Chapter 2

Production Planning and Control

CHAPTER HIGHLIGHTS

- *Introduction*
- *Planning Phase*
- *Action Phase and Control Phase*
- *Continuous Production System*
- *Break Even Analysis*
- *Interpretation of Break Even Chart*
- *Margin of Safety*
- *Capacity Planning and Utilization*
- *Optimum Plant Capacity*
- *Bottlenecking*
- *Production Over Capacity*
- *Aggregate Planning and Forecasting*
- *Difference Between Forecasting and Prediction*

Introduction

Production planning and control is viewed as the nervous system of a manufacturing system. The primary concern of production and control is the delivery of products to the inventory stocks according to some predetermined schedule. Every activity in the manufacturing or production cycle must be planned, organised, co-ordinated and controlled to achieve the objectives. From a long term point of view, production planning largely deals with the planning of plant construction, its layout, the product line, product design, product development etc. Short range planning focuses on immediate activities such as product storage, achievement of target, wage budgets etc.

The ultimate objective of production planning and control is to contribute to the profits of the enterprise. This is accomplished by keeping the customers satisfied through the meeting of delivery schedules. Further, the specific objectives of production planning and control are to establish the routes and schedules for the work that will ensure the optimum utilisation of raw materials, labour and machines to provide the means for ensuring the operation of the plants in accordance with the plans. Production planning and control is essentially concerned with the control of work in-process. To control work in- process effectively, it becomes necessary to control not only the flow of materials but also the utilisation of people and machines.

The planning process within an organisation is dynamic and continuous. It is the process of deciding the future course of action of the organisation well in advance so that executives at different levels will play their role as per the guidelines. The type of decisions the organisation has to take can be explained as follows:

1. Strategic decisions – which are taken at top levels.
2. Tactical decisions – which are taken at middle levels.
3. Operational decisions – which are taken at bottom levels. Production planning and control can be analysed in three phases. They are:
   (a) Planning phase
   (b) Action phase
   (c) Control phase.

Planning Phase

It has two categories, namely 'prior planning' and 'active planning'. Prior planning means pre-production planning. This includes all planning efforts which are taking place before the active planning. Active planning means the actual production planning, which includes various activities directly related to the production at micro level immediately following the prior planning.

The prior planning process includes:

1. Product development and design
2. Forecasting
3. Aggregate planning
4. Master scheduling
5. Material requirement planning etc.

Active planning includes:

1. Process planning and routing
2. Master planning
3. Material planning and routing
4. Tool planning
5. Loading
6. Scheduling etc.

Action Phase

The major step of the action phase is dispatching. Dispatching is the transition from the planning phase to the action phase. It is in this phase that the workers are ordered to start manufacturing the product.

The process of dispatching includes the following tasks:

1. Job order
2. Store order
3. Tool order
4. Time ticket
5. Inspection order
6. Move order.

These orders cover all the aspects that are to be taken care of while performing an operation at the action phase.

Control Phase

Control phase has the major steps as given below:

1. Progress reporting
2. Corrective action.

In progress reporting, the data regarding what is happening with the production process is collected. It also helps to make a comparison between the present level of performance with the planned level of performance.

In the progress report, data related to material rejection, equipment failures, process variations, operator efficiency, operator absenteeism, tool life etc. are to be furnished, after collecting and analysing the data pertaining to them. This data is actually used for the Analysis of Variances to identify critical areas. Immediate attention must be diverted to those areas for corrective actions.

The tasks under corrective actions are something to be performed abruptly. There should be provision for handling an unexpected event. Some of the corrective actions are:

1. Creating schedule flexibility
2. Schedule modification
3. Capacity modification
4. Expediting work and so on.

If the progress reporting indicates deviations from the set targets, the action to be taken is known as expediting. Replanning the whole affair sometimes becomes essential if 'expediting' fails to bring the deviated plan to its right path.

Continuous Production System

It involves a continuous flow of materials using special purpose machines. Standardised items in large quantities are produced using this system. It is divided into two categories:

1. Mass and flow line production,
2. Continuous or process production.

Mass and flow line production Large scale production using specialised machines and processes is called mass production. Products like safety pins, chocolates, plastic goods etc are produced using mass production. In flow line production, the items are processed in continuous stages from process to process. Automobiles, electronic goods etc., are made using this process. There is a continuous steady flow of materials in this process.

Continuous or process production This method is used when the product is consumed fast and the demand is continuous. Electricity, petrol etc. are examples of this system.

Intermittent Production System

This system has interrupted flow of materials through the plant. Components of different nature are produced using general purpose machines. Small quantities are produced using this system. The classifications of this system are:

1. Batch production
2. Job production.

Batch production As per the order of the consumer, the items are produced in batches. The material flow is intermittent, and the maintenance of equipment and machinery is essential. Apparels, paints, sheet metal works etc. are some examples of batch production.

Job production Items are made according to the special requirement of the customer. The product design for the item is time consuming. Skilled workers and special purpose attachments for machinery are required. The number of items to be manufactured are small and sometimes, it may be only one item.

Direction for examples 1 to 3: Two machines A and B are used to make an industrial product. The details of the machine are given below:

	M/c A	M/c B
1. Investment	₹60000	₹100000
2. Interest on borrowed capital	15%	15%
3. Operating cost (cost per hour)	₹12	₹10
4. Production/hr	6 pieces	10 pieces

The overhead costs are ₹120000. The machines work effectively for 4000 hrs in two shifts during the year.

Example 1: For regular production, the machine which is desirable is
(A) M/c A (B) M/c B
(C) Both machines are alike (D) Cannot be compared.

Solution:

Table 1 *Comparison*

No.	Item	M/c A	M/c B
1.	Overhead cost	₹120000	₹120000
2.	Investment	₹60000	₹100000
3.	Interest charge	$\frac{60000\times15}{100}$ = 9000	$\frac{100000\times15}{100}$ =15000
4.	Operating cost	4000 × 12 = 48000	4000 × 10 = 40000
5.	Total annual costs (excluding investment and 0/H)	₹57000	₹55000
6.	No. of pieces produced per year	4000 × 6 = 24000	4000 × 10 = 40000
7.	Annual cost/produced	$\frac{57000}{24000}$ = ₹2.375	$\frac{55000}{40000}$ = ₹1.375

As the cost of production is less for machine B, M/c B may be preferred for regular production.

