= 1518/0.632 =2400

(ii) Frequency of production run = D/Q*

= 12000/2400 =5

(iii) Production Time = Q*/p = 2400/60= 40 days

# ABC Analysis Problems

1) **Ten items are kept in the inventory. The details regarding the number of items used per annum and price per unit are given below. Classify the items into A,B,C Class**

| Item No. | Annual Usage | Price |
|---|---|---|
| 1 | 200 | 40 |
| 2 | 100 | 360 |
| 3 | 2000 | 0.2 |
| 4 | 400 | 20 |
| 5 | 6000 | 0.04 |
| 6 | 1200 | 0.8 |
| 7 | 120 | 100 |
| 8 | 2000 | 0.7 |
| 9 | 1000 | 1 |
| 10 | 80 | 400 |

**Solution**

| Item No. | Annual Usage | Price | Annual Usage Value | % of Annual Usage | ABC Class |
|---|---|---|---|---|---|
| 1 | 200 | 40 | 8000 | 8 | B |
| 2 | 100 | 360 | 36000 | 36 | A |
| 3 | 2000 | 0.2 | 400 | 0.4 | C |
| 4 | 400 | 20 | 8000 | 8 | B |
| 5 | 6000 | 0.04 | 240 | 0.24 | C |
| 6 | 1200 | 0.8 | 960 | 0.96 | C |
| 7 | 120 | 100 | 12000 | 12 | B |
| 8 | 2000 | 0.7 | 1400 | 1.4 | C |
| 9 | 1000 | 1 | 1000 | 1 | C |
| 10 | 80 | 400 | 32000 | 32 | A |
| | | **TOTAL** | **100000** | **100** | |

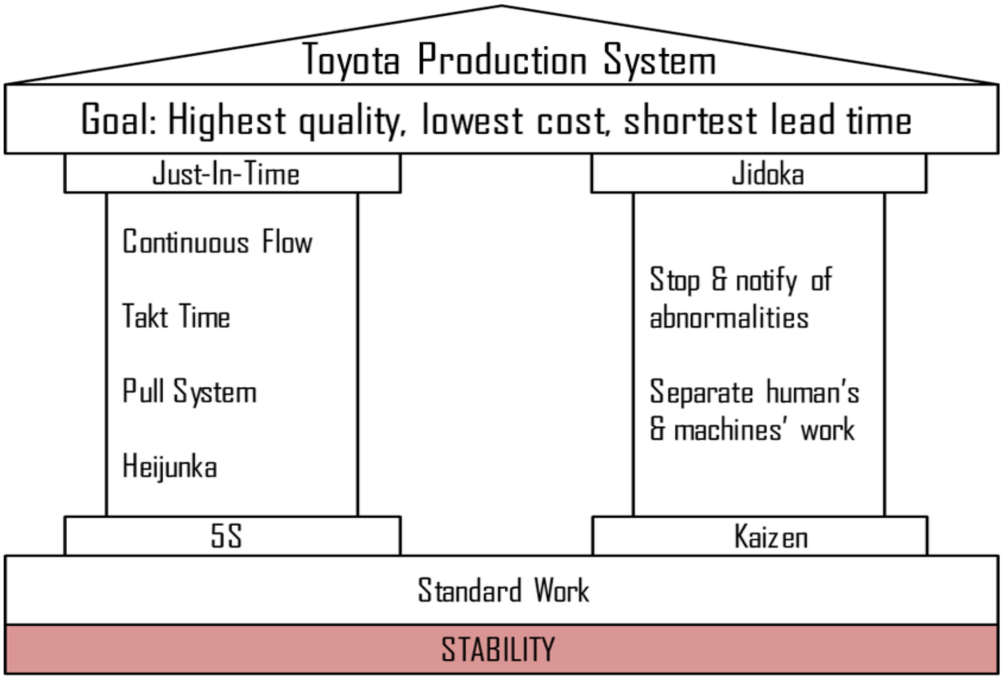
| Item No. | Annual Usage | Price | Annual Usage Value | % of Annual Usage | ABC Class |
|---|---|---|---|---|---|
| 2 | 100 | 360 | 36000 | 36 | A |
| 10 | 80 | 400 | 32000 | 32 | A |
| 7 | 120 | 100 | 12000 | 12 | B |
| 1 | 200 | 40 | 8000 | 8 | B |
| 4 | 400 | 20 | 8000 | 8 | B |
| 8 | 2000 | 0.7 | 1400 | 1.4 | C |
| 9 | 1000 | 1 | 1000 | 1 | C |
| 6 | 1200 | 0.8 | 960 | 0.96 | C |
| 3 | 2000 | 0.2 | 400 | 0.4 | C |
| 5 | 6000 | 0.04 | 240 | 0.24 | C |
| | | **TOTAL** | **100000** | **100** | |

| ABC Class | Item No. |
|---|---|
| **A** | 2 |
| | 10 |
| **B** | 1 |
| | 4 |
| | 7 |
| **C** | 3 |
| | 5 |
| | 6 |
| | 8 |
| | 9 |

# EXPERIMENT NO. - 6

**Aim – Case Study of Just In Time (JIT) Manufacturing – Toyota Production System (TPS)**

Toyota developed the Toyota production system (TPS). TPS borrowed ideas from ford but developed the just in time philosophy (JIT) pull concept to address the issues or high cost associated with fords large inventories. The Toyota production system in an integrated system, that comprises of its management philosophy and practices.




## House of quality

Toyota visualized its values, principals way of working and the ,most important tools in the Toyota house of quality, the roof of the house expresses the goals of the organization (best quality - lowest cost-shortest lead time-best safely- high morale). The foundation of the house addresses the principles, followed by number conditions that are always needed. Here you can find standardized work and visual management. There are two pillars. The first pillar is called Jidoka and is about building in quality thaw second pillar is called Just In Time and inclines a number of logistical principles and tools. In the centre of the house you will find the continuous effort of improving the organization.

## SEVEN WASTES

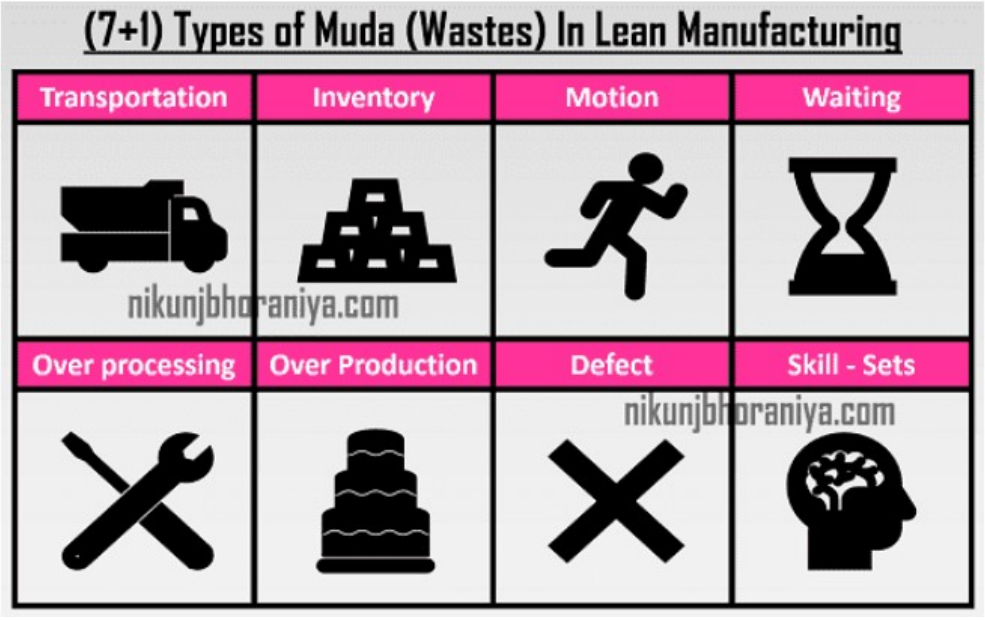
### What is Muda?

→ Muda means waste or we can say that any activity that consumes resources but not creating value for the organization or customer.

### 7 Types of Muda (Wastes) In Lean Manufacturing

→ The 7 types of Muda in lean manufacturing are mentioned below.

→ Refer to this article for a detailed presentation with the infographics of 7 Types of Wastes in Lean Manufacturing.



→ Nowadays one more waste is added into muda that is un-utilized talent or skill set.

- Transportation
- Inventory
- Motion or Movement loss
- Waiting
- Overprocessing
- Overproduction
- Defective Parts

→ We can eliminate all these wastes with the help of Various Kaizen Activities.

## What is Mura?

→ Mura means unevenness in any process or schedule.

→ Unevenness can be eliminated by Line Balancing or Level Scheduling for any process.

→ We can also say mura means variation or fluctuation in any process.

→ Sometimes there are many fluctuations in product demand so it will directly reflect on the production planning fluctuations. This is the very basic example of Mura.

➡ Refer to the below basic examples of Mura

⇢ Uneven Customer Demand

⇢ Uneven Production Speed

⇢ Uneven Work Load Distribution

⇢ Product Quality is not consistent

## What is Muri?

→ Muri means overburden on the equipment or on the person.

→ In other words, we can say that if we are running equipment on a higher load for a long time that is called overburden or muri.

→ Also, if we tell the operator to work long period of time without taking any breaks that are also overburdened.

→ We can see this kind of wastes when the product demand is increased at that time machine and operators are working on overburden like in extra shift.

→ So it will create the problems like breakdowns, defect generation, etc.

➡ Refer to the below basic examples of Muri

⇢ Working in overtime or for a longer time due to uneven customer demand

⇢ Noise level is very high in the working area

⇢ The machine is running out of capacity due to high customer demand

⇢ Overloading of truck

## Example of Muda Mura Muri Wastes:

→ Let us take one real-life example for understanding this concept.

→ One logistic company needs to transport 6000kg of material from Location A to B.

→ So there are many transportation scenarios that are possible, out of that we will take three different cases for understanding the concept.

**Case 01:**

→ Transportation company load 6000kg material in a truck and make a single trip.

→ But the truck's load caring capacity is 3000kg.

→ So it is Muri types of waste. It is overburdened on the truck.

→ So truck might be leading to breakdowns.

**Case 02:**

→ We can take a second case If the truck makes two trips of 2000kg in the first trip and the second trip of 4000kg.

→ This is the case of Mura because there is the unevenness of materials arriving at the destination location.

→ Due to the unevenness of material sometimes it creates problems of handling and storage.

→ Also, it is an example of Muri - overburden on an operator to multiple time loading and unloading activity need to do that is due to two trips instead of a single trip.

→ So these wastes are not adding any value to the supplier or customer.

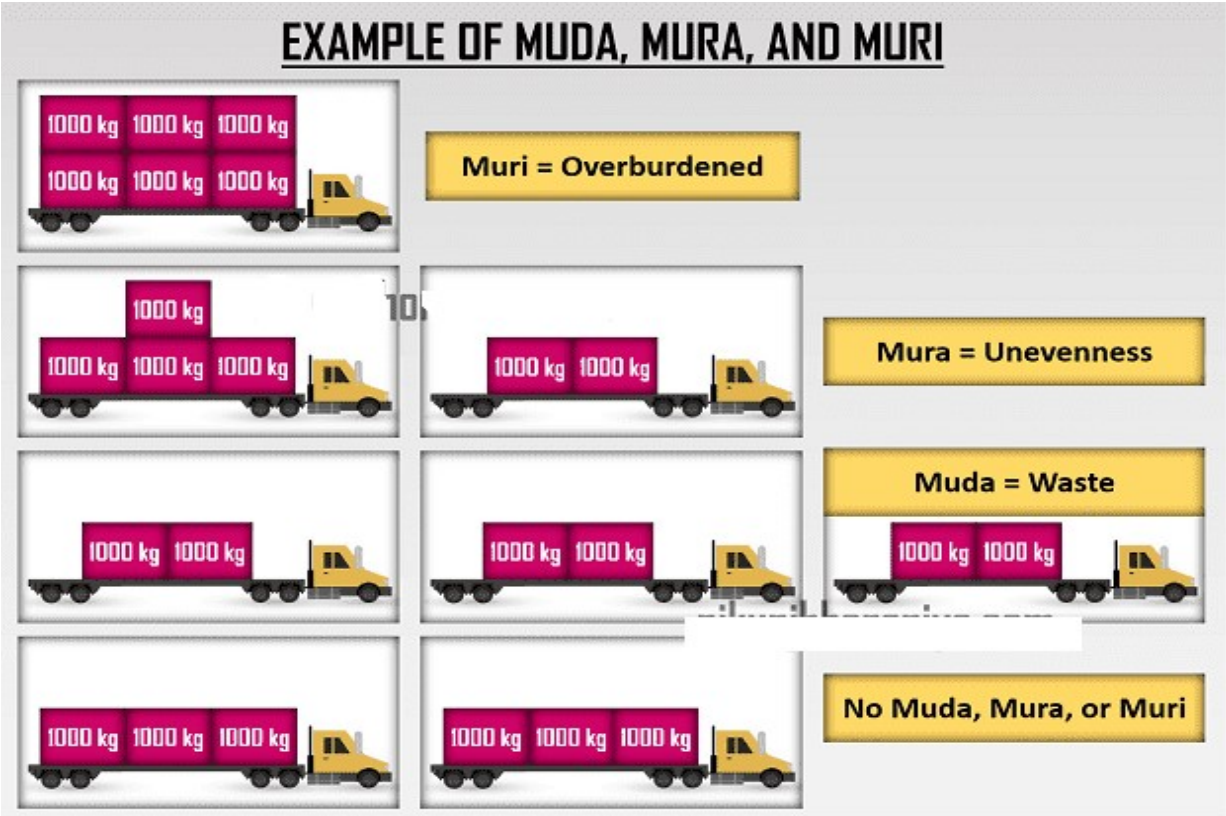
**Case 03:**

→ In the third case, we make three trips of loading 2000kg material on a single trip.

→ So this is an example of underloading of trucks.

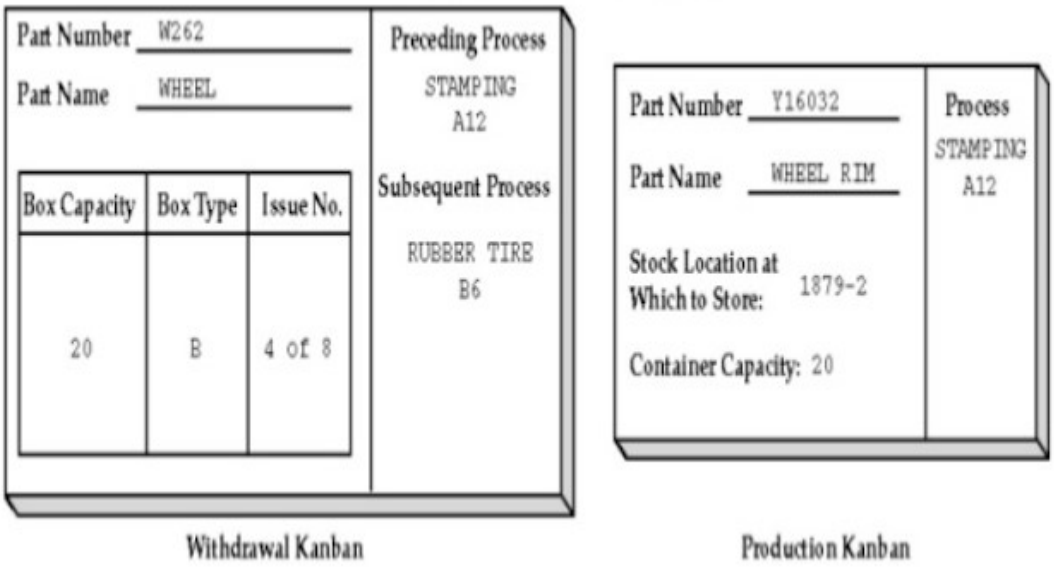
→ So it is a Muda means waste.

→ The only way to eliminate all types of waste we need to arrange two trucks having a capacity of 3000kg and make two trips of 3000kg each.

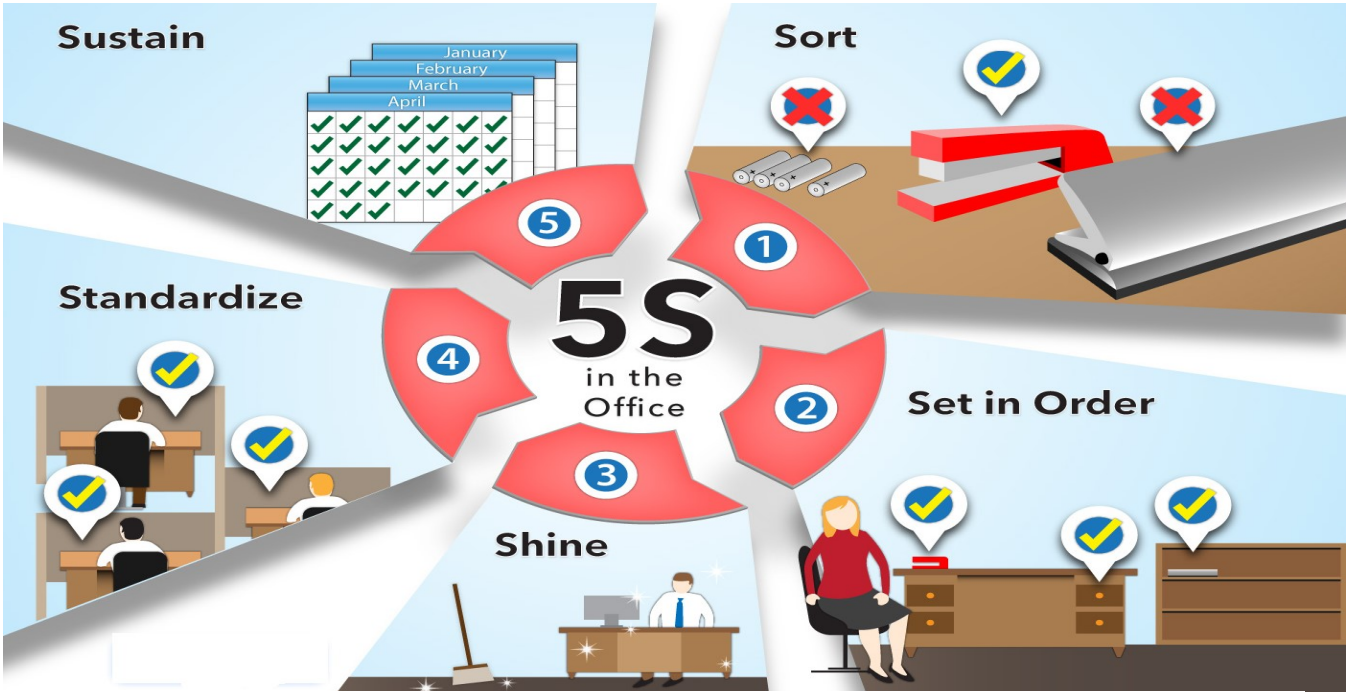



1. **Production Kanban**: For signaling production, and includes everything that a Withdrawal Kanban has
    1. materials required as inputs at the preceding stage
    2. parts required as inputs at the preceding stage

2. **Withdrawal Kanban**: For specifying delivery that is needed, including
    1. part number
    2. part name
    3. lot size
    4. routing process
    5. name of the next process
    6. location of the next process
    7. name of the preceding process
    8. location of the preceding process
    9. container type
    10. container capacity
    11. number of containers released

