

plant location means deciding a suitable location, place, area etc where the unit or factory shall start functioning.

→ The size of the plant as a big roll to play in the success or failure of the plant.

→ plant location deals with two activities.

1. selection of a proper geographical area.
2. selecting a particular size within that reason.

Factor affecting plant location

1. Availability of raw materials.
2. proximity to market.
3. Transport facilities.
4. Availability of power, fuel or gas.
5. water supply.
6. Disposal facilities of waste product.
7. climatic and atmospheric condition.
8. Availability of labour.
9. momentum of establish industry.
10. preference of outstanding businessmen and govt. subsidy.
11. Township selection.
12. Advantages of rural area.

plant layout

The plant layout is the physical arrangement of buildings, machinery, equipments, work places and other facilities of production in order to process the product in the most efficient manner.

→ According to Sansonneti and Mallick "it is the placing the right equipment coupled with right place, to permit the processing of a product unit in the most effective manner through the shortest possible distance and in the shortest possible time."

Need of plant layout

Two plants having similar operation may not have identical layout. This may be due to size of plant, nature of process and management calibre.

- There are design changes in the product.
- There is an expansion of enterprise.
- There is purposed variation in the size of department.
- Some new product is to be added to the existing line.

Objective of good plant layout

- It should provide overall satisfaction to all concerned.
- Material handling and internal transportation from one operation to the next is minimized and efficiently controlled.

- the production bottlenecks and points of congestion are to be eliminated so that input raw material and semibinished parts move best from one work station to another.
- it should provide high work in process turnover.
- it should provides workers convenience, promote job satisfaction and safety for them.
- it should avoid ~~unneste~~ unnecessary investment of capital and provide space for future expansion of plant.

principle of plant layout

→ According to Muther there are six basic principle of best layout. There are

1. principle of overall integration

According to this principle the best layout is one which provides integration of production facilities like men, machinery, raw material, supporting activities and any other such factors which result in the best compromise.

2. principle of minimum distance

According to this principle the moment of men and materials should be minimized.

3. principle of flow

The best layout is one which arranges the work station for each process or operation in the same order or a sequence that brings assemble the materials.

4. principle of cubic space utilisation

According to this, space available both in vertical and horizontal direction is most economically and effectively utilise.

5. principle satisfaction and safety

According to this principle best layout is one which provides satisfaction and safety to all workers concerned.

6. principle of ~~flex~~ flexibility

According to this the best layout which provides flexibility of adoption a new product and rearrangement at a minimum cost and least inconvenience.

process layout / functional layout

- The process layout is particularly useful where low volume of production is need.
- If the product are not standardize, the process layout is more desirable, because it has greater process flexibility than other.
- In this type of layout the machines are not arranged according to the sequence of operation but are arranged according to the nature or type of operations.
- This layout is commonly suitable for non respective jobs.
- same type of operation facilities are grouped together such as lathes will be

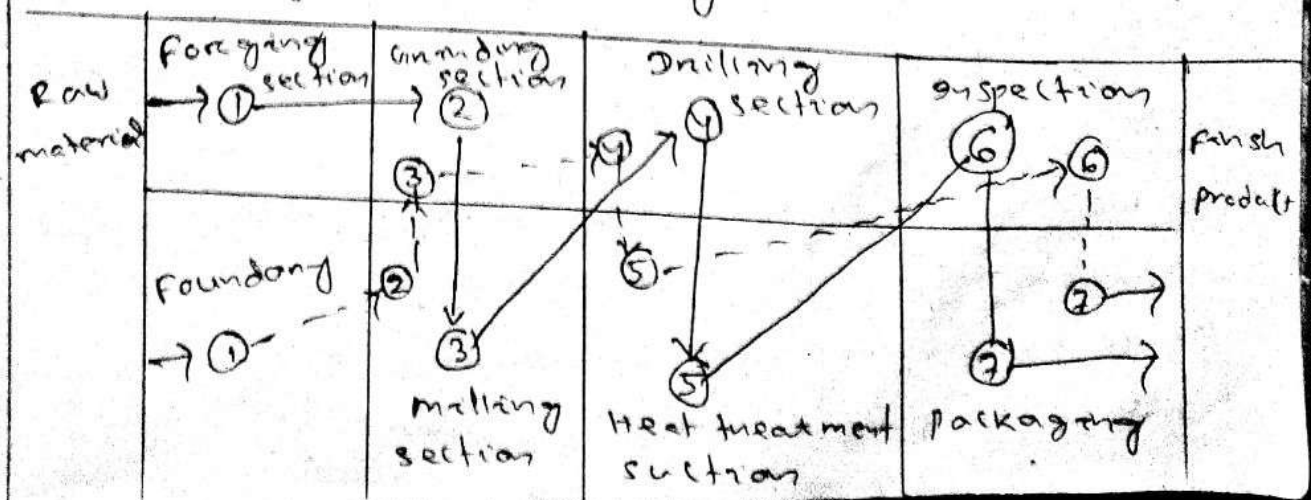
placed at one place, all drill machines are at another place and so on.

Advantages

- It offers better and more efficient supervision through specification at various levels.
- There is a greater flexibility in equipment and man. Thus load distribution is easily controlled.
- Greater utilisation of equipment ~~work~~ available is possible.
- Breakdown of equipment can be easily handled by transferring work to another machine.
- There will be less duplication of machines. Thus total investment in equipment purchase will be reduced.

Disadvantage

- more floor space required.
- production control is more difficult and more costly.
- Handling and back tracking of material is too much.
- Routing and scheduling is more difficult.



product layout / synthetic layout

- all the processing equipment and machines are arranged according to the sequence of the operation of a product, the layout is called product layout.
- on this type of layout, only one product or one type of product is produced in an operating area.
- This product must be standardized and produced in large quantities in order to justify the product layout.
- the raw material is supplied at the one end of the line and goes from one operation to next quite rapidly with a minimum work in process, storage and material handling.

Advantages

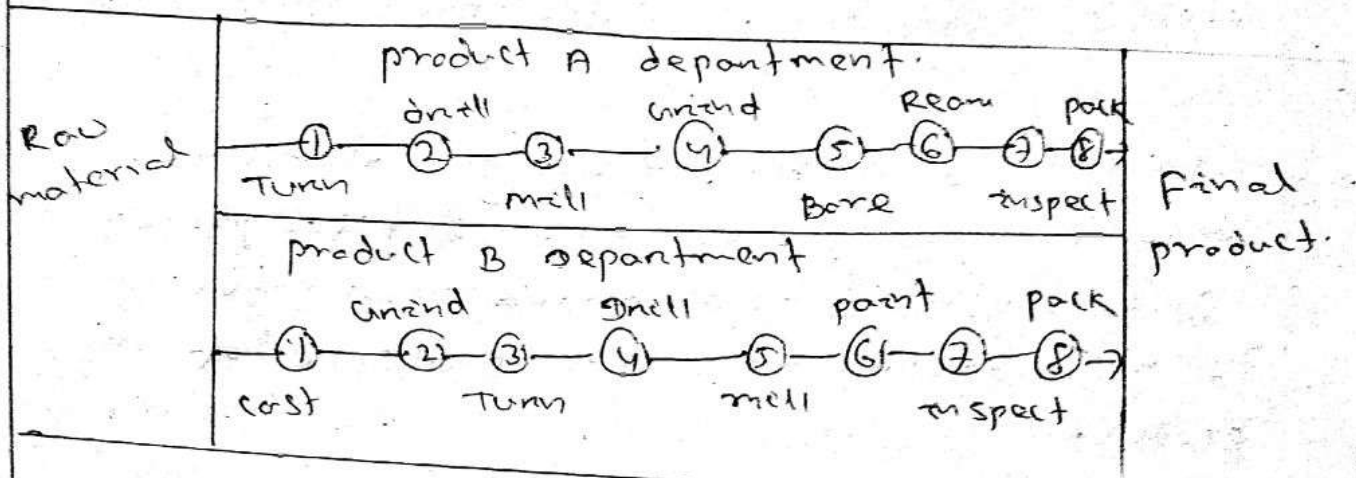
- It lowers the total material handling cost.
- there is less work in process.
- Less floor area is occupied by material in transit and for temporary storage.
- Greater simplicity of production control.
- Total producing time is also minimize.

Disadvantages

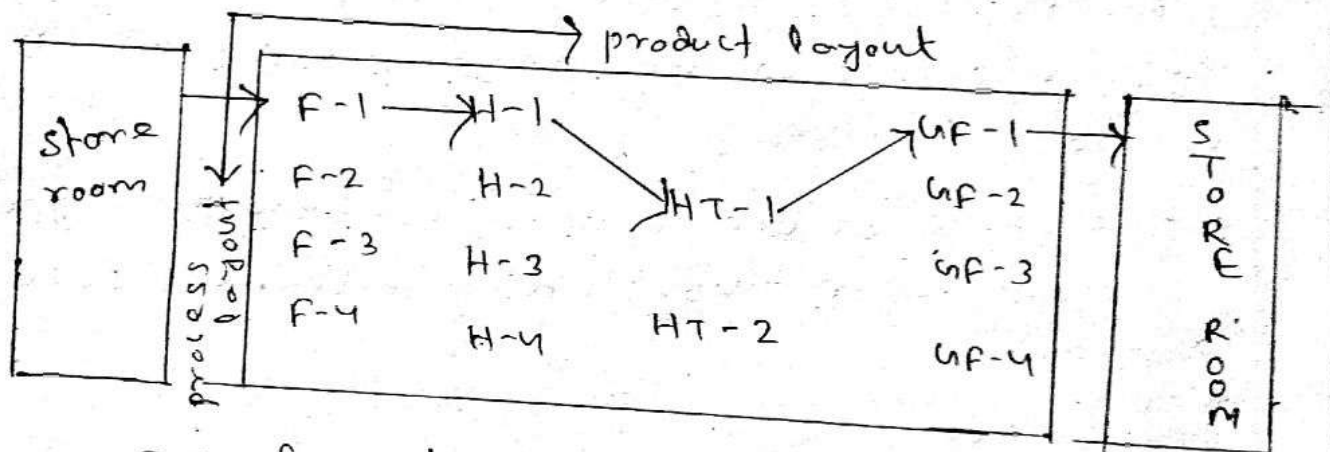
- No flexibility which is generally required is obtained in this layout.
- A single machine break down may shut down the whole production line.

→ specialisation specialise and strict supervision is essential.

→ The manufacturing cost increase with a fall in volume or production.



Combination layout



F → Blank forging hammers.

H → Hobbing bar cutting gear teeth.

HT → Heat treatment furnaces.

GF → Gear finishing machines.

→ A combination of process and product layout combination combines the advantages of both type of layouts.

→ more over, these days pure product or process layout are rare. most of the manufacturing sections are arranged in

process layout with manufacturing lines occurring here and there where ever the condition permits.

→ A combination layout is possible where an atom is being made in different types and sizes.

→ In such cases ~~machinery~~ machinery is arranged in a process layout but the process grouping is then arranged in a sequence to manufacture very types and sizes of product.

→ The point to note is that, no matter the product varies in size and time, the sequence of operation remains same or similar.

* The above figure shows a combination type of layout for manufacturing different sizes of gear.

Application

→ Files, hacksaw, circular metals saws, wood saws etc can be manufacture on a combination type of layout.

* A combination layout is also useful when no of atoms are produced in same sequence but non of the atoms are to be produced in bulk manner.

fixed position layout

- Layout by fixed position of the product is inherent in ship, building, air craft, manufacture, big pressure vessel fabrication.
- In other types of layout discussed earlier the product moves past stationary production equipment but in that case men and equipment are moved to the material, which remains at one place and product is completed at that place where the material lies.

Definition and concept of operation research

- Operation research is the organised application of the modern science, mathematics and computer techniques to complex military, government, ~~business~~ business or industrial problems arising in the direction and management of large systems of men, material, money and machines.
- The purpose is to provide the management with explicit quantitative understanding and assessment of complex situations.
- Operation ~~rese~~ research sees the optimum strength of all sphere and thus provides optimum solution to organisational problem.
- Operation aids, resolving, business problems and in planning and investigation of measure of operational decision.

Linear programming

Linear programming is powerful mathematical technique for finding the best use of the limited resources of a concern.

- It may be defined as a technique which allocates 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.
- Linear programming can be applied effectively only if

1. The objectives can be stated mathematically
2. The resources can be measured as quantities.
3. There are too many alternative solutions to be evaluated conveniently.
4. The variables of the problem bear a linear relationship.