Example 2: If only 4000 pieces are produced in an year, the machine that can be preferred for regular production is
(A) M/c A (B) M/c B
(C) both are equal (D) Data is insufficient.

Solution:

No.	Item	M/c A	M/c B
1.	Interest charge	₹9000	₹15000
2.	No. of hrs to produce 4000 products	$\frac{4000}{6}$	$\frac{4000}{10}$
3.	Operating cost	$\frac{4000}{6}\times12$ = 8000	$\frac{4000}{10}\times10$ = 4000
4.	Total cost	17000	19000
5.	Cost/unit product	$\frac{17000}{4000}$ = ₹4.25	$\frac{19000}{4000}$ = ₹4.75

As the cost per unit production is less for M/c A = M/c A is preferred.

Example 3: Considering the above details, the number of pieces to be produced per year so that the cost of production will be the same for both the machines is
(A) 4800 (B) 5300 (C) 6000 (D) 6400.

Solution:
From the details furnished, the operating cost/piece for machine A is 12/6 = ₹2, and for machine B is $\frac{10}{10}$ = ₹1.
Let 'x' pieces be produced for equal cost of production.
Then for machine A, the cost of production is $2x + 9000$. For machine B, the cost of production is $x + 15{,}000$.
$\therefore\ 2x + 9000 = x + 15000.$
$x = 6000$
$\therefore$ The number of pieces = 6000.

Direction for examples 4 to 6: A company has to process a number of components on a monthly basis. The processing time (M/c) required for every component is 36 min/component. An import part is required at the rate of 1.2 Kg/component. The skilled man power required is 12 min/component.
Availability of inputs are as given below:

Item	Availability	% of utilisation
Hours available for equipment	500/month	85%
Imported part	1000 Kg/month	95%
Skilled man power(hrs)	250 hrs/month	65%

Example 4: Under these conditions, the maximum possible production is
(A) 813 (B) 719 (C) 760 (D) 708.

Solution:
Subject to the availability of the inputs, we can calculate the number of components that could be produced.
Availability of machine hours

$$= \frac{500\times85}{100} = 425 \text{ hrs.}$$

No. of items that could be produced

$$\frac{425\times60}{36} = 708.$$

Availability of imported components

$$= \frac{1000\times95}{100} = 950 \text{ Kg}\cdot$$

Every component requires 1.2 Kg.
No. of components that can be produced

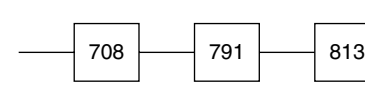
$$= \frac{950}{1.2} = 791.$$

Availability of manual skilled man power

$$= \frac{250\times65}{100} = 162.5 \text{ hrs} = 9750 \text{ min}.$$

No. of components that could be produced

$$= \frac{9750}{12} = 813.$$



It has a bottleneck at 708.
∴ The maximum possible production is 708.

Example 5: In the above data, if skilled man power is increased by 15%, the maximum production will be
(A) 935 (B) 845 (C) 910 (D) 708.

Solution:
Increasing the man power is not sufficient to overcome the bottleneck. Therefore, maximum production remains the same = 708.

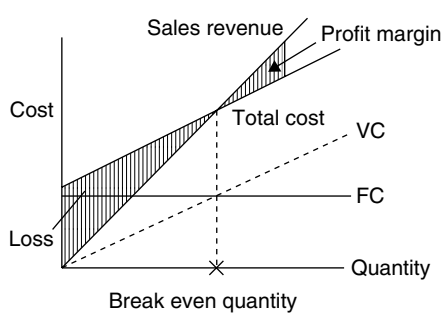
Example 6: 'Expediting' is a part of
(A) planning phase (B) action phase
(C) control phase (D) evaluation phase.

Solution:
When the process deviates from the planned path, expedition is required. It is in the control phase.

Break Even Analysis

It is a technique used to establish a relation among the quantity produced, sales income and production expenditure. Break even analysis is also known as Profit Volume Analysis.

This identifies a stage in the business when the total revenue becomes equal to the total cost of production. This point of production is known as Break Event Point. When the cost of production and the revenue are plotted in an $x-y$ plane, with the quantity of production along the x-axis and cost along the y-axis, we get a graph as shown.



Break even point indicates the no-profit no-loss point. If the production rate is maintained according to the break even point, the firm reaches the saddle point of no profit or no loss.

Terms Related to Break Even Analysis

Production Cost

Production cost or cost of production takes into account all the costs going into production. The main components contributing to the cost of production are

1. Fixed cost
2. Variable cost.

Fixed costs are those costs that remain constant at all levels of production. It does not depend on the quantity produced. Fixed costs include the cost of building, interest on borrowings, salary, rent of the building, etc. Variable cost is the cost which varies with the output. When greater quantities are produced, the variable cost will be greater, accordingly.

Sales Revenue

It is the amount received by selling the product at the rate of selling price. The sales revenue must exceed the total cost for the firm to make profit.

Formula for Break Even Analysis

Let 'x' quantity be produced so that the total revenue and total cost of production are equal for a firm.

Assume 'F' as the fixed cost. Let 'v' be the variable cost per unit produced and 'p' be the selling price per unit. 'p' is the sales revenue per unit. As the quantity produced is 'x', the total cost of production is

$$F + xv$$

Total sales revenue is xp.

Then $$F + xv = xp$$

$$\therefore F = x(p - v)$$

$$\therefore x = \frac{F}{p - v}$$

∴ x is the break even quantity. x indicates the quantity to be produced to attain the no-profit no-loss condition.

Break even point is also expressed in terms of the break even revenue.