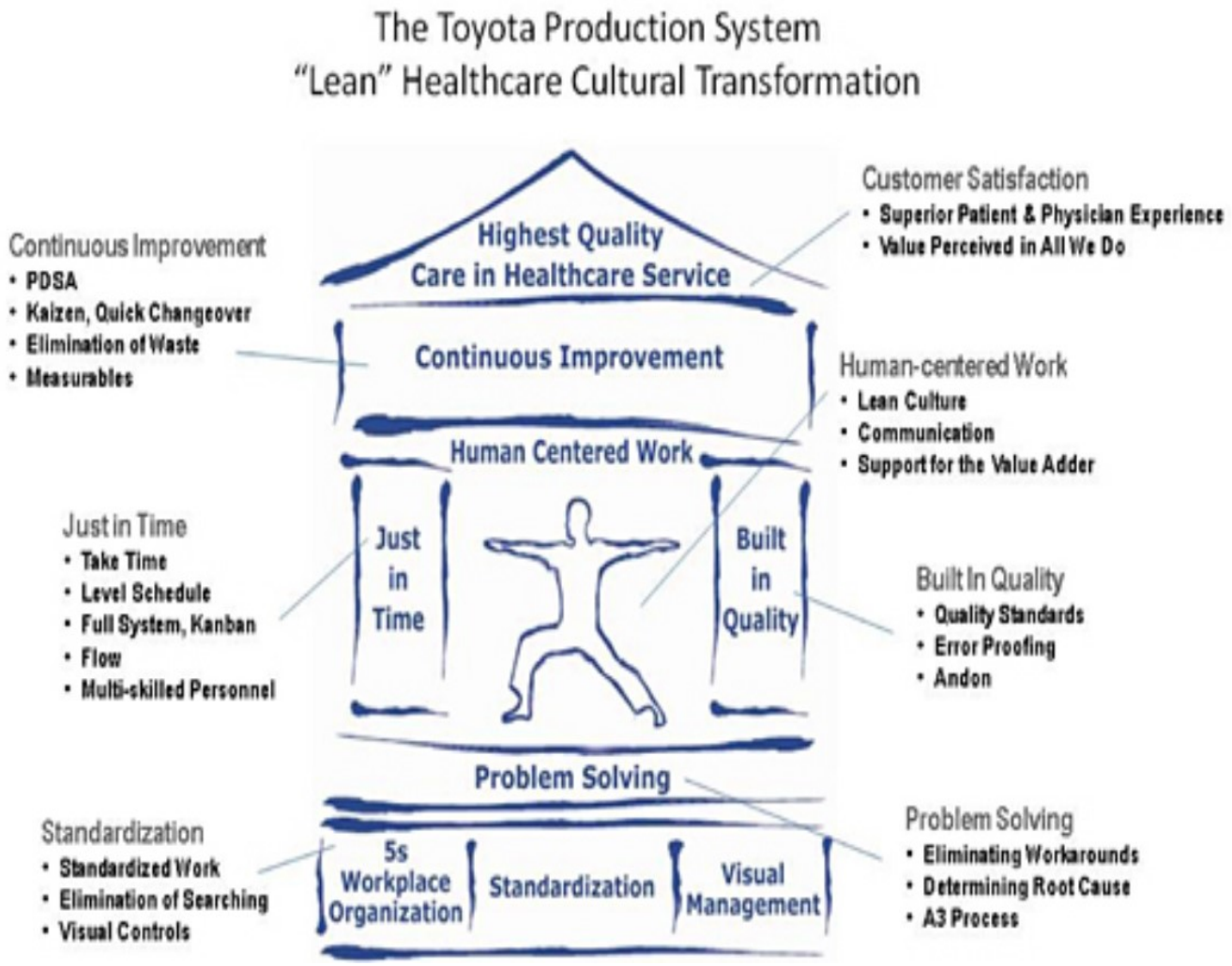



## 5 S - Workplace Organization Tool




1. **Sort:** Remove all unneeded items from the workplace.
2. **Set In Order:** Make a place for everything and put everything in its' place.
3. **Shine:** Thoroughly clean and inspect everything in the work area (preventative cleaning also applies).
4. **Standardize:** Maintain the improvements through discipline and structure.
5. **Sustain:** Continue to support 5S efforts through auditing, job descriptions that include maintenance of the system, management support and expectations, etc.

## EXAMPLE – 2 – Health Care System at Toyota Production System




The Toyota Production System is a human-centered (versus tool-based) business performance improvement process that enables organizations to minimize waste and errors while optimizing performance and quality.

Like many quality solutions, TPS strives for the complete elimination of waste. Though many consider TPS synonymous with lean manufacturing systems (Lean) or just-in-time (JIT) systems, it is not. While Lean/JIT solutions revolve around a set of select applications or tactical tools that facilitate waste reduction and mandate organizational change, the Toyota Production System is a complete management system that focuses on people and on improving *how they work together* to reduce waste. TPS methodologies focus on every facet and all aspects of the value stream or patient/care provider experience. TPS — based strategies and solutions offer uniquely systemic and sustainable transformations at all levels of a healthcare organization And though instituting a TPS-based transformation requires an initial investment by healthcare providers, TPS advocates insist

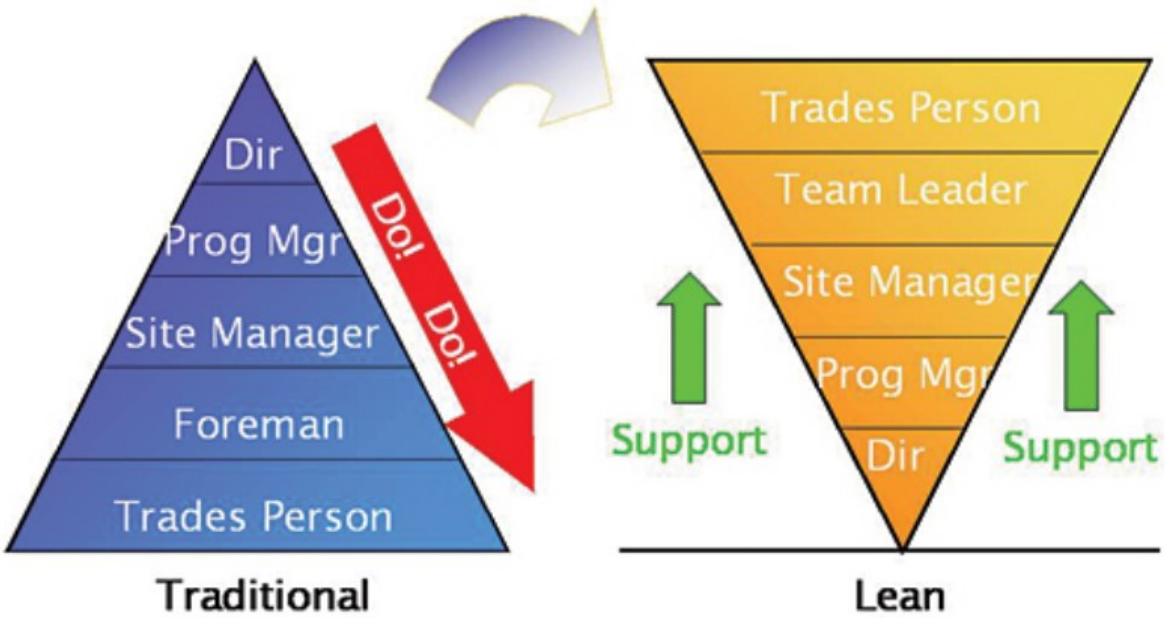
that the rewards outweigh the drawbacks; the initial investment is typically recouped within the first year. They claim that implementing these solutions now will ensure hospitals and other healthcare providers ride out the healthcare revolution — and improve the quality of care in the process, ensuring systemic, sustainable improvement.

**How TPS Works**

By focusing on people and processes instead of tools and technologies, TPS offers healthcare providers and their staff the flexibility they need to respond to daily changes that emerge due to regulations, patient conditions, market conditions, and more.

Where many quality solutions are essentially executive directives, with TPS, individuals and teams within the healthcare organization drive the TPS transformation. Participants identify and implement the tools and procedures that they determine will minimize waste and errors and improve the "flow" or smoothness of their work.

Human Centered Behavior

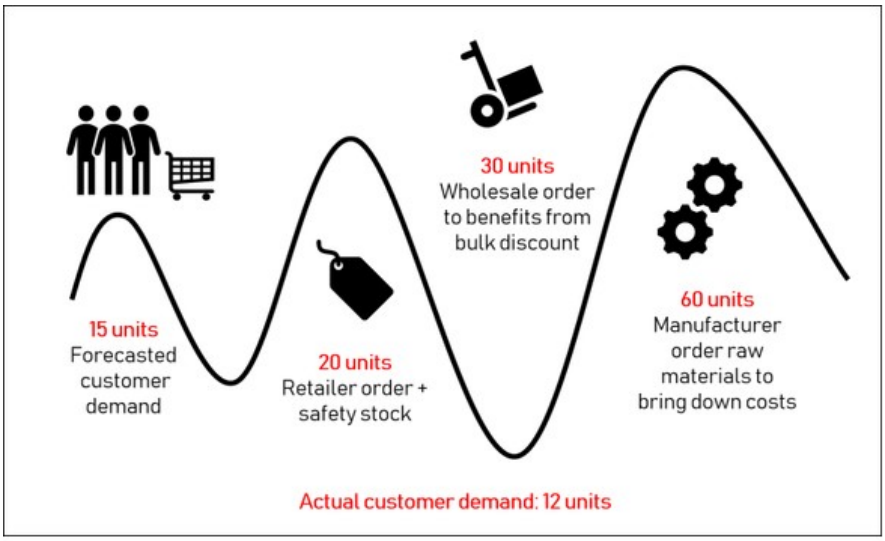



The focus of every process, investment, decision, and change is on establishing or improving the way that individuals closest to the patient are able to serve them. In implementations, the organization develops a system that makes problems readily apparent and then provides employees with the tools to identify and eliminate them. In healthcare this means first understanding what the patient needs, then rallying around those who provide patient services, and giving them the facilities, processes, systems, and leadership support they need to deliver this to every patient, every day.

## Experiment No.-7

**Aim – Study on Bullwhip Effect, Risk Pooling and Green Supply Chains**

# Bullwhip Effect


The bullwhip effect is a supply chain phenomenon describing how small fluctuations in demand at the retail level can cause progressively larger fluctuations in demand at the wholesale, distributor, manufacturer, and raw material supplier levels. The effect is named after the physics involved in cracking a whip. A change in any link along the supply chain can profoundly affect the rest of the supply chain. The bullwhip effect can be costly to all the organizations in the supply chain.

Excess inventory can result in waste, while insufficient inventory can lead to reduced lead time, poor customer experience, and lost business.

**Example: During COVID_19 (Egg supply):**

As economies went into lockdown and consumers flocked to stock up on essentials, one item in Singapore was overwhelmingly in demand in eggs For periods in March and April, they were frequently missing from grocery shelves, both digital and in-store. Distributors in the import-dependent city-state scrambled to increase their stocks.

Fast forward to June, when distributors had to throw away more than 250,000 eggs due to oversupply. Here is how the bullwhip effect can unfurl: Consumers jump to the conclusion that there is a shortage of goods, the moment they see empty shelves, even though the supply chain might still be functioning smoothly. Seeing the spike in demand, retailers then place more orders. That, in turn, forces distributors to request an increase in production.

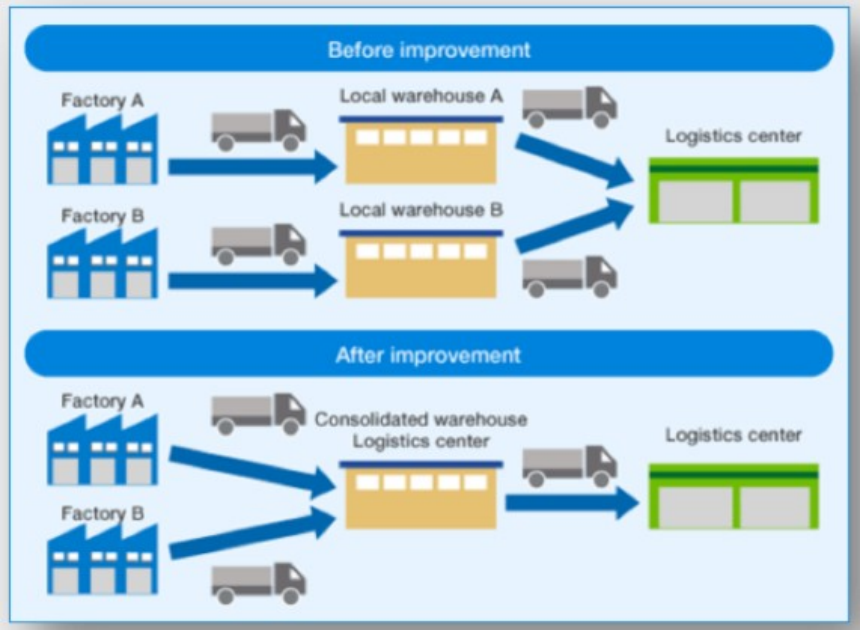
There is distortion in the signal which goes all the way upstream to the supplier of raw material. This impacts logistics as warehouses are unable to cope with extra volume that has not been matched by sales, leading to obsolete and excess stock.

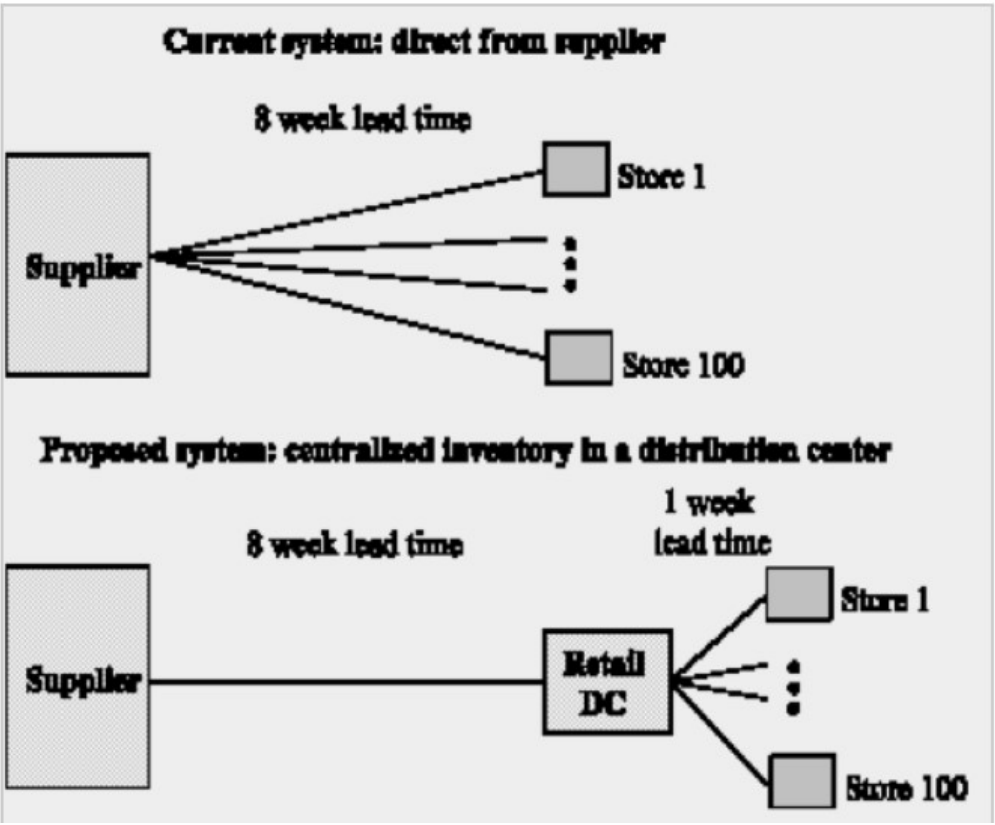
The core problem is companies' inability to make accurate forecasts in a volatile environment. This was especially true this year. There was hardly a modern precedent for the pandemic, and so no historical data on which firms could rely.

## Risk Pooling

One of the proposed solutions to small businesses is to use the inventory pooling strategy, which can increase the company's service level and reduce its supply chain (SC) costs. The increase in the service level (Z value) and the reduction in the SC costs are affected by the number of consolidated inventories and distribution centers (DCs) Consolidation can work efficiently with large-scale companies due to their large demand, but can also work for small business if they shared their inventories and DCs with other businesses.

Another huge benefit offered by the inventory pooling strategy is the shorter lead-time resulted from the consolidation. To illustrate, when many grocery businesses consolidate their inventories and DCs into a centralized one, this will result in a inventory with great capacity that is able to order a batch size every week or so. This allows the business to get their ordered products from the centralized inventory at the same day, rather than waiting for the shipment to arrive from the main supplier, which may take couple of weeks.

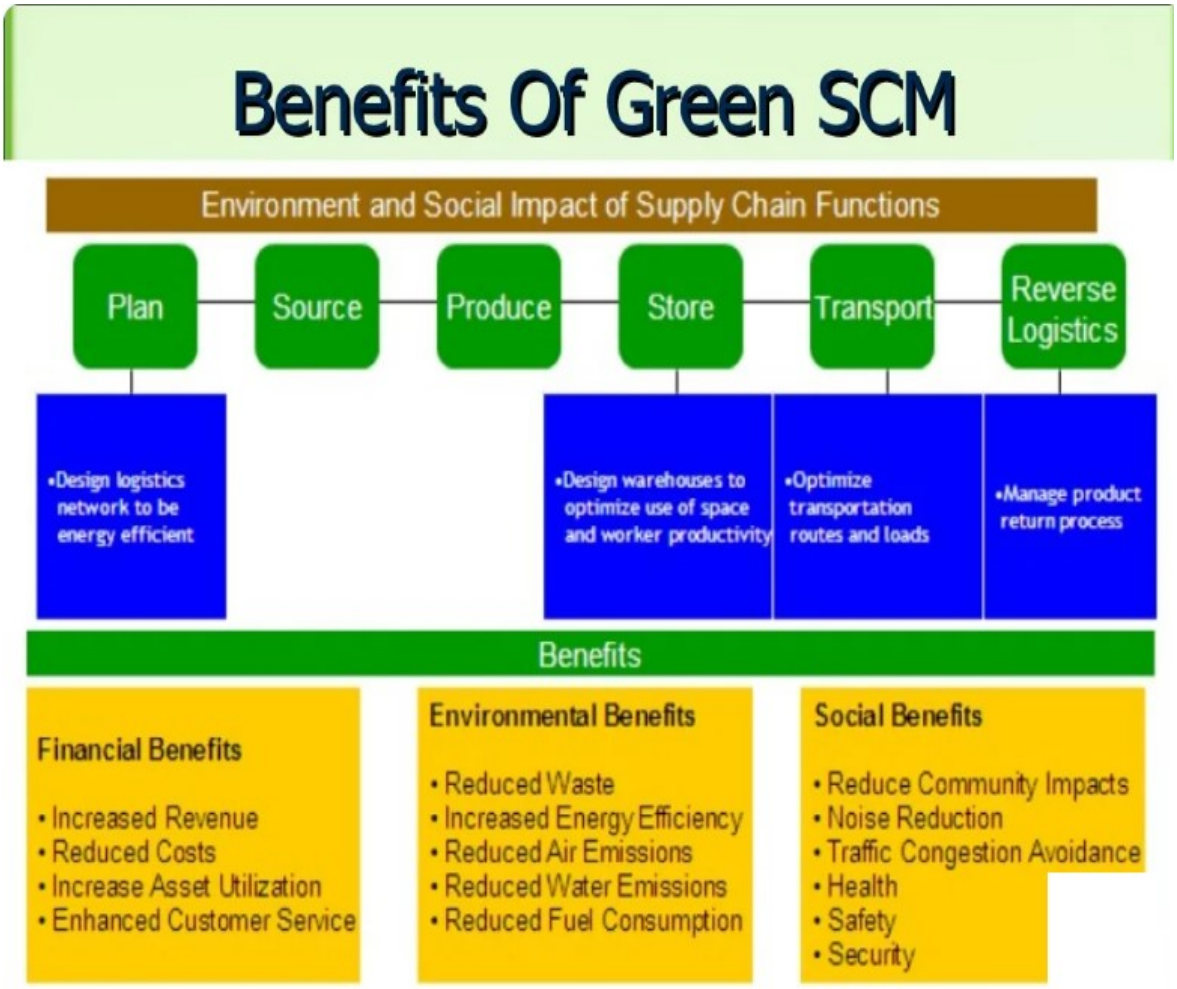

Before improvement
Factory A
Local warehouse A
Logistics center
Factory B
Local warehouse B
After improvement
Factory A
Consolidated warehouse
Logistics center
Logistics center
Factory B