A linear programming model may look as under
 maximize $Z = c_1x_1 + c_2x_2 + \dots + c_nx_n$
 subjected to conditions

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \dots + a_{1n}x_n \leq b_1$$

$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + \dots + a_{2n}x_n \leq b_2$$

$$a_{m1}x_1 + a_{m2}x_2 + a_{m3}x_3 + \dots + a_{mn}x_n \leq b_m$$

$$b_i \geq 0, i = 1, 2, 3, \dots, m$$

$$x_j \geq 0, j = 1, 2, 3, \dots, n$$

Graphical method

- simple two dimensional linear programming problems can be easily and rapidly solved by this technique.
- The technique can be easily mastered and shows a visual illustration of the relationships.
- But as the numbers of production and constraints increase, it is very difficult to show and interpret the relationships on a simple two dimensional graph.
- This method can easily be applied with upto 2 variables.

Graphical method a solution of Lpp

fixed procedure for solving graphical problem.

1. set up the objective function (which is maximize or minimize)
2. set up the constraints equation.
3. set up the non-negativity restrictions.
4. convert the constraints equation into intercept from of a straight line.
5. plot the constraints equations on graphical solution space.
6. identify the common solution space satisfied by all the equation.
7. consider the corner point of the convex solution space.
8. substitute the corner point into the objective function to get maximum or minimum.

Q1 →

maximize $Z = 12x_1 + 16x_2$ (objective function)

subjected to $10x_1 + 20x_2 \leq 120$

$8x_1 + 8x_2 \leq 80$ } constraint function.

x_1 and $x_2 \geq 0$ (non-negativity restrictions)

Ans

$$10x_1 + 20x_2 = 120 \quad \text{--- (1)}$$

when $x_1 = 0$, $x_2 = 6$

$$\Rightarrow 10 \times 0 + 20x_2 = 120$$

$$20x_2 = 120$$

$$x_2 = \frac{120}{20} = 6$$

when $x_2 = 0$, $x_1 = 12$

$$10x_1 + 20 \times 0 = 120$$

$$10x_1 = 120$$

$$\Rightarrow x_1 = 120/10 = 12$$

x_1	0	12
x_2	6	0

$$8x_1 + 8x_2 = 80 \quad (2)$$

when $x_1 = 0, x_2 = 10$

$$\Rightarrow 8 \times 0 + 8x_2 = 80$$

$$\Rightarrow 8x_2 = 80$$

$$x_2 = \frac{80}{8} = 10$$

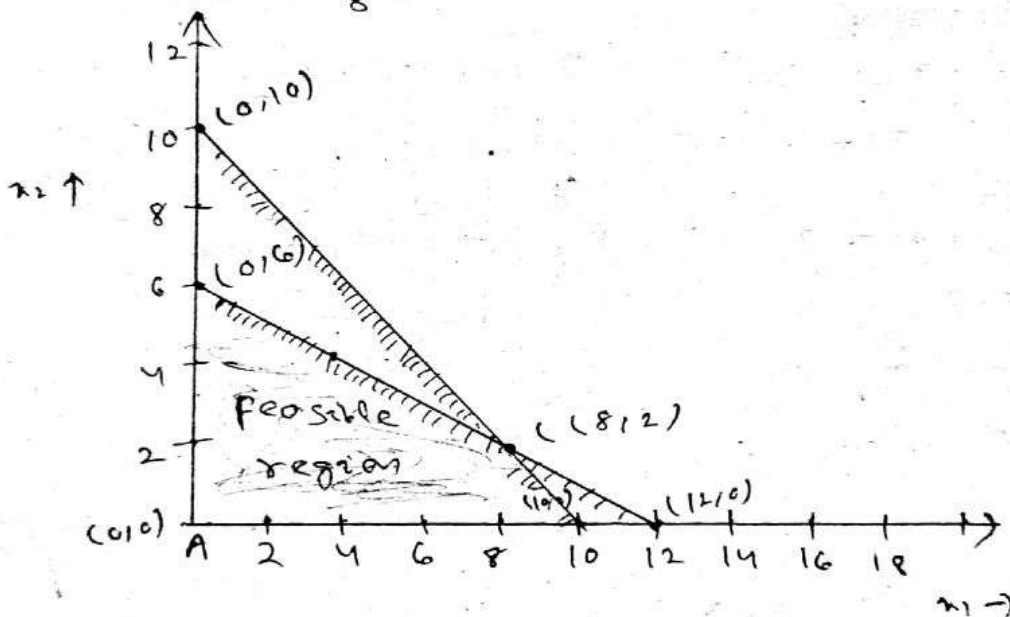
x_1	0	10
x_2	10	0

when $x_2 = 0, x_1 = 10$

$$8x_1 + 8 \times 0 = 80$$

$$\Rightarrow 8x_1 = 80$$

$$\Rightarrow x_1 = \frac{80}{8} = 10$$



$$10x_1 + 20x_2 = 120 \quad (1)$$

$$8x_1 + 8x_2 = 80 \quad (2)$$

$$\text{eqn (1)} \times 8 \rightarrow 80x_1 + 160x_2 = 120 \times 8$$

$$\text{eqn (2)} \times 10 \rightarrow 80x_1 + 80x_2 = 800$$

$$\begin{array}{r} 80x_1 + 160x_2 = 960 \\ - (80x_1 + 80x_2 = 800) \\ \hline 80x_2 = 160 \end{array}$$

$$x_2 = \frac{160}{80} = 2$$

$$x_1 = 8$$

$$Z_A(0,0) = 12 \times 0 + 16 \times 0 = 0$$

$$Z_B(10,0) = 12 \times 10 + 16 \times 0 = 120$$

$$Z_C(8,2) = 12 \times 8 + 16 \times 2 = 128$$

$$Z_D(0,6) = 12 \times 0 + 16 \times 6 = 96$$

$$\therefore Z_{\max} = 128 \text{ at point } C(8,2)$$

Q2 → Minimize $Z = 4x_1 + 6x_2$

subject to $x_1 + x_2 \geq 8$

$6x_1 + x_2 \geq 12$

x_1 and $x_2 \geq 0$

Ans

$$x_1 + x_2 = 8 \text{ --- (1)}$$

When $x_1 = 0, x_2 = 8$

When $x_2 = 0, x_1 = 8$

$$\Rightarrow x_1 + 0 = 8$$

$$\Rightarrow x_1 = 8$$

x_1	0	8
x_2	8	0

$$6x_1 + x_2 = 12 \text{ --- (2)}$$

When $x_1 = 0, x_2 = 12$

$$\Rightarrow 6 \times 0 + x_2 = 12$$

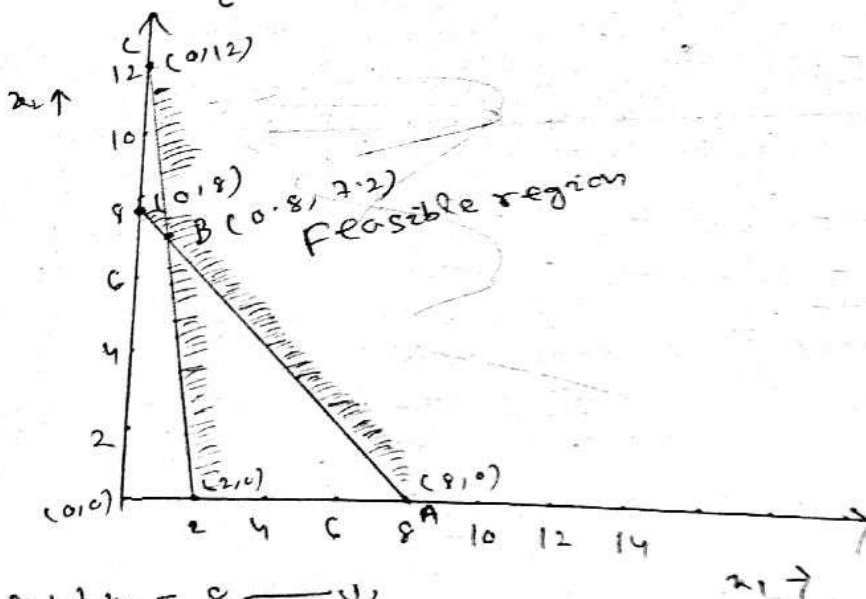
$$\Rightarrow x_2 = 12$$

When $x_2 = 0, x_1 = 2$

$$6x_1 + 0 = 12$$

$$\Rightarrow x_1 = \frac{12}{6} = 2$$

x_1	0	2
x_2	12	0



$$x_1 + x_2 = 8 \text{ --- (1)}$$

$$6x_1 + x_2 = 12 \text{ --- (2)}$$

subtracting eqn (2) - eqn (1)

$$5x_1 = 4$$

$$x_1 = \frac{4}{5} = 0.8$$

$$x_2 = 8 - x_1$$

$$= 8 - 0.8 = 7.2$$

$$Z_A(8, 0) = 4 \times 8 + 6 \times 0 = 32$$

$$Z_B(0.8, 7.2) = 4 \times 0.8 + 6 \times 7.2 = 46.4$$

$$Z_C(0, 12) = 4 \times 0 + 6 \times 12 = 72$$

$\therefore 2 \text{ min} = 32 \text{ at point } A(8/0)$.