Break even revenue = break even quantity × selling price/unit

$$= x \times p.$$

∴ Break even revenue

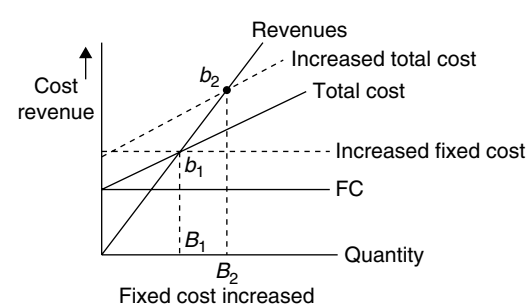
$$xp = \frac{Fp}{p - v}$$

$$\text{Break even revenue} = \frac{F}{1 - \frac{v}{p}}$$

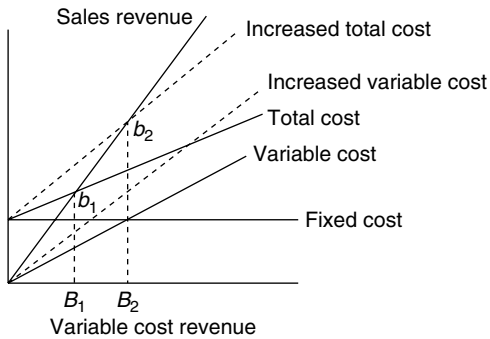
This expression is in terms of rupees.

The graphical representation gives a clear picture of the trend of the total cost and revenue. This keeps the manager in a better position to take decisions. It gives probable profits and losses at various levels of output.

Interpretation of Break Even Chart

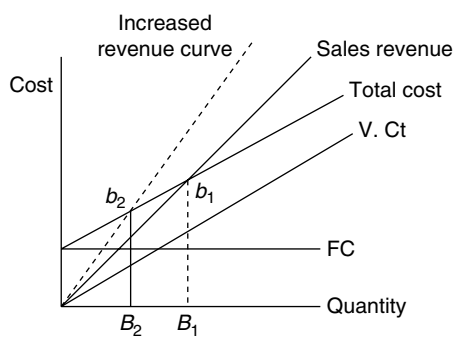


When the fixed cost increases and all other quantities remain the same, the BEP (Break even point) gets shifted from B_1 to B_2. That means, The break even condition could be achieved only at a larger volume of production.



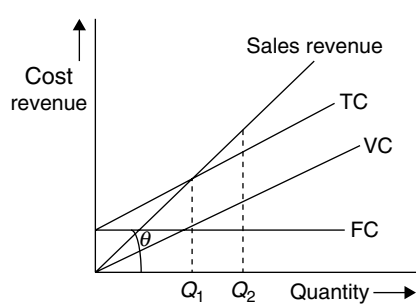
When the variable cost increases, the break even point again shifts towards the right, demanding an increase in the volume of production for achieving break even condition.

If the sales price is increased, the slope of the sales revenue curve increases.



When the selling price increases, the break even point is shifted to the left, i.e., towards the lower range. That means, at a lower volume of production, the break even condition could be achieved.

Margin of Safety



Let Q_1 be the quantity to be produced at the break even condition. But at the operating condition prevailing, if the quantity produced is Q_2, then, $\frac{Q_2 - Q_1}{Q_1}$ is the margin of safety. It is the extent to which we can reduce the volume of production without suffering any loss.

Angle of Incidence

If angle of incidence θ is the angle made by the sales revenue line with the quantity axis, as 'θ' increases, break even condition will occur at an earlier point, indicating a case of less volume of production for the break even condition.

If θ decreases, the break even condition occurs at a later point, indicating a case of more volume of production for the break even condition.

Let Q_1 be the break even quantity. If 'F' is the fixed cost and A is the variable cost per unit at BEP, then $F + AQ_1 = BQ_1$, where B is the revenue per unit.

$$\therefore Q_1 = \frac{F}{B - A}$$

If the plant operates at a point corresponding to a production rate Q_2 ; $Q_2 > Q_1$

then

margin of safety = Δ

$$\Delta = \frac{Q_2 - Q_1}{Q_1} = \frac{Q_2}{Q_1} - 1.$$

If 'Z' is the profit of the plant, $Z = (Q_2 - Q_1)\, B$

i.e., $$Q_2 - Q_1 = \frac{Z}{B}$$

But, $$\Delta = \frac{Q_2 - Q_1}{Q_1} = \frac{Z/B}{F/(B - A)}$$

$$\Delta = \frac{Z}{F} \times \frac{B - A}{B}.$$

Example 7: A company manufactures an aircraft component. The committed cost of the firm is ₹4000000 per year. The variable cost for each component is ₹2000. The component is sold at a rate of ₹3000 per component. The break even quantity is

(A) 21800 units (B) 3200 units
(C) 4000 units (D) 4500 units.

Solution:

Break even point

$$x = \frac{F}{p - v} = \frac{4000000}{3000 - 2000}$$

$$= \frac{4000000}{1000} = 4000 \text{ units.}$$

Direction for examples 8 to 10: An item is produced in a plant. The fixed cost per month is ₹6000. The variable cost is evaluated to be ₹2/unit. The selling price is ₹7/unit.

Example 8: The break even volume shall be

(A) 1200 units (B) 1500 units
(C) 1800 units (D) 2200 units.

Solution:

Fixed cost = ₹6000
Variable cost = ₹2/unit
Selling price = ₹7/unit

Break even quantity $= \frac{6000}{7-2} = 1200$ units.

Example 9: If we produce 1000 units and sold them completely the profit is

(A) ₹ + 1000 (B) ₹ – 1000
(C) ₹ + 1500 (D) ₹ – 1500.

Solution:

When $x = 1000$, the cost of production is $6000 + x \times 2$, revenue $= x \times 7$.

$\therefore$ Profit is $7x - (6000 + 2x)$, but $x = 1000$

i.e, $7 \times 1000 - 8000 = -₹1000$.

Example 10: For achieving a profit of ₹4000, the quantity to be produced is

(A) 6000 (B) 4000
(C) 3000 (D) 2000.

Solution:

Profit is to be ₹4000

$x \times 7 - (6000 + 2x) = 4000$

$5x = 10000 \quad \therefore x = 2000$ units.

Example 11: The production manager of a company has to decide to operate an automatic machine in the place of a semi automatic machine. The following data is available.