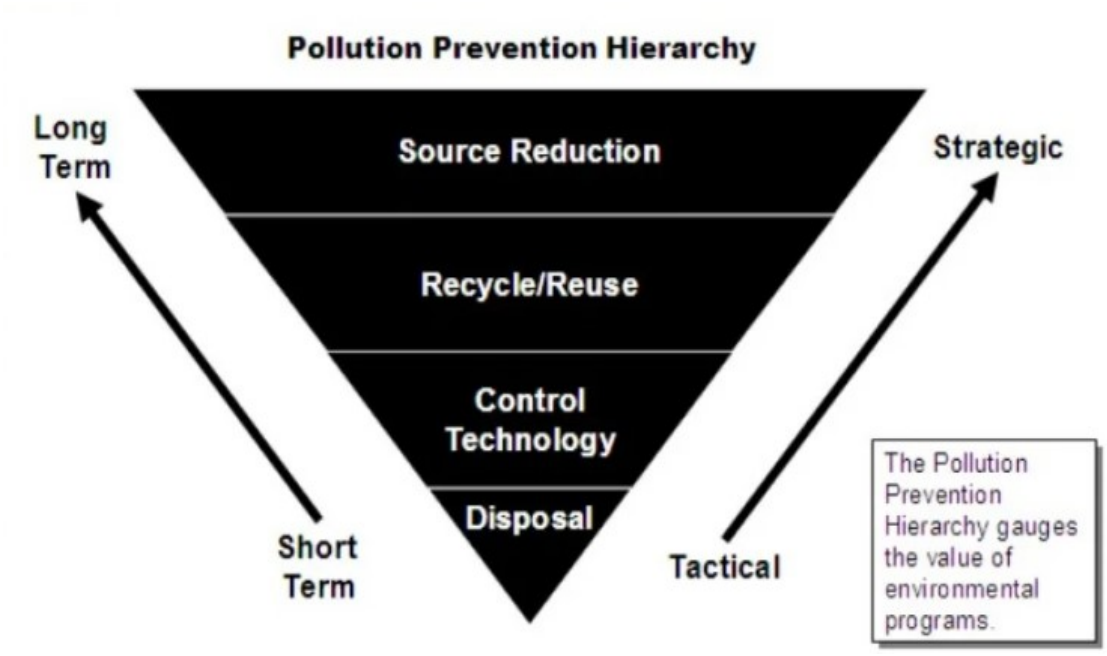

Current system: direct from supplier
8 week lead time
Supplier
Store 1
Store 100
Proposed system: centralized inventory in a distribution center
1 week
lead time
8 week lead time
Supplier
Retail
DC
Store 1
Store 100

# GREEN SUPPLY CHAIN MANAGEMENT

## What is green supply chain management

Integrating environment thinking into supply chain management, including product design, material Sourcing and selection, manufacturing processes, delivery of the final product to the consumer and end of life management of the product after its useful life






## Areas to Green the supply chain

1. Designing of products
2. Production
3. Material purchase
4. Packaging
5. Logistics and reverse Logistics

### 1. Designing of products

An eco-friendly design approach leads

- ✓ Less material usage
- ✓ Minimum operations
- ✓ Proper use of computational fluid dynamic Scan used to reduce the exhaust emissions are designing level

### 2. Production

- ✓ Achieving economies of scale in production
- ✓ Lean manufacturing approach
- ✓ Fuel efficient tools and machines
- ✓ Selecting less carbon intensive energy sources

### 3. Material Purchase

- ✓ Implementing green purchase policies
- ✓ Technical support to vendors to reduce the emission
- ✓ Guidelines for usage of less hazardous of materials

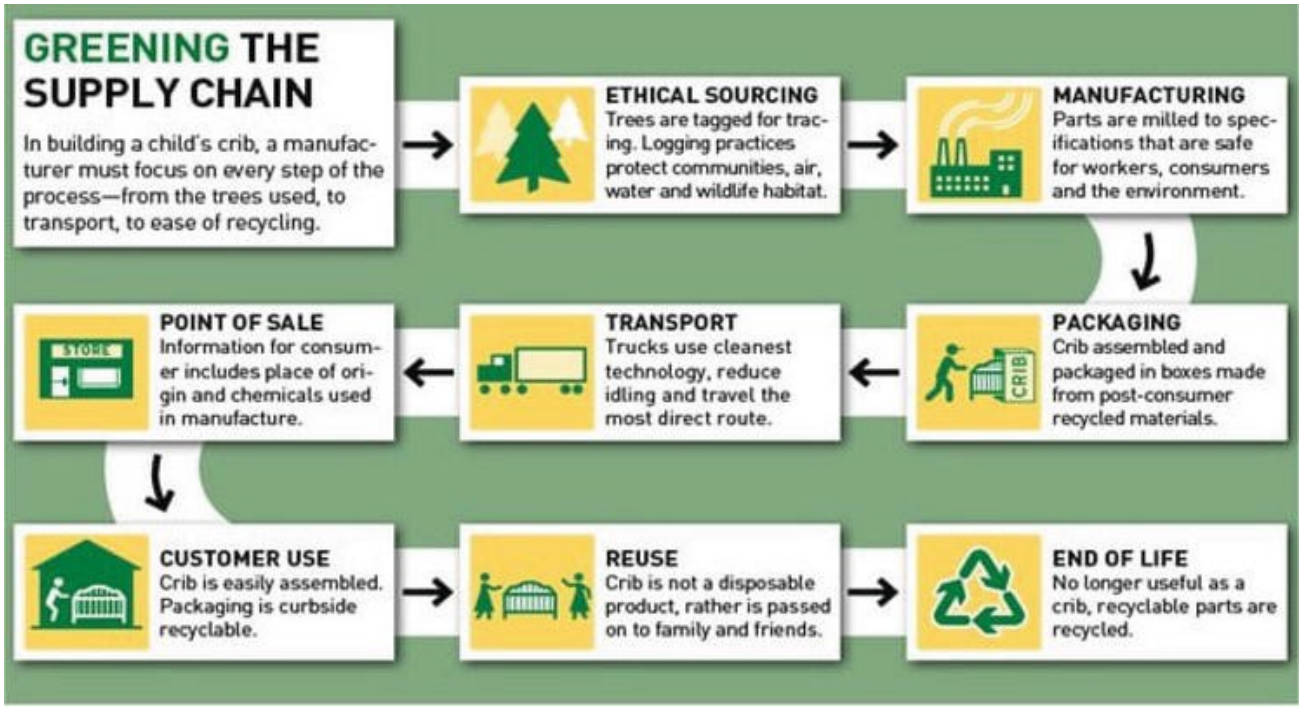
### 4. Packaging

- ✓ Mercury free
- ✓ Non toxic( minimized toxicity)
- ✓ PVC or DEHP free
- ✓ Recyclability
- ✓ Hazardous waste considerations
- ✓ Durability/reusability
- ✓ Energy efficient

### 5. Logistics

- ✓ Optimizer truck loads
- ✓ Direct shipment to the customer
- ✓ Routing of distribution
- ✓ Reverse Logistics

## Green supply chain of child's crib manufacturer



# Experiment No.-8

**Aim - Study on Information Technology: A Supply Chain Enabler –**

**- Barcode,**

**- Radio Frequency Identification (RFID),**

**- Build-To-Order (BTO)**

Information of the supply chain is the essential link between all supply chain processes and members. Computer and information technology allows real-time, online communications throughout the supply chain. Technologies that enable the efficient flow of products and services through the supply chain are referred to as "enablers," and information technology has become the most important enabler of effective supply chain management. Supply chain managers like to use the phrase "in modern supply chain management, information replaces inventory." Although this statement is not literally true companies need inventory at some point, not just information—information does change the way supply chains are managed, and these changes can lead to lower inventories. Without information technology supply chain management would not be possible at the level it is currently being accomplished on a global basis. Some of the more important IT supply chain enablers are shown in Figure 1

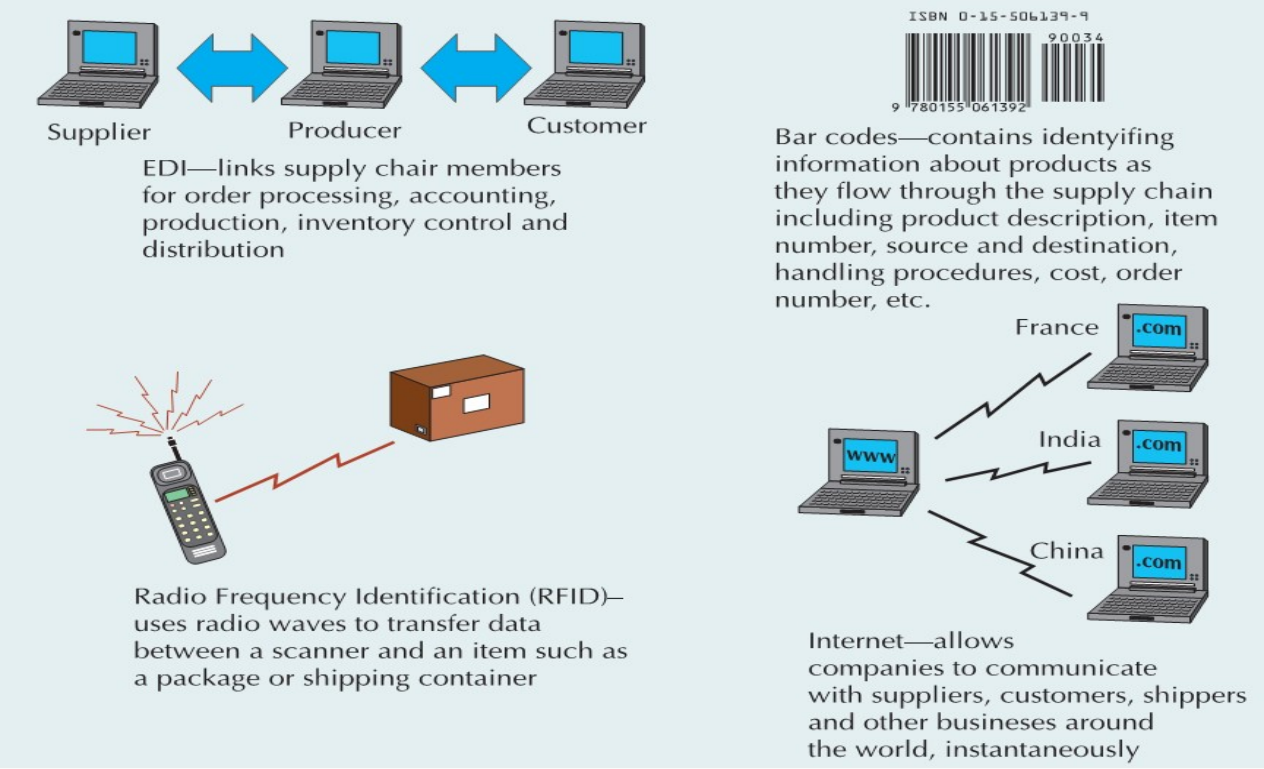



Fig 1 - Important IT supply chain enablers

# BAR CODES

A bar code is what is referred to as an "automated data collection" system, or "auto-ID." In barcoding, computer-readable codes are attached to items flowing through the supply chain, including products, containers, packages and even vehicles. The bar code contains identifying information about the item. It might include such things as a product description, item number, its source and destination, special handling procedures, cost, and order number. A food product can be identified down to the farmer who grew it and the field it was grown in. When the bar code information is scanned into a company's computer by an electronic scanner, it provides supply chain members with critical information about the item's location in the supply chain.

Bar code technology has had a huge influence on supply chain management, and it is used by thousands of companies in different situations. Package delivery companies like FedEx and UPS use bar codes to provide themselves and customers with instantaneous detailed tracking information. Supermarkets use scanners at cash registers to read prices, products, and manufacturers from Universal Product Codes (UPCs).

When bar codes are scanned at checkout counters, it also creates point-of-sale data—an instantaneous computer record of the sale of a product. This piece of information can be instantly transmitted throughout the supply chain to update inventory records. Point-of-sale data enable supply chain members - suppliers, producers and distributors—to quickly identify trends, order parts and materials, schedule orders and production and plan for deliveries.

Initially, barcodes represented data by varying the widths and spacings of parallel lines. These barcodes, now commonly referred to as linear or one-dimensional (1D), can be scanned by special Optical Scanners, called barcode readers, of which there are several types. Later, two-dimensional (2D) variants were developed, using rectangles, dots, hexagons and other patterns, called matrix codes or 2D barcodes, although they do not use bars as such. 2D barcodes can be read using purpose-built 2D optical scanners, which exist in a few different forms 2D barcodes can also be read by a digital camera connected to a microcomputer running software that takes a photographic image of the barcode and analyses the image to deconstruct and decode the 2D barcode. A mobile device with an inbuilt camera, such as smartphone, can function as the latter type of 2D barcode reader using specialized application software.

## Structure of Barcode:

A typical barcode consists of the following:

**Quiet Zone -** The minimum required space for bar codes scan-ability, preceding the Start Character of a bar code symbol. The quiet zone should be free from any printing and be the same colour and reflectance as the background of bar code symbol. The Quiet Zone should be ten times the width of the narrowest element in the bar code, or 0.25 inch minimum. Also known as Clear Area.

**Start Code -** Indicates the start of the barcode. These are special bar code characters & they signify the start of data to the scanner/reader. Start characters are usually stripped off and not transmitted to the host.

**Data -** The actual data barcode stores.

**Check Digit** - Check digit (not always present) is a mathematical sum that is used to verify the accuracy of the other elements of the barcode. It is the extra digit added at the end of a barcode to allow the scanner to confirm that it read the bar code correctly.

It is typically stripped from the data and not transmitted to the host.

Stop Code Indicates the stopping point of the barcode. These characters signify the end of data to the scanner/reader. They are also stripped off and not transmitted to the host.

**Trailing Quiet Zone -** Another clear space with no printing following the stop Character.

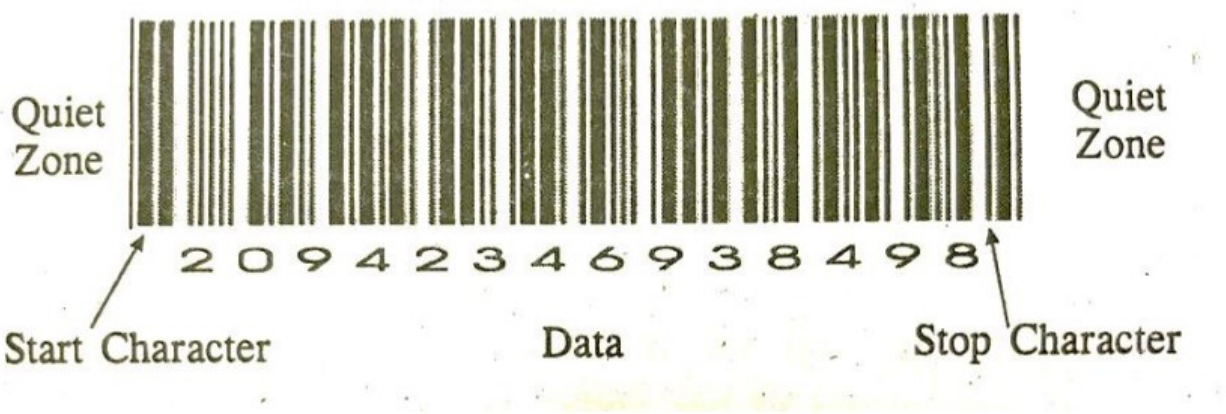
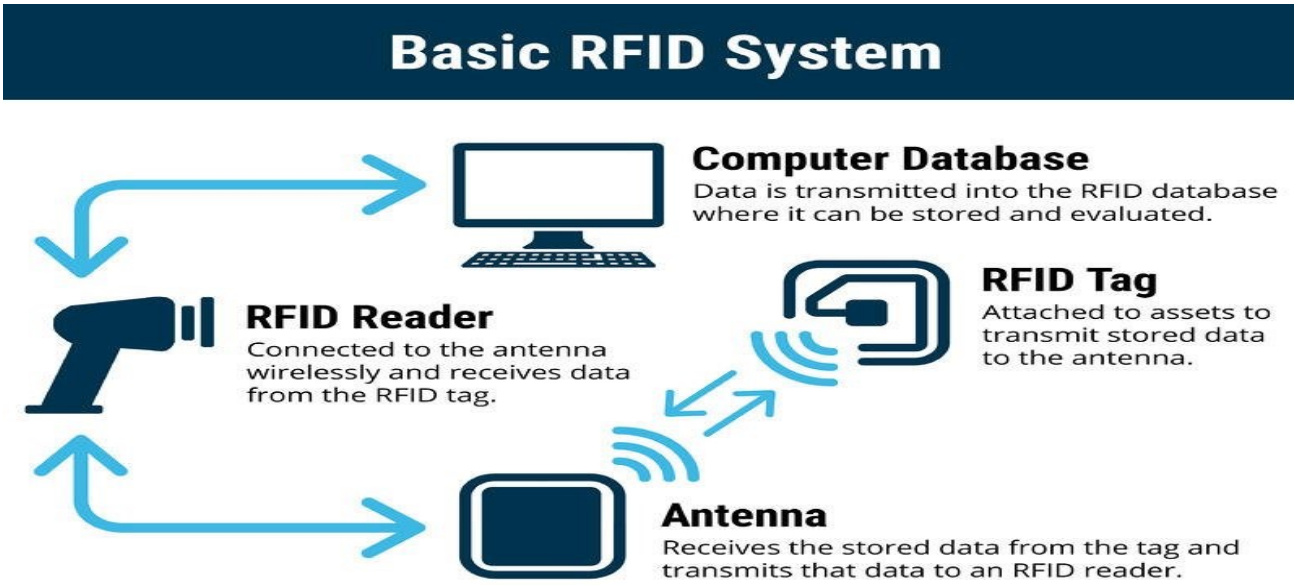



**Diagram illustrating structure of Barcode**

## Radio Frequency Identification (RFID)

While a barcode is the most commonly used auto-ID system, a more technologically advanced system is radio frequency identification (RFID). RFID technology uses radio waves to transfer data between a reader, (that is, a scanner), and an item such as a shipping container or a carton. RFID consists of a tiny microchip and computer, often a small, thin ribbon, which can be put in almost any form—for example between layers of cardboard in a box, or on a piece of tape or a label. An RFID "tag" stores a unique identification number. RFID scanners transmit a radio signal via an antenna to "access" the tag, which then responds with its number. The tag could be an Electronic Product Code (EPC), which could be linked to databases with detailed information about a product item. Unlike bar codes, RFID tags do not need a direct "line of sight" to read, and many tag can be read simultaneously over a long distance.




RFID has a number of advantages over barcodes. RFID tags do not need a direct "line of sight" to read, and many tags can be read simultaneously over a long distance. When products arrive at a location, such as a retail store, shipping dock, or warehouse, each barcode has to be scanned individually, whereas RFID readers placed at an entry site (like a door) can automatically scan a whole pallet of different products automatically and instantaneously. As such, RFID provides complete visibility of product location, is faster, reduces labor usage, and is more accurate than barcodes. With barcodes it is difficult to know how much product is in a store; however, RFID readers inside a store (or warehouse) can continuously monitor what is available, and when the inventory reaches a certain level it can be reordered. When items are stored in a warehouse, the barcode on the item to be stored has to be scanned as well as the barcode fixed to the location; however, RFID eliminates these steps.