Q3 $\rightarrow$ maximize $Z = 100x_1 + 60x_2$

subject to $5x_1 + 10x_2 \leq 50$

$8x_1 + 2x_2 \geq 16$

$3x_1 - 2x_2 \geq 6$

$x_1, x_2 \geq 0$

$\text{M1 } 5x_1 + 10x_2 = 50 \text{ --- (1)}$

when $x_1 = 0, x_2 = 5$

$$\Rightarrow 5 \times 0 + 10x_2 = 50$$

$$\Rightarrow x_2 = \frac{50}{10} = 5$$

when $x_2 = 0, x_1 = 10$

$$\Rightarrow 5x_1 + 10 \times 0 = 50$$

$$\Rightarrow 5x_1 = 50$$

$$\Rightarrow x_1 = \frac{50}{5} = 10$$

x_1	0	10
x_2	5	0

$8x_1 + 2x_2 = 16 \text{ --- (2)}$

when $x_1 = 0, x_2 = 8$

$$\Rightarrow 8 \times 0 + 2x_2 = 16$$

$$\Rightarrow 2x_2 = 16$$

$$\Rightarrow x_2 = \frac{16}{2} = 8$$

when $x_2 = 0, x_1 = 2$

$$\Rightarrow 8x_1 + 2 \times 0 = 16$$

$$\Rightarrow 8x_1 = 16$$

$$\Rightarrow x_1 = \frac{16}{8} = 2$$

x_1	0	2
x_2	8	0

$3x_1 - 2x_2 = 6 \text{ --- (3)}$

when $x_1 = 0, x_2 = -3$

$$\Rightarrow 3 \times 0 - 2x_2 = 6$$

$$\Rightarrow -2x_2 = 6$$

$$x_2 = \frac{-6}{2} = -3$$

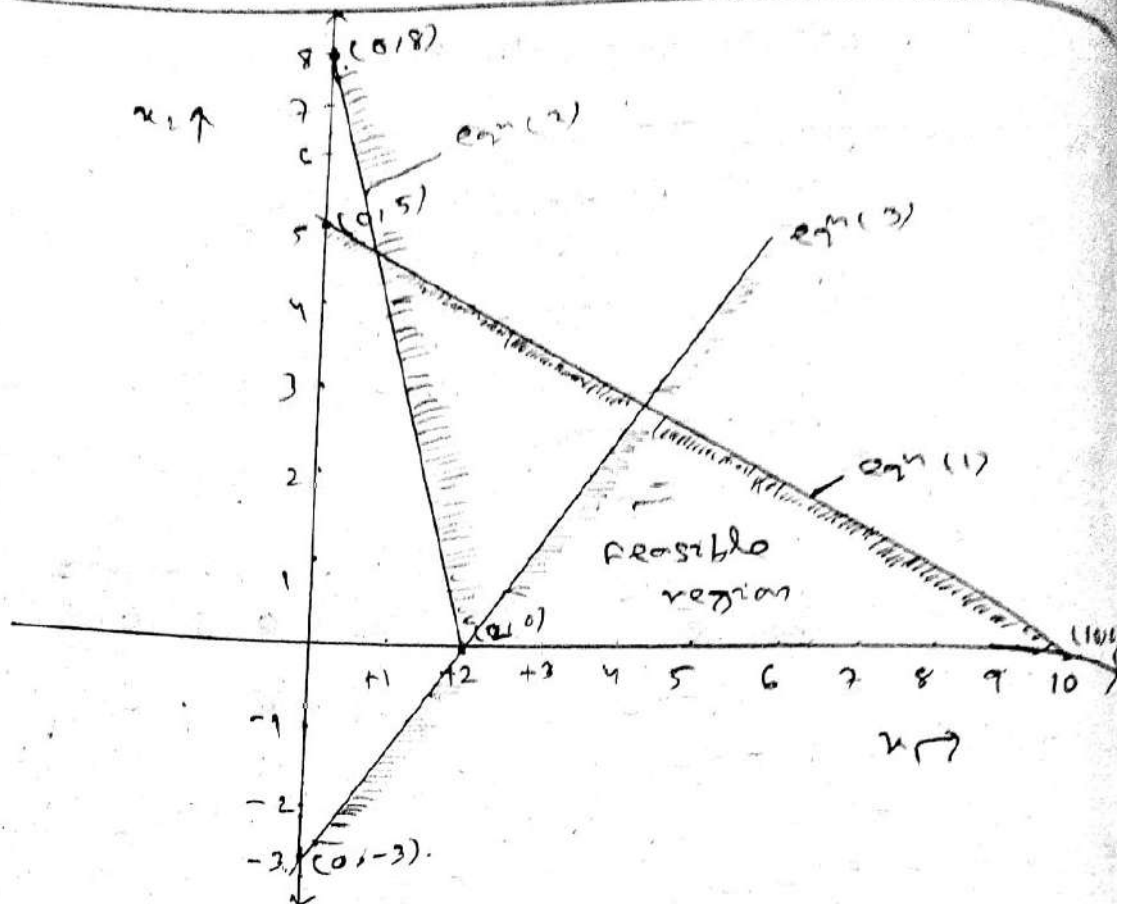
when $x_2 = 0, x_1 = 2$

$$\Rightarrow 3x_1 - 2 \times 0 = 6$$

$$\Rightarrow 3x_1 = 6$$

$$\Rightarrow x_1 = \frac{6}{3} = 2$$

x_1	0	2
x_2	-3	0



$$5x_1 + 10x_2 = 50 \text{ --- (1)}$$

$$3x_1 - 2x_2 = 6 \text{ --- (3)}$$

$$\text{eqn (1)} \times 1 \rightarrow 5x_1 + 10x_2 = 50$$

$$\text{eqn (3)} \times 5 \rightarrow 15x_1 - 10x_2 = 30$$

$$\hline 20x_1 = 80$$

$$\therefore x_1 = \frac{80}{20} = 4$$

$$x_2 = 3$$

$$Z_A(2, 0) = 100 \times 2 + 60 \times 0 = 200$$

$$Z_B(10, 0) = 100 \times 10 + 60 \times 0 = 1000$$

$$Z_C(4, 3) = 100 \times 4 + 60 \times 3 = 580$$

$$\therefore Z_{\max} = 1000 \text{ at point B}(10, 0)$$

$$\text{Q4} \rightarrow \text{maximize } Z = 20x_1 + 40x_2$$

$$\text{subject to } x_1 + 4x_2 \leq 24$$

$$3x_1 + x_2 \leq 21$$

$$x_1 + x_2 \leq 8$$

$$x_1, x_2 \geq 0$$

Ans $x_1 + 4x_2 = 24$ — (1)

when $x_1 = 0$, $x_2 = 6$

$\Rightarrow 0 + 4x_2 = 24$

$\Rightarrow x_2 = \frac{24}{4} = 6$

when $x_2 = 0$, $x_1 = 24$

$\Rightarrow x_1 + 4 \times 0 = 24$

$\Rightarrow x_1 = 24$

x_1	0	24
x_2	6	0

$3x_1 + x_2 = 21$ — (2)

when $x_1 = 0$, $x_2 = 21$

$\Rightarrow 3 \times 0 + x_2 = 21$

$\Rightarrow x_2 = 21$

when $x_2 = 0$, $x_1 = 7$

$3x_1 + 0 = 21$

$x_1 = \frac{21}{3} = 7$

x_1	0	7
x_2	21	0

$x_1 + x_2 = 8$ — (3)

when $x_1 = 0$, $x_2 = 8$

when $x_2 = 0$, $x_1 = 8$

x_1	0	8
x_2	8	0

Q5 $\rightarrow$ minimize $Z = 3x_1 + 4x_2$

subject to $5x_1 + x_2 \geq 10$

$x_1 + x_2 \geq 6$

$x_1 + 4x_2 \geq 12$

x_1 and $x_2 \geq 0$

Ans $5x_1 + x_2 = 10$ — (1)

when $x_1 = 0$, $x_2 = 10$

$\Rightarrow 5 \times 0 + x_2 = 10$

$\Rightarrow x_2 = 10$

when $x_2 = 0$, $x_1 = 2$

$\Rightarrow 5x_1 + 0 = 10$

$x_1 = \frac{10}{5} = 2$

x_1	0	2
x_2	10	0

$x_1 + x_2 = 6$ — (2)

when $x_1 = 0$, $x_2 = 6$

$\Rightarrow 0 + x_2 = 6$

when $x_2 = 0$, $x_1 = 6$

x_1	0	6
x_2	6	0

$$x_1 + 4x_2 = 12 \quad (3)$$

when $x_1 = 0, x_2 = 3$

$$0 + 4x_2 = 12$$

$$\Rightarrow 4x_2 = 12$$

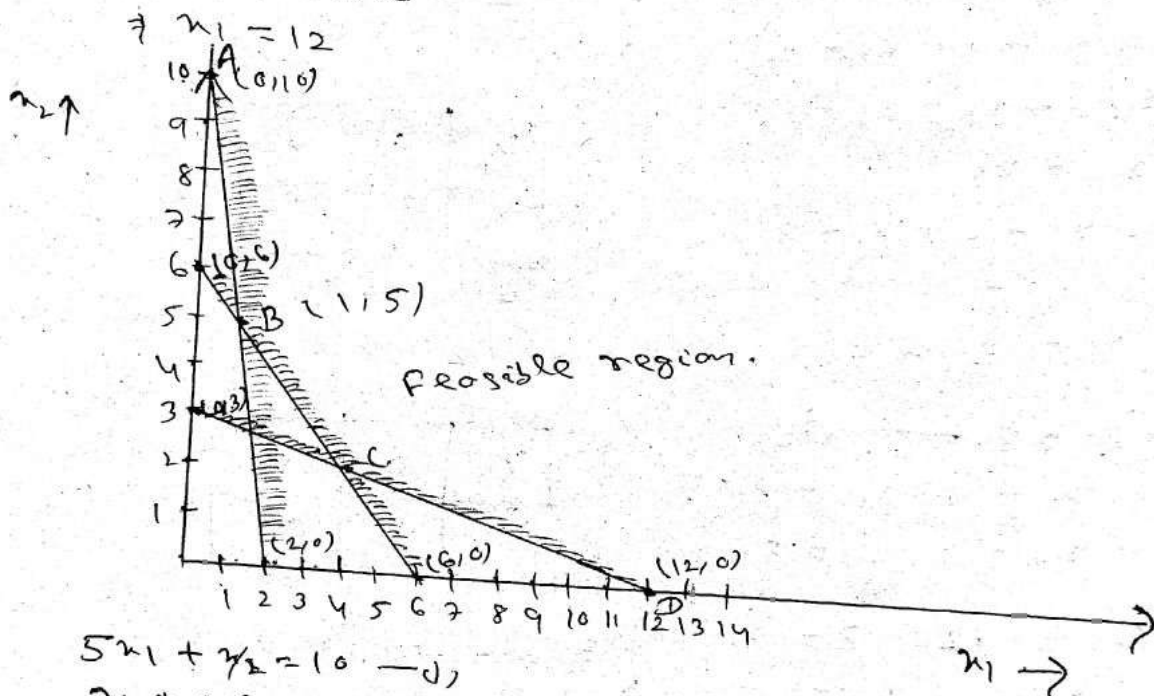
$$x_2 = \frac{12}{4} = 3$$

x_1	0	12
x_2	3	0

when $x_2 = 0, x_1 = 12$

$$\Rightarrow x_1 + 4 \times 0 = 12$$

$$\Rightarrow x_1 = 12$$



$$5x_1 + x_2 = 10 \quad (1)$$

$$x_1 + 4x_2 = 6 \quad (2)$$

$$4x_1 = 4$$

$$\Rightarrow x_1 = \frac{4}{4} = 1$$

$$x_2 = 5$$

Subtracting eqn (3) - eqn (2)

Again $x_1 + x_2 = 6 \quad (3)$

$$x_1 + 4x_2 = 12 \quad (3)$$

$$3x_2 = 6$$

$$x_2 = \frac{6}{3} = 2$$

$$x_1 = 4$$

$$Z_A(0,10) = 3 \times 0 + 4 \times 10 = 40$$

$$Z_B(1,5) = 3 \times 1 + 4 \times 5 = 23$$

$$Z_C(4,2) = 3 \times 4 + 4 \times 2 = 20$$

$$Z_D(12,0) = 3 \times 12 + 4 \times 0 = 36$$

$$Z_{min} = 20 \text{ at point } (4,2)$$

Q6 → minimize $Z = 2x + 3y$
 subject to $x + y \geq 6$
 $2x + y \geq 7$
 $x + 4y \geq 8$

$$x_1, x_2 \geq 0$$

Ans

$$x + y = 6 \text{ — (1)}$$

when $x = 0, y = 6$

when $y = 0, x = 6$

x	0	6
y	6	0

$$2x + y = 7 \text{ — (2)}$$

when $x = 0, y = 7$

$$\Rightarrow 2x + 0 = 7$$

$$y = 7$$

when $y = 0, x = 3.5$

$$\Rightarrow 2x + 0 = 7$$

$$x = \frac{7}{2} = 3.5$$

x	0	3.5
y	7	0

$$x + 4y = 8 \text{ — (3)}$$

when $x = 0, y = 2$

$$\Rightarrow 0 + 4y = 8$$

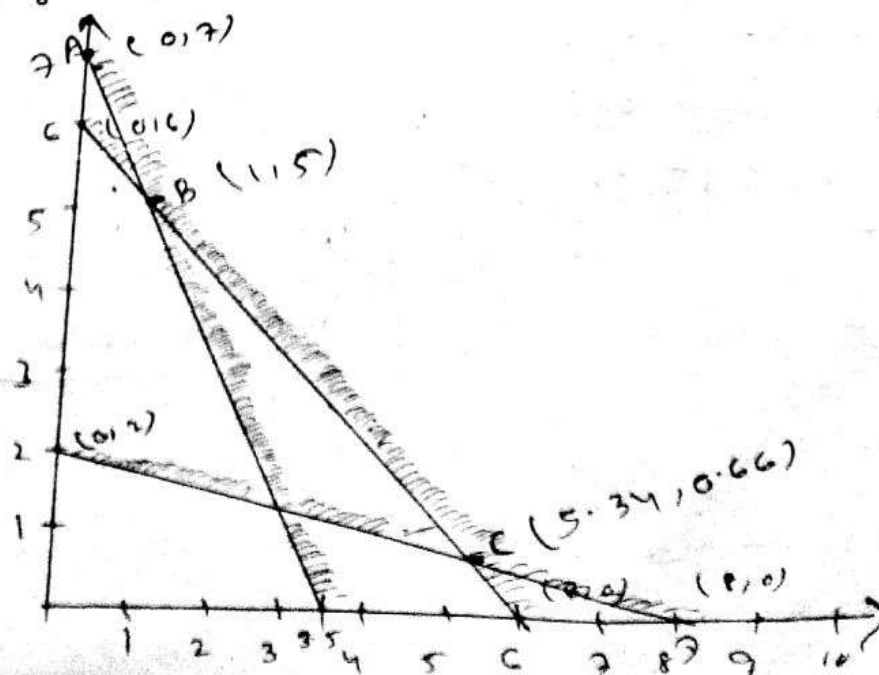
$$\Rightarrow y = \frac{8}{4} = 2$$

when $y = 0, x = 8$

$$\Rightarrow x + 4 \times 0 = 8$$

$$\Rightarrow x = 8$$

x	0	8
y	2	0



$$\begin{aligned} x+y &= 6 \quad \text{--- (1)} \\ 2x+y &= 7 \quad \text{--- (2)} \end{aligned}$$

subtracting eqn (2) - eqn (1)

$$\begin{aligned} x &= 1 \\ y &= 5 \end{aligned}$$

$$\begin{aligned} x+y &= 6 \quad \text{--- (1)} \\ x+y &= 8 \quad \text{--- (3)} \end{aligned}$$

subtracting eqn (3) - eqn (1)

$$\begin{aligned} 3y &= 2 \\ y &= \frac{2}{3} = 0.66 \\ x &= 5.33 \end{aligned}$$

