FOR INTERNAL CIRCULATION ONLY

LECTURE NOTES

ON

INDUSTRIAL ENGINEERING & MANAGEMENT

DIPLOMA 6th SEMESTER

COMPILED BY

ER.S.P.SWAIN

ASST. PROFESSOR

DEPARTMENT OF MECHANICAL ENGINEERING

UTKAL INSTITUTE OF ENGINEERING AND TECHNOLOGY

Affiliated to SCTE&VT, Govt. of Odisha
Approved by AICTE, Govt. of India

CONTENT

CH-1 (PLANT ENGINEERING)

Plant location-

- Plant location means deciding a suitable location, area, place where the plant will start functioning.

- Plant location involves two major activities i.e. first to select a proper geographic region and second selecting a specific site within the region.

Features governing plant location- The
various features of plant location are

Various factors affecting plant location are discussed below:

1) Nearest to raw material:
   - It is essential for the organization to get raw material in right qualities and time in order to meet the production.
   - It will reduce the cost of transporting raw material from vendors end to the plant, especially those plants, which consume raw material in heavy.
2) Transport facility:
   - A lot of money is spent both in transporting raw material and the finished goods.
   - Depending upon the size of raw material and finished goods, a suitable method of transportation like roads, rails, water, air, and pipeline selected.
3) Nearness to market:
   - It reduces the cost of transportation as well as the chances of the finished products getting damaged and spoiled in wet. Moreover a plant being near to the market can render quick service to customer.
4) Availability of labour:
   - Stable labour force of right kind, of adequate size and at reasonable rates with its proper attitude towards work is a few factors which governs a plant location at major extent.
5) Availability of fuel and power:
   - Availability of fuel and power is especially needed for the proper function in production.
6) Availability of water:
   - Water is used for processing as in paper and chemical industries and is also required for drinking and sanitary purpose. Depending upon the capture of plant water should be available in adequate quantity and in proper quality.
7) Climatic condition:
   - Climate greatly influence human efficiently and behavior. Some industry requires specific climatic condition e.g. textile mill require humidity. So control of climate is necessary for the production.
8) Law and taxation:
   - In order to have a balanced regional growth of industries, both central and state govt. in our country offer the package of incentive like exemption from a sales tax and excise duties for a specific period.
9) Land:
   - Topography, area, the shape of the site, cost, drainage and other facilities, the probability of flood, earthquake etc. influence the selection of plant location.
10) Community attitude:
   - Success of an industry depends very much on the attitude of local people and whether they want work or not.
11) Presence of related industry.

12) Existence of hospitals, marketing centers, schools, banks, post office, clubs etc.

13) Local bye-laws, taxes, building ordinances etc.

14) Housing facility.

15) Security.

16) Facilities for expansion.

Plant layout-

Plant lay out is a plan of facilities including personnel, operating equipment, storage space, material handling equipment and all other supporting services along with the design of supporting services along with the design of best structure to contain all the facilities.

Objective of plant layout-

Objectives of plant layout are :

- Streamline the flow of materials through the plant.
- Minimize material handling.
- Effective utilization of men, space, equipment.
- Provide employee safety and comfort.
- Flexibility of manufacturing operations and arrangements – Facilitate manufacturing process.
- Maintain high turnover of in process inventory Principles of plant layout:

1. Principle of integration or utilization: - A good layout is one that integrates men, material, machines and supporting services and others in order to get maximum effectiveness.

2. Principle of minimum distance: - This principle with the minimum travel of man and materials. The total distance travelled by men and materials should be minimum and straight line movement should be preferred.

3. Principle of cubic space utilization: - The good layout is one that utilizes both horizontal and vertical space the height is also to be utilized effectively.

4. Principle of flow: - A good layout is one that makes the materials to move in forward direction towards the completion stage.

5. Principle of safety and security and satisfaction of plant and machinery against fire, theft: - A good lay out is one that gives due consideration to the worker safety and satisfaction and safeguards the plant and machinery against fire, theft etc.

6. Principle of minimum handling: - A good layout is one that gives reduction in the material handling.

7. Principle of maximum flexibility: - The good layout is one that can be altered without much cost and time i.e. future requirements should be taken while designing the present design.

Advantages of plant layout:

1. Advantages to the worker: - A good layout will reduce the effort of the worker and minimize the manual material handling.

2. Advantages to the management: - Effective plant layout reduces the labour cost and enhances the productivity thus ultimately reducing the cost per unit.

3. Advantages to manufacturing:-Minimize the movement between work centre and also reduce manufacturing cycle.

4. Advantages to production control:- A good layout facilitates production through uniform and uninterrupted flow of materials and it helps in meet the production in time period with effectiveness.

Process Layout-

It is also known as functional layout. This layout is recommended for batch production.

All machines performing similar type of operation are grouped together at one location in the process layout all lathe, milling machines etc. are grouped in the shop. In process layout the arrangement of facilities are grouped together according to their function.

Advantages: ----

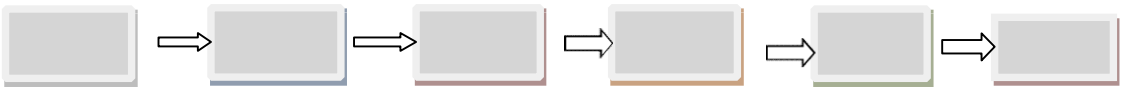
- Flexibility of equipment and personnel.
- Lower investment on account of comparatively less number of machines and lower cost of general purpose machines.
- Higher utilization of production facilities.
- Greater flexibility in the work distribution to machineries and workers.
- Variety of job makes the job challenging and interesting.

Disadvantages: ----

- Backtracking and long movements may occur in handling of materials.
- Process time is prolonged which reduce the inventory turnover and increase the investment in inventory.
- Production planning and control is difficult.
- More space is required.
- Lower productivity due to number of space.

product layout

- In this typeof layout, the machines are arranged in the sequence as required by the product.
- If the volume of production of one or more product is large, the facilities can be arranged to achieve efficient flow of materials and lower cost per unit.
- Special purpose machines are used which perform the required function quickly and reliably.
- The equipment is closely placed along the sequence in which item is processed. The product layout is shown



Advantages:

- Reduced material handling cost due to mechanized system and straight flow.
- Perfect line balancing which eliminate idle capacity.
- Manufacturing cycle is short due to uninterrupted flow of materials.
- Simplified production, planning and control.

- Unskilled workers can learn and manage the production.

Disadvantage:

- Lack of flexibility.
- Large capital investment.
- Special purpose machine.
- Break down in m/c in sequence may result in stoppage of production. Combination layout-
  A combition of process and product layout combines the advantages of the both type of layout.
- Pure product or process layout are rarely seen due to ,most of the manufacturing sections are arranged in process layout with manufacturing lines occurring here and there (scattered) when ever the conditions permit.
- A combition layout is possible where an item is being made in different types and sizes.
- In such cases machinery is arranged in a process layout but the process grouping is there arranged in a sequence to manufacture various types and sizes of products.
- The point to note is that no matter the products varies in size type the sequence of operations remain same and similar.
- A combination type of layout for manufacturing different sized gears.

……..END…….

CH-2 (OPERATIONS RESEARCH)

OPERATION RESEARCH:

- Operations research, or operational research in British usage, is a discipline that deals with the application of advanced analytical methods to help make better decisions. Further, the term 'operational analysis' is used in the British (and some British Commonwealth) military as an intrinsic part of capability development, management and assurance.
- In particular, operational analysis forms part of the Combined Operational Effectiveness and Investment Appraisals , which support British defense capability acquisition decision- making.

APPLICATIONS:

O.R. is a problem solving and decision taking technique. It is considered a kit of scientific and programmable rules which provides the management a “quantitative basis” for decisions concerning the operation under its control.

1. Allocation and Distribution in Projects:

(i) Optimal allocation of resources such as men materials machines, time and money to projects.

(ii) Determination and deployment of proper workforce.

(iii) Project scheduling, monitoring and control.

2. Production and Facilities Planning:

(i) Factory size and location decision.

(ii) Estimation of number of facilities required.

(iii) Preparation of forecasts for the various inventory items and computation of economic order quantities and reorder levels.

(iv) Scheduling and sequencing of production runs by proper allocation of machines.

(v) Transportation loading and unloading, (vi) Warehouse location decision.

(vii) Maintenance policy decisions.

3. Programmes Decisions:

(i) What, when and how to purchase to minimize procurement cost.

(ii) Bidding and replacement policies.

4. Marketing:

(i) Advertising budget allocation.

(ii) Product introduction timing.

(iii) Selection of advertising media.

(iv) Selection of product mix.

(v) Customer's preference of size, colour and packaging of various products.

5. Organization Behaviour:

(i) Selection of personnel, determination of retirement age and skills.

(ii) Recruitment policies and assignment of jobs.

(iii) Recruitment of employees.

(iv) Scheduling of training programs.

6. Finance:

(i) Capital requirements, cash flow analysis.

(ii) Credit policies, credit risks etc.

(iii) Investment decision.

(iv) Profit plan for the company.

7. Research and Development:

(i) Product introduction planning.

(ii) Control of R&D projects.

(iii) Determination of areas for research and development.

(iv) Selection of projects and preparation of their budgets.

(v) Reliability and control of development projects thus it may be concluded that operation research can be widely utilized in management decisions and can also be used as corrective measure.

linear programming-

Linear programming is a mathematical technique which involves the allocation of limited resources in an optimal manner.

use of linear programming

- Linear programming is powerful mathematical technique for finding the best use of limited resources of a concern.
- It may be defined as a technique which allocates the scarce available resources under condition of certainty in an optimum manner, to achieve the company objectives which may be maximum overall profit or minimum overall cost. OR
- Linear programming (LP; also called linear optimization) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships.
- Linear programming is a special case of mathematical programming (mathematical optimization).

procedure for solving LPP by graphical method. procedure for solving LPP by graphical method

Step 1: Consider each inequality constraint as an equation.

Step 2: Plot each equation on the graph, as each will geometrically represent a straight line.

Step 3: Mark the region. If the inequality constraint to that line is . then the region below the line lying in the first quadrant (due to non-negativity of variables) is shaded. For the inequality constraint sign, the region above the line in the quadrant is shaded. The points lying in the common region will satisfy all the constraints simultaneously. The common region thus obtained is called feasible region.

Step 4: Assign an arbitrary value, say zero, to the objective function.