Date	Automatic	Semi-automatic
Time for the job	2 min	5 min
Set-up time	2 hrs	1.5 hrs
Cost/hr	₹20	₹12

The quantity of production above which the automatic machine is profitable is

(A) 72 (B) 70 (C) 66 (D) 52.

Solution:

Let 'x' be the quantity.

The cost of the automatic machine is $\left(2 + \frac{2x}{60}\right) \times 20$.

The cost of the semi-automatic machine is

$$\left(1.5 + \frac{5}{60}x\right)12.$$

At no-profit no-loss condition

$$40 + \frac{40x}{60} = 18 + x$$

$$22 = x - \frac{4}{6}x = \frac{2x}{6} = 66 \text{ units.}$$

If the production exceeds 66 units, the automatic machine is economical.

Example 12: Two machines A and B are under consideration for machining a given part.

The following data is obtained:

EQPT	Preparation cost	Production time (mt)	Machining and operation cost ₹/hour
Machine A	₹30	30	75
Machine B	₹150	15	120

The break even quantity above which B is economical is

(A) 20 (B) 18 (C) 16 (D) 12.

Solution:

Let 'x' be the break even quantity. Cost of production as per machine $A = 30 + 30x.\frac{75}{60}$

Cost as per machine B

$$150 + 15x \times \frac{120}{60}$$

At break even condition

$$30 + 37.5x = 150 + 30x$$
$$\therefore \quad 37.5x - 30x = 150 - 30$$
$$7.5x = 120$$
$$x = 16.$$

Capacity Planning and Utilisation

The most important responsibility of the production and operation management is the effective utilisation of the capacity. Capacity management means:

Plan and control the capacity, so that the level of operation matches with the level of demand. Capacity is defined as the rate of productive capacity of a facility. Capacity is often expressed as a volume of output per period of time.

Capacity planning is categorised into:

1. Long term capacity planning
2. Short term capacity planning.

Long term capacity plans are mainly concerned with the investments in new buildings, locations, facilities, equipments etc. Long term capacity planning may spread over more than two years.

Short term capacity plans take into account the size of work force, budgets, products and raw material storages etc.

The capacity of a plant is expressed as the rate of output. But, in case the plant produces different types of products in different rates, then the volume rate of output cannot represent the plant capacity. Then, the capacity of the plant is expressed in terms of the money value of all the products put together. Money value means the total production value in terms of money.

Capacity planning involves the following important steps:

1. Assessing the capacity of the existing facilities.
2. Identifying and fixing sources of capacity for future use.
3. Forecasting long – range future capacity needs.
4. Evaluating alternative sources of capacity considering technological, financial, economical advantages.

Capacity planning becomes necessary, when an organisation decides to increase the volume of production to achieve economic advantage. Capacity planning is necessitated when

1. The need for a new facility is established.
2. The organisation decides to introduce a new product into the market.

Optimum Plant Capacity

Plant capacity is related to the cost of production. When the volume of production increases, it results in the reduction of the average cost per unit produced.

For a given system of production, there is an optimum volume of output as per the year's output, that results in the least average unit cost. This level of production is known as the "Best operating level" of the plant.

Bottlenecking

When firms manufacture many products, the load on the equipment and the facilities vary. This variation occurs due to the change of product mix. The required output rates of the products may not match with the existing output rates of the machines and facilities. Consequently, there will be an imbalance among the work load on different machines. Hence, some machine or facility will become a 'bottleneck centre'. This limits the production capacity of the plant and consequently increases the cost of production.

To overcome bottlenecking:

1. Additional facilities and machines added at the bottle neck work centre.
2. Overtime is given for increased work input to overcome bottlenecking and for solving imbalance.
3. Sub-contract the excess work load at bottleneck centers.

All the three cases discussed above increase the cost of production. A relative evaluation of all the three cases is required to adopt one.

Another method considered for overcoming the problem of bottlenecking is to change the product mix. Here, too we should consider the relative merits and demerits. For effective utilisation, load on all the work centres must be uniform.

Production Over Capacity

Usually, it is very difficult to forecast the demand because, there is always an element of uncertainty with the demand. Sometimes, the forecast demand will be high. Then, we should build up the capacity over the existing capacity to cater to the anticipated demand projection. There are certain cases where maintaining over capacity for plants is justified. These are:

1. Fixed costs of the plant and facility are not high.
2. Subcontracting is not desirable because of the nature of the product and process.
3. The time required for capacity enhancement is long.
4. Capacity below the optimum capacity is highly uneconomical.

Production Under Capacity

When the demand forecast indicates a reduced demand, we go for maintaining the plant and capacity below optimum. This is the case of under capacity.

But, there are certain situations which will prefer under capacity. The cases are:

1. The time to build up capacity is very short.
2. Technology change is very fast.
3. Rate of obsolescence of plant and facility is very high.

Aggregate Planning

Aggregate planning is always an intermediate – term planning. It is actually the planning process carried out over a short period ranging from 3 months to 6 months. In the case of aggregate planning, there is not going to be any change in the existing facilities of operation.

When there is a large fluctuation of demand or when we are attracted to a raw product mix or when we are interested to introduce a new product into the market over and above the existing ones, in such situations, without increasing or decreasing any of the existing facility, we manage with the present system with a short term rearrangement or optimisation to accommodate the changed situation. This is aggregate planning. Aggregate planning seeks the best combination to minimise costs.

Once various capacities which are available under different categories are known, the next task is to identify a feasible and optimal combination of the capacities to manufacture the given set of products as per the pre-determined production volume such that, the total cost of manufacturing is minimised.

Since the company manufactures several products using the given set of facilities, requirement of resources for these products are to be aggregated to a common unit. Therefore, aggregate planning aims at finding the best combination of various available capacities to match with the resource requirements.

Aggregate Planning Strategies

The following strategies can be used singly or in combination for smoothing the fluctuations in the demand:

1. Varying the size of work force
2. Overtime utilisation
3. Sub-contracting.

If a single strategy is used to meet the demand, it is known as pure strategy.