$$Z_A (0, 7) = 2 \times 0 + 3 \times 7 = 21$$

$$Z_B (1, 5) = 2 \times 1 + 3 \times 5 = 17$$

$$Z_C (5.34, 0.66) = 2 \times 5.34 + 3 \times 0.66 = 12.66$$

$$Z_D (8, 0) = 2 \times 8 + 3 \times 0 = 16$$

$$Z_{\max} = 12.66 \text{ at point } C (5.33, 0.66)$$

Q77 maximize $Z = x + 5y$

subject to $5x + 6y \leq 30$

$3x + 2y \leq 12$

$x, y \geq 0$

A) $5x + 6y = 30 \quad \text{--- (1)}$

when $x = 0, y = 5$

$$\Rightarrow 5 \times 0 + 6y = 30$$

$$\Rightarrow y = \frac{30}{6} = 5$$

when $y = 0, x = 6$

$$\Rightarrow 5x + 6 \times 0 = 30$$

$$\Rightarrow x = \frac{30}{5} = 6$$

x	0	6
y	5	0

$$3x + 2y = 12 \quad \text{--- (2)}$$

when $x = 0, y = 6$

$$\Rightarrow 3 \times 0 + 2y = 12$$

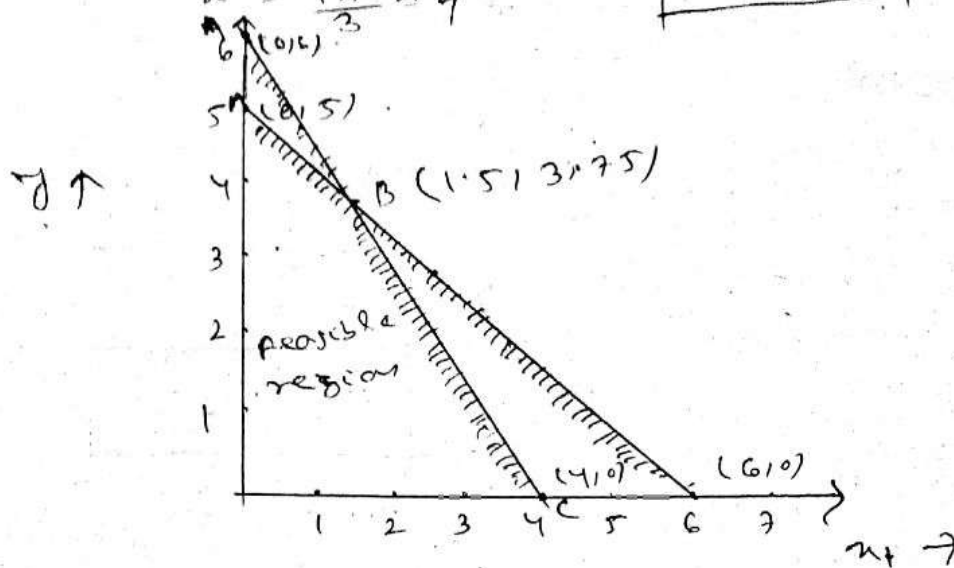
$$\Rightarrow y = \frac{12}{2} = 6$$

when $y=0$, $x=4$

$$3x + 0 = 12$$

$$x = \frac{12}{3} = 4$$

x	0	4
y	6	0



$$5x + 6y = 30 \quad \text{--- (1)}$$

$$3x + 2y = 12 \quad \text{--- (2)}$$

$$\text{eqn (1)} \times 1 \rightarrow 5x + 6y = 30$$

$$\text{eqn (2)} \times 3 \rightarrow 9x + 6y = 36$$

$$4x = 6$$

$$x = \frac{6}{4} = 1.5$$

$$y = 3.75$$

$$Z_A(0, 5) = 0 + 5 \times 5 = 25$$

$$Z_B(1.5, 3.75) = 1.5 + 5 \times 3.75 = 20.25$$

$$Z_C(4, 0) = 4 + 5 \times 0 = 4$$

$$Z_{\max} = 25 \text{ at point } A(0, 5)$$

Q8) maximize $Z = 5x + 6y$

$$\text{subject to } x + 4y \leq 32$$

$$2x + y \leq 36$$

$$x, y \geq 0$$

Ans

$$x + 4y = 32 \quad \text{--- (1)}$$

when $x=0$, $y=8$

$$0 + 4y = 32$$

$$\Rightarrow y = \frac{32}{4} = 8$$

When $y=0$, $x=32$

$$x + 1 \times 0 = 32 \\ \Rightarrow x = 32$$

x	0	32
y	8	0

$$2x + y = 36 \quad (2)$$

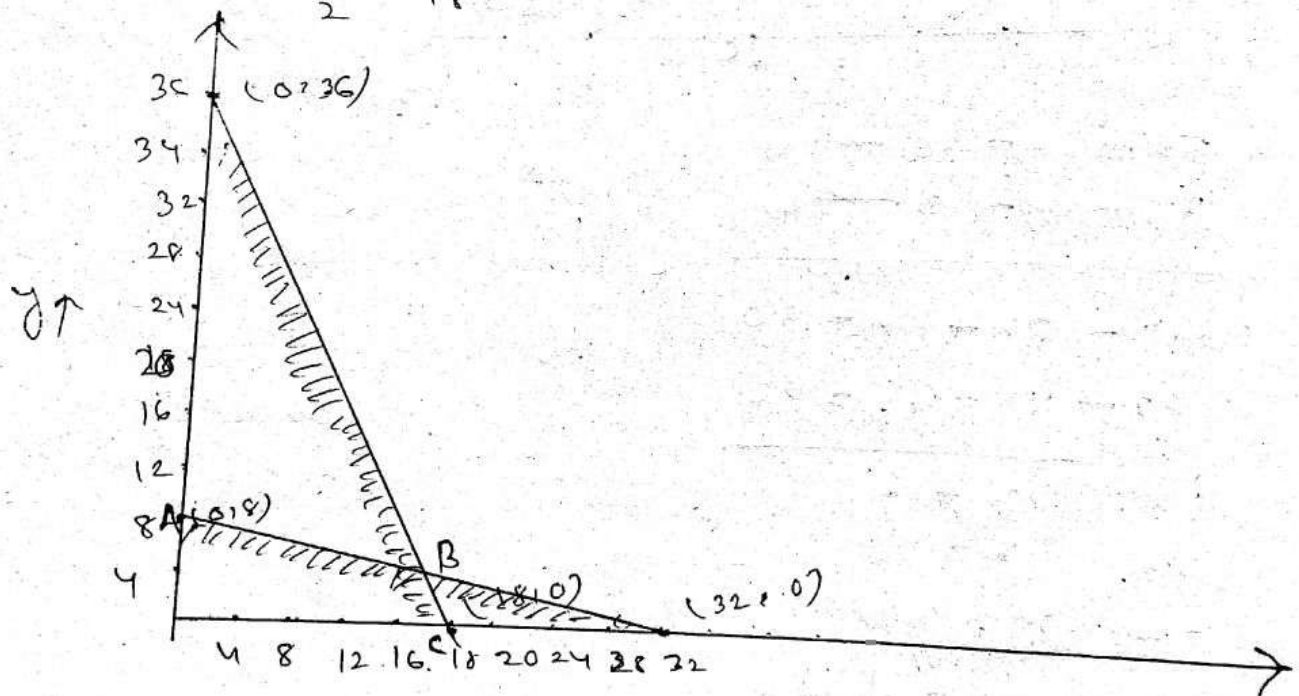
When $x=0$, $y=36$

$$\Rightarrow 2 \times 0 + y = 36 \\ y = 36$$

When $y=0$, $x=18$

$$\Rightarrow 2x + 0 = 36 \\ \Rightarrow x = \frac{36}{2} = 18$$

x	0	18
y	36	0



$$\begin{aligned} \text{eqn (1)} \times 2 &\rightarrow 2x + 8y = 64 \\ \text{eqn (2)} \times 1 &\rightarrow 2x + y = 36 \\ \hline &7y = 28 \\ &y = 4 \\ &x = 16 \end{aligned}$$

$$Z_A(0, 8) = 5 \times 0 + 6 \times 8 = 48$$

$$Z_B(16, 4) = 5 \times 16 + 6 \times 4 = 104$$

$$Z_C(18, 0) = 5 \times 18 + 6 \times 0 = 90$$

$\therefore Z_{\max} = 104$ at point $B(16, 4)$

Q9 → maximize $Z = 8x + 6y$
 subject to $4x + 2y \leq 60$
 $2x + 4y \leq 48$
 $x, y \geq 0$

now $4x + 2y = 60$ — (1)

when $x = 0$, $y = 30$

$\Rightarrow 4 \times 0 + 2y = 60$

$y = \frac{60}{2} = 30$

when $y = 0$, $x = 15$

$4x + 2 \times 0 = 60$

$x = \frac{60}{4} = 15$

$2x + 4y = 48$ — (2)

when $x = 0$, $y = 12$

$\Rightarrow 2 \times 0 + 4y = 48$

$\Rightarrow y = \frac{48}{4} = 12$

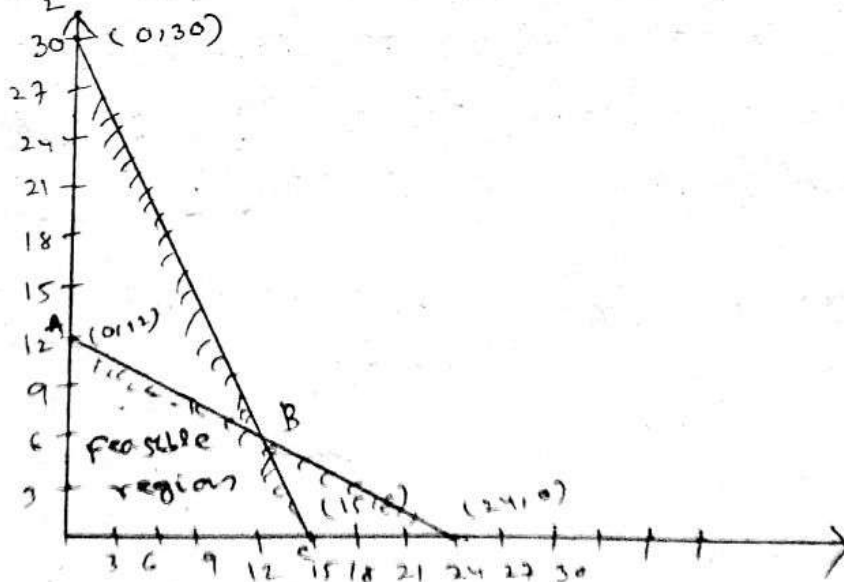
when $y = 0$, $x = 24$

$\Rightarrow 2x + 4 \times 0 = 48$

$\Rightarrow x = \frac{48}{2} = 24$

x	0	15
y	30	0

x	0	24
y	12	0



eqn (1) $\times 1 \Rightarrow 4x + 2y = 60$

eqn (2) $\times 2 \Rightarrow 4x + 8y = 96$

$\underline{\hspace{1cm}}$
 $-6y = -36$

$y = 6$

$$Z_A(0,12) = 8 \times 0 + 6 \times 12 = 72$$

$$Z_B(12,6) = 8 \times 12 + 6 \times 6 = 132$$

$$Z_C(15,0) = 8 \times 15 + 6 \times 0 = 120$$

$Z_{max} = 132$ at point B(12,6)

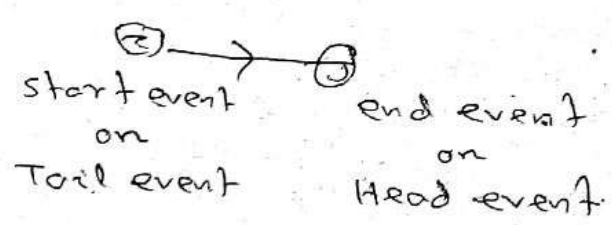
Term related to network planning method

1. Event

An event is a specific instant of time which marks the starts and end of an activity.

→ Event consumes neither time nor resources.

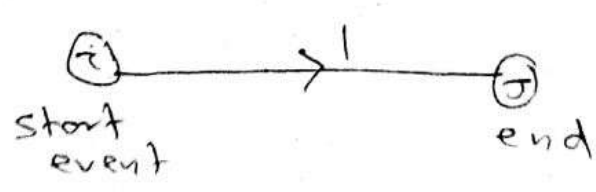
→ It is represented by a circle and event number is written within the circle.



2. Activity

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

→ An activity is shown by an arrow (→) and it begins and ends with an event.



→ Unlike event, an activity consumes time and resources.

→ Activities are classified as

1. critical activity

On a network diagram, critical activities are those which if consume more than their estimated time, the project will be delayed.