Step 5: Draw the straight line to represent the objective function with the arbitrary value (a straight line through the origin).

Step 6: Stretch the objective function line till the extreme points of the feasible region. In the maximization case, this line will stop farthest from the origin, passing through at least corner of the feasible region. In the minimization case, this line will stop nearest to the origin, passing through at least one corner of feasible region.

Step 7: Find the co-ordinates of the extreme points selected in step 6 andfind the maximum and minimum value of Z.

1. Solve the following LPP by graphical method.

Minimize $Z = 20X_1 + 10X_2$

Subject to, $X_1 + 2X_2 \leq 40$

$3X_1 + X_2 \geq 30$

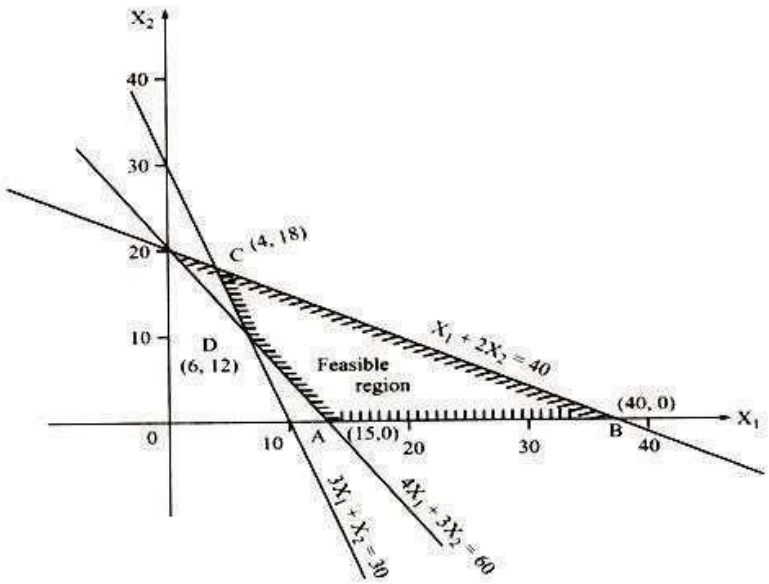
$4X_1 + 3X_2 \geq 60$, $X_1, X_2 \geq 0$.

Solution Replace all the inequalities of the constraints by equation

$$X_1 + 2X_2 = 40 \text{ If } X_1 = 0 \Rightarrow X_2 = 20$$
$$\text{If } X_2 = 0 \Rightarrow X_1 = 40$$

$\therefore$ $X_1 + 2X_2 = 40$ passes through (0, 20) (40, 0)
$3X_1 + X_2 = 30$ passes through (0, 30) (10, 0)
$4X_1 + 3X_2 = 60$ passes through (0, 20) (15, 0)

Plot each equation on the graph.



The feasible region is *ABCD*.

C and *D* are points of intersection of lines.

C intersect $X_1 + 2X_2 = 40,\quad 3X_1 + X_2 = 30$

and, *D* intersect $4X_1 + 3X_2 = 60,\quad X_1 + X_2 = 30$

$C = (4, 18)$

$D = (6, 12)$

Corner points	*Value of* $Z = 20X_1 + 10X_2$
$A(15, 0)$	300
$B(40, 0)$	800
$C(4, 18)$	260
$D(6, 12)$	240 (Minimum value)

$\therefore$ The minimum value of Z occurs at D (6, 12). Hence, the optimal solution is $X_1 = 6, X_2 = 12$.

Q2

Maximize

Z=X+5Y WHEN

5X+6Y≤30

3X+2Y≤12

X,Y≥0

SOLVE IT BY LPP METHOD

Answer-

EQUALISIERING THE EQUATION

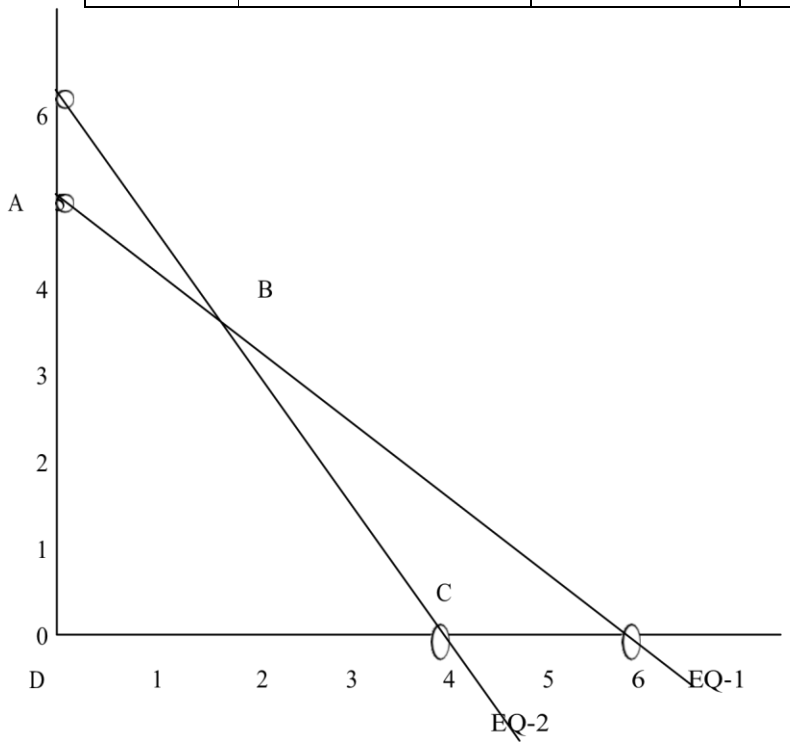
5X+6Y=30 (1)

3X+2Y=12 (2)

X=0

Y=0

EQ NO	EQUATION	FOR X=0	FOR Y=0
1	5X+6Y=30	(0,5)	(6,0)
2	3X+2Y=12	(0,6)	(4,0)



The points are-

A=(0,5)

B=(1.5,3.75)

INDUSTRIAL ENGINEERING MANAGEMENT

C=(4,0)

D=(0,0)

Point B will be get by solving the two equations (EQ-1 & EQ-2)

5X+6Y=30

3*(3x+2y=12)

So the equations are- 5X+6Y=30

9X+6Y=36

(-) (-) (-)

-4X =-6

So $X=-\frac{-6}{-4}$ =1.5

Putting the value of X in the equation-

5X+6Y=30

5*1.5+6Y=30

7.5+6Y=30 6Y=30-7.5

6Y=22.5

Y=3.75

Putting the value of X andY in the equation and the value of Z are

Z=X+5Y

A(0,5)=25

B(1.5,3.75)=20.25

C(4,0)=4

D(0,0)=0

Hence the point A has the maximum value of Z and the value is 25

Q3

Minimize

Z=60X+40Y

Subjected to

30X+10Y≥240

10X+10Y≥ 160

20X+60Y≥ 480

X,Y≥0

Solve it by LPP Method.

ANSWER-

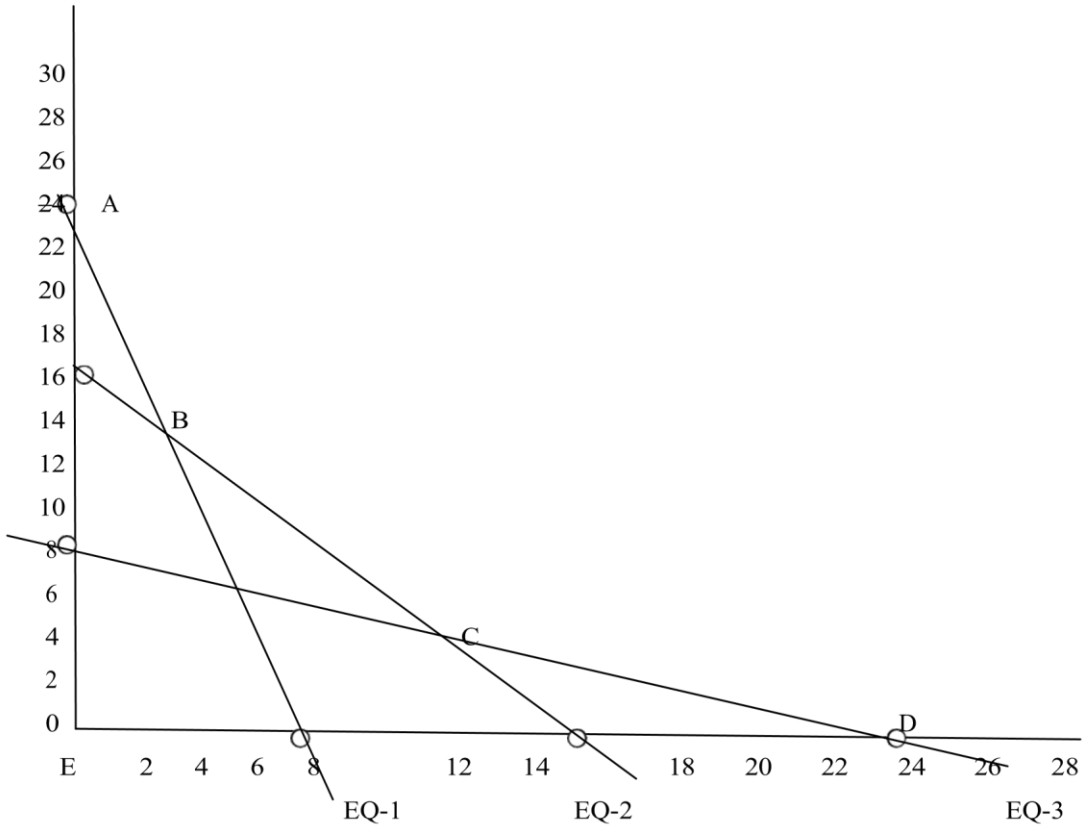
Equalisizing the equation

30X+10Y=240 10X+10Y=160

20X+60Y=480 X=0

Y=0

EQ NO	EQUATION	FOR X=0	FOR Y=0
1	30X+10Y=240	(0,24)	(8,0)
2	10X+10Y=160	(0,16)	(16,0)
3	20X+60Y=480	(0,8)	(24,0)



CALCULATING EQ -1 AND EQ-2

10

16

30X+10Y=240

10X+10Y=160 (-)

(-) (-)

=80

$X=\frac{80}{20}$ 20X X=4

Putting the value of X in

30X+10Y=240 30*4+10Y=240

120+10Y=240

10Y=240-120

10Y=120

Y=12

CALCULATING EQ-2 AND EQ-3 2(10X+10Y=160)

20X+60Y=480

20X+20Y=320 20X+60Y=480

(-) (-) (-)

-40Y=-160

Y=160/4

Y=4

Putting the value of Y in EQ

20X+60Y=480

20X+240=480 X=480-240

20

X=12

CORNER POINTS	Value of Z=60X+40Y
A(0,24)	960
B(4,12)	720
C(12,4)	880
D(24,0)	1440

Point B has the minimum value and the value is 720

CPM:

A deterministic model with well- known activity times based upon the past experience. It assumes that, the expected time is actually the time taken. It is an activity oriented system.