In a global supply chain RFID tags make it possible for a supplier or retailer to know automatically what goods they have and where they are around the world. For example, a retailer could distinguish between three cartons of the same product and know that one was in the warehouse in Asia, one was in the store, and one was in ocean transit, which would speed up product location, delivery, and replenishment. Figure 10.6 shows some of the advantages RFID provides. RFID technology also has obvious security benefits by being able to identify all items being shipped into the United States on an airplane or a ship.

Walmart has mandated that its top suppliers put RFID tags carrying EPC codes on pallets and cases, and Kroger, Target, and CVS are doing the same. Walmart estimates that the following benefits will result from RFID:

a. Labor to scan barcodes on cases and pallets will be eliminated.

b. On-shelf monitoring will decrease stock-outs in stores.

c. Prevention of product shrinkage, vendor fraud, and theft.

d. Decreased distribution center costs by tracking over 1 billion pallets annually.

e. Provide inventory visibility enabling a 20% reduction in inventory levels.

f. Savings of over $8 billion per year.

However, RFID technology does have some disadvantages. RFID technology is not yet standardized, which makes it difficult to track items that move from one system to another. Using RFID is more costly than using barcodes: individual RFID tags are expensive relative to barcodes, and the readers are costly. It has been estimated that it costs more than $2 million to RFID-enable a typical warehouse. As a result, it is likely that both barcodes and RFID will be used by companies for supply chain management for years to come.

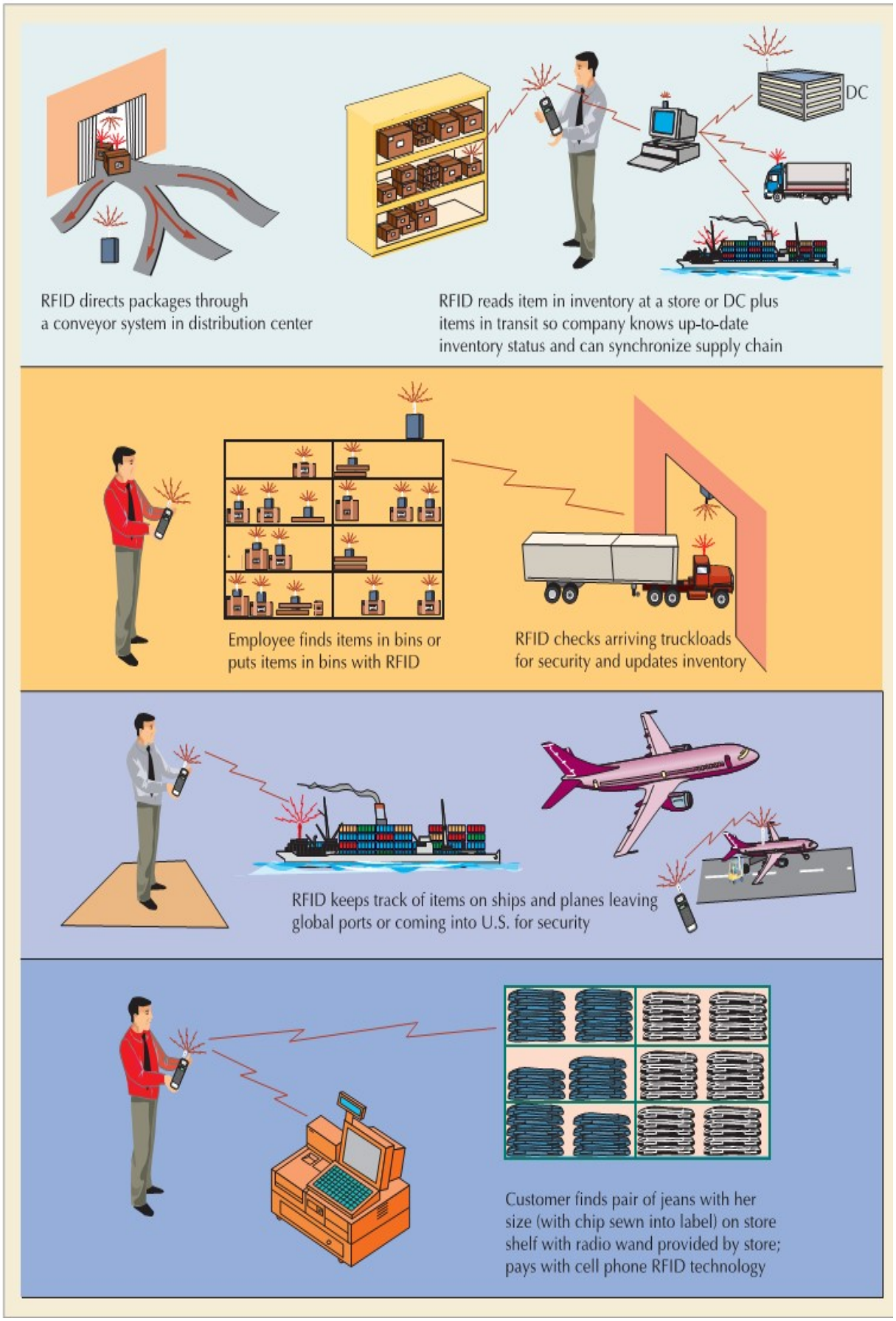



Fig -2 – RFID Capabilities

## Build-To-Order (BTO)

Build to order is a methodology and manufacturing practice where a product is created once a confirmed order is received. The build to order process is critical to avoid creating expensive products that may not sell and to avoid tying up capital in inventory.


Dell was the first computer company to move to a direct-sell-to-customers model over the Internet. Its popular build-to-order (BTO) models were initially based on telephone orders by customers. Dell created an efficient supply chain using a huge number of weekly purchase orders faxed to suppliers. However, Dell now sends out orders to suppliers over the Internet every few hours or less. Dell's suppliers are able to access the company's inventories and production plans, and they receive constant feedback on how well they are meeting shipping schedules.

Dell's Web site allows the customer to configure a PC with the desired features; to order and track the order status, allowing the customer to follow their purchase in real time from order to delivery; and to be notified by e-mail as soon as the order is shipped. Also, Dell created secure private sites for corporate and public sector customers to provide access to service and support information customized to the customer's products. In addition, Dell provides online access to technical reference materials and self-diagnostic tools that include symptom-specific troubleshooting modules that walk customers interactively through common systems problems.

## Experiment No. - 9

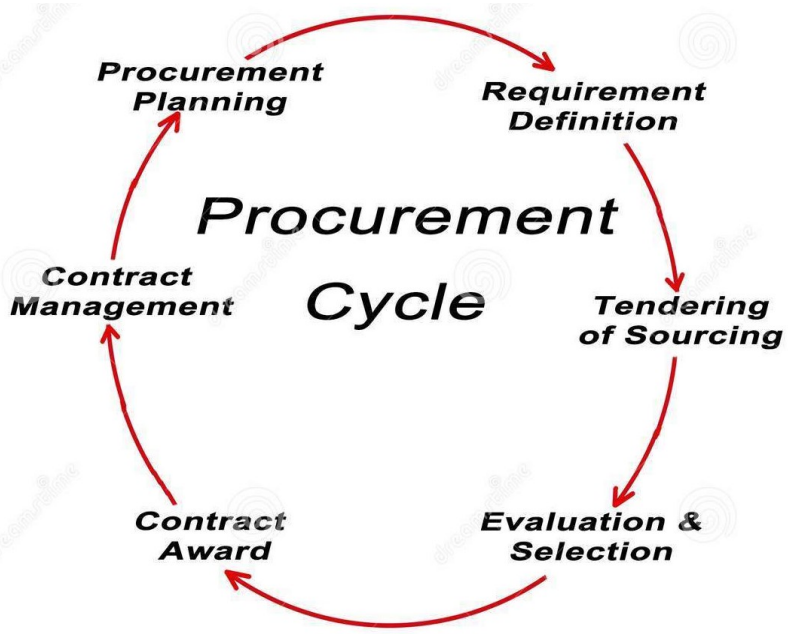
Aim – Study on **Procurement, Outsourcing**

- **E -Procurement,**
- **E-Market places,**
- **ERP (Enterprise Resource Planning) Modules**

### ❖ Procurement

Procurement is the term used when a company needs to obtain goods or services from a third party, such as vendors or suppliers. Procurement should be done in such a way that the goods and sources purchased are of high quality while also keeping costs in mind.

Procurement is the act of obtaining goods or services, typically for business purposes. Procurement is most commonly associated with businesses because companies need to solicit services or purchase goods, usually on a relatively large scale.




A key element in the development of a successful partnership between a company and a supplier is the establishment of linkages. The most important linkage is information flow; companies and suppliers must communicate—about product demand, about costs, about quality, and so on—in order to coordinate their activities. To facilitate communication and the sharing of information many companies use teams. Cross-enterprise teams coordinate processes between a company and its supplier.

## ❖ Outsourcing

The selection of suppliers is called sourcing; suppliers are literally the "source" of supply. Outsourcing is the act of purchasing goods and services that were originally produced in-house from an outside supplier. Outsourcing is nothing new; for decades companies have outsourced as a short-term solution to problems such as an unexpected increase in demand, breakdowns in plants and equipment, testing products, or a temporary lack of plant capacity. However, outsourcing has become a long-term strategic decision instead of simply a short-term tactical one. Companies, especially large, multinational companies, are moving more production, service and inventory functions into the hands of suppliers. Figure 9.1 shows the three major categories of goods and services that companies tend to outsource.

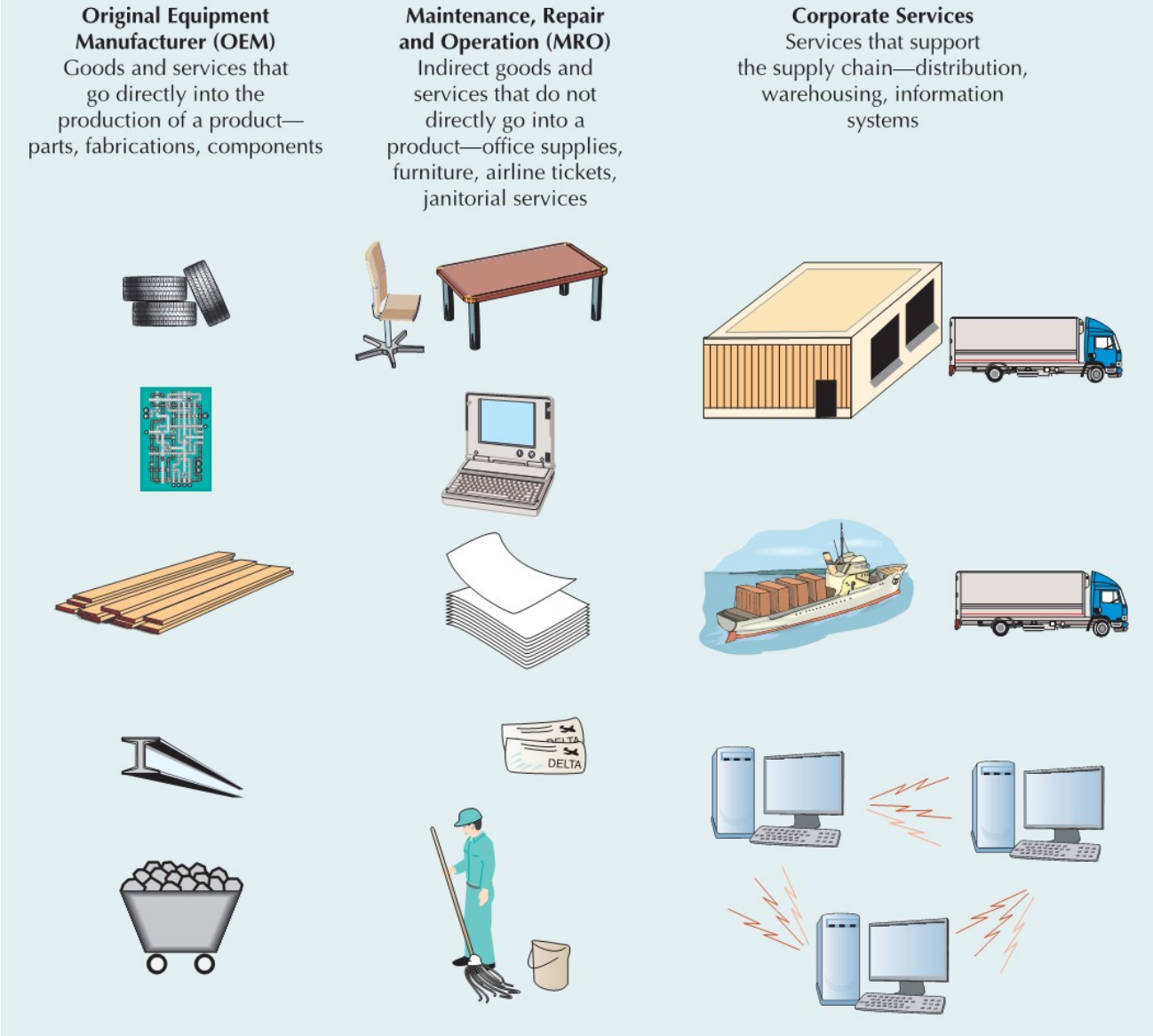



**Figure 9.1 Three major categories of goods and services that companies tend to outsource.**

Many companies are outsourcing as a strategic move so that they can focus more on their core competencies, that is, what they do best. They let a supplier do what the company is not very good at and what the supplier is most competent to do. Traditionally, many companies, especially large ones, attempted to own and operate all of their sources of supply and distribution along the supply chain so that they would have direct managerial control and reduce their dependence on potentially unreliable suppliers. They also thought it was more cost effective. However, this stretched these companies' resources thin, and they discovered they did not have the expertise to do everything well. In addition, management of unwieldy, complex supply chains was often difficult. Large inventories were kept throughout the supply chain to buffer against uncertainties and poor management practices. The recent trend toward outsourcing provides companies with greater flexibility and resources to focus on their own core competencies, and partnering relationships with suppliers provides them with control. In addition, many companies are outsourcing in countries where prices for supply are lower, such as China.

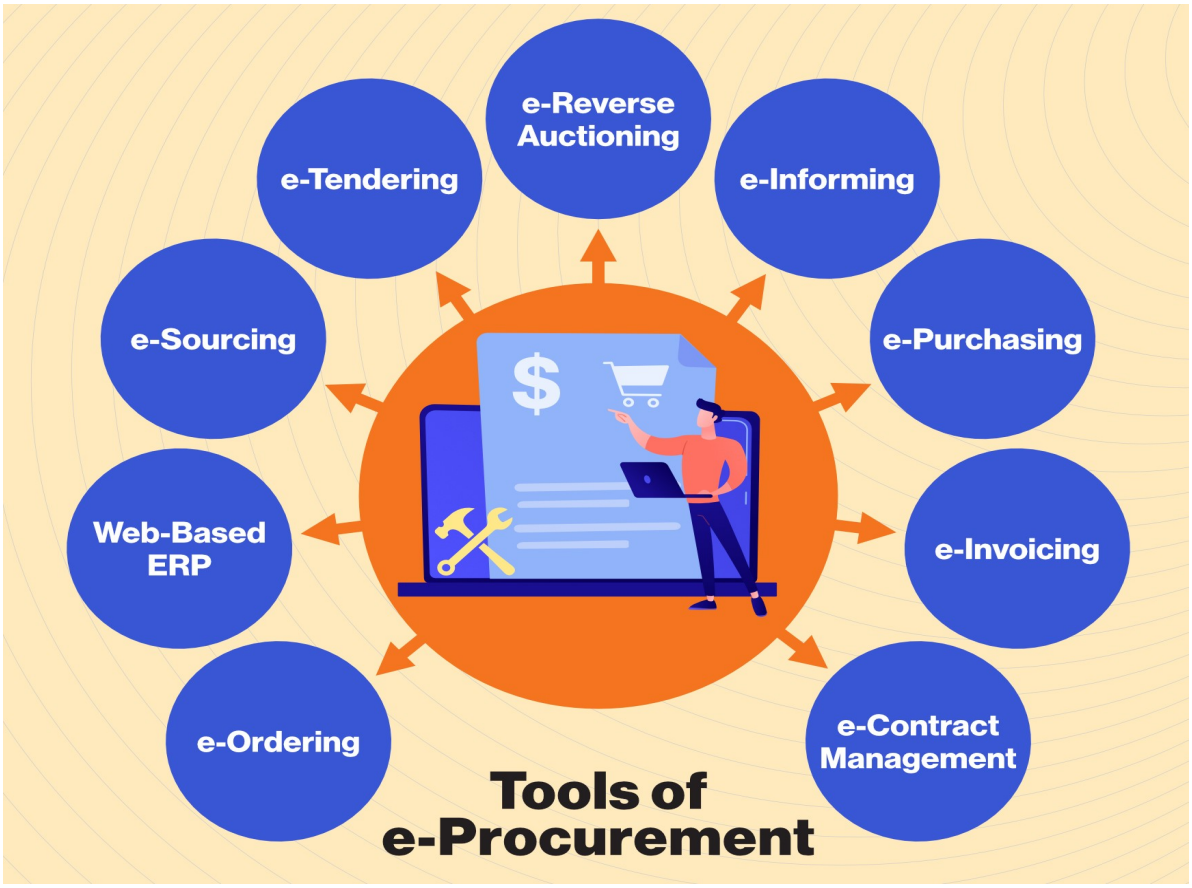
By limiting the numbers of its suppliers a company has more direct influence and control over the quality, cost, and delivery performance of a supplier if the company has a major portion of that supplier's volume of business. The company and supplier enter into a partnership in which the supplier agrees to meet the customer's quality standards for products and services and helps lower the customer's costs. The company can also stipulate delivery schedules from the supplier that enables them to reduce inventory. In return, the company enters into a long-term relationship with the supplier, providing the supplier with security and stability. It may seem that all the benefits of such an arrangement are with the customer, and that is basically true. The customer dictates cost, quality and performance to the supplier. However, the supplier passes similar demands on to its own suppliers and in this manner the entire supply chain can become more efficient and cost effective.

## ❖ E-Procurement

E-Procurement is part of the business-to-business (B2B) commerce being conducted on the Internet, in which buyers make purchases directly from suppliers through their Web sites, by using software packages or through e-marketplaces, e-hubs, and trading exchanges. The Internet can streamline and speed up the purchase order and transaction process from companies. Benefits include lower transaction costs associated with purchasing, lower prices for goods and services, reduced labor (clerical) costs, and faster ordering and delivery times.

What do companies buy over the Internet? Purchases can be classified according to two broad categories: manufacturing inputs (direct products) and operating inputs (indirect products). Direct

products are the raw materials and components that go directly into the production process of a product. Because they tend to be unique to a particular industry, they are usually purchased from industry-specific suppliers and distributors. They also tend to require specialized delivery; UPS does not typically deliver engine blocks. Indirect products do not go directly into the production of finished goods. They are the maintenance, repair, and operation (MRO) goods and services we mentioned previously (Figure 9.1). They tend not to be industry specific; they include things like office supplies, computers, furniture, janitorial services, and airline tickets. As a result they can often be purchased from vendors like Staples, and they can be delivered by services like UPS.