→ An activity is called critical if its earliest starts time plus the time taken by it is equal to latest finishing time.

2. Non-critical activities

Such activities have provision so that, even if they consume a specified time over and above the estimated time, the project will not be delayed.

3. Dummy activities

When two activities start at the same instant of time the head events are joined by a dotted arrow and this is known as dummy activities.

→ Dummy activity consumes neither time nor resources.

→ A Dummy activity may be critical activity or non-critical activity.

4. Critical path

→ It is that sequence of activities which decides the total project duration.

→ A critical path is formed by critical activities.

→ A critical path consumes maximum resources and it is the longest path and consumes minimum time.

5. Duration

Duration is the estimated or actual time required to complete a task.

6. Total project time

It is the time which will be taken to complete a project and is found from the sequence of critical activities.

7. E.S.T (Earliest start time)

→ It is the earliest time at which an activity can start and is calculated by moving from first to last event.

* In case merge event, EST is calculated among all paths and the maximum of it is taken as the EST for the subsequent activity.

8. EFT (Earliest finishing time)

It is the earliest time at which an activity can be completed.

$$EFT = EST + \text{duration of time}$$

9. LFT (Latest finishing time)

→ It is the maximum time at which an activity is completed.

→ It is calculated by moving backward (we proceed from right to left in the network)

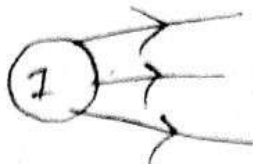
→ In case of burst event LFT are calculated in all paths and minimum of it is taken as LFT for that event.

10. LST (Latest start time)

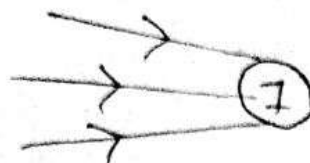
It is the latest possible time by which an activity can start.

$$LST = LFT - \text{duration of time}$$

Burst event



Merge event

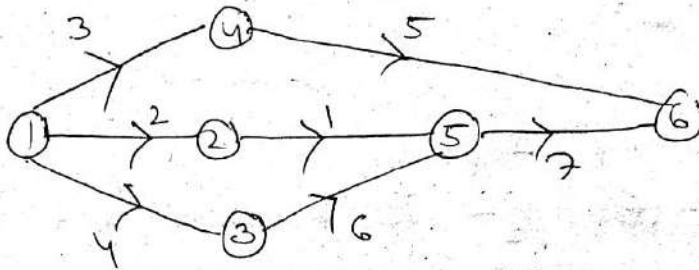


Q1) Find the critical path and construct the network diagram.

Activity	Project duration
1-2	2
1-3	4
1-4	3
3-5	6
2-5	1
4-6	5
5-6	7

m

Network diagram



path

1-2-5-6	10
1-4-6	8
1-3-5-6	17

∴ Among all the path 1-3-5-6 the longest path on the network and is known as critical path.

float / slack

→ slack is reference to an event and float is with respect to an activity.

Total float

→ It is the additional time which a non-critical activity can consume without increasing the project duration. However the total float may affect the float in previous and subsequent activities.

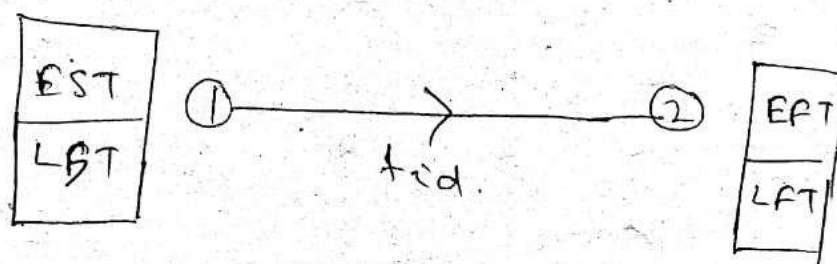
→ Total float may be defined as the difference between LFT and EFT.

Free float

Free float = Total float - Head event slack

Interference float

Independent float = Total float - free float



$$1) \text{ Total float} = \text{LFT} - \text{EFT}$$

$$= (\text{LFT})_2 - [(\text{EST})_1 + \text{dur.}]$$

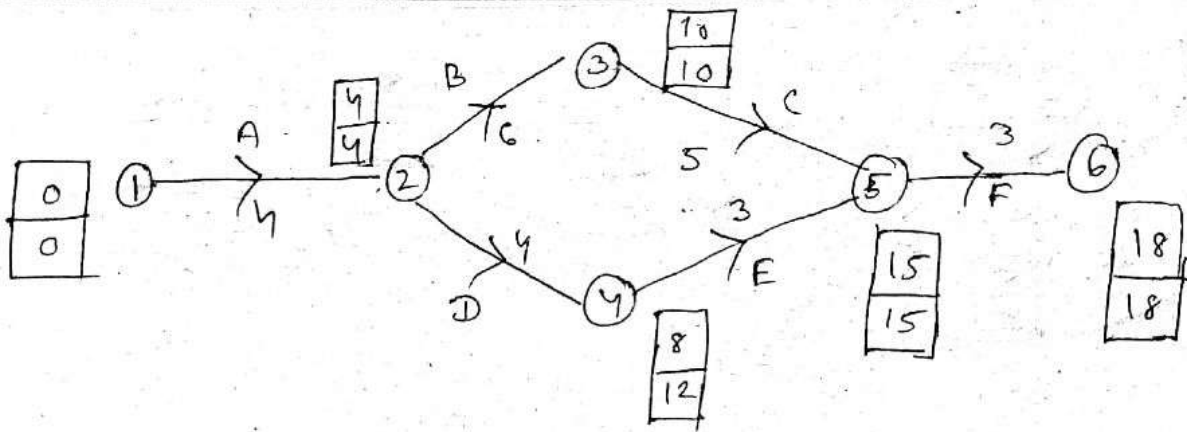
$$\boxed{\text{EFT} = \text{EST} + \text{duration}}$$

$$2) \text{ Free float} = \text{Total float} - \text{Head event slack}$$

$$= \text{Total float} - (\text{LFT} - \text{EST})_2$$

$$3) \text{ Independent float} = \text{Total float} - \text{free float}$$

Q27 A small engineering project consist of 6 activities normally A, B, C, D, E and F with duration of 4, 6, 5, 4, 3 and 3 day respectively. Draw the network diagram and calculate EST, LST, EFT, LFT and floats. mark the critical path and find total project duration.

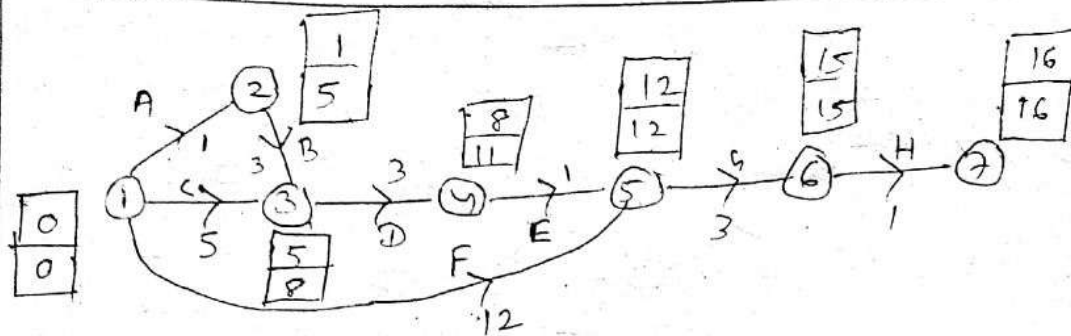


Activity	project duration time (D)	EST	EFT (EFT ₁₀)	LFT	LST (LST ₁₀)	Total float	Free float
A	4	0	4	4	0	0	0
B	6	4	10	10	4	0	0
C	5	10	15	15	10	0	0
D	4	4	8	12	8	4	0
E	3	8	11	15	12	4	4
F	3	15	18	18	15	0	0

Q3) Activity Time duration

1-2 (A)	1
2-3 (B)	3
1-3 (C)	5
3-4 (D)	3
4-5 (E)	1
1-5 (F)	12
5-6 (G)	3
6-7 (H)	1

Draw the network diagram and EST, EFT, LST, LFT



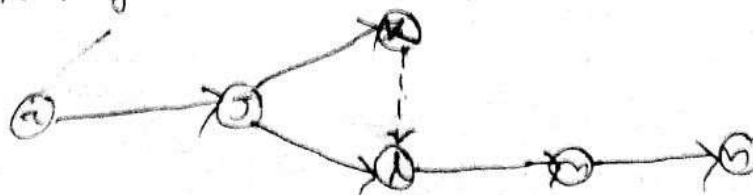
Activity	project duration time	EST	EFT	LFT	LST	Total float	Free float
1-2 (A)	1	0	1	1			
2-3 (B)	3	1	4	5			
1-3 (C)	5	0	5				
3-4 (D)	3	5	8				
4-5 (E)	1	8	9				
1-5 (F)	12	0	12				
5-6 (W)	3	12	15				
6-7 (H)	1	15	16				

predecessor

if an activity which must be completed before particular activity starts then it is known as predecessor activity to that particular activity.

Successor activity

if an activity (a) can start only after completion of one more activities say b & c then activity a is called successor activity to b and c.



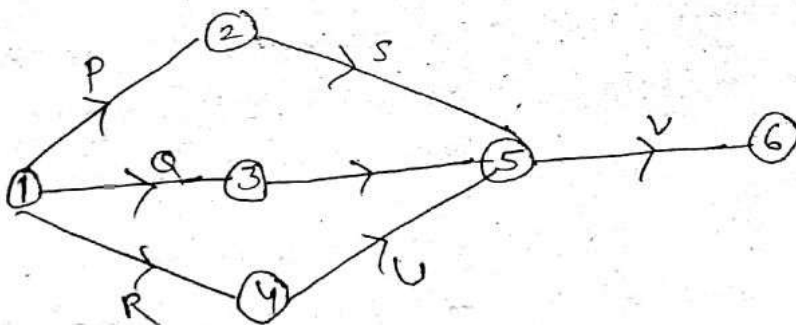
* Activity (i-j) is predecessor activity
(j → k), (j → l)

* Activity $(j \rightarrow k)$: $(j \rightarrow l)$ succession activity of $(i \rightarrow j)$

Q4) A project consist of 7 activities. Activities P, Q, R run simultaneously. The relationship among the various activity is as follows.

Activity	Immediate succession
P	S
Q	T
R	U

Activity V is the last operation of the project and it is also immediate successor to S, T and U. Draw the network diagram.



Q5) Draw the network diagram for the following product.

- i) A and B starts concurrently.
- ii) C follows A.
- iii) D follows A but precedes E.
- iv) F follows B but precedes H & G.
- v) G follows F but precedes H.
- vi) H follows G but precedes E.
- vii) E and I terminate at the same time.

1. PERT (project evaluation and review technique)

- PERT stands for project evaluation and review technique.
- This technique is useful to manage all projects which can be split into activities and having uncertainty with estimation of time of their completion.
- It must be noted that PERT system involves a probabilistic approach and is best suited for R & D work in which measure uncertainties exist.
- Thus PERT system is preferred for those operations which are of non-repetitive nature or in which precise time determination for various activities can not be done.
- The PERT system uses a network diagram consisting of events which are to be established to achieve the project objectives.

Difference between cpm and PERT.

cpm

PERT

- | | |
|--|---|
| → It stands for critical path method. | → It stands for project evaluation and review technique. |
| → It is activity oriented. | → It is event oriented. |
| → Certainty is associated with cpm. | → Uncertainty is associated with PERT. |
| → It uses one time estimate to evaluate project duration time. | → It uses three times of estimate to evaluate project duration time.
(Optimistic time, pessimistic time and most likely time.) |

1. t_o (Optimistic time)

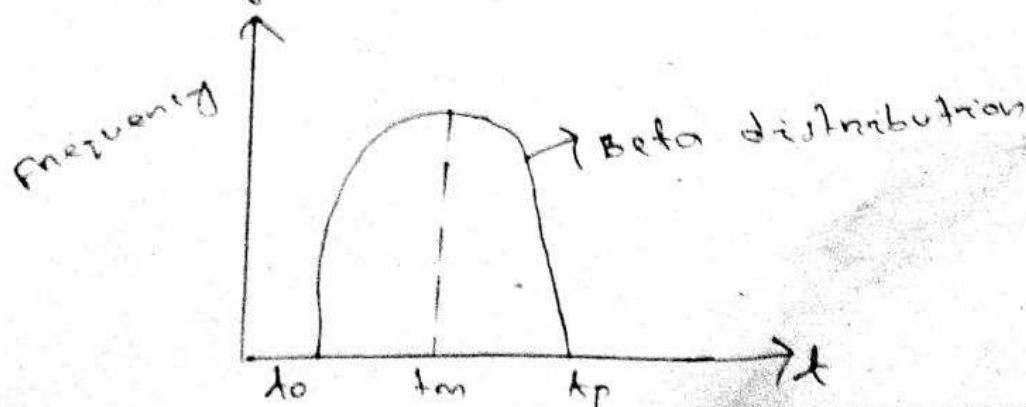
It is the minimum time that is required to complete an activity when every resource is available.