PERT:

A probabilistic model with uncertainty in activity duration. Expected time is calculated from t_0,t_m,and t_p. It is an event oriented approach.

critical activity-

The critical activities are those which if consume more than their time, the project will be delayed.

- A critical activity is marked by a thick arrow mark.

Event.

An event is specific instant of time which marks the start and end of an activity. It consumes neither time nor source.

- It is represented by a circle and the event circle is written within the circle.

Activity.

Every project consists of a number of job operations or tasks which are called activity.

- It consumes time and resources.
- An activity is shown by an arrow and it begins and ends with an event.

Dummy activity.

When two activities start at the same instant of time the head events are joined by a dotted arrow known as Dummy activity.

- It is an activity which depicts relationship over the other but does not consume time or resources. It is indicated by dotted line.
- critical path.

The sequence of critical activities in a network is called critical path.

- It is the longest path in the network from the starting event to the ending event and defines the minimum time required to complete the job.
- It is denoted by a double line.
- critical path method

: In critical path method for each activity earliest start time(EST) and latest start time(LST) are computed.

The path will the longest time sequence is called critical path.

- The length of the critical path determines the minimum time in which the entire project can be completed.

EST.

It is known as earliest start time.

- It is the earliest event time of the tail end event.
- It is denoted by ES.
- It is the earliest time at which an activity can start and is calculated by moving from first to last event in a network diagram.

LST.

It is known as earliest start time.

- It is the latest event time of by which an activity can start.
- LST = LFT- duration of that activity.

EFT.

It is known as earliest finish time.

- It is the earliest possible time at which an activity can finish.
- EFT = EST+ duration of that activity LFT.

It is known as latest finish time.

- It is calculated by moving backward i.e. from last event to first event of the network diagram.
- It is the last event time of the head event.

Float?

Float is the difference between the time available for completing an activity and time necessary to complete the same. Float is with reference to activity. slack?

The slack of an event is the difference between the latest and earliest event time. The event with zero slack time known as critical event. optimistic time.

It is the smallest time taken to complete the activity if everything goes well. It is denoted by $t_{0.}$

most likely time.

It refers to the estimate of the normal time the activity would take. This assumes normal delays. It is the mode of probability distribution. It is denoted by t_m.

pessimistic time.

It is the longest time that an activity would take if everything goes wrong. It is denoted by $t_{p.}$ pessimistic time estimate.

pessimistic time estimate

$$t_e = \left[\frac{t_o + 4t_m + t_p}{6} \right]$$

formula for variance of the activity. variance of the activity

$$\sigma^2 = \left[\frac{t_p \quad t_o}{6} \right]^2$$

procedure for PERT. step1: draw the project network.

Step2: compute the expected duration of each activity using the formula.

$$t_e = (t_o + 4t_m + t_p)/6$$

Also calculate the expected variance,

$$\sigma^2 = (t_p - t_o)^2/6$$

Step3: compute the earliest start, earliest finish, latest finish and total float of each activity.

Step4: find the critical path and identify the critical activities.

Step5: compute the project length variance σ^2 which is the sum of the variance of all the critical activities and hence find the standard deviation of project length σ.

Step6: calculate the standard normal variable

$$Z = \frac{Ts - Te}{\sigma}$$

Where Ts= The scheduled time to complete the project.

Te= Normal expected project length duration.

□ = Expected standard deviation of the project length.

Using the normal curve, we can estimate the probability of completing the project within a specified time.

procedure for CPM.

Step1: List all the jobs and then draw an arrow (network) diagram. Each job is indicated by an arrow with the direction of the arrow showing the sequence of jobs. The length of the arrows has no significance. The arrows are placed based on predecessor and concurrent relation within the job.

Step2: Indicate the normal time (t_{ij}) for each activity (i, j) above the arrow which is deterministic. Step3: Calculate the earliest `start time for each event and write the earliest time E_i for each event i in the . Also calculate the latest finish and latest start time. From this we calculate the latest time $L_j$for each event j and put it in the .

Step4: Tabulate the various time, namely, normal time, earliest time and latest time on the arrow diagram.

Step5: Determine the total float for each activity by taking the difference between the earliest start and latest start time.

Step6: Identify the critical activities and connect them with the beginning and the ending events in the network diagram by double line arrows. This gives the critical path.

Step7: calculate the total project duration.

PERT	CPM
1. A probabilistic model with uncertainty in activity duration. Expected time is calculated from t_0, t_m, t_p.	1. A deterministic model with well-known activity times based upon the past experience. It assumes that, the expected time is actually the time taken.
2. An event oriented system.	2. An activity oriented system.
3. PERT terminology employs words like network diagram, event, and slack	3. CPM terminology employs words like arrow, diagram, nodes, and float.
4. The use of dummy activities is necessary for representing the sequence	4. The use of dummy activities is not necessary. The arrow diagram thus becomes slightly simpler.
5. PERT basically doesn't distinguish between critical and non-critical activities.	5. CPM marks critical activities.

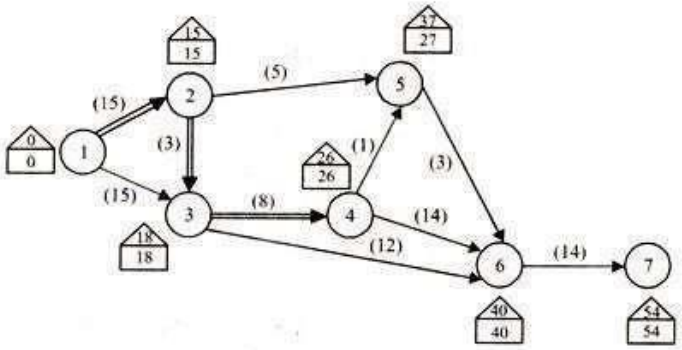
6. PERT finds the application in projects where resources men, material and money are always made available as and when required.	6. CPM is employed to those projects where minimum overall cost is primary importance.
7. Especially suitable in defense projects and R & D where activity time cannot be reliably predicted.	7. Suitable for problems in industrial setting, plant maintenance, civil construction project etc.

A small maintenance project consists of the following jobs, whose precedence relationships are given below.

Job	1–2	1–3	2–3	2–5	3–4	3–6	4–5	4–6	5–6	6–7
Duration (days)	15	15	3	5	8	12	1	14	3	14

1. Draw an arrow diagram representing the project.
2. Find the total float for each activity.
3. Find the critical path and the total project duration.

Solution



Forward pass calculation In this we estimate the earliest start and the earliest finish time ES_j given by,

$ES_j = \underset{i}{\text{Max}}\ (ES_i + t_{ij})$ where, ES_i is the earliest start time and t_{ij} is the normal time for the activity (i, j).

$$ES_1 = 0$$
$$ES_2 = ES_1 + t_{15} = 0 + 15 = 15$$
$$ES_3 = \text{Max}\ (ES_2 + t_{23}, ES_1 + t_{13})$$
$$= \text{Max}\ (15 + 3, 0 + 15) = 18$$
$$ES_4 = ES_3 + t_{34} = 18 + 8 = 26$$
$$ES_5 = \text{Max}\ (ES_2 + t_{25}, ES_4 + t_{45})$$
$$= \text{Max}\ (15 + 5, 26 + 1) = 27$$
$$ES_6 = \text{Max}\ (ES_3 + t_{36}, ES_4 + t_{46}, ES_5 + t_{56})$$
$$= \text{Max}\ (18 + 12, 26 + 14, 27 + 3)$$
$$= 40$$
$$ES_7 = ES_6 + t_{67} = 40 + 14 = 54.$$

Backward pass calculation In this we calculate the latest finish and latest start time LF_i, given by $LF_i = \underset{i}{\text{Min}}\ (LF_j - t_{ij})$ where, LF_j is the latest finish time for the event j 12.

$$LF_7 = 54$$
$$LF_6 = LF_7 - t_{67} = 54 - 14 = 40$$

$$LF_5 = LS_6 - t_{56} = 40 - 3 = 37$$

$$LF_4 = \text{Min}\,(LS_5 - t_{45}, LS_6 - t_{46})$$
$$= \text{Min}\,(37 - 1, 40 - 14) = 26$$

$$LF_3 = \text{Min}\,(LF_4 - t_{34}, LF_6 - t_{36})$$
$$= \text{Min}\,(26 - 8, 40 - 12) = 18$$

$$LF_2 = \text{Min}\,(LF_5 - t_{25}, LF_3 - t_{23})$$
$$= \text{Min}\,(37 - 5, 18 - 3) = 15$$

$$LF_1 = \text{Min}\,(LF_3 - t_{13}, LF_2 - t_{12})$$
$$= \text{Min}\,(18 - 15, 15 - 15) = 0$$

The following table gives the calculations for critical path and total float.

Activity	Normal time	Earliest		Latest		Total float
		Start	Finish	Start	Finish	$LF_j - ES_j$ or $LF_i - ES_i$
		ES_i	ES_j	LF_i	LF_j	
1 – 2	15	0	15	0	15	⓪
1 – 3	15	0	15	3	18	3
2 – 3	3	15	18	15	18	⓪
2 – 5	5	15	20	32	37	17
3 – 4	8	18	26	18	26	⓪
3 – 6	12	18	30	28	40	10
4 – 5	1	26	27	36	37	10
4 – 6	14	26	40	26	40	⓪
5 – 6	3	27	30	37	40	10
6 – 7	14	40	54	40	54	⓪

From the above table, we observe that the activities 1—2, 2—3, 3—4, 4—6, 6—7 are the critical activities and the critical path is given by, 1—2—3—4—6—7

The total time taken for project completion is 54 days.