Each of the strategies given above are pure strategies. Instead, if a combination of pure strategies is used to meet the demand, it is called a 'mixed strategy'.

Elements of Production Planning and Control

In short, the elements of production planning and control can be summarised to the following elements:

1. Forecasting
2. Planning
3. Routing
4. Loading
5. Scheduling
6. Dispatching
7. Expediting.

Forecasting

The first step is to forecast the demand. This is the process of collecting valuable information regarding the sales trend, behaviour of the market, availability of materials etc. This is infact a part of the planning process. A good forecasting gives sufficient input for planning. There are many methods for forecasting. It is to be appropriately chosen depending on the purpose.

Planning

This is a process of giving a guideline for the action. Based on the information received from forecasting, the programmes are planned. It includes capacity planning, planning order intake strategies, developing sales/purchase strategies etc. It also includes developing production guidelines and making policy decisions. The planning shall be short – range, medium – range and long – range based on the periods for which the planning is made.

Routing

Routing prescribes the sequence of operations of production. It decides where and by whom work is to be done. Routing forms the basis for loading and scheduling. In a continuous manufacturing system, the routing is done in advance with respect to production. Routing is a vital function in the case of intermittent production system and it becomes mechanical in a continuous manufacturing system with a clear layout. Routing sheets are prepared with symbols.

Loading

It is the process of converting shop orders to work loads on individuals and machines. The manager must be aware of the capacity of machines and as to what extent can it be loaded to ensure efficient utilisation of the capacity. Routing also decides about the individuals who are to carry out the task and the extent to which they can be loaded.

Scheduling

It is the process of preparing a time table for the operation. It fixes the sequences in which the tasks are to be accomplished. It also fixes the time required for each operation.

Dispatching

It gives a start for the work. It is the process of initiating work. The 'start order' is to dispatch. It is to set the productive activities in motion through the release of orders and instructions according to the planned times and sequences. It authorises, the start by releasing materials, tools and components. It gives instructions to the operators.

Expediting

If a deviation is observed between the pre – planned and actual path, it is to be brought back to the right path using appropriate corrective measures. This process is known as expediting. Expediting or 'follow up' or 'progress' reporting as it is sometimes called is a logical step after dispatching.

Master Scheduling

It is also known as master production schedule. In a master schedule, the type and quantity of materials to be provided at each time in the future is clearly indicated. Master schedule is derived from the production plan. But, it details the material requirement at various stages. It can generate material planning and capacity planning information. It balances the demands against resources.

Example 13: A machine is required to produce three products *A*, *B*, and *C*. The annual demand for the products *A*, *B* and *C* is 300, 400 and 500 respectively. The processing time required for each in the machinary is 4, 6 and 3 hrs respectively. If the unit works on an 8 hr shift for 250 days a year, the number of machines required is

(A) 2 (B) 3 (C) 4 (D) 5.

Solution:

Products	Annual demand	Processing time per unit	Total processing time
A	300	4	1200
B	400	6	2400
C	500	3	1500
			5100 hrs

Total hours available/year = 8×250

$= 2000$ hrs.

Total processing time required for the three products = 5100 hrs.

No. of machines required $\frac{5100}{2000} = 2.55$

$= 3$ nos.

Direction for questions 14 and 15: The design capacity of a plant is 60000 tons of a product per day. But the effective capacity is only 50000 tons/day. The actual output is measured to be 35000 tons/day.

Example 14: The efficiency of the plant is
(A) 90% (B) 85% (C) 80% (D) 70%.

Solution:

$$\text{Efficiency} = \frac{\text{actual output}}{\text{effective capacity}}$$

$$= \frac{35000}{50000}$$

$$= \frac{7}{10} = 70\%.$$

Example 15: The % utilisation of the plant is
(A) 74.2% (B) 70.2%
(C) 63.2% (D) 58.3%.

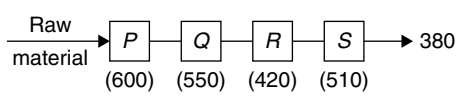
Solution:

$$\text{Percentage utilisation} = \frac{\text{actual output}}{\text{design capacity}}$$

$$\frac{35000}{60000} = \frac{35}{60} = \frac{7}{12}$$

$$= 58.3\%.$$

Example 16: A factory has four work centres for a particular product. The centres are in a series. The raw material passes through the work centres successively to produce the product. The capacity of each work centre is as shown. The system efficiency is



(A) 90.4% (B) 86.5%
(C) 82.5% (D) 80.6%.

Solution:
In the system, there is a bottle neck at '*R*'. This decides the system capacity.

$\therefore$ System capacity = 420
But the actual output = 380

$$\therefore \text{The system efficiency} = \frac{380}{420} = 90.4\%.$$

Example 17: A factory operates on an 8 hr single shift basis/day, for 6 days/week. There are 12 machines of the same type. If the machines are utilised 80% of the time at a system efficiency of 70%, then the rated output in terms of standard hours/week is
(A) 412 hrs (B) 412 hrs
(C) 323 hrs (D) 267 hrs.

Solution:
Total hours available/week = $12 \times 8 \times 6$
= 576 hrs.
Percentage utilisation = 80

$$0.8 = \frac{\text{Effective hours of work}}{\text{Total hours}}$$

$\therefore$ Effective hrs = 0.8 × total hours
$= 0.8 \times 576$
= 460.8 hrs

$$\text{System efficiency} = \frac{\text{actual output}}{\text{effective output}}$$

$$0.7 = \frac{\text{Actual output}}{460.8}$$

$\therefore$ Actual output = 322.56
= 323 hrs.

Direction for examples 18 to 20: A company plans to buy a machine whose production capacity is 150000 units per annum. The machine forms part of the series product line. The system efficiency of the product line in which this machine has the least production rate, is 80%.

Example 18: The system capacity is
(A) 162000/annum (B) 168500/annum
(C) 187500/annum (D) 190500/annum

Solution:

$$\text{System efficiency} = \frac{\text{actual output}}{\text{system capacity}}$$

$$0.8 = \frac{150000}{\text{system capacities}}$$

$$\therefore \text{System capacity} = \frac{150000}{0.8}$$

= 187500/annum.