2. t_m (most likely time)

It is the time required on average to complete an activity when every resource is available.

3. t_p (Pessimistic time)

This is the worst time required to complete an activity when every resource is available.



$$\rightarrow \text{Estimated time } (t_e) = \frac{t_o + 4 \times t_m + t_p}{6}$$

$$\rightarrow \text{Standard deviation} = \sigma = \frac{t_p - t_o}{6}$$

$$\rightarrow \text{variance} = \sigma^2.$$

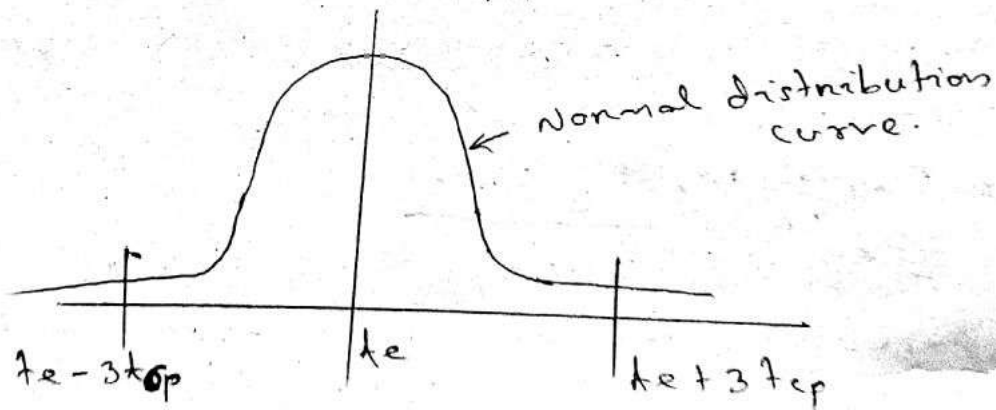
standard deviation

For finding project duration time the variance of critical path should be taken which is sum of variance of activities lying on critical path.

mathematically,

$$\sigma = \sqrt{\sum \text{variance of critical path.}}$$

The project completion time are expected to follow normal distribution.



where,

t_e = estimated time.

σ_p = standard deviation on critical path.

The probability of completing a project is given by a formula.

$$\therefore Z = \frac{D - T_e}{\sigma_{cp}}$$

where,

Z = it is belongs to normal distribution curve.

D = Desired completion time.

T_e = critical path time estimate.

σ_{cp} = standard deviation of critical path.

NOTE

case-1

When, $Z=0$, then

probability of completion is 50%.

case-2

When, $Z=1$, then

probability of completion is 84.13%.

case-3

When, $Z=-1$, then

probability of completion is 15.87%.

case-4

When, $Z=2$, then

probability of completion is 97.2%.

case-5

When, $Z=-2$, then

probability of completion is 2.8%.

case-6

When, $Z=3$, then

probability of completion is 99.86%.

case-7

When, $Z=-3$, then

probability of completion is 0.14%.

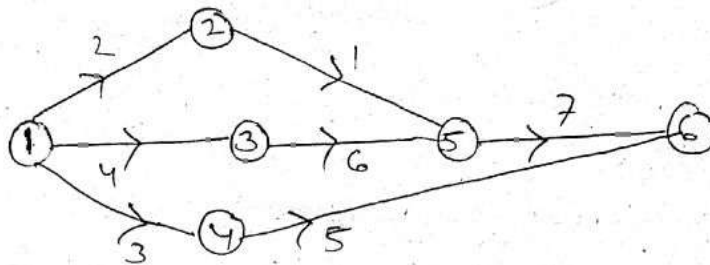
Q6 → The time estimates for activities of a PERT network is given below.

Activity	t_o	t_m	t_p
1-2	1	1	7
1-3	1	4	7
1-4	2	2	8
2-5	1	1	1
3-5	2	5	14
4-6	2	5	8
5-6	3	6	15

- Draw the network and identify all the paths.
- Determine expected project length.
- Calculate the standard deviation and variance of the project.
- What is the probability that the project will be completed.
- At least 4 weeks earlier than expected time.
- No more than 4 weeks later than expected time.

Ans 1

Activity	t_o	t_m	t_p	$t_e = \frac{t_o + 4t_m + t_p}{6}$	$\sigma = \frac{t_p - t_o}{6}$	σ^2
1-2	1	1	7	2	1	1
1-3	1	4	7	4	1	1
1-4	2	2	8	3	1	1
2-5	1	1	1	1	0	0
3-5	2	5	14	6	2	4
4-6	2	5	8	5	1	1
5-6	3	6	15	7	2	4



path

$$1-2-5-6 \quad | \quad 3+7=10$$

$$1-3-5-6 \quad | \quad 4+6+7=17$$

$$1-4-6 \quad | \quad 3+5=8$$

$\therefore$ critical path = expected project duration time = maximum of all the paths = 17 weeks.

(d) (i) $D = 17 \text{ weeks} - 4 \text{ weeks} = 13 \text{ weeks}$

$$Z = \frac{D - T_e}{\sigma_{cp}}$$

$$\sigma_{cp} = \sqrt{\sigma_{1-3}^2 + \sigma_{3-5}^2 + \sigma_{5-6}^2}$$

$$\sigma_c = \sqrt{1+4+4} = 3$$

So $Z = \frac{13 - 17}{3} = -\frac{4}{3} = -1.33$

From the table showing area under normal distribution curve the value corresponding to -1.33 is 0.4082, the probability is $0.5 - 0.4082 = 0.0918$

(ii) $D = 17 \text{ weeks} + 4 \text{ weeks}$

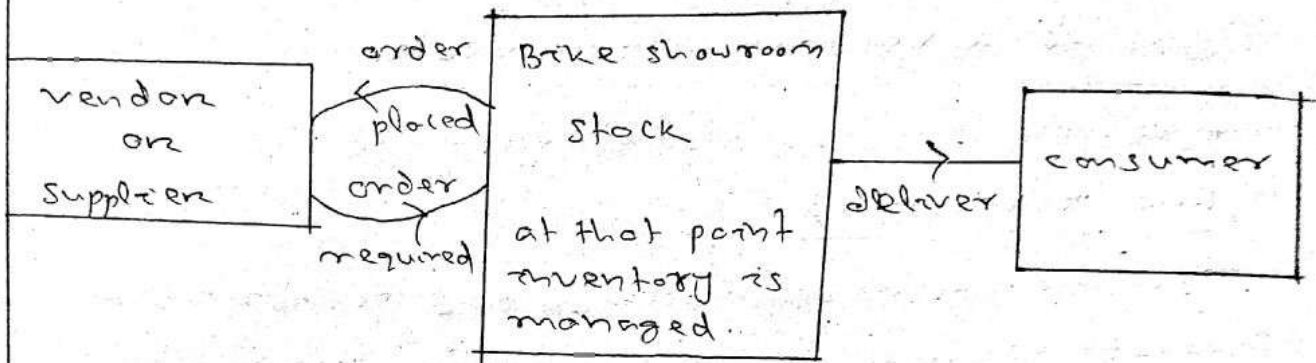
$$D = 21 \text{ weeks}$$

$$Z = \frac{21 - 17}{3} = \frac{4}{3} = 1.33$$

probability of completion time = 0.9082

Inventory

Inventory means any kind of stock of raw material and which is to be used in future.



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

Objective of inventory control

- The objectives are to minimized investment in inventory.
- to minimized the service levels to the buyers & customer and its own operating department.
- smooth and uninterrupted products and hence, no stock out.
- utilisation of working capital.
- Helps in minimizing loss due to deterioration, obsolescence damage.
- Alleviate the possibility of duplicate ordering.
- improvement in customer relationship because of timely delivery of goods and services.

Definition of inventory control

Inventory control may be defined as the scientific method of finding out how much stock should be maintained in order to meet the production

demands and be able to provide right type of material at right time in the right quantities and at competitive process.

Types of inventory classification

→ Inventory may be classified as follows

1. Raw inventories

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

2. In process inventories

They are semi-finished goods at various stages of manufacturing cycle.

3. Finished inventories

They are finished goods lying in stock rooms and waiting to be dispatched.

Indirect inventories

They include lubricants and other items like spare parts needed for proper operation, repair and maintenance during manufacturing cycle.

Costs involved in inventory

Ordering cost

Cost incurred for placing and receiving an order.

→ Ordering cost include transportation cost, labour charges etc.

∴ ordering cost per unit = $\text{Rs } 100 / \text{ordering}$

→ Total ordering cost per year = $\text{No. of orders in a year} \times \text{ordering cost per unit}$

Holding or carrying cost.

material cost

This is the cost of any item.

→ Total material cost = no. of item $\times$ price of item per unit.

Ordering cost

Cost involve bore placing and receiving an order.

→ This also known as procurement cost.

Let ordering cost = C_o = Rs 100/order.

cost involve in ordering cost.

→ Transportation cost.

→ Loading and unloading cost.

→ inspection cost.

carrying cost / holding cost.

cost involve in carrying or holding the product till consumed.

unit = C = Rs 100/unit/year

cost involve in holding cost.

→ space cost.

→ worker cost.

→ Electricity cost.

→ interest on capital invested.

C_p = unit cost of the product.

= Rs 1000/unit.

i = rate of interest per annum

= 10%.

$$C = \frac{C_p \times i}{100} = \frac{1000 \times 10}{100} = \text{Rs } 100/\text{unit}/\text{year}$$

Basic E.O.Q model

Assumptions

- instant and infinite replenishment.
- No shortage allow.
- Lead time should be zero.

Aim → Total cost should be minimum.

Annual demand = D unit/year.

ordering cost/order = C_o

Holding cost or carrying cost = $C = \frac{C_p \times i}{100}$

C_p = unit cost of the product.

i = rate of interest per annum.

Q = quantity of order placed.

Total cost/year = ordering cost/year + holding cost/year + material cost.

ordering cost/year = ordering cost/year
= number of orders/year $\times$
ordering cost/order

$$\therefore O.C./year = \frac{D}{Q} \times C_o$$

Inventory carrying cost/year = $C \cdot C / year$

= Avg. inventory $\times$ unit carrying cost/year

= $\frac{\text{max. inventory} + \text{min. inventory}}{2} \times \text{unit carrying cost/year}$

$$= \frac{Q + 0}{2} \times C$$

$$\Rightarrow C.C./year = \frac{Q}{2} \times C$$

→ material cost = Annual demand $\times$ unit cost of the product.

$$= D \times C_p$$

$$\rightarrow \text{Total cost/year} = \frac{D}{Q} \times C_o + \frac{Q}{2} \times C_i + D \times C_p$$

For minimum of total cost/year, $\frac{d(T.C)}{dQ} = 0$

$$\Rightarrow \frac{d}{dQ} \left[\frac{D}{Q} \times C_o + \frac{Q}{2} \times C_i + D \times C_p \right] = 0$$

$$\Rightarrow -\frac{D}{Q^2} \times C_o + \frac{C_i}{2} = 0$$

$$\Rightarrow \frac{D}{Q^2} \times C_o = \frac{C_i}{2}$$

$$\Rightarrow Q = \sqrt{\frac{2 \cdot D \cdot C_o}{C_i}}$$

Q1 → The rate of consumption of a particular item is 20 unit/year. The cost of procurement (placing an order and receiving the goods) per order is Rs 40. The unit cost is 100 rupees. The inventory carrying cost is 0.16%, and it depends upon the average stock. Determine E.O.Q.