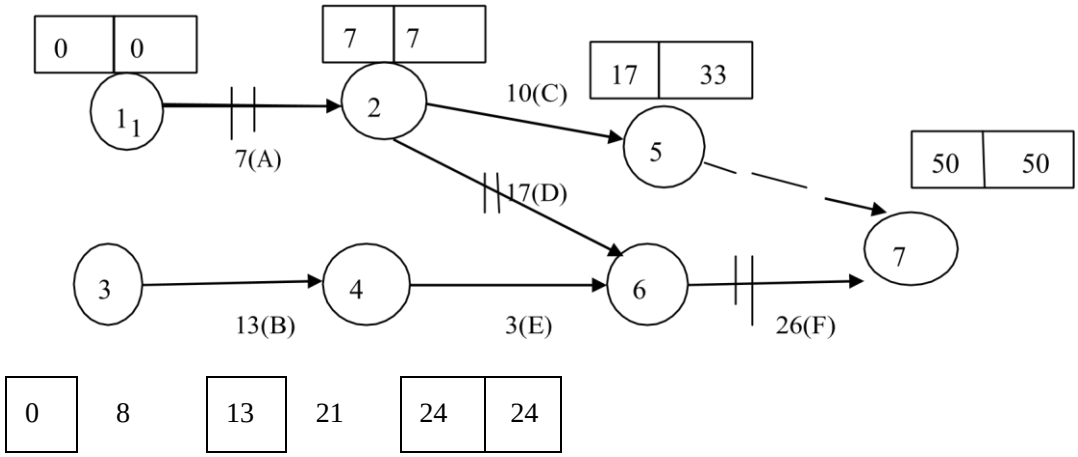
Q2

ACTIVITY	PREDUCESUR	DURATION
A	--	7

B	--	13
C	A	10
D	A	17
E	B	3
F	D,E	26

SOLVE IT BY CPM METHOD AND FIND THE TOTAL DURATION OF PROJECT

ANSWER-



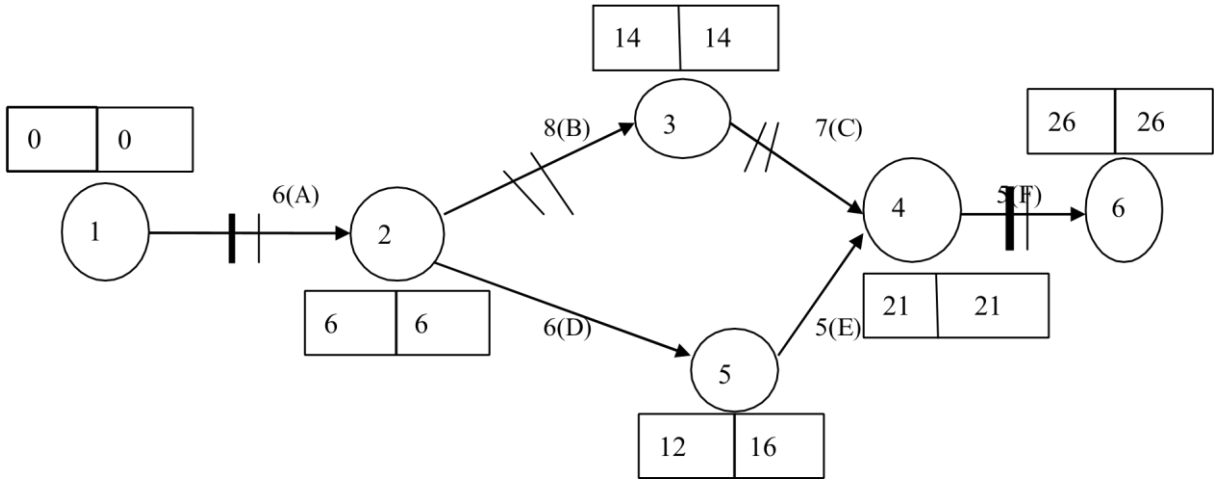
PATH	ACTIVITY	DURATION	EST	LST	EFT	LFT	TOTAL FLOAT
1-2	A	7	0	7	0	7	0
3-4	B	13	6	13	17	21	8
2-5	C	10	7	17	23	33	16
2-6	D	17	7	24	7	24	0
4-6	E	3	13	26	21	24	8
6-7	F	26	24	50	24	50	0

HENCE 1-2-6-7 IS THE CRITICAL PATH AND TOTAL DURATION IS 50 DAYS

Q-3

ACTIVITY	DURATION IN DAYS	PROPERATION
1-2 A	6	--
1-3 B	8	A
3-4 C	7	B
4-5 D	6	A
5-6 E	5	D
6-7 F	5	C,E

ANSWER-



PATH	ACTIVITY	DURATION	EST	LST	EFT	LFT	TOTAL FLOAT
1-2	A	6	0	0	6	6	0
2-3	B	8	6	6	14	14	0
2-4	C	7	14	14	21	21	0
2-5	D	6	6	10	12	16	4
4-5	E	5	12	16	17	21	4
5-6	F	5	21	21	26	26	0

IS THE CRITICAL PATH AND THE TOTAL DURATION OF DAYS ARE-26

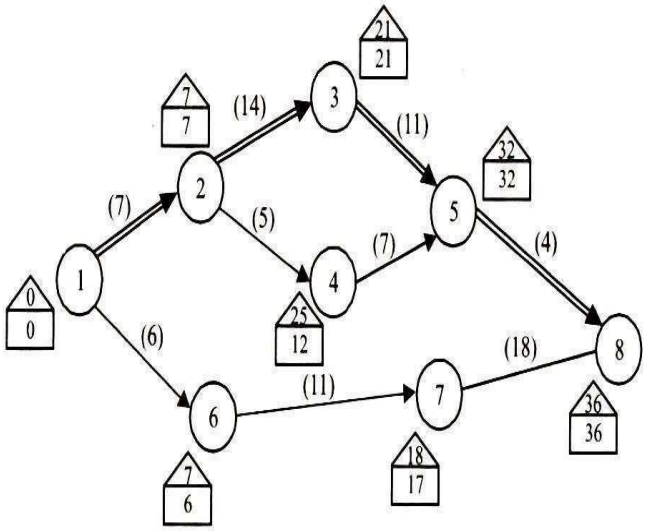
Example 15.11 The following table shows the jobs of a network along with their time estimates.

Job	*1–2*	*1–6*	*2–3*	*2–4*	*3–5*	*4–5*	*6–7*	*5–8*	*7–8*
a (days)	1	2	2	2	7	5	5	3	8
m (days)	7	5	14	5	10	5	8	3	17
b (days)	13	14	26	8	19	17	29	9	32

Draw the project network and find the probability of the project completing in 40 days.

Solution First we calculate the expected time and standard deviation for each activity.

Activity	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$
1–2	$\frac{1+(4\times7)+13}{6} = 7$	$\left(\frac{13-1}{6}\right)^2 = 4$
1–6	$\frac{2+(4\times5)+14}{6} = 6$	$\left(\frac{14-2}{6}\right)^2 = 4$
2–3	$\frac{2+(4\times14)+26}{6} = 14$	$\left(\frac{26-2}{6}\right) = 16$
2–4	$\frac{2+(5\times4)+8}{6} = 5$	$\left(\frac{8-2}{6}\right)^2 = 1$
3–5	$\frac{7+(4\times10)+19}{6} = 11$	$\left(\frac{19-7}{6}\right)^2 = 4$
4–5	$\frac{5+(5\times4)+17}{6} = 7$	$\left(\frac{17-5}{6}\right)^2 = 4$
6–7	$\frac{5+(8\times4)+29}{6} = 11$	$\left(\frac{29-5}{6}\right)^2 = 16$
5–8	$\frac{3+(3\times4)+9}{6} = 4$	$\left(\frac{9-3}{6}\right) = 1$
7–8	$\frac{8+(4\times17)+32}{6} = 18$	$\left(\frac{32-8}{6}\right)^2 = 16$



Expected project duration = 36 days

Critical path 1–2–3–5–8

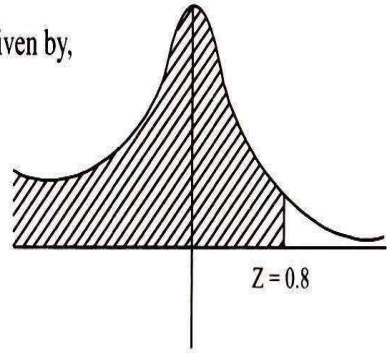
Project length variance, $\sigma^2 = 4 + 16 + 4 + 1 = 25$

$\sigma = 5$

The probability that the project will be completed in 40 days is given by,

$P(Z \le D)$

$$D = \frac{T_s - T_e}{\sigma} = \frac{40 - 36}{5} = \frac{4}{5} = 0.8$$



Area under the normal curve for the region $Z \le 0.8$

$P(Z \le 0.8)$

$= 0.5 + \phi(0.8)$ [$\phi(8) = 0.2881$ (from table)]

$= 0.5 + 0.2881 = 0.7881$

$= 78.81\%$

Conclusion If the project is performed 100 times, under the same conditions, there will be 78.81 occasions for this job to be completed in 40 days.

CH-3 (INVENTORY CONTROL)

Inventory.

- Inventory is a detailed list of those movable items which are necessary to manufacture a product and to maintain the equipment and machinery in good working order.

Inventory control

- Inventory control may be defined as the scientific method of finding out how much stock should be maintained in order to meettheproduction demand and be able to provide right type of material at right time in the right quantities at competitive prices.

Classify inventories.

Inventories are classified as follows

1. Raw Inventory
2. In-process Inventory
3. Finished Inventory
4. Indirect Inventor

Inventory is a detailed list of those movable items which are necessary to manufacture a product and to maintain the equipment and machinery in good working order. Inventories are classified as follows

1. Raw Inventory
2. In-process Inventory
3. Finished Inventory
4. Indirect Inventory

Raw Inventory: They include raw material and semi-finished products supplied by another firm and which are raw items for the present industry.

In-process Inventory: They are semi-finished goods at various stages of manufacturing cycle.

Finished Inventory: They are finished goods lying in stock rooms and waiting dispatch.

Indirect Inventory: They include lubricant and other items like spare parts needed for proper operation, repair and maintenance during manufacturing cycle.

objective of inventory control

Inventory control may be defined as the scientific method of finding out how much stock should be maintained in order to meettheproduction demand and be able to provide right type of material at right time in the right quantities at competitive prices.