Example 19: The machine work for 1800 hrs per year and time for the production of each part is 80 sec. If percentage utilisation of the machine is 60% and efficiency of machine is 90%, the output of the machine is (per hour)
(A) 24 (B) 28 (C) 36 (D) 47.

Solution:
No. of hrs/annum = 1800

$$\therefore \text{No. units/hr} = \frac{187500}{1800}$$

= 104 units/hr

$$\text{Capacity of the unit per hour} = \frac{3600}{80}$$

= 45 units/hr.
Actual output = $45 \times 0.9 \times 0.6 = 24$.

Example 20: The number of machines required is
(A) 4 (B) 5 (C) 6 (D) 7

Solution:
The actual output = 24/hr
No. of units to be produced/hr = 104
$\therefore$ No. of machines required

$$= \frac{104}{24} = 4.33 \approx 5 \text{ } nos.$$

Forecasting

Forecasting is nothing but peeping into the future. Some systematic and scientific methods have been developed to predict with certain precision about the future trend in the business world. Forecasting of sales, forecasting of demands, forecasting of business situation etc. are very common. The knowledge of what exactly happened in the previous years would be the back ground about which the forecasting is made. A proper forecast requires a careful assessment of the factors which are both controllable and uncontrollable, both within and outside the organisation.

The period of forecasting is the time range selected for forecasting, depending on the purpose for which the forecast is made. The period may vary. Depending on the period, the forecast can be termed as short range forecast, medium range forecast or long range forecast. To work out the expected capital expenditure for the coming years, long range forecasting is used. Short range forecasting is used for production planning and the like.

Forecasting is essentially the study of internal and external forces that shape the demand and supply. The shape of the things to come will depend upon how we manage the controllable factors.

Difference between Forecasting and Prediction

Forecasting	Prediction
1. Forecasting implies time series and future projections.	**1.** Prediction involves the expected change in the future.
2. It uses the past data.	**2.** It involves judgement.
3. It is logical and scientific.	**3.** It is an intuitive process.
4. Error analysis is possible.	**4.** It is very difficult to perform error analysis.
5. All forecasts are predictions.	**5.** All predictions are not forecasts.

Accuracy of a Forecast

It is essential to have a good measure of effectiveness of the forecasting method. It can be used to compare alternative forecasting methods and identify the models which need adjustments. Forecast error is the difference between the actual demand and the forecasted demand. The error should be as minimum as possible which implies the accuracy of the forecast method.

Forecasting Errors

Mean Absolute Deviation (MAD)

It is a measure of the forecast error and it measures the average forecast error. It deals with the magnitude of the error. It is calculated as the sum of the absolute values of the forecast errors for all periods divided by the total no. of periods.

$$\text{MAD} = \sum_{i=1}^{n} \frac{|D_t - F_t|}{n}$$

As in MAD, errors are measured without considering sign. It expresses the magnitude but not the direction of the error.

BIAS or Mean Forecast Error (MPE)

$$\text{BIAS} = \sum_{i=1}^{n} \frac{(D_t - F_t)}{n}$$

This measures the forecast error with regard to direction and shows any tendency to over forecast and under forecast. Positive BIAS indicates that forecast is underestimated and negative BIAS indicates that forecasting is over estimated.

Running Sum of Forecast Error (RSFE)

$$\text{RSFE} = \sum_{i=1}^{n} (D_t - F_t)$$

It is the summation of errors.

Mean Square Error (MSE)

$$\text{MSE} = \sum_{i=1}^{n} \frac{(D_t - F_t)^2}{n}$$

Mean Absolute Percentage Error (MAPE)

It is the mean of percentage deviation of the forecasted demand from the actual demand.

$$\text{MAPE} = \frac{1}{n}\left[\sum_{i=1}^{n} \frac{|D_t - F_t|}{D_t}\right] \times 100.$$

Tracking Signal

It tells how well the forecast is predicting actual values.

$$\text{TS} = \frac{\text{RSFE}}{\text{MAD}}$$

Forecasting Methods

Delphi Method

When we launch a new product in the market, the acceptability of the product cannot be naturally predicted, because past data is not available. Therefore, time – series analysis is impractical. We have to depend on expert judgement or logical assessment.

In Delphi method, a panel of experts are identified. A series of structured questionnaires are given to them. Their identity will not be revealed among them. This is to avoid a bias of opinions. Responses are collected in 2 or 3 rounds and from that, a conclusion is arrived at. This method is generally used for long range forecasting.

Trend Analysis (Interpolation)

This is applicable when sufficient data from the previous records are available. Data is plotted against time and the line of best fit is determined by statistical methods. From the equation of the line, forecast for the next period can be easily found. From the plot, the trend of the data can be seen. It gives an idea about the market behaviour.

Moving Average Method

In this method, the forecast does not solely depend on the older data nor on the latest data. It is a discrete averaging method.

Periods in the past beyond a certain level are considered irrelevant. The message given in this method is that history helps plan the future, but not much of the past is important. This technique retires the old data and inducts fresh data into its calculation.

Mean (simple average) method The forecast for, next period (period t+1) will be equal to the average of the all past historical demands.

$$F_{t+1} = \frac{\sum_{i=1}^{t} d_i}{t}$$

Simple moving average method The forecast for the next period (period $t + 1$) will be equal to the average of a specified number (n) of the most recent observations, with each observation receiving the same emphasis (weight).

$$F_{t+1} = \frac{\sum_{i=1}^{n} d_{(t-i)}}{n}$$

Weighted moving average method The forecast for the next period (period $t + 1$) will be equal to a weighted average of a specified number of the most recent observations.

$$F_{t+1} = \sum_{i=1}^{n} w_i \; d_{(t-i)}$$

where $w_1 > w_2 > w_3$……

Time Series Method

This is a modified version of the weighted moving average method. It is known as the exponential smoothing method.