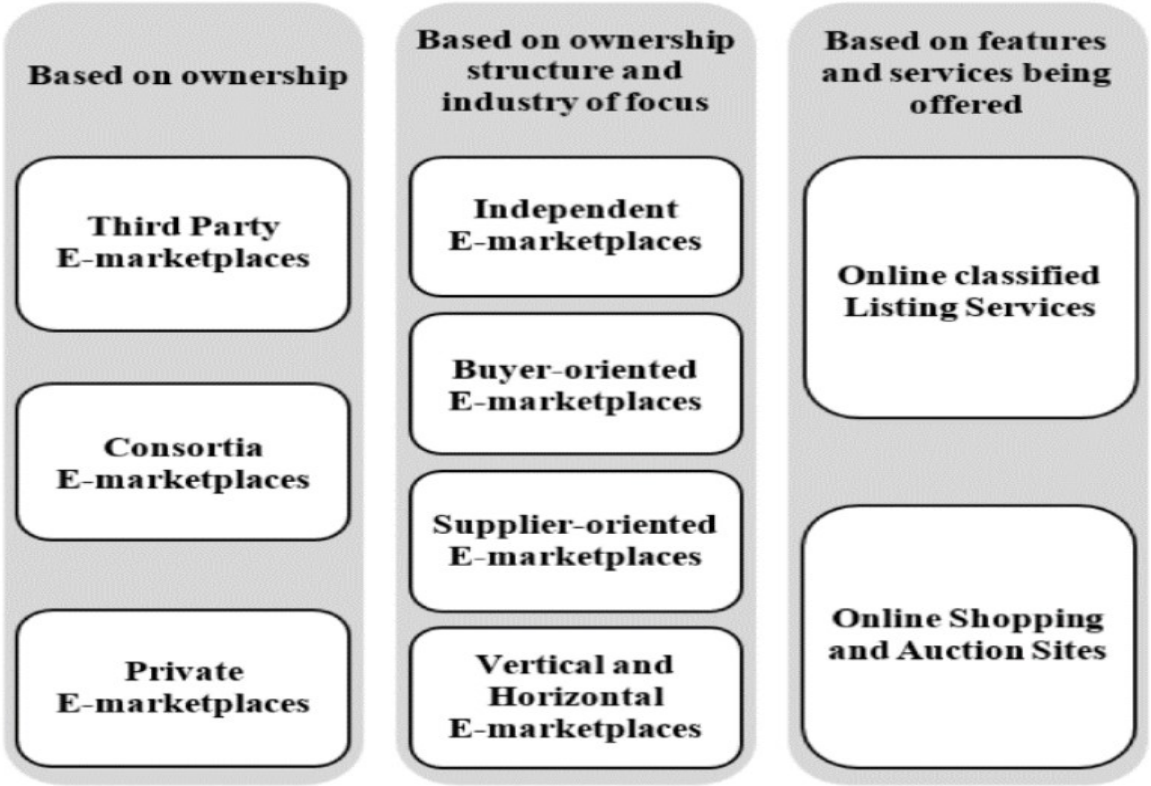

More companies tend to purchase indirect goods and services over the Internet than direct goods. One reason is that a company does not have to be as careful about indirect goods since they typically cost less than direct products and they do not directly affect the quality of the company's own final product. Companies that purchase direct goods over the Internet tend to do so through suppliers with whom they already have an established relationship.

## ❖ E-Market Places

E-marketplaces or e-hubs consolidate suppliers' goods and services at one Internet site like a catalogue. For example, e-hubs for MROs include consolidated catalogues from a wide array of suppliers that enable buyers to purchase low-value goods and services with relatively high transaction costs more cheaply and efficiently over the Internet. E-hubs for direct goods and services are similar in that they bring together groups of suppliers at a few easy-to-use Web sites.

E-marketplaces like Ariba provide a neutral ground on the Internet where companies can streamline supply chains and find new business partners. An e-marketplace also offers services such as online auctions where suppliers bid on order contracts, online product catalogues with multiple supplier listings that generate online purchase orders, and request-for-quote (RFQ) service through which buyers can submit an RFQ for their needs and users can respond.

### Types of E- Market Places



## 1) Independent e-marketplace

An independent e-marketplace is usually a business-to-business online platform operated by a third party which is open to buyers or sellers in a particular industry. By registering on an independent e-marketplace, you can access classified ads or requests for quotations or bids in your industry sector. There will typically be some form of payment required to participate.

## 2) Buyer-oriented e-marketplace

A buyer-oriented e-marketplace is normally run by a consortium of buyers in order to establish an efficient purchasing environment. If you are looking to purchase, participating in this sort of e-marketplace can help you lower your administrative costs and achieve the best price from suppliers. As a supplier you can use a buyer-oriented e-marketplace to advertise your catalogue to a pool of relevant customers who are looking to buy.

## 3) Supplier-oriented e-marketplace

Also known as a supplier directory, this marketplace is set up and operated by a number of suppliers who are seeking to establish an efficient sales channel via the internet to a large number of buyers. They are usually searchable by the product or service being offered.

Supplier directories benefit buyers by providing information about suppliers for markets and regions they may not be familiar with. Sellers can use these types of marketplace to increase their visibility to potential buyers and to get leads.

## 4) Vertical and horizontal e-marketplaces

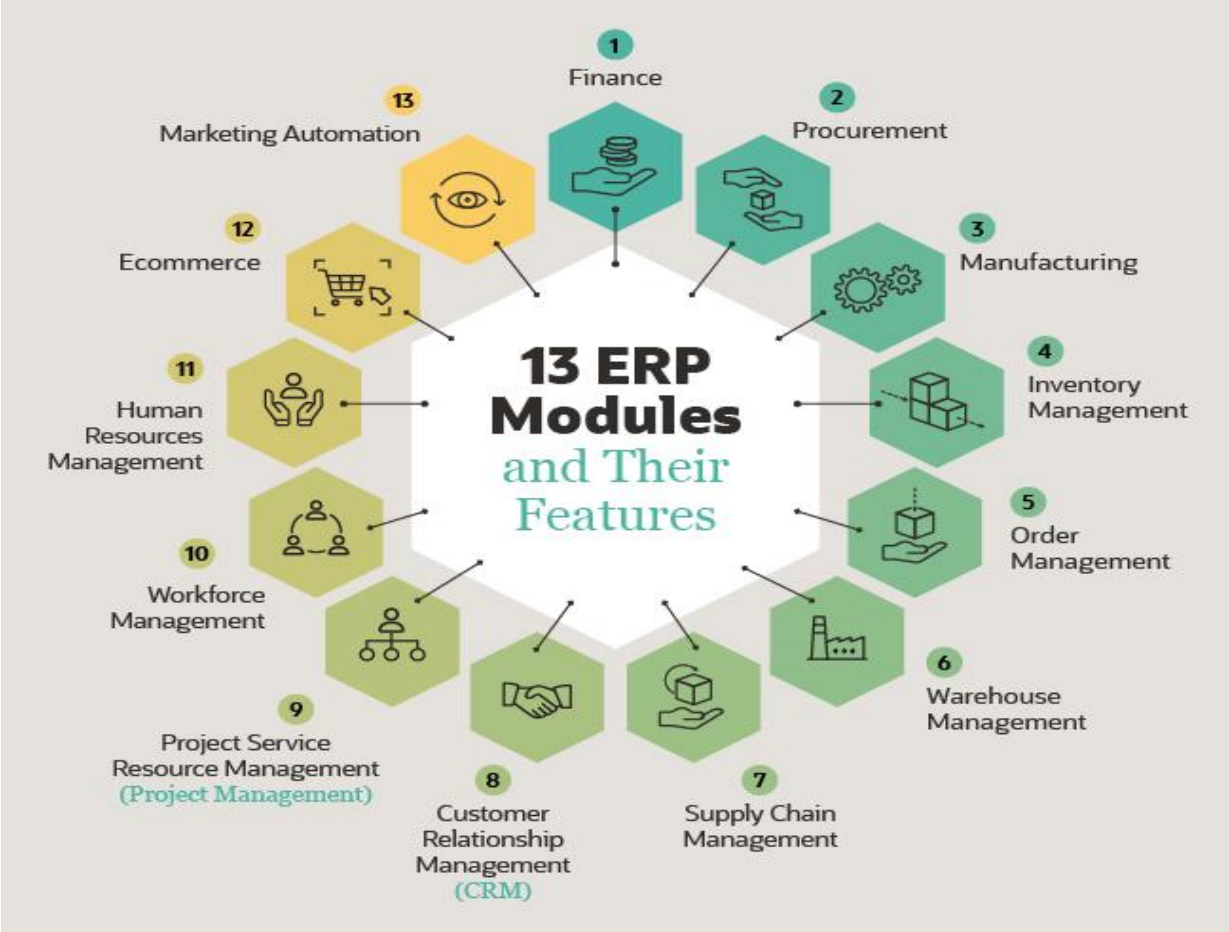
Vertical e-marketplaces provide online access to businesses vertically up and down every segment of a particular industry sector such as automotive, chemical, construction or textiles. Buying or selling using a vertical e-marketplace for your industry sector can increase your operating efficiency and help to decrease supply chain costs, inventories and procurement-cycle time.

A horizontal e-marketplace connects buyers and sellers across different industries or regions. You can use a horizontal e-marketplace to purchase indirect products such as office equipment or stationery.

## ❖ ERP( Enterprise Resource Planning) Modules

**Enterprise Resource Planning (ERP)** is the integrated management of main business processes, often in real time and mediated by software and technology.

**Enterprise Resource Planning (ERP)** refers to a type of software that organizations use to manage day-to-day business activities such as accounting, procurement, project management, risk management and compliance, and supply chain operations.



## Experiment No. – 10

Aim – Practice on Quality Tools

1) **Process Flowcharts**
2) **5 Whys**
3) **Cause And Effect Diagrams**
4) **Check sheets**
5) **Histograms**
6) **Pareto Analysis**
7) **Scatter Diagrams**

# 1) Process Flowcharts

A flowchart is a visual representation of the sequence of steps and decisions needed to perform a process. Each step in the sequence is noted within a diagram shape. Steps are linked by connecting lines and directional arrows. This allows anyone to view the flowchart and logically follow the process from beginning to end.

A flowchart is a powerful business tool. With proper design and construction, it communicates the steps in a process very effectively and efficiently.

Flowcharts are pictorial representations of a process. By breaking the process down into its constituent steps, flowcharts can be useful in identifying where errors are likely to be found in the system. By breaking down the process into a series of steps, the flowchart simplifies the analysis and gives some indication as to what event may be adversely impacting the process.

**It is used for the following purpose**

1. To review the process with goal of improvement.

2. To document the process.

3. To plan a new project.

4. To better communicate

5. To train new employees on processes.

6. To introduce and explain new processes to existing employees.

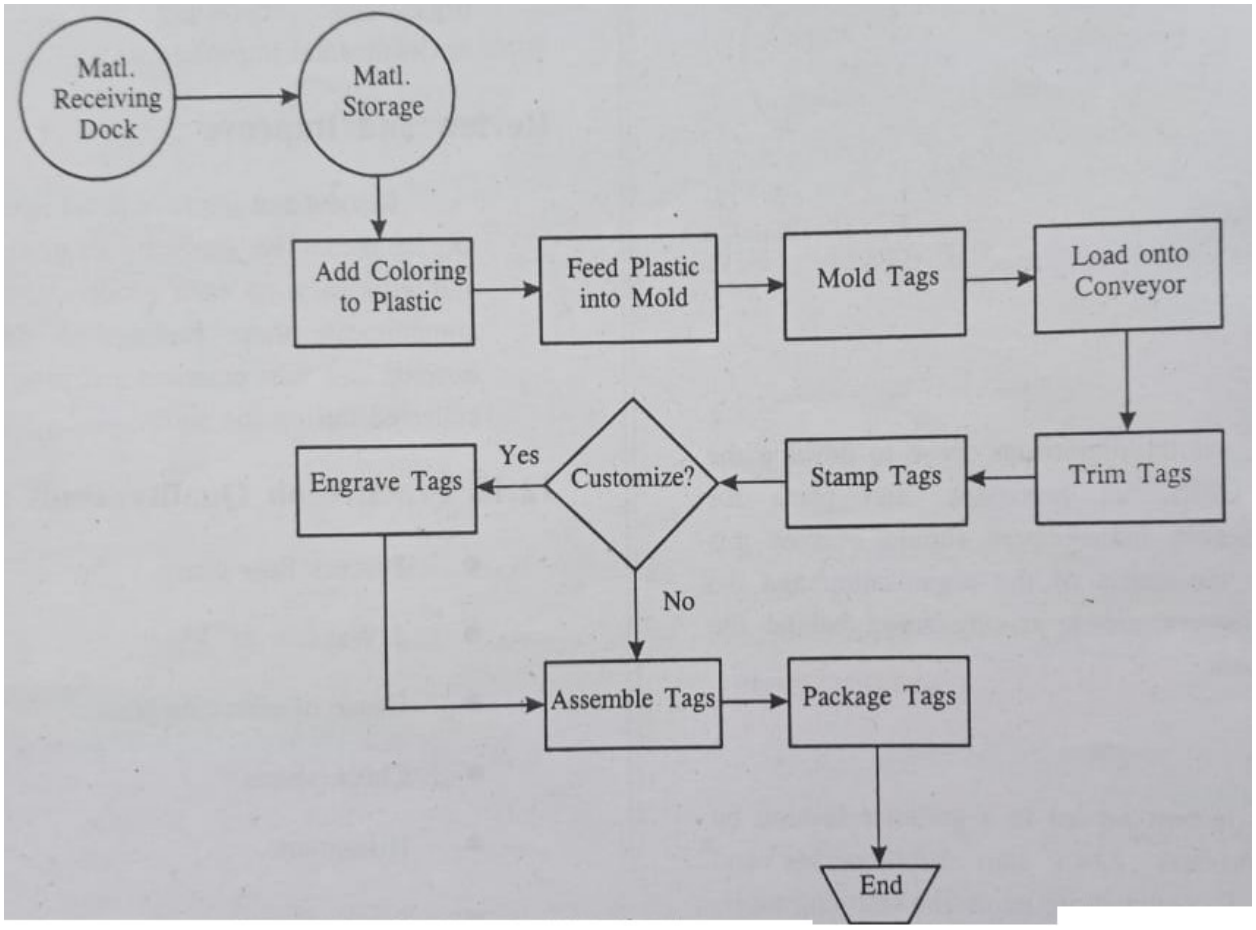
## Benefits

1. Standardization

2. Process improvement

3. Defined operating procedure.

**Example – Plastic Tag Production Flowchart**



## 2) 5(Five) Whys

It is an iterative interrogative technique used to explore the cause and effect relationship underlying a particular problem. The primary goal of technique is to determine the root cause of a defect or problem repeating the question "Why?" Each answer forms the basis of the next question.

5 whys are used for troubleshooting, quality improvement and problem solving, but it is most effective when used to resolve simple or moderately difficult problems. To develop a better and more detailed understanding of the problem To implement solutions those don't just address the symptoms and have a lasting more permanent impact to the ROOT CAUSE.

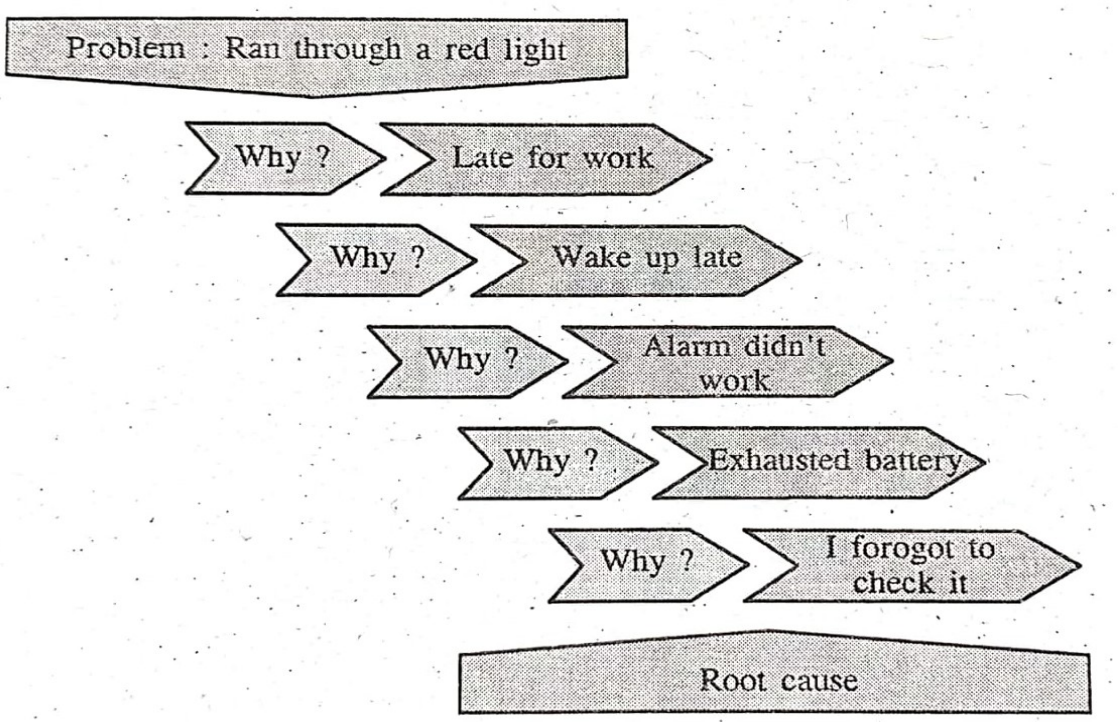
### Procedure

1. Form a team
2. Define the problem.
3. Ask Why?
4. Take Action

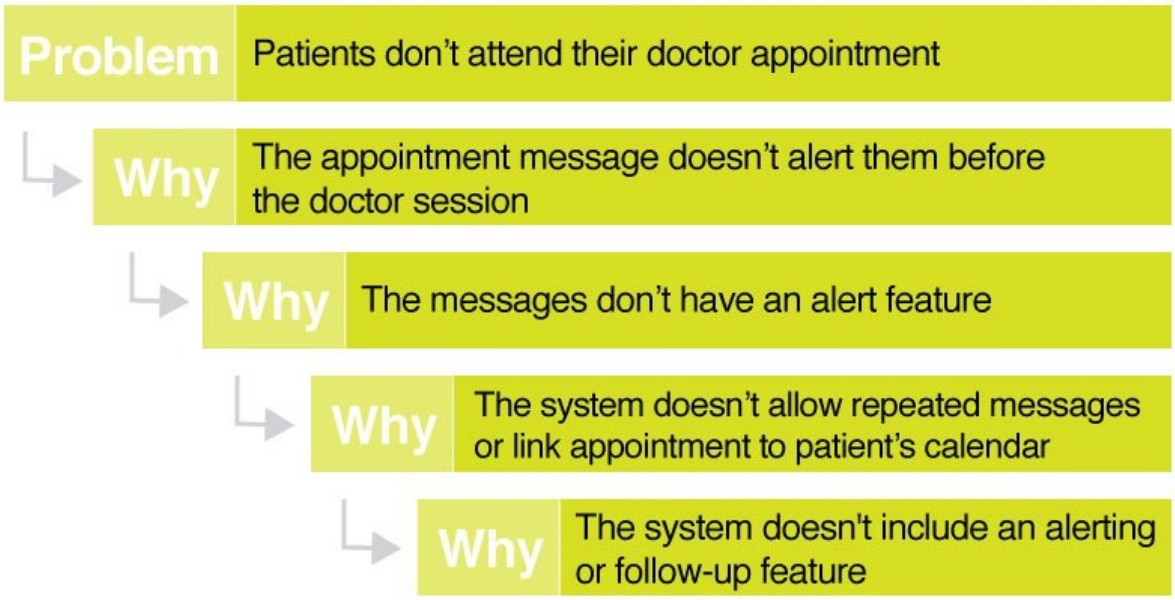
**Example: 1 –Production Line Stopped**

1. **"Why did the robot stop?"**
   The circuit has overloaded, causing a fuse to blow.
2. **"Why is the circuit overloaded?"**
   There was insufficient lubrication on the bearings, so they locked up.
3. **"Why was there insufficient lubrication on the bearings?"**
   The oil pump on the robot is not circulating sufficient oil.
4. **"Why is the pump not circulating sufficient oil?"**
   The pump intake is clogged with metal shavings.
5. **"Why is the intake clogged with metal shavings?"**
   Because there is no filter on the pump.