The objectives are:

- To ensure adequate supply of products to customer and avoid storage - To make sure that the financial investment in inventories is minimum.
- Efficient purchasing, storing, consumption for materials.
- To maintain timely record of inventories of all items.
- To maintain the stock within the limits.; - To minimize investment in inventory.
- To ensure that the supply of raw material and finished good will remain continuous so that production process not altered and demand of customer are duly met.

This is achieved by

a) Providing a suitable and secure storage location.

b) Providing enough storage space.

c) A definite inventory identification system.

d) Periodic inventory checkup.

e) Up to date and accurate record keeping. Function of inventory

1. Separate different operations from one another and make them independent so that each operation can be performed economical.
2. Maintain smooth and deficient production flow.
3. Purchased in desired quantity and notify the effect of changes in prices or supply.
4. Keeps a process continually operating.
5. Create motivational effect.

EOQ

- A problem which always remains is that how much material may be ordered at a time. The industry must know what raw materials they are purchased for their respective production.

The known details about the raw material are called Economic Order Quantity. economic order quantity

- A problem which always remains is that how much material may be ordered at a time. The industry must know what raw material they are purchased for their respective production. The known details about the raw material are called Economic Order Quantity Demand

Demand refers to the number of items required per period.

- The demand patterns of items may be either deterministic or probabilistic lead time

The time gap between the placing of an order and the actual arrival of the inventory is known as lead time.

order cycle

The time period between the placements of two successive orders is referred to as an order cycle.

time horizon.

The time period over which the inventory will be controlled is known as time horizon. recorder level.

The level between maximum stock and minimum stock at which the purchasing activity start.

Buffer stock.

It refers to the extra inventory maintained in addition to the inventory required, corresponding to normal consumption level. safety stock.

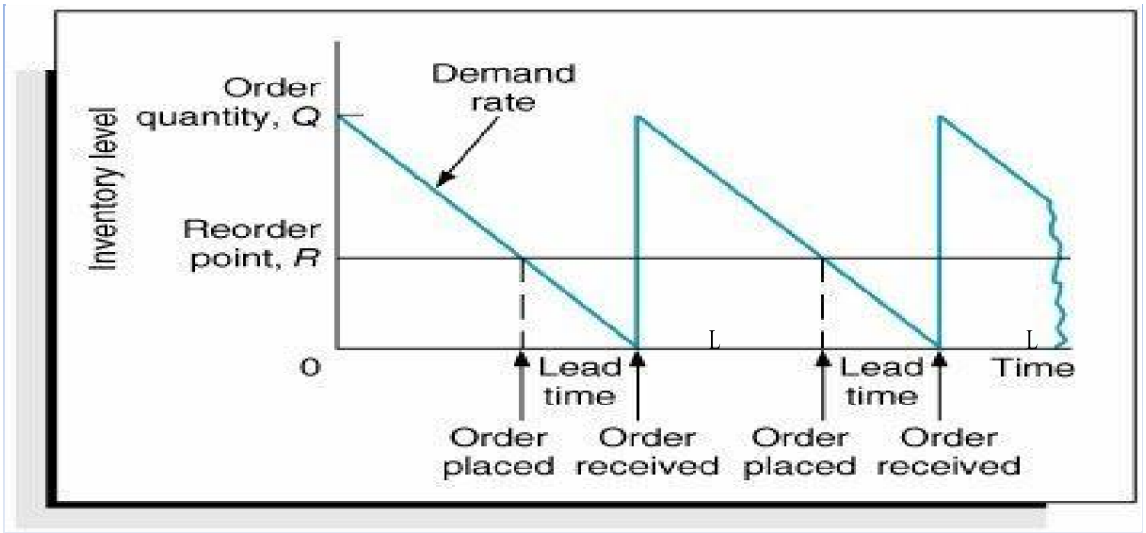
It is maintained as a protection against stock out. The greater the safety stock maintained less is the risk of stock out.

Reorder level. It is that level of an inventory at which the order is placed.

Economic Order Quantity.

A problem which always remains is that how much material may be ordered at a time.

The industry must know what raw material they are purchased for their respective production.



The known details about the raw material are called Economic Order Quantity.

When inventory 'OQ' is in stores it consumes gradually in quantity from 'A' along 'AD' at uniform rate. It takes 'L' number of days between initiating order and receiving required inventory.

- Therefore the quantity reaches point 'B' purchase requisition is initiated from 'B' to 'C'.
- From 'C' to 'D' inventory procurement. At point 'D' only reserve stock is left, the order material is supposed to reach and again the total quantity shoots to its maximum value i.e.'A'.
- Maximum quantity 'OA' is the upper or maximum limit which the inventory can be kept in the stores at any time.

- Minimum quantity 'OE' is the lower or minimum limit to which must be kept in the stores at any time.

The purpose of stock holding

(a) Avoid running out of stock.
(b) Make sure the pre decided delivery dates.
(c) Provide quick availability of material.
(d) Takes care of price fluctuation and storage of inventory in the market.

- Standard order A′D is the difference between maximum and minimum quantity.
- Reorder point B indicates that it is high time to initiate a purchase order and if not done the inventory may exhaust.

From B′ to D′ is lead time 'L' it includes

(a) Time to prepare purchase requisition and placing the order.
(b) Time taken to deliver purchase order to the seller.
(c) Time for the seller to prepare inventory.
(d) Time for the inventory to be dispatched from vendors end and reach to customer.

1. Given that,

Annual usage U=60 units.

Procurement cost P= Rs. 15 per order

Cost per price C= Rs. 100

Cost of carrying inventory I, percentage including expenditure on obsolence, taxes, insurance, deterioration etc is 10%.

Calculate EOQ.

Ans: Given,

U=60 units

P= Rs. 15 per order

C= Rs. 100

I= 10%= 0.1

$$EOQ=\sqrt{2\square\square}/\square\square$$

$$= \sqrt{2 * 60 * 15}/\ 100 * 0.1$$

=13.41 units

EOQ= 14 units

Therefore no of ordered per year = $\frac{60}{14}$ = 5

Hence EOQ = $\frac{60}{5}$ = 12 units (Ans)

2. Find EOQ from the following data: Average annual demand = 30,000 units
Inventory carrying cost = 12% of units value per year
Cost of placing an order = Rs. 70 Cost of unit = Rs.2 Ans:

Given,

U=30,000 units P= Rs. 70
C= Rs. 2
I= 12%= 0.12

$$EOQ=\sqrt{2UP/C}$$

$$= \sqrt{2 * 30000 * 70/2 * 0.12}$$

=4183.30 units

EOQ= 4184 units

Therefore no of ordered per year = $\frac{30000}{4184} = 7.17 = 8$

Hence EOQ = $\frac{30000}{8}$ = 3750 units (Ans)

3. ABC Corporation has got a demand for 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 is estimated at 9% of average inventory investment. Determine

(i) EOQ
(i) Optimum number of orders to be placed per annum

Ans: Given,

U=10,000 units P= Rs. 36
C= Rs. 2
I= 9%= 0.09

(I) $EOQ=\sqrt{2UP/C}$

$$= \sqrt{2 * 10000 * 36/2 * 0.09}$$

=2000 units

(II) Optimum number of orders

Optimum number of orders= □

□□□

_____

—

= $\sqrt{2000}$ 10000 = 5

Hence EOQ = $\frac{10000}{5}$ = 2000 units (Ans)

4. A manufacture has to supply his customer 3600 units of his product per year. Inventory carrying cost amount Rs.12 per unit per annum. The setup cost per run is Rs. 80.

Find:

1. EOQ
2. Optimum number of supply per optimum order.
3. Optimum period of supply per optimum period

Ans: Given,

U=3600 units

P= Rs. 80 per order

I= 1.2 Rs/unit/annum

(i) EOQ=$\sqrt{2\square\square/\square\square}$

$= \sqrt{2 * 3600 * 80}/1.2$

=692.82units

EOQ= 693 units

(ii) Optimum number of orders

Optimum number of orders= $\frac{\square}{\square\square\square}$

$= \frac{3600}{693} = 5.19 = 5$ order

(iii) Optimum period of supply per optimum period

$= \frac{1}{N} = \frac{1}{5} = 0.2$ years

ABC analysis:

As the size of industry increases, the number of items to be purchased and the care of them.

– Purchase and control of all items at a time and in bulk much before their use irrespective of their price problems, blocks involve a lot of money and man hours and therefore uneconomical.

– ABC analysis helps segregating the items from one another and tells how much valued the item is.

Procedural step:

(a) Identify all items used in an industry.

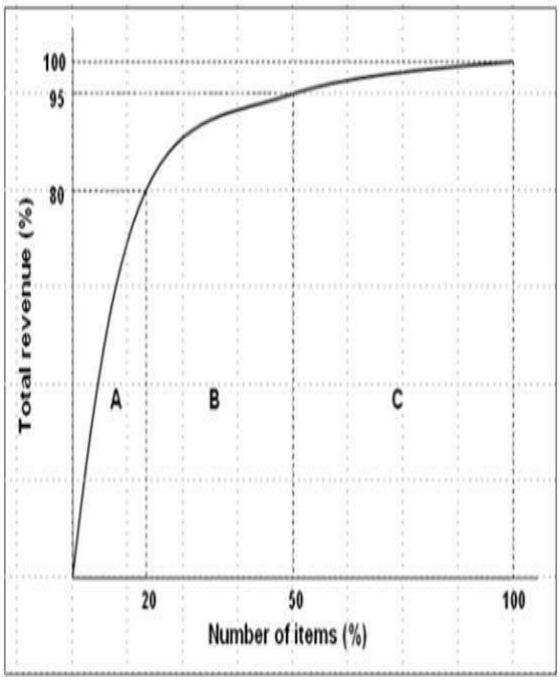
(b) List all items as per their value.

(c) Count the number of high, medium and low valued items.

(d) Find the percentage of High, medium and low valued items.

High valued items normally contribute for 80% or of total inventory cost and medium and low valued items 15% and 5%.

(e) A graph can be plotted between percent of items on X-axis and percent of total inventory cost on Y-axis.



- A-Items are high valued but are limited or few in number. Such items should be

thought of in advance and purchase well in time. A detailed record of their receipt and issue should be kept and proper handling and storage should be provided. These are shown by A.

- B-Items are the medium valued and their number lies in between A and C items. They are important than C items. B items also require careful storage and handling.
- C-Items are low valued, but maximum number items.

These items do not need any control. These are last important like clips, all pins, rubber bands etc. They are generally procured just before they finish. No records are normally kept for these items.

..... END.....