Consider that the old forecast given for the current period was 100. But the actual sales observed in the present period is '90'. Then, the new forecast for the next period shall be obtained by giving a weightage for the old forecast and the present actual sales. Let us give 'α' the weightage for the current sales. Then, $(1 - \alpha)$ is the weightage given to the old forecast. 'α' is known as the smoothing constant. In the previous example, if $\alpha = 0.2$, forecast for the next period is

$$= 0.2 \times 90 + 0.8 \times 100$$
$$= 18 + 80 = 98$$

or $F_{t+1} = \alpha D_t + (1 - \alpha) F_t$

$$F_{t+1} = \alpha D_t + (1 - \alpha) F_t$$
$$= \alpha D_t + (1 - \alpha)[\alpha D_{t-1} + (1 - \alpha) F_{t-1}]$$
$$= \alpha D_t + \alpha (1 - \alpha) D_{t-1} + (1 - \alpha)^2 F_{t-1}$$
$$= \alpha D_t + \alpha (1-\alpha) D_{t-1} + (1-\alpha^2)[\alpha D_{t-2} + (1-\alpha) F_{t-2}]$$
$$= \alpha D_t + \alpha (1-\alpha) D_{t-1} + \alpha (1-\alpha)^2 D_{t-2} + (1-\alpha)^3 F_{f-2}$$

$$F_{t+1} = \alpha D_t + \alpha (1 - \alpha) D_{t-1} + \alpha (1 - \alpha)^2 D_{t-2} + \alpha (1 - \alpha)^3 D_{t-3} + (1 - \alpha)^4 F_{t-4}$$

Roughly, α factor is taken as

$$\alpha = \frac{2}{[\text{Number of periods in moving average}] + 1}$$

If $\alpha = 0.2$, it is roughly equal to 9–period moving average.

Simple Linear Regression Model

This is the mathematical method of obtaining the line of best fit between the dependent variable (demand) and an independent variable (time).

The dependent variable (y) and the independent variable (x) are related by a straight line.

$$y = a + bx.$$
$$\Sigma y = a \, \Sigma 1 + b \, \Sigma x \Rightarrow \Sigma y = an + b \, \Sigma x$$

Multiplying by Σx on both the sides

$$\Sigma x . \Sigma y = an \, \Sigma x + b(\Sigma x)^2 \qquad (1)$$
$$y = a + bx$$
$$\Rightarrow xy = ax + bx^2$$
$$\therefore \Sigma xy = a \, \Sigma x + b \, \Sigma x^2$$

Multiplying by n on both the sides

$$n \, \Sigma xy = an \, \Sigma x + bn \, \Sigma x^2 \qquad (2)$$

From (1) and (2),
we get:

$$b = \frac{n \Sigma xy - \Sigma x . \Sigma y}{n \Sigma x^2 - (\Sigma x)^2}$$

and

$$a = \frac{\Sigma y - b \Sigma x}{n}$$

where n = number of periods or observations.

Special case: Least square method

When independent variable x is linear and is the year of sales etc., then it can be put such that $\Sigma x = 0$.

$$\therefore b = \frac{\Sigma xy}{\Sigma x^2} \text{ and } a = \frac{\Sigma y}{n}$$

Solved Examples

Example 21: The demand for washing machines in five towns have resulted in the generation of the following data during investigation.

Population (lakhs) in town	5	7	8	11	14
Demand of washing m/c in thousands	9	13	11	15	19

Demand for washing machine in a town where the population is 10 lakhs is (in thousands)

(A) 14.44 (B) 15.33 (C) 15.86 (D) 16.23.

Solution:

Data can be tabulated as follows:

x	y	xy	x^2
5	9	45	25
7	13	91	49
8	11	88	64
11	15	165	121
14	19	206	195
$\Sigma x = 45$	$\Sigma y = 67$	$\Sigma xy = 655$	$\Sigma x^2 = 455$

Let $y = a + bx$ be the line of regression.

Then,

$$\Sigma Y = na + b\Sigma x \quad (1)$$
$$\Sigma xy = a\Sigma x + b\Sigma x^2 \quad (2)$$
$$67 = 5a + 45\,b$$
$$655 = 45\,b + 455\,b.$$

Two equations are obtained: one directly from the assumed regression line and the other after multiplying the equation of line with the average of x and then taking the sum. (1) becomes

$$\left.\begin{aligned} 67 &= 5a + 45b\} \times 9 \\ 655 &= 45\,a + 455\,b \\ 603 &= 45\,a + 405\,b \end{aligned}\right\} \text{Subtraction}$$

$$52 = 50b,\ b = \frac{52}{50} = 1.04$$

$$67 = 5a + 45 \times 1.04$$

$\therefore\ a = 4.04$

$\therefore$ The line is $y = 4.04 + 1.04x$

Required to find 'y' when $x = 10$,

$$y = 4.04 + 1.04x$$
$$= 14.44 \text{ thousand.}$$

Example 22: The annual sales of fork lifts manufactured by a company from 2009 is given in the following table.

The anticipated sales during the year 2014 is (in thousands)

(A) 96 (B) 93 (C) 90 (D) 83

Solution:

Tabulate the data as follows.

Year	2009	2010	2011	2012	2013
Sales (1000)	53	64	86	54	83

Year	x	y	xy	x^2
2009	–2	53	–106	4
2010	–1	64	–64	1
2011 = A	0	86	0	0
2012	1	54	54	1
2013	2	83	166	4
	0	340	50	10
	$\Sigma x = 0$	$\Sigma y = 340$	$\Sigma xy = 50$	$\Sigma x^2 = 10$

As the variable 'x' represents years, take 'x' as, $x = \dfrac{X - A}{C}$.

When X is the specified year, A = the year coming almost at the middle of the series and 'c' the interval between the years (uniform).

$\dfrac{X - A}{c} = X$;

X = year
A = Mid year = 2011
C = Interval = 1
$N = 5$

$$\Sigma y = na + b\Sigma x$$
$$340 = 5a + 0\ ;\ a = 68$$
$$\Sigma xy = a\Sigma x + b\Sigma x^2$$
$$50 = 10a + 10\,b,\ b = 5$$

The line is

$$y = a + bx$$
$$y = 68 + 5x.$$

Put $x = 3$ ($x = 3$ indicates the year 2014)

$y = 68 + 15 = 83$ thousand.