2. No. of orders per year.

Al given data

Rate of consumption in a year / annual demand
 $= D = 20 \text{ units/year}$

ordering cost / order = $C_o = \text{Rs } 40$.

unit cost of product = $C_p = \text{Rs } 100/-$

rate of interest = 0.16%.

$$\text{Holding cost} = \frac{C_p \times i}{100} = \frac{100 \times 0.16}{100} = 16$$

$$E.O.Q = \sqrt{\frac{2D C_o}{c}}$$

$$= \sqrt{\frac{2 \times 20 \times 40}{16}} = 10 \text{ unit}$$

2. No. of orders/year = $\frac{D}{Q} = \frac{20}{10} = 2 \text{ unit/year}$

Q27 A manufacturer requires rivets at an approximately constant rate of 2500 kgs/year. The cost of rivet is Rs 40/kg. The company's purchase manager estimates that the carrying cost of inventory is 10%/year, procurement cost is Rs 200/order. Determine EOQ

2. No. of orders/year.

3. Total cost of inventory.

Ans Given data

Annual consumption = $D = 2500 \text{ kg}$

ordering cost = $C_o = 200/\text{order}$

unit cost = $C_p = \text{Rs } 40$

rate of interest = inventory carrying rate = 10%

holding / carrying cost/year = C

$$C = \frac{C_p \times i}{100} = \frac{40 \times 10}{100} = 4 \text{ units}$$

1. $EOQ = \sqrt{\frac{2 \cdot D \cdot C_o}{c}} = \sqrt{\frac{2 \times 2500 \times 200}{4}} = 500 \text{ kg}$

2. No. of orders/year = $\frac{D}{Q} = \frac{2500}{500} = 5 \text{ unit/year}$

3. Total cost = ordering cost + holding cost + material cost

$$= \frac{D}{Q} \times C_o + \frac{Q}{2} \times C + D \times C_p$$

$$= \frac{2500}{500} \times 200 + \frac{500}{2} \times 4 + 2500 \times 40$$

$$= 102000/-$$

Q37 Given that

- 1) Annual uses, $U = 60$ units
- 2) procurement cost, $p = \text{Rs } 15/\text{order}$.
- 3) cost/price, $c = \text{Rs } 100$
- 4) cost of carrying inventory i , a percentage including expenditure on obsolescence, taxes, insurance, deterioration etc $= 10\%$.

calculate EOQ and No. of orders/year.

As Annual consumption/uses, $D = 60$ units.

ordering cost/order $= C_0 = 15$

unit cost of the product, $C_p = 100/-$

$i = \text{rate of interest per annum} = \text{cost of carrying inventory in terms of percentage} = 10\%$.

1. Holding cost/unit $= \frac{C_p \times i}{100} = \frac{100 \times 10}{100} = 10$

So

$$EOQ = \sqrt{\frac{2DC_0}{C}} = \sqrt{\frac{2 \times 60 \times 15}{10}} = 13.41 \text{ units.}$$

2. No. of order $= \frac{D}{Q} = \frac{60}{13.41} = 4.47 \approx 5 \text{ unit}$

Q47 The rate use of a particular raw material known stores is 20 units/year. The cost of placing and receiving an order is Rs 40. The cost of each unit is Rs 100. The cost of carrying inventory in percentage per year is ~~0.16~~ 0.16. Determine the EOQ and no. of ordering per year.

Ans Annual Uses, $D = 20$ unit

ordering cost per order $= C_o = \text{Rs } 40$

unit of the product $= C_p = 100/-$

rate of interest per annum in percentage $= i = 0.16$

→ holding cost / annum $= \frac{C_p \times i}{2} = \frac{100 \times 0.16}{2} = 16$

1. $E.O.Q = \sqrt{\frac{2 D C_o}{C}} = \sqrt{\frac{2 \times 20 \times 40}{16}} = 10 \text{ unit}$

2. No. of order / annum $= \frac{D}{Q} = \frac{20}{10} = 2 \text{ unit / annum.}$

E.O.Q (Economic order quantity)

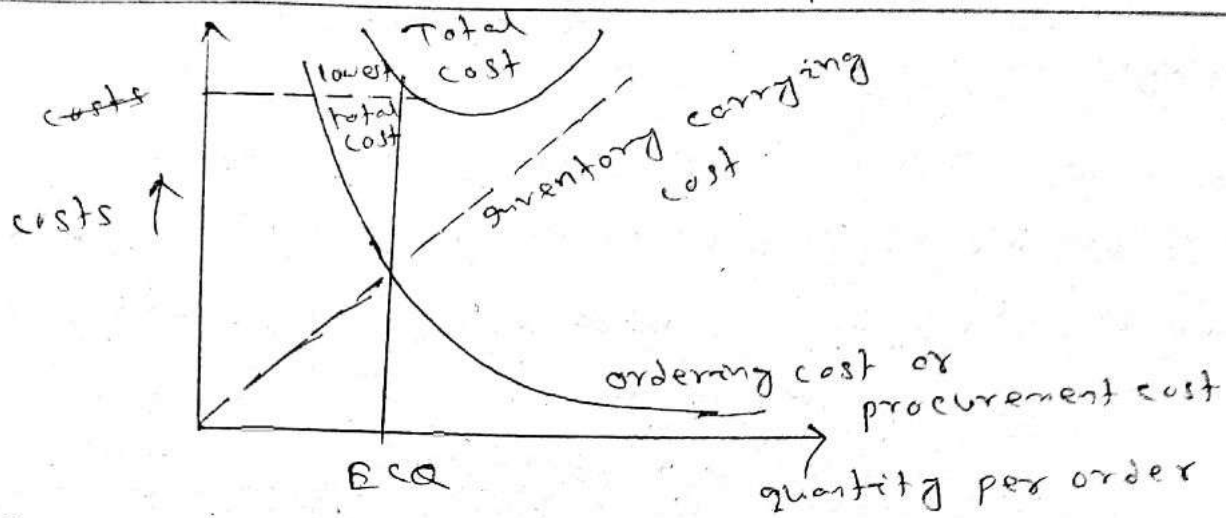
Economic order quantity is one which permits lowest cost per unit and is most advantageous.

* The amount of material procure or quantity produced during one production run by an enterprise is known as lot size.

→ The quantity to be ordered depends upon a no. of factor. It is evident that with increase in inventory size, expenditure of storage, deterioration and obsolescence etc. is likely to increase where as expenditure or setting up of the plant, procurement of material etc will decrease.

→ Thus with lot size there are two set of factors having opposite contribution towards expenditure.

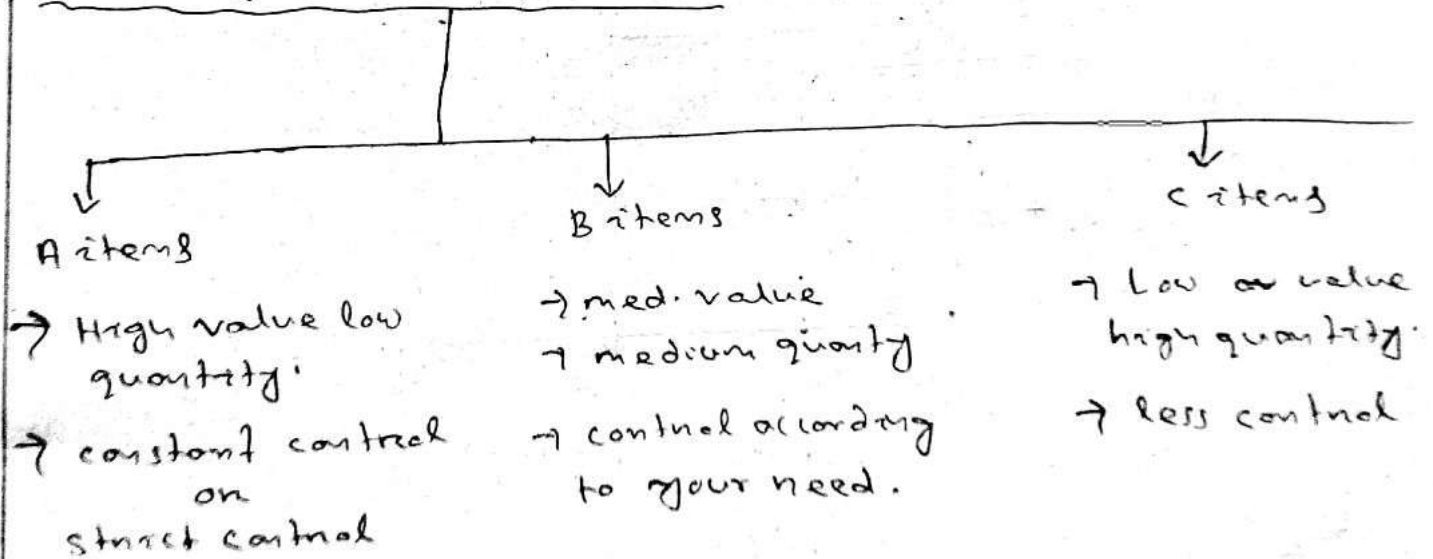
→ The lot size for which total cost per period is minimum is known as economic lot size or economic order quantity.



E.O.Q

EOQ is that size of order which minimizes total annual (or other time period as determined by individual firms) cost of carrying inventory and cost of ordering under the assumed condition of certainty of annual demand.

Inventory control technique

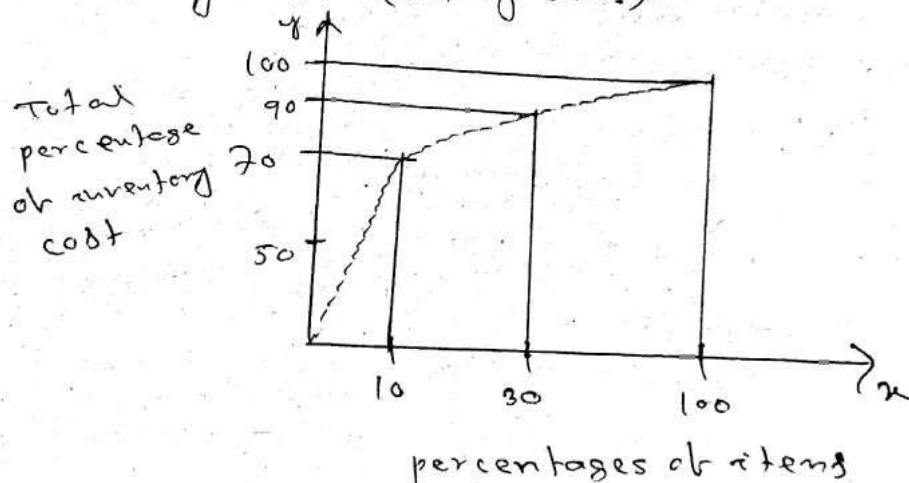


ABC analyses (always better control analysis)

→ ABC analysis help segregating the items from one another and tells how much valued the items is and controlling it to what extent is in the interest of the organisation.

procedural steps

- identify all the items used in manufacturing
- List all the items as per their value.
- count the number of high valued, medium valued, and low valued items.
- find the percentages of high, medium and low valued items. High valued items normally contribute from 70% of total cost and medium and low valued items are 20% and 10% of total cost respectively.
- A graph can be plotted between percentages of items (on x axis) and percentage of total inventory cost (on y axis).



Explanation

A class items

- A items are high valued but are limited or few in number. They need careful and close inventory control.
- maximum and minimum limits and ~~reorder~~ reorder point is set for A items.
- A detailed record of their received and issues should be kept and proper handling and storage facilities should be provided for them.

→ Generally A items generally accounts for 70% of total inventory cost and they constitute about 10% of total items.

B class items

→ B items are medium valued and their number lies in between A and C items.

→ Such items need moderate control but more important than C items.

→ They are purchased on the basis of past requirements, record of received and issues is kept and a procurement order is placed as soon as the quantity touches the reorder point.

→ B items generally accounts for 20% of total inventory cost and constitute about 15-20% of total items.

C items

→ C items are low value but maximum number items.

→ These items do not need any control, rather controlling them is uneconomical.

→ They are generally procured just before they vanish.

→ No expediting is necessary, no records are normally kept and a safety stock of 3 months or even more can be purchased at any instant.

→ C items generally accounts for 10-5% of total inventory cost and they constitute about 70-75% of total items.

Q57 Usha corporation has got the demand for particular parts at 10000 units per year. The cost per unit is Rs 2 and its cost rupees 36 to place an order and the process delivery. The inventory carrying cost is estimated as 9% of average inventory investment. Determine EOQ

2. optimum no. of orders to be placed per annum.
3. minimum total cost of inventory per annum.

Ans Annual demand, $D = 10000$ units
 unit cost of the product, $C_p = 2$
 ordering cost / order, $C_o = 36$
 rate of interest, $i = 9\%$

So

$$C = \frac{C_p \times i}{100} = \frac{2 \times 9}{100} = 0.18$$

$$1. \text{EOQ} = \sqrt{\frac{2 \times D \times C_o}{C}} \\ = \sqrt{\frac{2 \times 10000 \times 36}{0.18}} = 2000 \text{ unit / order.}$$

$$2. \text{No. of orders per annum} = \frac{D}{Q} = \frac{10000}{2000} = 5 \text{ unit}$$

$$3. \text{Total cost} = \frac{D}{Q} \times C_o + \frac{Q}{2} \times C + D \times C_p \\ = \frac{10000}{2000} \times 36 + \frac{2000}{2} \times 0.18 + 10000 \times 2 \\ = \text{Rs } 20360$$

function of inventory

→ Inventory shocks as cushions

Against shocks due to demand / supplier fluctuations, it separates different manufacturing operations from one another and make them independent so that each operation can be performed economically.