CH-4 (PLANT MAINTENANCE)

Maintenance- the process of preserving a condition or situation or the state of being preserved. plant maintenance Plant maintenance helps in maintaining and increasing the efficiency of plant facility reducing the operating cost and increase the effectiveness of the production.

Plant maintenance is essential to achieve specified level of quality and reliability and efficient working. objective of plant maintenance.

The objective of plant maintenance is

– To increase functional reliability of production facilities.

– To maximize the useful life of the equipment.

– To minimize the total production cost.

– To minimize the frequency of interruptions to production by reducing breakdown.

INDUSTRIAL ENGINEERING MANAGEMENT

To maximize the production capacity from given equipment resources.

- To enhance the safety of manpower.

Duties, functions and responsibilities of plant maintenance department.

The different duties, functions and responsibilities of maintenance department are as follows:

(a) INSPECTION ……

- Inspection is the routine schedule checks of the plant facilities to examine their condition and to check for needed repairs.
- Inspection is required for the safe and efficient operation of equipment and machinery.
- Inspection makes certain that every working equipment receives proper attention.

(b) ENGINEERING…….

- Engineering involves alteration and improvements in existing equipment's and building to minimize breakdowns.

(c) MAINTENANCE…….

- Maintenance of existing plant equipment.
- Maintenance of existing plant buildings and other service facilities such as yards, central stores, roadways etc.
- Preventive maintenance. (d) REPAIR……
- Maintenance department carries out repairs to change the unsatisfactory conditions found during inspection.
- Repair is an unscheduled works its emergency in nature.

(e) OVERHAUL…..

- Overhaul is a planned, scheduled, and reconditioning of plant facilities such as machinery.
- Overhaul involves replacement, reconditioning, reassembly etc.

(f) CONSTRUCTION…..

- Maintenance department handles construction wood, brick, steel structure, cement, electrical insulation etc.

(g) SALVAGE…..

- Maintenance department handle disposition of scrap or surplus material.
- The collection and disposition of surplus equipment's, materials, supplies etc.

(h) CLERICAL JOBS…..

- Maintenance department keep records of cost.
- It keeps records of time progress on jobs.
- Records important features of buildings and production, equipment's, electrical insulation, water, steam, air and oil lines, transportation facilities.

(i) Generation and distribution of power and other utilities.

- (j) Administration and supervision of labour force.

(k) Providing plant protection.

(l) Insurance administration.

(m) Establishing and maintaining a suitable store of maintenance materials.

(n) Housekeeping involves the cleaning of equipment, buildings, toilets, and washroom (o) Pollution and noise control.

Types of maintenance

Plant maintenance helps in maintaining and increasing the efficiency of plant facility reducing the operating cost and increase the effectiveness of the production.

The various types of maintenance that are practiced in a plant are

(i) Preventive maintenance

(ii) Break down or corrective maintenance

(iii) Scheduled maintenance

(iv) Predictive maintenance

Preventive maintenance: -- In preventive maintenance equipment conditions are measured periodically or a non-continuous basis enable maintenance men to take a timely action such as equipment adjustment, repair etc.

- Preventive maintenance extends the service life of equipment without fear of failure preventive maintenance.

A system of scheduled, planned or preventive maintenance tries to minimize the problem of breakdown maintenance.

- It locates weak spots in all equipment's provides them regular inspection and minor repairs thereby reducing the danger of breakdown.
- It involves periodic inspection of equipment and machinery to uncover conditions that lead to production breakdown and harmful depreciation.

Preventive maintenance includes:

- Proper identification of all items, their documentation and coding.
- Inspection of plant and equipment at regular interval.
- Proper lubrication, cleaning of equipment.
- To upkeep the machine through minor repairs.
- Failure analysis and planning for their elimination.

Breakdown/ corrective Maintenance: --

- It is an emergency based policy in which the plant or equipment is operated until it fails and then it is brought back into running condition by repair.
- Breakdown maintenance is economical for those equipment whose down time and repair cost are less than any other type of maintenance

Scheduled maintenance: --

- Schedule maintenance is stitch in time procedure aims at avoiding breakdown.
- Breakdown can be dangerous to life as far as possible should be minimized.

- Scheduled maintenance involved inspection, lubrication; repair and overhaul of certain equipment's which if neglected can result in break down.
- It is generally followed for overhauling of machines; cleaning of water and other tanks, white washing of building etc.

Predictive maintenance: --

INDUSTRIAL ENGINEERING MANAGEMENT

It locates weak spots in all equipment's provides them regular inspection and minor repairs thereby reducing the danger of breakdown.

- It involves periodic inspection of equipment and machinery to uncover conditions that lead to production breakdown and harmful depreciation. predictive maintenance It is a comparatively a newer maintenance technique.
- It makes use of human senses or other sensitive instrument such as audio gauges, vibration analyzer, amplitude meters, pressure, temperature and strain gauges to predict troubles before the equipment fails.
- Unusual sounds coming out of rotating equipment's predicts a trouble, an electric motor cable excessively hot at one point predicts trouble.
- Simple hand touch can point at many unusual conditions and predict a trouble.
- In preventive maintenance equipment conditions are measured periodically or a non- continuous basis enable maintenance men to take a timely action such as equipment adjustment, repair etc.

- Preventive maintenance extends the service life of equipment without fear of failure.

Recent development in Plant Maintenance: --

In recent years there is a use of variety of management techniques for plant maintenance. This technique have led to

- Nance Increase in maintenance efficiency.
- Reduced maintenance
- Improved service. (A) USE OF WORK STUDY: ---
- Work study improves maintenance scheduling and eliminates a great deal of frustration on the part of production supervision.

(B) USE OF NETWORK PLANNING TECHNIQUE: ---

- Maintenance costs have been cut down.
- Plant utilization has been raised.
- CPM is very useful for planning and control of large maintenance projects. (C) USE OF OPERATIONS RESEARCH: --
- Operations research handles maintenance problems such as economic level of spare parts when to replace an item. (D) USE OF COMPUTERS: ---
- Computers when used for managing maintenance problem provide more efficient operation and controlled.
- Computers can prepare maintenance work orders giving accurate work order description and job timing.
- Reduce cost of keeping records equipment.

.....END.....

CH-5 (INSPECTION AND QUALITY CONTROL)

Inspection.

- It is defined as the checking the acceptability of a product. It is an essential part of production through which the necessary control over the quality of a product is maintained right from the raw material stage to final finished product.
- Inspection is measures aimed at checking, measuring, or testing of one or more product characteristics and to relate the results to the requirements to confirm compliance.

Quality Control.

- Quality control, or QC for short, is a process by which entities review the quality of all factors involved in production. It defines quality control as "A part of quality management focused on fulfilling quality requirements". planning of inspection.

While planning for inspection the following questions are decided before the inspection starts:-

Where to inspect? – Place

When to inspect? – Time

- How to inspect? – Method
- How much to inspect? – Degree of inspection
- What to inspect? – Parameters
- Who should inspect? – Person

Place of Inspection (Where to Inspect?):-

- The place of inspection largely depends upon the manufacturing conditions, circumstances and plant layout. Generally, three types of location are permitted for inspection. (Floor, centralised, separate room).

(a) Floor inspection: - It can be done at the machine itself. In continuous productions industries where every operation is linked through conveyors, it is not advised to carry product at a separate place for inspection. The advantages of it can be enlisted as:

- It saves the transportation of material to inspection room.
- It provides quick inspection service.
- It is best suited for bulky products.

(b) Centralised/ separate inspection room:- In this system the products are brought to a separate inspection room or centrally located inspection counter.

It has following advantages.

- Inspection conditions are better because precession instruments can be used.
- More accurate and be used.
- Less chances of inspector being influenced.

Time of Inspection (When to Inspect?):-

There is no hard and fast rule as when the product is to be inspected but some general rules which may be followed are:

- Inspection should be done at each halt
- Inspection should be done after each operation in the process.

The above rules help in fixing the responsibility for any defective work. This also helps in knowing where the quality is respectively not being followed. Broadly there are three stages of inspection.

- In coming material inspection.
- In process material inspection at each and every stage of halt.
- Outgoing or final inspection. Parameters (what to Inspect):-
- The first phase of an inspection system is to decide what parameters are to be checked or inspected during the inspection.
- The parameter may be different for different kinds of jobs.

- So, the inspectors should be known clearly about the parameters to be checked e.g. diameter, length etc.
- These make the variation to be studied in case of statistical analysis.

Person (Who should inspect?):-

Before we start inspection of a product or process, we should appoint the persons for a particular parameters or products.

- So, that he will be responsible for any discrepancies in the process for that particulars parameter or product.

Types of inspection.

The different types of inspection are:

- Remedial
- Preventive
- Operative inspection
- Incoming in process
- Final inspection

Remedial and preventive inspection:-

- Major difference between the two is that the latter attempts at prevention, the former on cure.
- Preventive inspection lays emphasis on removing assignable variables by paying special attention to the possibility of defects and waste is eliminated to the maximum possible extent.
- Preventive inspection is also known as constructive inspection and has thus the positive approach rather than the negative approach involved in remedial or corrective inspection.
- Remedial detects parts that are defective, thus it tries to discover defects which have already occurred. It tries to filter the good from the bad ones. Operative / stage inspection (key point inspection):-
- The inspection which takes place at each stage or at end of some functional operations, this inspection automatically fixes the responsibility of a worker or operation which caused the defect.
- It almost eliminates the need of final inspection and the defective piece is nipped in the bud, thereby eliminating the further wastage and the cost involved. Incoming or receiving inspection:-
- Materials inspection is concerned with the control of a quality of the raw material and purchased parts.
- It is also known as incoming inspection. It examines everything coming into the plant e.g. materials, parts, assemblies, equipment's etc. The received material is generally checked for (a) Requirement laid down in purchase order.

(b) Damages, corrosion, Cracks etc.

(c) Test report in case of raw-materials.

-
- In case of necessity, the persons of the inspections department inspect the materials at the supplier's plant, before its delivery or even when it is in the process of productions.

In-process Inspection:-

- It examines the parts and products in the plant at any stage of manufacturing process.
  It is mainly used as tool to anticipate and prevent subsequent production difficulties.

The objectives of this type of inspections are:

1. Prevention of unnecessary hard work on the assembly floor.
2. Prevention of waste of large amount of material by inspecting mass production operations in the beginning as well as subsequent operations.
3. Prevention of rework on spoiled parts.
4. To ensure against loss of parts while in transit from one process to another.