**Example: 2 – Ran Through a Red Light**




**Example: 3 – Patients don't attend their doctor appointment**



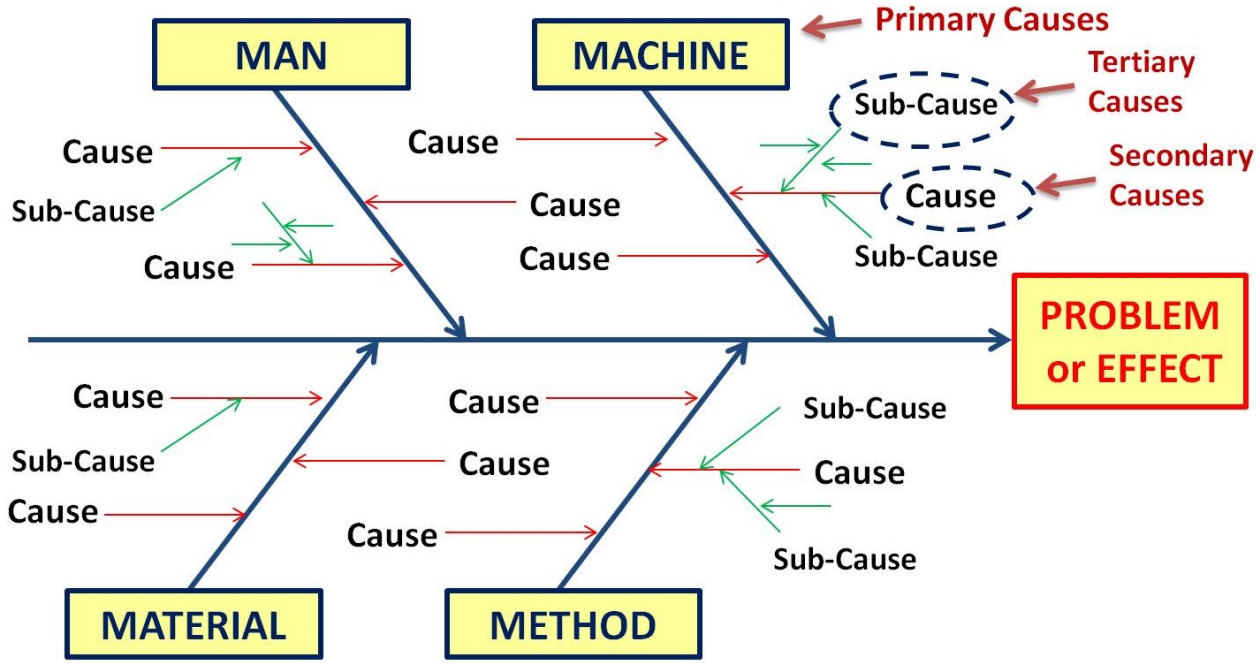
### 3) Cause and Effect Diagrams

A Cause-and-Effect Diagram is a tool that helps identify, sort and display possible causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. This type of diagram is sometimes called an "Ishikawa diagram" because it was invented by Kaoru Ishikawa, or a "fishbone diagram" because of the way it looks.

Constructing a Cause and Effect Diagram can help your team when you need to

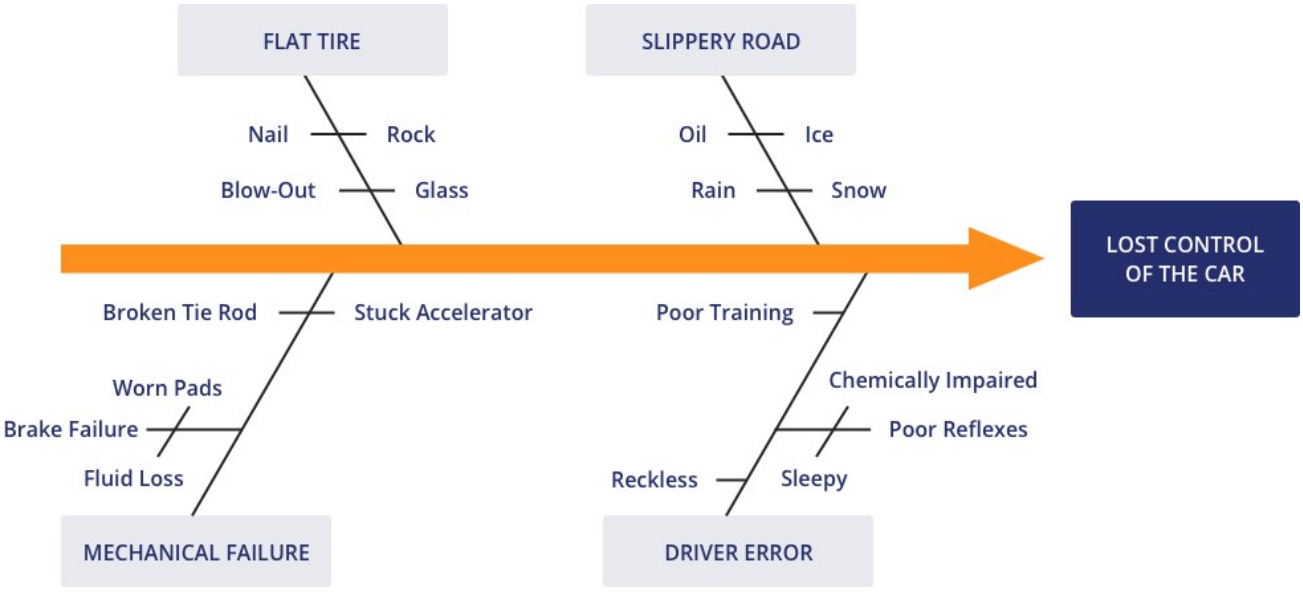
1) Identify the possible root causes, the basic reasons, for a specific effect, problem or condition.
2) Sort out and relate some of the interactions among the factors affecting a particular process or effect.
3) Analyze existing problems so that corrective action can be taken.

## General Layout of Cause and Effect Diagram

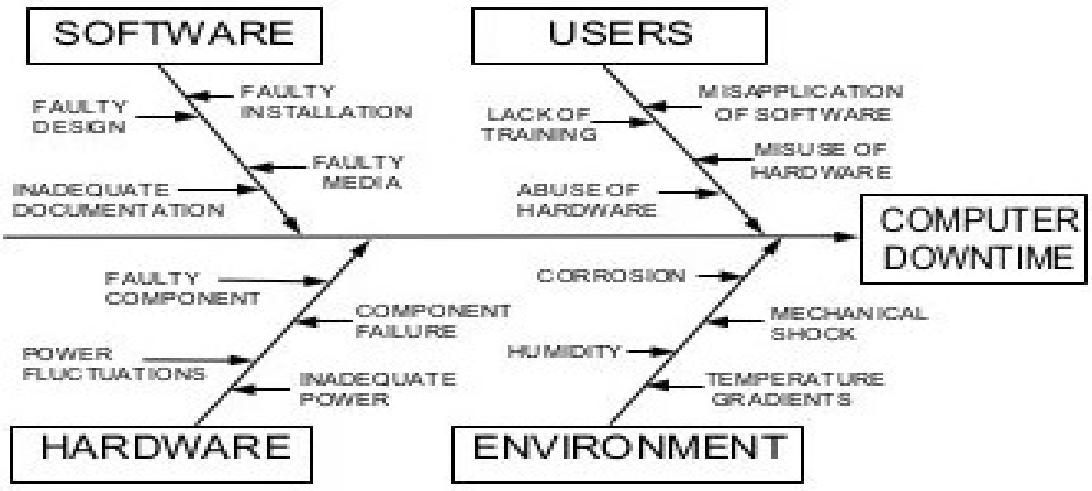


**Example: 1 – Lost Control of Car**

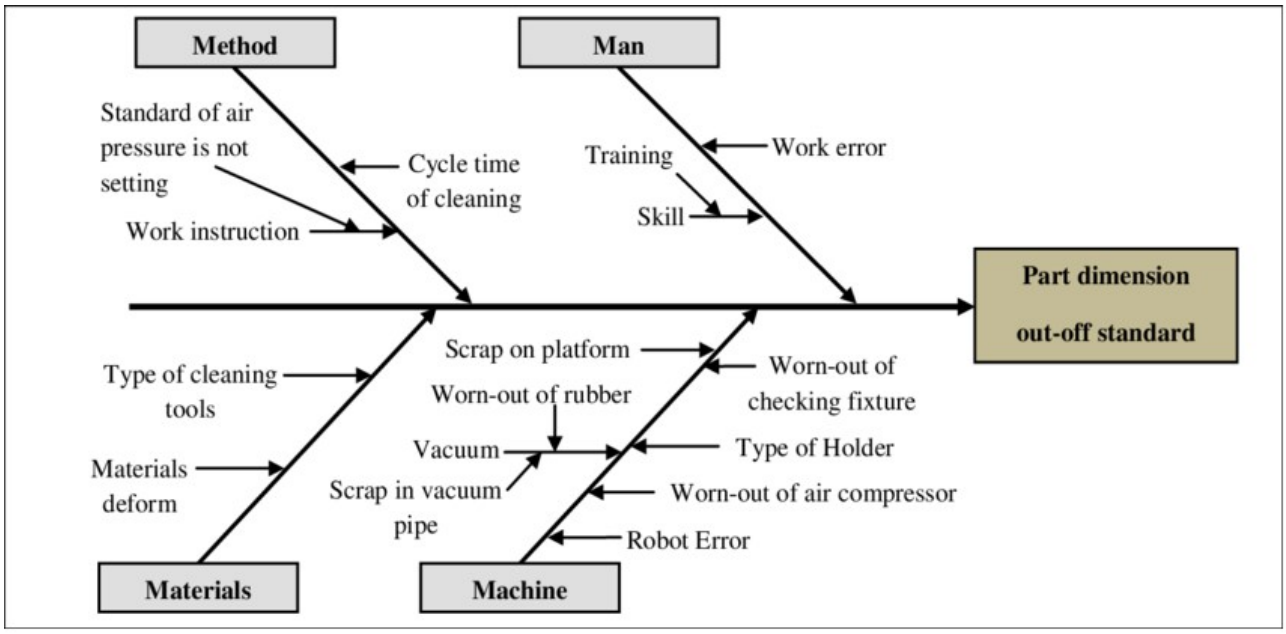
A simple cause-effect diagram is shown in Figure. The phenomenon to be explained is "Lost control of car." Some of the possible major factors contributing to that lost control are a flat tire, a slippery road, mechanical failures, and driver error. Each of these major categories of causes may, in turn, have multiple causes. A flat tire may come from a nail, a rock, glass, or a blow-out from material failure. The causal relationship can be traced back still more steps in the causal chain if necessary or appropriate. Lost control may arise from a mechanical failure; that failure may be a brake failure, which, in turn, may come either from fluid loss or from worn pads. You can probably think of other factors to add to this diagram.



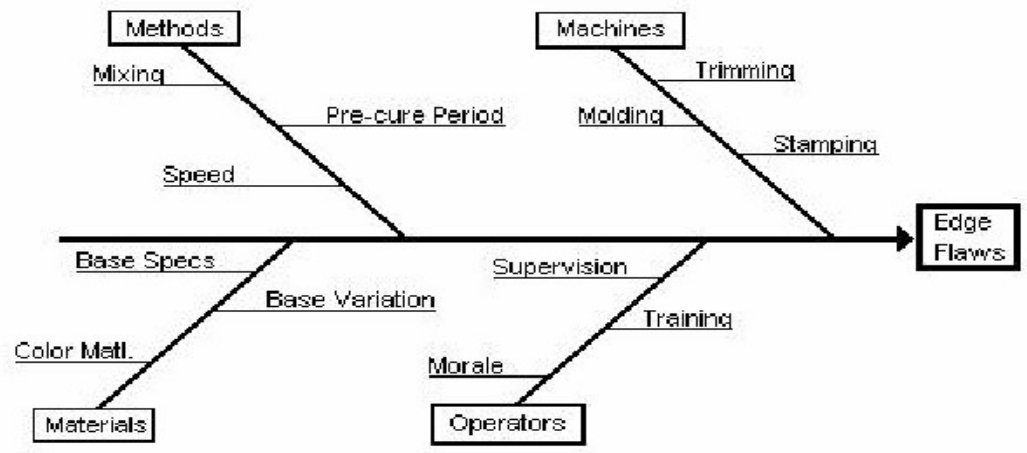

**Example: 2 – Computer Down Time**



**Example: 3 – Part Dimension Out – Off Standard**

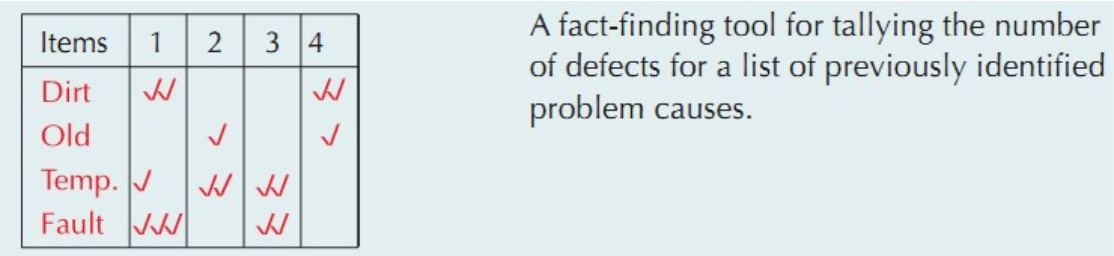



**Example: 4 – Edge Flaws**



## 4) Check sheets

A check sheet is a list of causes of quality problems with the number of defects resulting from each cause.



| Items | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Dirt | √√ | | | √√ |
| Old | | √ | | √ |
| Temp. | √ | √√ | √√ | |
| Fault | √√√ | | √√ | |

A fact-finding tool for tallying the number of defects for a list of previously identified problem causes.

The Check Sheet is a simple document that is used for collecting data in real time and at the location where the data is generated. The document is typically a blank form that is designed for the quick, easy and efficient recording of the desired information, which can be either quantitative or qualitative. When the information is quantitative, the chock sheet is sometimes called a tally sheet.

A defining characteristic of a check sheet is that data is recorded by making marks ("checks") on it. A typical check sheet is divided into regions and marks made in different regions have different significance. Data is read by observing the location and number of marks on the sheet. It is used when

1. When data can be observed and collected repeatedly by the same person or at the same location.

2. When collecting data on the frequency or patterns of events, problems, defects, defect location, defect causes, or similar issues

3. When collecting data from a production process

**The data to be recorded can be based on;**

**(a) Attributes:** Go or no-go situations, binary classification like right or wrong, present or absent, i.e. discrete countable data.

**(b) Variables:** Data from measurement collectable on a continuous scale, e.g. diameter of a piston, tensile strength of a piece of rod, etc.,

According to the type of data to be collected, check sheets are designed. In-addition to variable checksheet and attribute checksheet, there can be defect location sheet or measles chart. On a process flowchart or engineering drawing are marked errors, defects and problems. Accumulation of crosses or other marks on the document indicates as to where the major or most frequent occuring defects can be found.

**Example :1 - Check sheet used to collect the data on telephone interruption.**

| Reason | Day | | | | | |
|---|---|---|---|---|---|---|
| | Mon | Tues | Wed | Thurs | Fri | Total |
| Wrong number | 𝍸 | \|\| | \|\| | 𝍸 | 𝍸 \|\| | 18 |
| Info request | \|\| | \|\| | \|\| | \|\|\| | \|\|\| | 19 |
| Boss | 𝍸 | \|\| | 𝍸 \|\| | \| | \|\|\|\| | 12 |
| Total | 12 | 6 | 10 | 8 | 13 | 49 |

**Example :2 – Motor Assembly Check Sheet**

**Motor Assembly Check Sheet**

Name of Data Recorder:

Location:

Data Collection Dates:

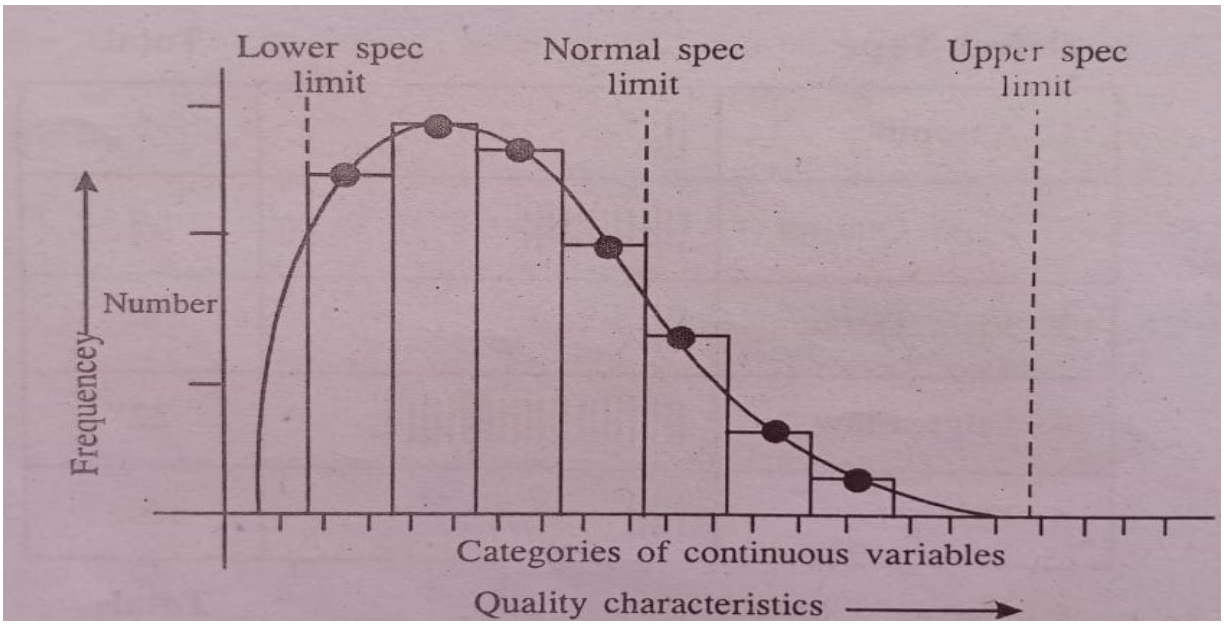
| Defect Types/ Event Occurrence | Dates | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | |
| Supplied parts rusted | | 𝍸 𝍸 | 𝍸 | 𝍸 | \|\| | | | 20 |
| Misaligned weld | | | \|\|\| | | | \|\| | | 5 |
| Improper test procedure | | | | | | | | 0 |
| Wrong part issued | | \| | | \|\| | | | | 3 |
| Film on parts | | | | | | | | 0 |
| Voids in casting | | | | 𝍸 | \|\| | | | 6 |
| Incorrect dimensions | | | | | | \|\| | | 2 |
| Adhesive failure | | | | | | | | 0 |
| Masking insufficient | | | | | \| | | | 1 |
| Spray failure | | | 𝍸 | | | | | 5 |
| TOTAL | | 10 | 13 | 10 | 5 | 4 | | |

## 5) Histograms

A Histogram is a chart that shows the frequency distribution of observed values of a variable.

Histogram is graphical summary of variations in a set of data. It enables us to see patterns that are difficult to see in a simple table of numbers.

In histogram the continuous variable is clustered into categories and the value of each cluster is plotted to give a series of bars.