→ Inventory, necessary evil for any enterprise

→ The invested capital remains ideal till the shocks are not consumed for smooth working of the organisation is not possible without inventory, so it is a ~~necessary~~ necessity.

→ Further it has been observed that costs of not having inventory are actually greater than cost of having them. Thus inventory is a necessary evil.

→ Inventory provides production economics

→ purchase of desired quantity nullifies the effect of change in price on supplier.

→ stocks brings economy in purchase of various inputs due to discount on bulk purchase.

→ Maintainance smooth and efficient production flow

→ It maintainance smooth and efficient production flow thus keeps a process continuous.

→ creation of motivational effect in decision making.

→ It creates motivational effect in decision and policy making.

$$\text{maximize } Z = 12x + 24y$$

$$\text{subject to } x + 4y \leq 20$$

$$3x + y \leq 15$$

$$x, y \geq 0$$

Ans

$x + 4y = 20 \quad \text{--- (1)}$

when $x = 0, y = 5$

$x + 4y = 20$

$y = \frac{20}{4} = 5$

when $y = 0, x = 20$

$x = 20$

x	0	20
y	5	0

$3x + y = 15 \quad \text{--- (2)}$

when $x = 0, y = 15$

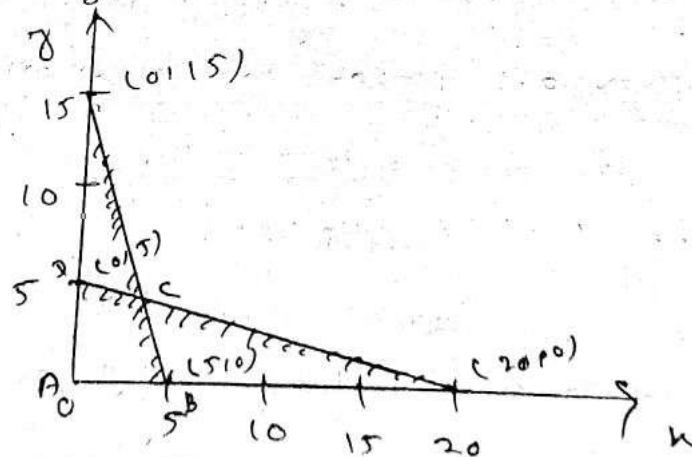
$3x + y = 15$

when $y = 0, x = 5$

$3x = 15$

$x = \frac{15}{3} = 5$

x	0	5
y	15	0



from eqⁿ (1) and eqⁿ (2)

$x + 4y = 20 \quad \text{--- (1)}$

$3x + y = 15 \quad \text{--- (2)}$

$x = 3.63$

$y = 4.09$

$Z_A(0,0) = 12 \times 0 + 24 \times 0 = 0$

$Z_B(5,0) = 12 \times 5 + 24 \times 0 = 60$

$$Z_c(3.63, 4.09) = 12 \times 3.63 + 24 \times 4.09 = 141.72$$

$$Z_b(0, 5) = 12 \times 0 + 24 \times 5 = 120$$

$\therefore Z_{\max} = 141.72$ at point $c(3.63, 4.09)$.

Q7 Find the graphical solution of Lpp below here the following condition.

$$\text{minimization, } Z = 60x + 40y$$

$$\text{subject to, } 30x + 10y \geq 240$$

$$10x + 10y \geq 160$$

$$20x + 60y \geq 480$$

$$x, y \geq 0$$

Ans

$$30x + 10y = 240 \quad \text{--- (1)}$$

$$\text{when } x=0, y=24$$

$$3 \times 0 + 10y = 240$$

$$y = \frac{240}{10} = 24$$

$$\text{when } y=0, x=8$$

$$3 \times x + 10 \times 0 = 240$$

$$x = \frac{240}{30} = 8$$

x	0	8
y	24	0

$$10x + 10y = 160$$

$$\text{when } x=0, y=16$$

$$10 \times 0 + 10y = 160$$

$$y = \frac{160}{10} = 16$$

$$\text{when } y=0, x=16$$

$$10 \times x + 10 \times 0 = 160$$

$$x = \frac{160}{10} = 16$$

x	0	16
y	16	0

$$20x + 60y = 480$$

$$\text{when } x=0, y=8$$

$$20 \times 0 + 60y = 480$$

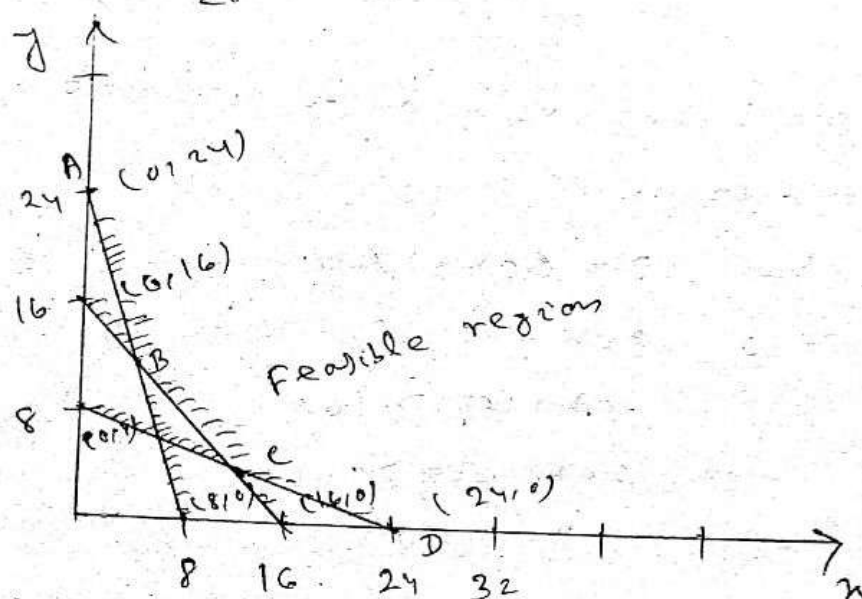
$$y = \frac{480}{60} = 8$$

x	0	24
y	8	0

When $y = 0$, $x = 24$

$$20x + 60 \times 0 = 480$$

$$x = \frac{480}{20} = 24$$



From eqn (1) and eqn (2)

$$30x + 10y = 240 \text{ --- (1)}$$

$$10x + 10y = 160 \text{ --- (2)}$$

$$x = 4, y = 12$$

From eqn (2) and eqn (3)

$$10x + 10y = 160 \text{ --- (2)}$$

$$20x + 60y = 480 \text{ --- (3)}$$

$$x = 12, y = 4$$

$$Z_A(0, 24) = 60 \times 0 + 40 \times 24 = 960$$

$$Z_B(4, 16) = 60 \times 4 + 40 \times 12 = 720$$

$$Z_C(12, 4) = 60 \times 12 + 40 \times 4 = 880$$

$$Z_D(24, 0) = 60 \times 24 + 40 \times 0 = 1440$$

$Z_{\min}$ at $= 720$ at point B(4, 12)

In modern industry, equipment and machinery as a very important part of the total productivity element than the case years ago.

→ more over with the development of special purpose and sophisticated machines, equipment and machinery cost a lot of more money and therefore their idle time downtime becomes much more expensive.

→ For this reason it is vitally important that the plant machinery should be properly maintained.

objective of plant maintenance

→ The objective of the plant maintenance is to achieve minimum break down and to keep the plant in good working condition at the lowest possible cost.

→ machine and other facilities should be kept in a such a condition which permits them to be used at their optimum capacity without any interpretation.

→ The maintenance division of the ~~factory~~ factory ensures the availability of the machine, buildings and services required by other sections of the factory for the performance of ~~the factory~~ their functions at optimum return on investment whether this investments be in material, machinery or personalty.

Importance of maintenance

- The importance of plant maintenance varies with the type of plant and its production.
- Equipment breakdown leads to an inevitable loss of production.
- An improperly maintained or neglected plant will sooner or later require expensive and frequent repairs, because with passage of time all machines or other facilities wear out and need to be maintained to function properly.
- Plant maintenance plays a prominent role in production management because plant breakdown creates problems such as loss in production time, rescheduling of production, failure to recover overheads, need for overtime etc.

Responsibility and duty of plant maintenance engineering department.

The different duties, functions and responsibility of the maintenance department are as follows.

1. Inspection

Inspection is concerned with routing schedule checks of the plant facilities to examine their condition and to check for needed repairs.

- Inspection ensure the safe and efficient operation of equipment and machinery.

→ frequency of inspections depends upon the intensity of use of the equipment.

2. Engineering

→ Engineering involves alteration and improvement in existing equipments and building to minimize breakdown.

+ maintenance department also undertakes engineering and supervision of constructional project that will eventually become part of the plant.

3. Maintenance (including preventive maintenance)

→ maintenance of existing equipment.

→ maintenance of existing plants ~~but~~ building and other facilities such as central stores, roadways, drainage etc.

→ preventive maintenance, preventive breakdown by well conceived plans of inspection, lubrication, adjustments, repair and overhaul.

4. Repair

maintenance department carry out corrective repairs to alleviate on satisfactory condition found during preventive maintenance inspection.

→ such a repair is an unscheduled work often of an emergency nature and is necessary to correct breakdown.

5. Overhaul

overhaul is a planned, & scheduled reconditioning condition of plant facilities such as machinery etc.

6. construction

in some organisation, maintenance department is provided with equipment and personal and it takes of construction job also.

7. Salvage

maintenance department may also handle disposition of scrap or surplus materials.

8. Clerical Jobs

maintenance department keeps records of costs, of time, progress on job, administration and supervision of labour course, insurance administration, house keeping etc.

Types of maintenance

1. Break down maintenance
2. scheduled "
3. preventive "
4. predictive "

1. Breakdown or corrective maintenance

→ Breakdown maintenance implies that repairs are made after the equipment is out of order and it can not perform its normal function any longer.

Ex → Electric motor will not start, A belt is broken etc.

→ After removing the fault the maintenance engineers do not attend the equipment again until another failure or breakdown occurs.

→ This type of maintenance may be quite justifiable in small factories which

* are indifferent to the benefits of scheduling.

→ It seldom demand an excess of normal operating capacity.

→ Breakdown maintenance practice is economical for those equipments whose downtime and repair cost are less this way than other type of maintenance.

→ Breakdown maintenance involves little administrative work, a few records and a comparatively small staff.

2. scheduled maintenance

- scheduled maintenance is a stick-in-time procedure aimed at avoiding breakdowns.
- Breakdown can be dangerous to life and as far as possible should be minimize.
- scheduled maintenance practice incorporates, inspections, lubrication, repair and overhaul of certain equipments which if neglected can result in breakdown.
- scheduled maintenance practice is generally followed for overhauling of machines, cleaning of water and other, white washing of building etc.

3. preventive maintenance

- A system of scheduled, planned or preventive maintenance tries to minimize the problem of breakdown maintenance generally it is a stick-in-time procedure.
- It locates weak spots in all equipments provide them regular inspection and minor repairs thereby reducing the danger of anticipated breakdown.
- The principle of preventive maintenance is that prevention is better than cure.
- * preventive maintenance involves

1. period inspection of equipment and machinery to uncover conditions that lead to production breakdowns and harmful depreciation.
2. ~~keep~~ upkeep of plant equipment to correct such condition which they are still in a minor stage.

objective of preventive maintenance

- To minimize the possibility of anticipated production interruption or measure breakdown.
- To make plant equipment and machinery always available and ready for use.
- To maintain the value of equipments and machinery by period inspection, repairs, overhaul etc.
- To reduce the work content of maintenance jobs.
- To minimize the optimum productive efficiency of the plant equipment and machinery.

↑ Predictive maintenance

- It is comparatively a newer maintenance technique.
- predictive maintenance technique are designed to help determine the condition of in-service equipment in order to estimate when maintenance should be performed.

→ This approach promises cost saving over routine or time based preventive maintenance because tasks are performed only when warranted.

It makes use of human senses or other sensitive instruments such as audio gauges, vibration sensors, pressure sensor, temperature sensor and resistance strain gauge to predict troubles before the equipment fails.

→ unusual sounds coming out of a rotating equipment predict a trouble.

ex → An electric cable excessively hot at one point predict a troubles.

→ predictive maintenance extends the service life of an equipment without fear of failure.