Final inspection:-

- In this type of inspection, the product is checked by appearance.
- So, that to know that every surface has gone through the required operations or not, before undergoing the appropriate tests or stores.
- It is a sort of centralised inspection and makes use of special testing instruments. Factors

Influencing the Quality of Manufacture:-

The following nine factors directly affect the quality of products and services.

- Market for products, services
- Manpower
- Materials
- Money
- Management
- Machines and Method
- Motivations of employees
- Modern information approaches
- Mounting product's needs

Market demand: - It occurs as per customers demand for a particular products type, quality and quantity.
Manpower: - Both for quality designs and for productions of quality goods, right type of men with required knowledge is essential.
Materials: - Due to pressure on production cost and quality requirements, it becomes necessary to work with wide variety of materials having right specification.
Money:- Increased competition, more mechanisation and lower profit margins have made scrap and rework losses as very serious cost of maintenance & improvement of quality have increased to a great extent. Money crunch touches the quality.

–

Management: - Without managements interest and active co-operations there can be no adequate quality.

Machines and Method: - Manufacturing equipment's have become more complex in order to meet high volume of production and high level of quality goals. The machines and technologies required are highly sensitive to meet quality goals.

Motivations of employees: - A motivated worker can produce better quality products and also he can increase the production rate. The motivation of the employees can be done by financially (Bonus, increments etc.).

Modern information approaches: - By implementing modern information approaches to the various production and marketing process the quality of products can be improved.

Mounting product's needs: - The right operation at right time in the production process can also improve the quality of products. Statistical Quality Control

Statistical quality control refers to the use of statistical methods in the monitoring and maintaining of the quality of products and services. One method, referred to as acceptance sampling, can be used when a decision must be made to accept or reject a group of parts or items based on the quality found in a sample.

Control Charts

It is the quality of the materials, batches, parts assemblies, during the course of their actual manufacture is the most important activity. The most important tool is control chart designed by Dr. W.A. Shewart's, for this purpose which is used for the study and control of repetitive processes.

X- Chart

The chart is based on the measurements data instead of data that arise simply form classification counting. Sample size can be smaller also. So, it is constructed to show the fluctuations of the means of samples about the mean of the process. This chart will help of the user in tracking down the assignable causes.

R-Chart

It is used to show fluctuations of the ranges of the samples about the average range R. This controls the general variability of the process and affected by the changes in variability. It is a chart for measures of spread.

Advantages of control chart

The control charts have the advantages given as under

1. The control chart gives Indication for the process is in control or out of control
2. It determines process variability.
3. It detects unusual variations taking place in a process.
4. It ensures the product quality level
5. It gives warning in time to rectify the process so that scrap or percentage rejection can be reduced.
6. It gives information's about the selection of process and setting of tolerance limits.
7. It also helps to build up the reputation of the organization through customer's satisfactions due to good quality of the products.
8. The inspection work reduces.

**********END**********

CH-6 (CONTEMPORARY QUALITY MANAGEMENT CONCEPT)

TQM.

Total quality management is an organization-wide philosophy with its core values centered on continually improving the quality of its product and services, and the quality of its processes, to meet and exceed customer expectations.

This means that everyone in the organization - from top management to the employees - plays a role in providing quality products and services to customers. Even suppliers and the customers themselves are part of the TQM.

Five Principles of TQM

- Produce quality work the first time
- Focus on the customer
- Have a strategic approach to improvement
- Improve continuously
- Encourage mutual respect and teamwork

Producing quality work (the first time) means quality is built into the processes for producing products or providing services, and continual improvement measures are taken to ensure the processes work every time.

- Employees are empowered to make decisions to improve a process and are provided with continual training to develop their skills.
- The purchasing department at Fun Time Travel evaluates data on client purchases to determine which packages are most popular with clients.
- This helps them to determine what stays and what goes.
- The information technology technicians monitor the website continually to assess whether clients are just browsing or actually making purchases.
- The IT guys also evaluate how long a booking takes to determine whether changes need to be made to the check-out process.

Focusing on the customer involves designing products or services that meet or exceed the customer's expectations.

- This involves the product itself, its functionality, attributes, convenience and even the means by which the information about a product is received by a client.
- The marketing department is responsible to get the cyber-word out to potential clients. Marketers use a wide variety of media sources, like social networking, email and even texting, to get the word out about Fun Time's website.
- If they notice traffic is not moving toward the website or that clients are not staying online long enough, they will make strong suggestions to the IT department and the research and development department to make changes immediately.

By having a strategic approach to improvement, processes are developed and tested to ensure the product or service's quality. This also involves making sure suppliers offer quality supplies needed to produce products.

- The purchasing department monitors client reviews to determine whether the ratings on the website are similar to those of actual past customers.

- This makes it possible for purchasing to add more travel packages to the company's inventory.

Improving continuously means always analyzing the way work is being performed to determine if more effective or efficient ways are possible, making improvements and striving for excellence all the time.

- The human resources department is interested in making sure employees are qualified to perform their jobs.
- By having qualified and trained employees on the team, the website will run effectively. Calls to the travel desk will be handled efficiently.
- Any interruption to the booking process will be quickly fixed, and improvements will be made.

Encouraging mutual respect and teamwork is important because it fosters a single-organizational culture of excellence by knowing that every employee from top to bottom of the hierarchy holds the same core principles at heart.

Benefits of total quality management (TQM) :

- Strengthened competitive position
- Adaptability to changing or emerging market conditions and to environmental and other government regulations
- Higher productivity
- Enhanced market image
- Elimination of defects and waste
- Reduced costs and better cost management
- Higher profitability
- Improved customer focus and satisfaction
- Increased customer loyalty and retention
- Increased job security
- Improved employee morale
- Enhanced shareholder and stakeholder value
- Improved and innovative processes

ISO-9000:

- ISO 9000 is a series of standards, developed and published by the International Organization for Standardization (ISO), that define, establish, and maintain an effective quality system for manufacturing and service industries.
- The ISO 9000 standard is the most widely known and has perhaps had the most impact of the 13,000 standards published by the ISO.
- It serves many different industries and organizations as a guide to quality products, service, and management.

- An organization can be ISO 9000-certified if it successfully follows the ISO 9000 standards for its industry.
- In order to be certified, the organization must submit to an examination by an outside assessor.

- The assessor interviews staff members to ensure that they understand their part in complying with the ISO 9000 standard, and the assessor examines the organization's paperwork to ensure ISO 9000 compliance.
- The assessor then prepares a detailed report that describes the parts of the standard the organization missed.
- The organization then agrees to correct any problems within a specific time frame.
- When all problems are corrected, the organization can then be certified.
- Today, there are approximately 350,000 ISO 9000-certified organizations in over 150 countries. ISO 9000:2005 (the actual standard name) explains the fundamentals of quality management systems (like ISO9001) and Vocabulary used in the ISO9000 Standards and:
- Describes the fundamentals of the QMS in the ISO9000 family.
- Defines the related terms in the ISO 9000 QMS.
- Is used as guidance when implementing ISO 9000 Standards.
- Does NOT have any requirements, so an organization does NOT certify to ISO 9000 It is scheduled to be updated in the next few years.

Standards in the ISO 9000 family include:

- ISO 9001:2015 - sets out the requirements of a quality management system
- ISO 9000:2015 - covers the basic concepts and language
- ISO 9004:2009 - focuses on how to make a quality management system more efficient and effective
- ISO 19011:2011 - sets out guidance on internal and external audits of quality management systems.

ADVANTAGES OF ISO 9000

- Increased marketability
- Reduced operational expenses
- Better management control
- Increased customer satisfaction
- Improved internal communication
- Improved customer service
- Reduction of product-liability risks
- Attractiveness to investors

ISO-14000:

ISO 14000 is a family of standards related to environmental management that exists to help organizations (a) minimize how their operations (processes, etc.) negatively affect the environment (i.e., cause adverse changes to air, water, or land); (b) comply with applicable laws, regulations, and other environmentally oriented requirements, and (c) continually improve in the above. The ISO 14000 series addresses the following aspects of environmental management:

- Environmental Management Systems (EMS)

- Environmental Auditing & Related Investigations (EA&RI)
- Environmental Labels and Declarations (EL)

Environmental Performance Evaluation (EPE)

- Life Cycle Assessment (LCA)

Terms and Definitions (T&D)

Compliance to an ISO 14000 EMS:

- Assures customers of your commitment to demonstrable environmental management
- Maintains excellent public relations
- Satisfies investor criteria and improves access to capital
- Obtains insurance at reasonable cost
- Enhances your image and market share
- Meets your clients' registration requirements
- Improves cost control by identifying and eliminating waste and inefficiency
- Lessens incidents that result in liability
- Reduces your consumption of materials and energy
- Facilitates the attainment of permits and authorizations
- Decreases the cost of complying with environmental regulations
- Improves industry-government relations

ISO 14000 registration

With respect to ISO 14000, registration is the formal recognition of an organization's ability to conform to the requirements of an EMS. Organizations may simply declare that their EMS meets the requirements of ISO 14001 ("self-declaration"). However, many organizations choose to have their EMS registered, usually to provide greater assurance to clients and the public, or because regulators and clients require it. The ISO 14000 standards and documents are being developed with the following key principles in mind:

- To result in better environmental management
- To encompass environmental management systems and the environmental aspects of products
- To be applicable in all countries
- To promote the broader interests of the public as well as users of these standards
- To be cost-effective, non-prescriptive and flexible so they are able to meet the differing needs of organizations of any type or size, worldwide
- As part of their flexibility, to be suitable for internal and/or external verification
- To be scientifically based
- Above all, to be practical, useful and usable

ISO 14000 standards- "Organization" and "Product" oriented

- The ISO 14000 series fall into two major groupings: organization-oriented and product-oriented documents. The organization-oriented standards provide complete guidance for establishing, maintaining and evaluating an EMS. They are also concerned with other organization- wide environmental systems and functions.