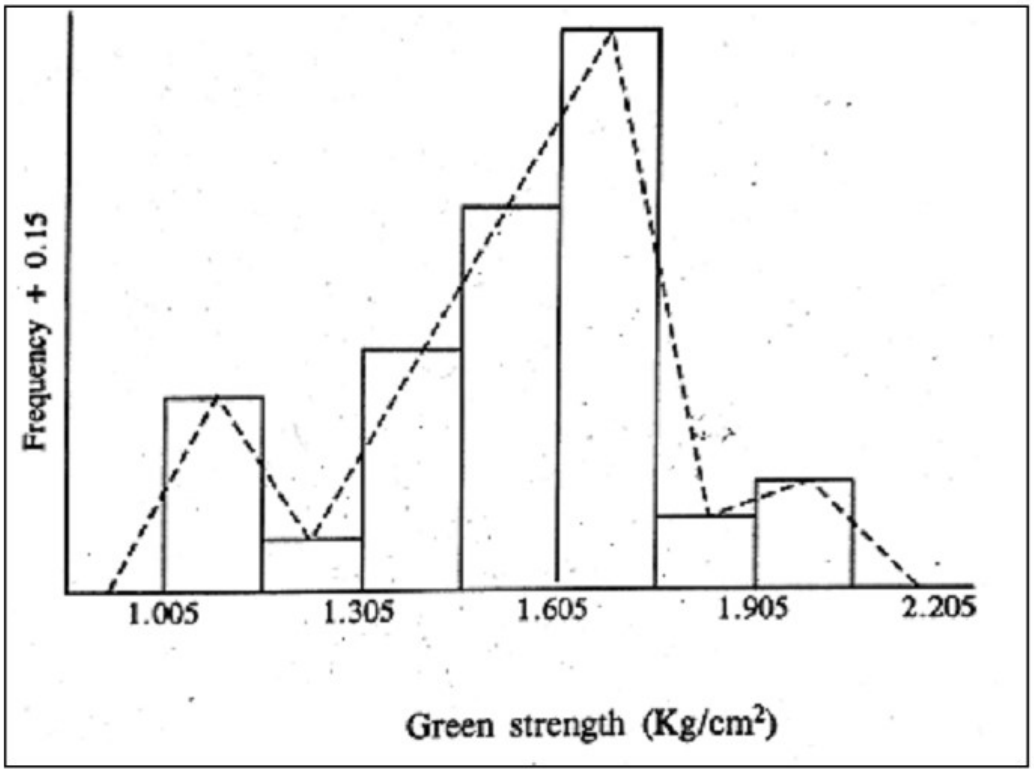



Histogram Frequency distribution may be graphically represented in the form of a histogram. The x-axis represents the quality characteristics under consideration while y-axis represents frequency divided by class width (range). The histogram consists of a series of rectangles built on the class intervals so that the area of the rectangle represent the corresponding frequency.

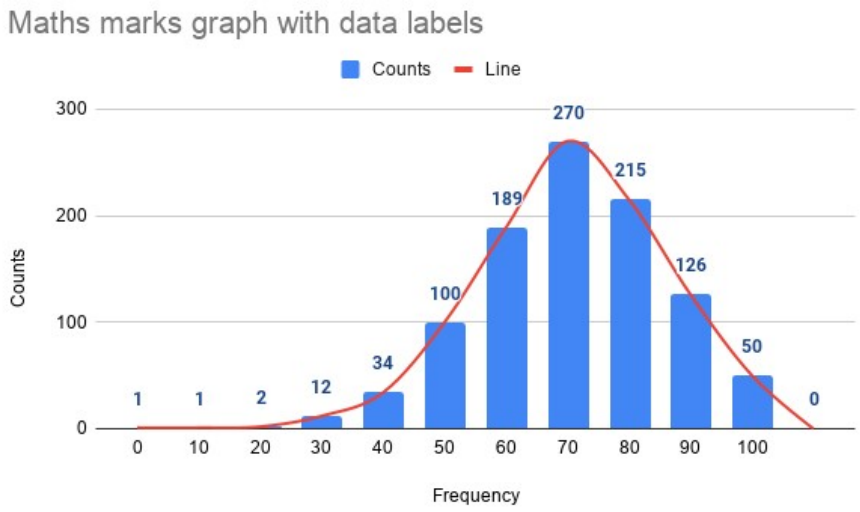
If the midpoints of topsides of the rectangles are joined, we obtain the frequency polygon. If we have a larger and larger number of observations and the class width is made smaller and smaller, the frequency polygon is expected to approach a smooth curve called frequency curve as shown in fig.

**Example: 1 - Strength during manufacturing of a part.**

| Green Strength | Frequency |
|---|---|
| 1.005-1.155 | 4 |
| 1.155-1.305 | 1 |
| 1.305-1.455 | 5 |
| 1.455-1.605 | 9 |
| 1.605-1.755 | 13 |
| 1.755-1.905 | 1 |
| 1.905-2.055 | 2 |
| Total | 35 |



**Example: 2 – Mathematics Marks Graph with Data Labels**



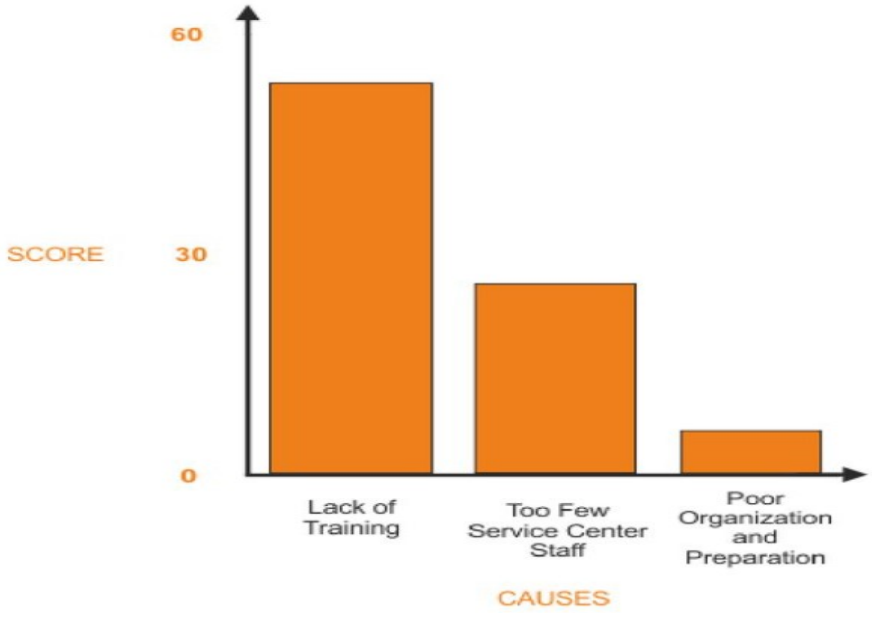

## 6) Pareto Analysis

Pareto Analysis is a technique used to identify quality problems based on their degree of importance. Pareto chart can be used to detect and present quality problems in increasing order of percentage of defects. The Pareto Analysis suggests that most of the problems arise from relatively few defects or causes. Pareto Analysis is called as 80:20 Rules indicating that 80% of the problems emerge from hardly 20% of the causes such as machine failure, service delay etc.

Pareto Chart helps to locate most important problem that needs to be given immediate action.

**Example: 1- Computer Service Center- Objective is to Increase Customer Satisfaction**

| # | Problem (Step 1) | Cause (Step 2) | Score (Step 3) |
|---|---|---|---|
| 1 | Phones aren't answered quickly enough. | Too few service center staff. | 15 |
| 2 | Staff seem distracted and under pressure. | Too few service center staff. | 6 |
| 3 | Engineers don't appear to be well organized. They need second visits to bring extra parts. | Poor organization and preparation. | 4 |
| 4 | Engineers don't know what time they'll arrive. This means that customers may have to be in all day for an engineer to visit. | Poor organization and preparation. | 2 |
| 5 | Service center staff don't always seem to know what they're doing. | Lack of training. | 30 |
| 6 | When engineers visit, the customer finds that the problem could have been solved over the phone. | Lack of training. | 21 |



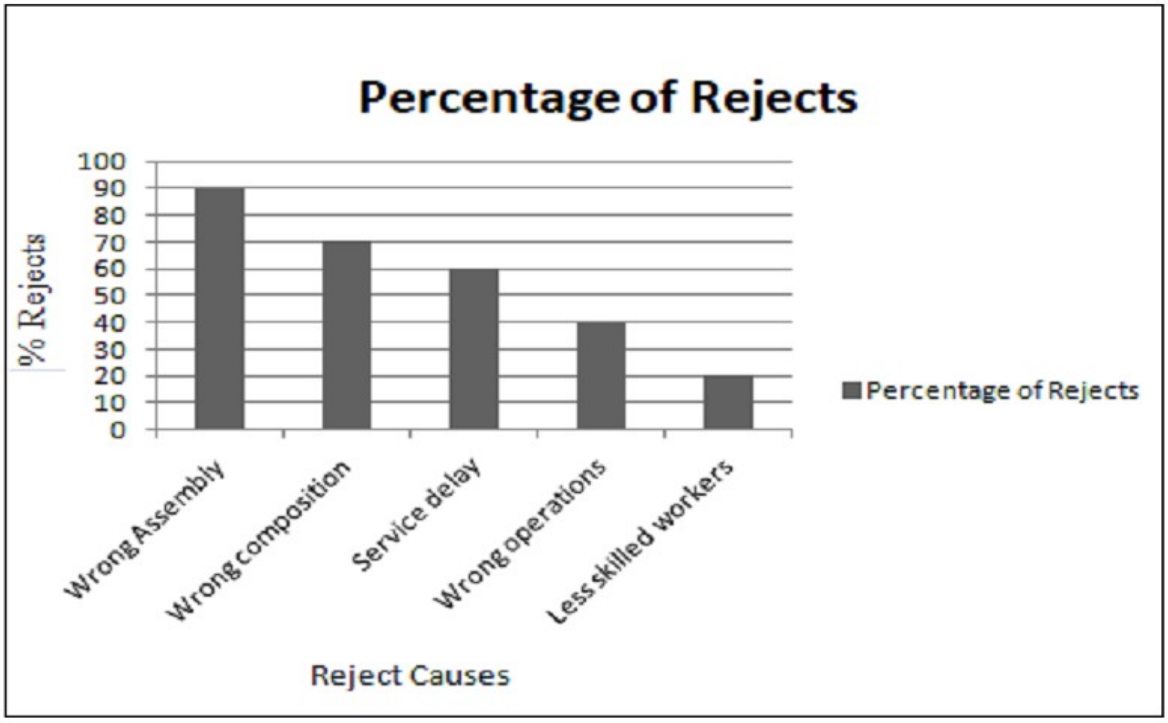

1) Lack of Training (items 5 to 6) -51 Complaints
2) Too few Service Centre Staff (items 1 to 26) -21 Complaints
3) Poor Organization and Preparation (items 3 to 4) - 6 Complaints

**Example: 2 - Causes for rejection at manufacturing facility is given below.**

| Reject Causes | Percentage of Rejects |
|---|---|
| Wrong operations | 40 |
| Less skilled workers | 20 |
| Wrong Assembly | 90 |
| Wrong composition | 70 |
| Service delay | 60 |

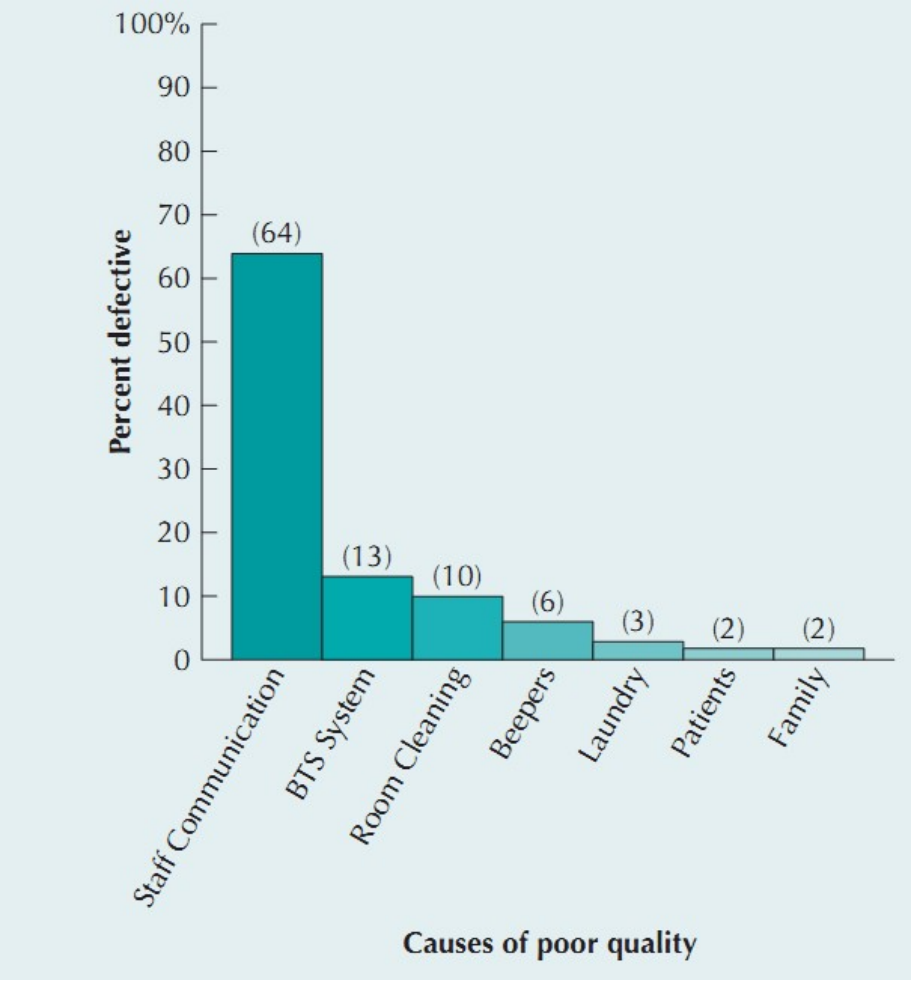
Reject causes are listed and ranked as per degree of importance.

| Reject Causes | Percentage of Rejects |
|---|---|
| Wrong Assembly | 90 |
| Wrong composition | 70 |
| Service delay | 60 |
| Wrong operations | 40 |
| Less skilled workers | 20 |



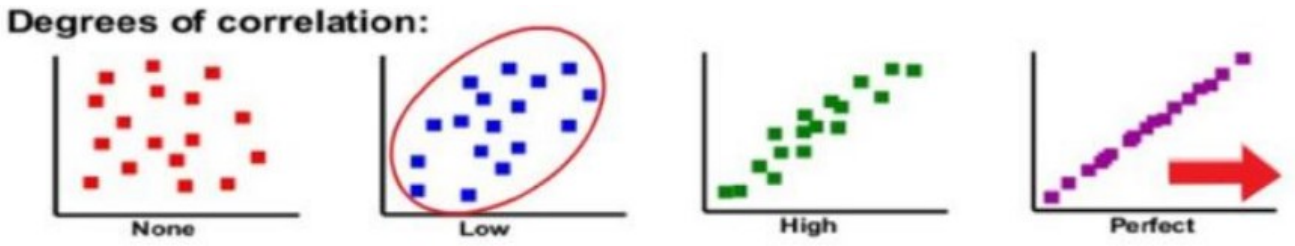
**Example: 3 - Hospital Bed Turnaround Time**

| Cause | Number of Defects | Percentage |
|---|---|---|
| Staff communication | 83 | 64% |
| BTS system | 17 | 13 |
| Room cleaning | 13 | 10 |
| Beepers | 7 | 6 |
| Laundry | 4 | 3 |
| Patients | 3 | 2 |
| Family | 3 | 2 |
| | 130 | 100% |



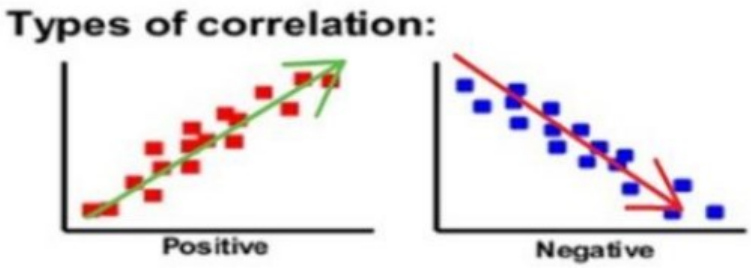
## 7) **Scatter Diagrams**

Scatter diagrams graphically show the relationship between two variables, such as the brittleness of a piece of material and the temperature at which it is baked. One temperature reading should result in a specific degree of brittleness representing one point on the diagram. Many such points on the diagram visually show a pattern between the two variables and a relationship or lack of one. This diagram could be used to identify a particular quality problem associated with the baking process.




1. As production speed increases, so number of defects increases. This is Positive Correlation

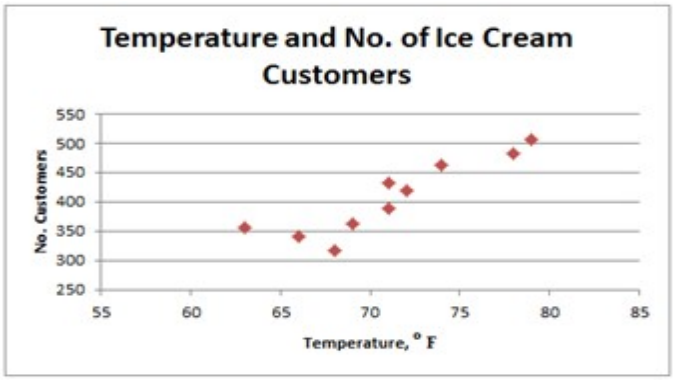
2. As worker training increases, so number of defects decreases. This is Negative Correlation.