The following is a list of the published organization-oriented ISO 14000 standards, TRs and guides:

- ISO 14001:2004, Environmental Management Systems-Specification With Guidance for Use
- ISO 14004:2004, Environmental Management Systems-General Guidelines on Principles, Systems and Supporting Techniques
- ISO 14010:1996, Guidelines for Environmental Auditing-General Principles
- ISO 14011:1996, Guidelines for Environmental Auditing-Audit Procedures-Auditing of Environmental Management Systems
- ISO 14012:1996, Guidelines for Environmental Auditing-Qualification Criteria for Environmental Auditors
- ISO 14031:1999, Environmental Management-Environmental Performance Evaluation- Guidelines
- ISO/TR 14032:1999, Environmental Management-Examples of Environmental Performance Evaluation (EPE)
- ISO/TR 14061:1998, Information to Assist Forestry Organizations in the Use of Environmental Management System Standards ISO 14001 and ISO 14004

JIT:

Just-in-time (JIT) manufacturing, also known as just-in-time production or the Toyota production system (TPS) is a methodology aimed primarily at reducing flow times within production as well as response times from suppliers and to customers.

- It is defined as an inventory strategy companies employ to increase efficiency and decrease waste by receiving goods only as they are needed in the production process, thereby reducing inventory costs.
- It works on a demand-pull basis, contrary to hitherto used techniques, which worked on a productionpush basis.
- To elaborate further, under just-in-time manufacturing (colloquially referred to as JIT production systems), actual orders dictate what should be manufactured, so that the exact quantity is produced at the exact time that is required.
- Just-in-time manufacturing goes hand in hand with concepts such as Kanban, continuous improvement and total quality management (TQM).
- Just-in-time production requires intricate planning in terms of procurement policies and the manufacturing process if its implementation is to be a success.
- Highly advanced technological support systems provide the necessary back-up that Just- in-time manufacturing demands with production scheduling software and electronic data interchange being the most sought after.

Advantages Just-In-Time Systems:

- Just-in-time manufacturing keeps stock holding costs to a bare minimum. The release of storage space results in better utilization of space and thereby bears a favorable impact on the rent paid and on any insurance premiums that would otherwise need to be made.
- Just-in-time manufacturing eliminates waste, as out-of-date or expired products; do not enter into this equation at all.

  As under this technique, only essential stocks are obtained, less working capital is required to finance procurement. Here, a minimum re-order level is set, and only once that mark is reached, fresh stocks are ordered making this a boon to inventory management too.
- Due to the aforementioned low level of stocks held, the organizations return on investment (referred to as ROI, in management parlance) would generally be high.
- As just-in-time production works on a demand-pull basis, all goods made would be sold, and thus it incorporates changes in demand with surprising ease. This makes it especially appealing today, where the market demand is volatile and somewhat unpredictable.
- Just-in-time manufacturing encourages the 'right first time' concept, so that inspection costs and cost of rework is minimized.
- High quality products and greater efficiency can be derived from following a just-in-time production system.
- Close relationships are fostered along the production chain under a just-in-time manufacturing system.
- Constant communication with the customer results in high customer satisfaction.
- Overproduction is eliminated when just-in-time manufacturing is adopted.

Disadvantages

Following are the disadvantages of Adopting Just-In-Time Manufacturing Systems

- Just-in-time manufacturing provides zero tolerance for mistakes, as it makes re-working very difficult in practice, as inventory is kept to a bare minimum.
- There is a high reliance on suppliers, whose performance is generally outside the purview of the manufacturer.
- Due to there being no buffers for delays, production downtime and line idling can occur which would bear a detrimental effect on finances and on the equilibrium of the production process.
- The organization would not be able to meet an unexpected increase in orders due to the fact that there are no excess finish goods.
- Transaction costs would be relatively high as frequent transactions would be made.
- Just-in-time manufacturing may have certain detrimental effects on the environment due to the frequent deliveries that would result in increased use of transportation, which in turn would consume more fossil fuels.

SIX SIGMA:

- "Six Sigma is a quality program that, when all is said and done, improves your customer's experience, lowers your costs, and builds better leaders. Origin of Six Sigma
- Six Sigma originated at Motorola in the early 1980s, in response to achieving 10X reduction in product-failure levels in 5 years.
- Engineer Bill Smith invented Six Sigma, but died of a heart attack in the Motorola cafeteria in 1993, never knowing the scope of the craze and controversy he had touched off.
- Six Sigma is based on various quality management theories. Features of Six Sigma
  Six Sigma's aim is to eliminate waste and inefficiency, thereby increasing customer satisfaction by delivering what the customer is expecting.
- Six Sigma follows a structured methodology, and has defined roles for the participants.
- Six Sigma is a data driven methodology, and requires accurate data collection for the processes being analyzed.
- Six Sigma is about putting results on Financial Statements.
- Six Sigma is a business-driven, multi-dimensional structured approach for:
- Improving Processes
- Lowering Defects
- Reducing process variability
- Reducing costs
- Increasing customer satisfaction
- Increased profits
- The word Sigma is a statistical term that measures how far a given process deviates from perfection.
- The central idea behind Six Sigma: If you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them and get as close to "zero defects" as possible and specifically it means a failure rate of 3.4 parts per million or
  99.9997% perfect.

Key Concepts of Six Sigma

At its core, Six Sigma revolves around a few key concepts.

- Critical to Quality: Attributes most important to the customer.
- Defect: Failing to deliver what the customer wants.
- Process Capability: What your process can deliver.
- Variation: What the customer sees and feels.
- Stable Operations: Ensuring consistent, predictable processes to improve what the customer sees and feels.
- Design for Six Sigma: Designing to meet customer needs and process capability.
- Our Customers Feel the Variance, Not the Mean. So Six Sigma focuses first on reducing process variation and then on improving the process capability.

Myths about Six Sigma

There are several myths and misunderstandings surrounding Six Sigma. Some of them few are given below:

- Six Sigma is only concerned with reducing defects.
- Six Sigma is a process for production or engineering.
- Six Sigma cannot be applied to engineering activities.
- Six Sigma uses difficult-to-understand statistics.
- Six Sigma is just training.

Benefits of Six Sigma

Six Sigma offers six major benefits that attract companies:

Generates sustained success
- Sets a performance goal for everyone
- Enhances value to customers
- Accelerates the rate of improvement
- Promotes learning and cross-pollination
- Executes strategic change quality

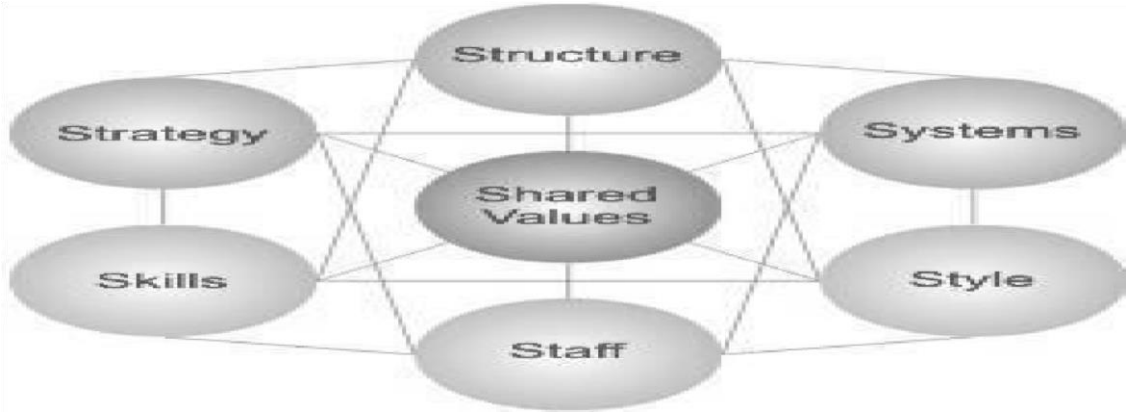
7 S:

The 7-S model involves seven interdependent factors which are categorized as either "hard" or "soft" elements:

- "Hard" elements are easier to define or identify and management can directly influence them: These are strategy statements; organization charts and reporting lines; and formal processes and IT systems.
- "Soft" elements, on the other hand, can be more difficult to describe, and are less tangible and more influenced by culture. However, these soft elements are as important as the hard elements if the organization is going to be successful.

Hard Elements	Soft Elements
Strategy Structure Systems	Shared Values Skills Style Staff

The way the model is presented in Figure 1 below depicts the interdependency of the elements and indicates how a change in one affects all the others.



Let's look at each of the elements specifically:

- Strategy: the plan devised to maintain and build competitive advantage over the competition.
- Structure: the way the organization is structured and who reports to whom.
- Systems: the daily activities and procedures that staff members engage in to get the job done.
- Shared Values: called "superordinate goals" when the model was first developed, these are the core values of the company that are evidenced in the corporate culture and the general work ethic.
- Style: the style of leadership adopted.
- Staff: the employees and their general capabilities.
- Skills: the actual skills and competencies of the employees working for the company.

Placing Shared Values in the middle of the model emphasizes that these values are central to the development of all the other critical elements. The company's structure, strategy, systems, style, staff and skills all stem from why the organization was originally created, and what it stands for. The original vision of the company was formed from the values of the creators. As the values change, so do all the other elements.

IMPORTANCE OF 7-S model:

- Improve the performance of a company.
- Examine the likely effects of future changes within a company.
- Align departments and processes during a merger or acquisition.
- Determine how best to implement a proposed strategy.

LEAN MANUFACTURING:

- Lean Manufacturing is the production control technique for eliminating the waste from your manufacturing.
- The Lean approach is based on finding efficiencies and removing wasteful steps that don't add value to the end product. There's no need to reduce quality with lean manufacturing – the cuts are a result of finding better, more efficient ways of accomplishing the same tasks.

- To find the efficiencies, lean manufacturing adopts a customer-value focus, asking "What is the customer willing to pay for?" Customers want value, and they'll pay only if you can meet their needs.

INDUSTRIAL ENGINEERING MANAGEMENT

They shouldn't pay for defects, or for the extra cost of having large inventories. In other words, they shouldn't pay for your waste.

Waste is anything that doesn't add value to the end product. There are eight categories* of waste that you should monitor:

- Overproduction – Are you producing more than consumers demand?
- Waiting – How much lag time is there between production steps?
- Inventory (work in progress) – Are your supply levels and work in progress inventories too high?
- Transportation – Do you move materials efficiently?
- Over-processing – Do you work on the product too many times, or otherwise work inefficiently?
- Motion – Do people and equipment move between tasks efficiently?
- Defects – How much time do you spend finding and fixing production mistakes?
- Workforce – Do you use workers efficiently?

The following steps should be implemented to create the ideal lean manufacturing system.

- Design a simple manufacturing system
- Recognize that there is always room for improvement
- Continuously improve the lean manufacturing system design The benefits of this goal include
- Decreased cycle time
- Less inventory
- Increased productivity
- Increased capital equipment utilization

**********END**********