**Examples :1- Ice Cream Correlation With Customers**

We might want to study the relationship between the outside temperature at noon and the total number of customers at an ice cream shop for a number of days. Here are the raw data in a chart and the resulting scatterplot when each pair of data is plotted.

| Temperature, °F (*x*) | No. Customers (*y*) |
|---|---|
| 68 | 317 |
| 63 | 355 |
| 74 | 463 |
| 72 | 419 |
| 79 | 507 |
| 78 | 482 |
| 71 | 433 |
| 71 | 388 |
| 69 | 362 |
| 66 | 340 |

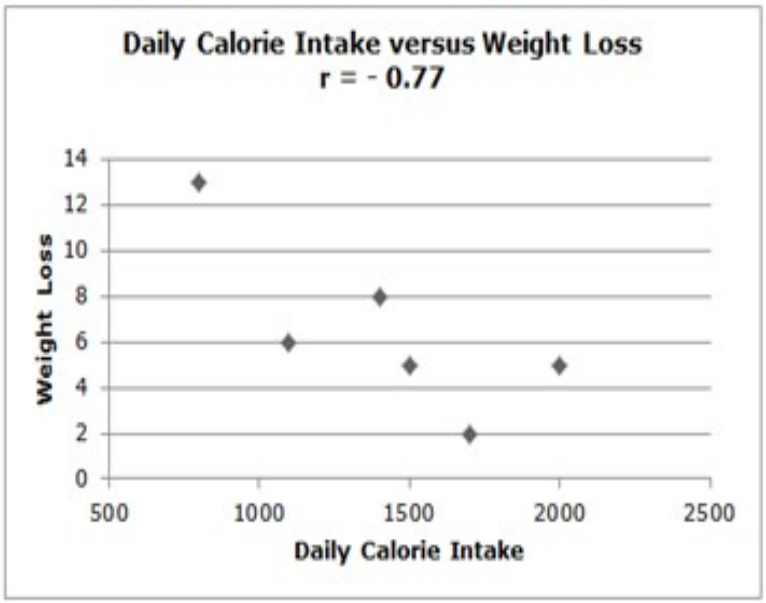


We see that for low temperatures, there are fewer customers, and when the temperature is higher, there are more customers. We call this a positive relationship between the temperature and the number of customers. That is, as the temperature goes up, the number of customers goes up. Notice that the data points on the scatterplot show a trend that increases up and to the right. This indicates a **positive relationship between the two variables.**

**Examples : 2- Daily Calorie Intake and the Amount of Weight You Lose**

There can also be a negative relationship between two variables. Consider the relationship between your daily calorie intake and the amount of weight you lose. In this case, the **more** calories you consume, the **less** weight you will lose. Here are a chart of data values and the scatterplot:

| Calories | Weight Loss |
|---|---|
| 800 | 13 |
| 1100 | 6 |
| 1500 | 5 |
| 1400 | 8 |
| 1700 | 2 |
| 2000 | 5 |



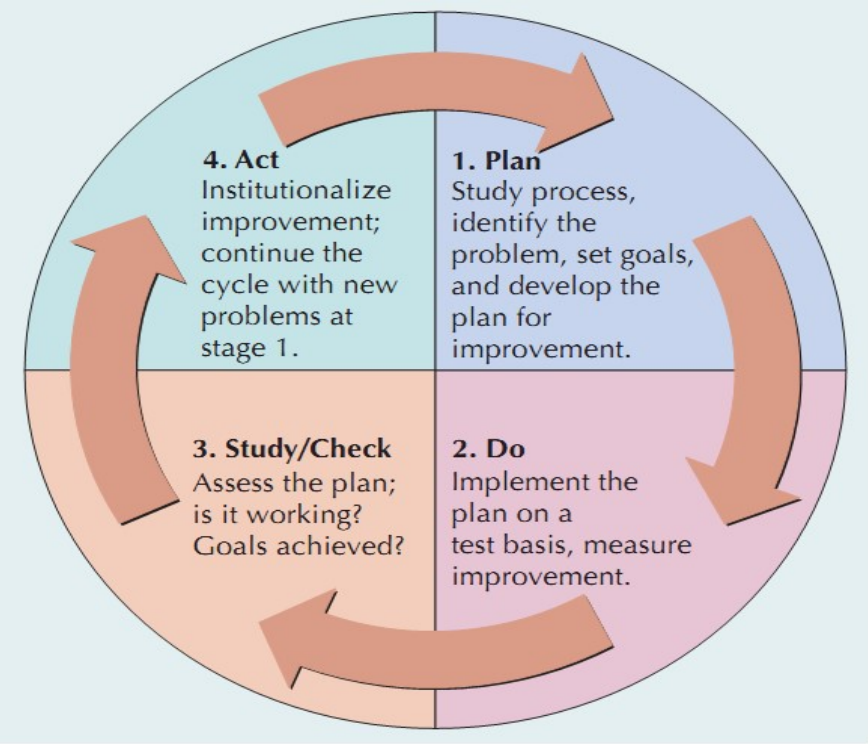
# Experiment No. – 11

Aim – Practice on

1) **Deming Wheel (PDCA Cycle)**
2) **Process Control Charts**
3) **Statistical Quality Control**
4) **ISO 9000 - Quality Management System (QMS)**
5) **ISO 14000 - Environmental Management System (EMS)**

## 1) Deming Wheel (PDCA Cycle)

**PDCA –Plan- Do-Check-Act i**s an iterative design and management method used in business for the control and continuous improvement of processes and products.



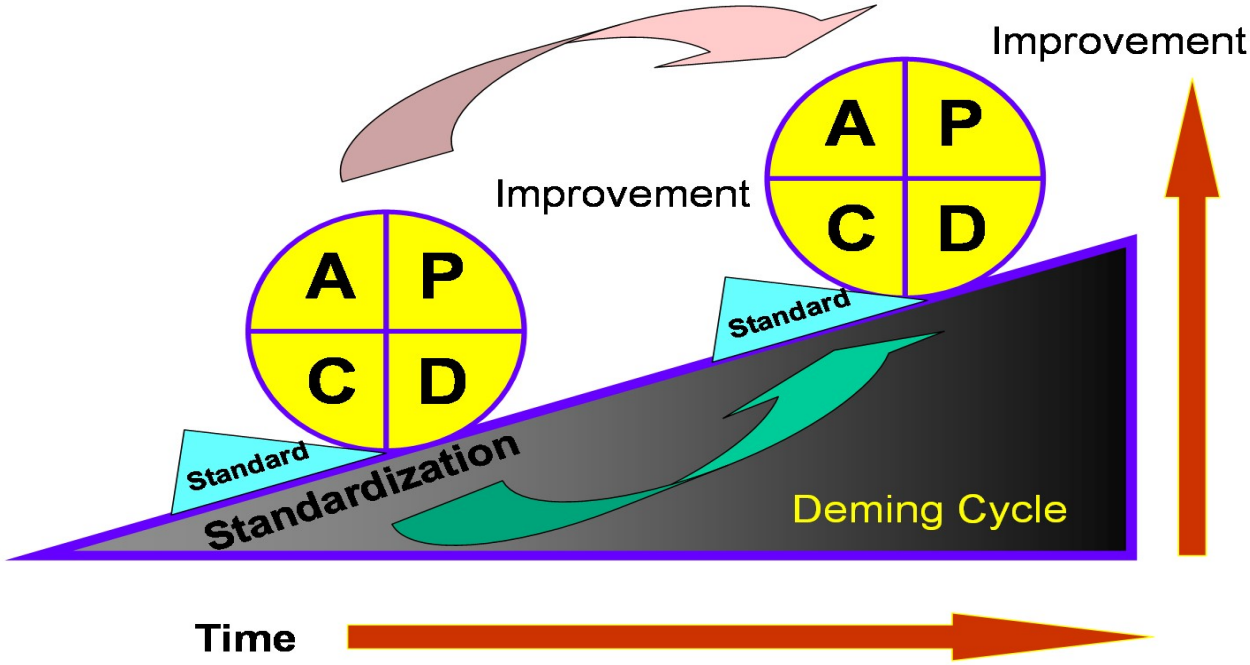

**Plan —** Determine goals for a process and needed changes to achieve them.

**Do —** Implement the changes.

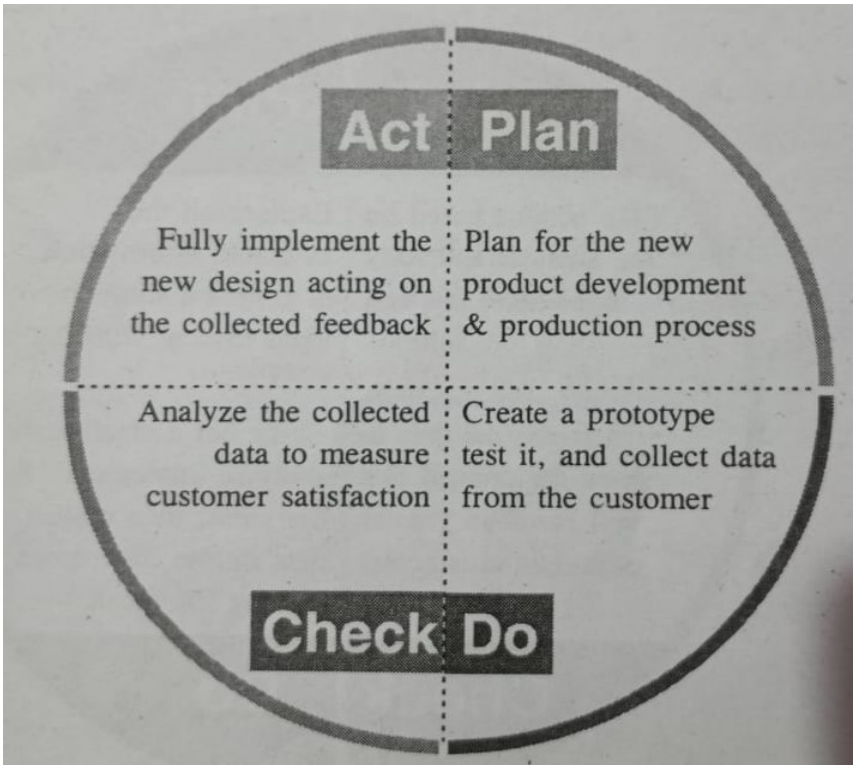
**Check —** Evaluate the results in terms of performance

**Act —** Standardize and stabilize the change or begin the cycle again, depending on the results

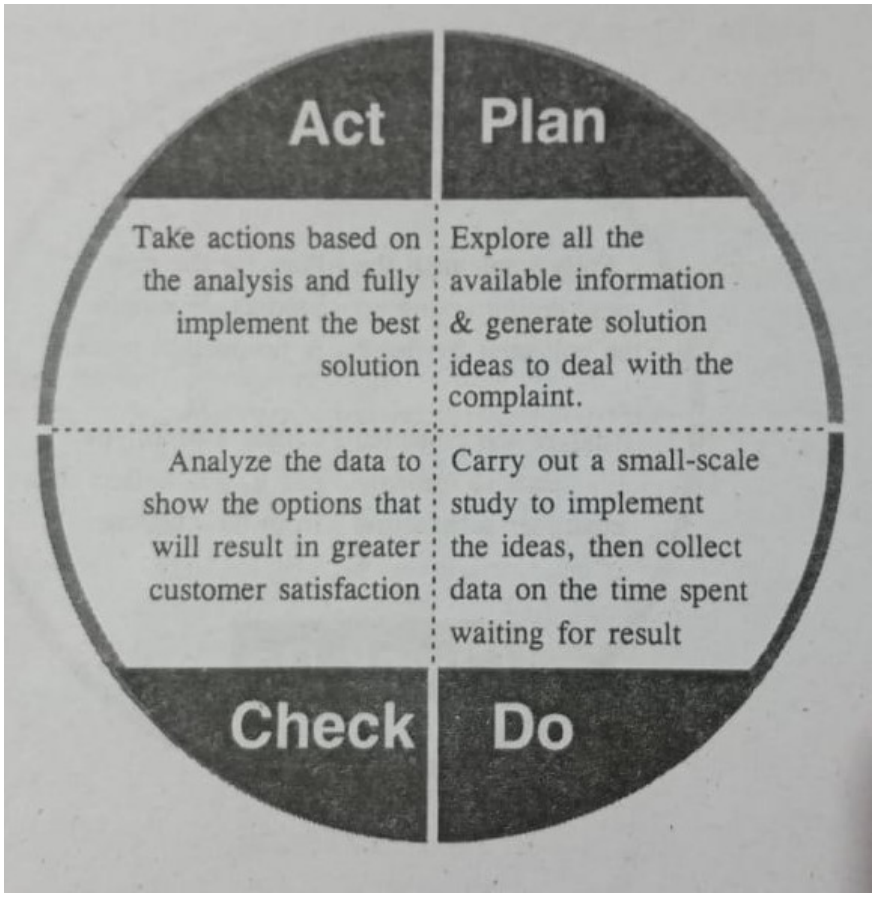
The use of the PDCA cycle doesn't necessarily stop once the Act phase is completed. The improved process may become the new baseline, and you should start again at the Plan phase. Multiple iterations of the PDCA cycle could be necessary to solve the problem permanently and reach the ultimate future state. Each cycle will bring you closer to your goals and will extend your knowledge further. Repeating the PDCA cycle frequently can also help implementing Kaizen and other continuous improvement initiatives.




**Example – 1- PDCA Cycle When a Team is initiating a New Product Development**



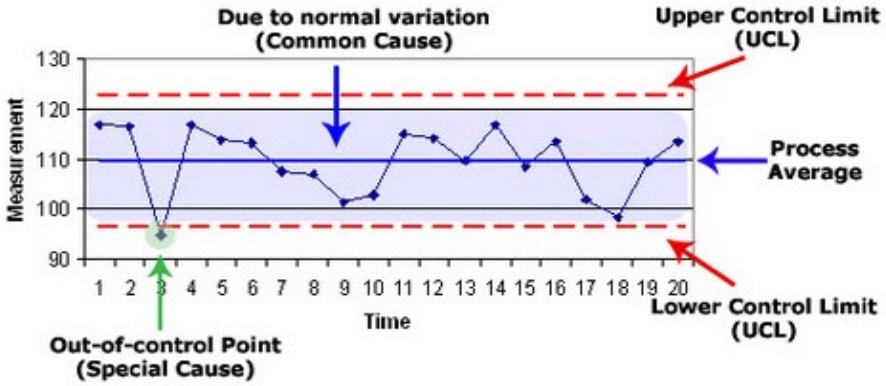
**Example – 2- PDCA Cycle When a Lab Team is Planning To Solve A Customer Compliant About Delayed Test Results at A Laboratory**



## 2) Process Control Charts

Process control charts are graphs or charts that plot out process data or management data in a time-ordered sequence. It's a specialized run chart. They typically include a center line, upper control limit, and lower control limit. as well. The center line represents the process mean or average (and sometimes the median).

The control limits represent the process variation and shows us what's typical or "common cause" variation. Based on the typical baseline period-to-period variation, those limits are calculated as to help us distinguish between "signal" and "noise." Again, these are calculated... they are part of "the voice of process" and you don't get to choose what the limits are. If you don't like the control limits or think they are too wide, you have to improve the process to reduce variation and noise, which is different than asking "what went wrong?" in any given time period.




## 3) Statistical Quality Control (SQC)

Statistical quality control is defined as the technique of applying statistical methods based on the theory of probability and sampling to establish quality standard and to maintain it in the most economical manner. Let us now outline the elements that constitute

**Elements of SQC**

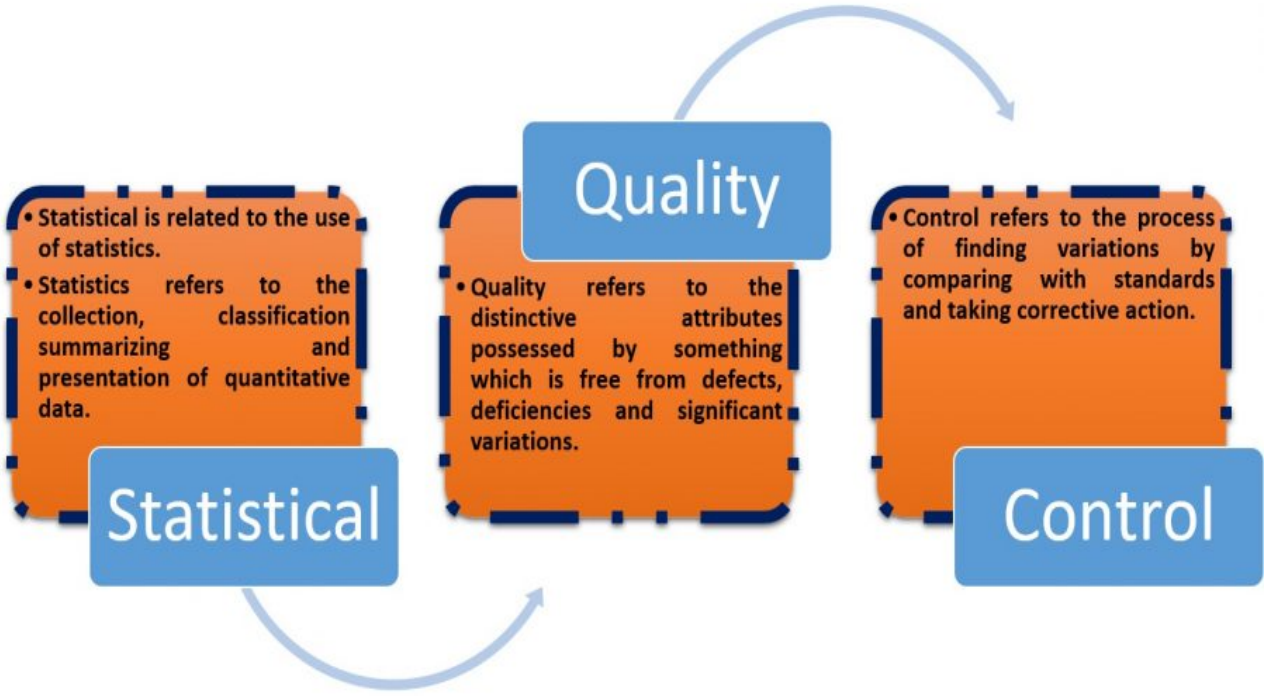
**a) Sample Inspection :** We know that 100% inspection needs huge expenditure of time, money, labour and resources. Further, if the nature of the product is such that it is completely destroyed during the process of inspection, e.g., a bulb, candle, ammunition, food, etc., 100% inspection is not practicable. Therefore, SQC is based on sampling inspection. In sampling inspection method, some items or units (called sample) are randomly selected from the process and then each and every unit of the sample is inspected.

**b) Use of Statistical Methods :** Some commonly used statistical tools such as random sampling, mean, range, standard deviation, mean deviation, standard error and concepts such as probability, binomial distribution, Poisson distribution, normal distribution, etc., are used in SQC. Since, quality control method involves extensive use of statistics, it is termed as Statistical Quality Control.

**c) Fundamental Objective :** The fundamental objective of SQC is to decide whether the unit produced is according to its specifications or not. If the unit produced is not according to its specifications and there is a variation in quality, it becomes necessary to trace the causes of variation and eliminate them if possible.

**d) Decision Making :** With the help of SQC, we decide whether the quality of the product or the process of manufacturing/producing goods is under control or not.

**e) Specifications, Production and Inspection :** SQC method helps in deciding about the specifications, production and inspection of an product.



## 4) ISO 9000 – Quality Management System

Standards are documented agreements that include technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions to ensure that materials, products processes, and services are fit for their purpose.

**ISO - "International Organization for Standardization".**

**ISO 9000 is defined as a set of international standards on quality management and quality assurance developed to help companies effectively document the quality system elements needed to maintain an efficient quality system. They are not specific to any one industry and can be applied to organizations of any size.**

It is an international standard accepted by more than 100 countries. ISO is a non-governmental organization established in 1947 by International. Standard Agency headquartered in Geneva. Principles of ISO are applicable to all organizations.

The ISO 9000 series of quality management standards, guidelines, and technical reports as first published in 1978, and it is reviewed at least every five years. It was most recently revised and updated in 2008.

### ISO 9000 series

| | |
|---|---|
| ISO 8402 | Quality systems vocabulary |
| ISO 9000 | Quality Systems - Guidelines for selection and use of standards on quality systems |
| ISO 9001 | Quality systems – Models for quality assurance in Design/Development, Production, Installation and Servicing |
| ISO 9002 | Quality Systems – Models for quality assurance in Production and Installation |
| ISO 9003 | Quality Systems – Models for quality assurance in final Inspection and Testing |
| ISO 9004 | Quality Management and Quality System elements - Guidelines |

### Advantages of ISO 9000 certification

1) To satisfy customers through quality products
2) To gain self confidence by getting results as per plan.
3) To achieve competitiveness in both the local and overseas markets.
4) To act as a blueprint for efforts to improve the quality system of the organization

## 5) ISO 14000 – Environmental Management System

**Environmental Management System**. It contains requirements for achieving and maintaining environmentally sound standards of doing business. The entire business process is considered, from product manufacturing to product performance and, ultimately, product disposal.

**Here are the key standards included in ISO 14000:**

(1) ISO 14001: Specification of Environmental Management Systems

(2) ISO 14004: Guideline Standard

(3) ISO 14010 – ISO 14015: Environmental Auditing and Related Activities

(4) ISO 14020 – ISO 14024: Environmental Labeling

(5) ISO 14031 and ISO 14032: Environmental Performance Evaluation

(6) ISO 14040 – ISO 14043: Life Cycle Assessment

(7) ISO 14050: Terms and Definitions

**Here are the six core elements of an EMS, according to the ISO 14001 standard:**

1) Environmental policy
2) Planning
3) Implementation
4) Study & correct
5) Management review
6) Continuous improvement