Direction for examples 23 and 24:

Example 23: The sales during 10 months (from Jan 2013 to Oct 2013) for an engineering product is given below. By simple moving average method (10 months), the forecast of sales for November 2013 is

Month	Sales ('000)
January	50
February	40
March	90
April	45
May	55
June	60
July	55
August	50
September	45
October	50

(A) 58 (B) 56 (C) 54 (D) 52.

Solution:

Month	Sales
J	50
F	40
M	90
A	45
M	55
J	60
Ju	55
A	50
S	45
O	50

$$\text{Average for 10 months} = \frac{540}{10} = 54.$$

Example 24: If the actual sales during November happens to be 60, then the 10 month moving average forecast for the month of December is (in thousands)
(A) 55 (B) 58 (C) 59 (D) 63.

Solution:
Forecast of December is the average of 10 months, sale for February to November.

$$\text{The forecast is } \frac{540 - 50 + 60}{10} = 55000.$$

Direction for questions 5 and 6: In a cycle shop, the sales during the last 3 months were as shown below.

Month	March	Feb	Jan
No. of cycles	18	16	19

Example 25: Assuming a smoothing constant of 0.8, the forecast for April is
(A) 20 (B) 18 (C) 17 (D) 16.

Solution:
We know that,

$$F_{t+1} = \alpha D_t + \alpha(1-\alpha) D_{t-1} + \alpha(1-\alpha)^2 D_{t-2} + \ldots\ldots\ldots\ldots$$
$$= 0.8 \times 18 + 0.2 \times 0.8 \times 16 + 0.8 \times 0.6419$$
$$= 17.56 = 18.$$

Example 26: If the actual sales during April happen to be 19, the forecast for May will be
(A) 9 (B) 18 (C) 20 (D) 17.

Solution:
We know that,

$$F_{t+1} = \alpha D_t + \alpha(1-\alpha) D_{t-1} + \ldots\ldots\ldots\ldots$$
$$F_{t+1} = \alpha D_t + (\alpha)[F_t]$$
$$F_{t+1} = F_t + \alpha [D_t - F_t]$$
$$= 18 + 0.8\,[19 - 18]$$
$$= 18.8 = 19.$$

Exercises

Practice Problems I

1. Consider the given data indicating the demand in 4 periods and production plans accordingly.

Period	Demand	Regular production	Over time	Other
1.	750	750	----	-----
2.	850	850	----	-----
3.	900	850	50	-----
4.	1000	850	50	-----

In the 4th period, there is a balance demand. This can be met by planning
(A) sub-contracting for balance demand
(B) using over time in period 2
(C) using regular production in period 1
(D) using overtime in period 1.

2. Production planning and controlling the authorisation of initiation of work in the work shop is
(A) loading chart (B) dispatch order
(C) schedule order (D) route plan.

3. Loading and scheduling activities will be comparatively difficult if the industrial activity is
(A) batch production
(B) single product continuous.
(C) continuous production with multi-products.
(D) process production.

4. Consider two small units A and B which are different, but producing the same product. The investment for A and B are 4 lakhs and 6 lakhs, respectively. The interest on the investment is 18% each. Operating cost of A is ₹200/hr and for B is ₹120/hr. The units operate for 4000 hrs and A produces 60 units/hr and B produces 75 units/hr. The unit preferable for regular production is
(A) A (B) B
(C) A and B are alike (D) data is insufficient.

5. A firm manufactures a new product and it is in a position to sell 400 pieces. The field cost is ₹10000. The cost per unit production is ₹40. If the firm can sell a unit at ₹65/unit, the net profit is (₹)
(A) zero (B) 2600 (C) 3200 (D) 4800.

6. The demand for a product during the years 2000, 2001, 2002, 2003 and 2004 is 3, 6, 8, 10, 12 respectively. The demand during the year 2005 is
(A) 15.2 units (B) 14.4 units
(C) 13.6 units (D) 13.2 units.

7. A machine was purchased for ₹10000 and the life of the machine is 8 years. The scrap value is ₹1500; the percentage of yearly depreciation is
(A) 14.6% (B) 18.3% (C) 21.2% (D) 24.8%.

8. Cost of a machine is ₹48000 and its and its useful life is 18 years. The scrap value at the end of life is ₹8000. The percentage reduction in its value at the end of the first year is
(A) 8.7% (B) 9.5% (C) 10.25% (D) 11.5%.

9. For a product manufactured in a firm, the actual demand in the market during the last 7 months is as shown:

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Demand	115	120	115	120	118	119	123

By 5 months, by moving average method, forecast for the month of May is
(A) 118 (B) 119 (C) 120 (D) 122.

10. Details of an assembly line is as shown below. The assembly line has 6 work stations. The total task time in the work station is given.

Work station	I	II	III	IV	V	VI
Task time	10	8	9	11	13	14

The line efficiency of the assembly line is
(A) 92.3% (B) 87.5% (C) 81.3% (D) 77.4%.

11. Demand forecast for the last month for a consumer product was 350 units. But the actual demand exceeded 384 units. Assuming an exponential smoothing constant of 0.3, the forecast for this month shall be
(A) 360 (B) 370 (C) 380 (D) 390.

12. The type of information that we get from the scheduling chart is
(A) when the work will be completed.
(B) to what extent the machines are utilised.
(C) when does the work start and how much will be completed at a particular time.
(D) to what extent can the idling time be eliminated.

13. In a workshop, there are two milling machines. One is an automatic type and the other one is of the conventional type. The following details are given.

	Automatic	Conventional
Set up time	65 min	20min
Machine time/price	6 min	30min
Cost of machin ing	₹750/hr	250/hr

The automatic machine shall be economical for a production rate exceeding
(A) 15 pieces (B) 18 pieces
(C) 22 pieces (D) 28 pieces.

14. A product is priced at ₹125. The labour cost and material cost amounts to ₹85 per unit produced. If the fixed cost for the production facility is 25000, the break even point is
(A) 1000 units (B) 850 units
(C) 625 units (D) 550 units.

Direction for questions 15 and 16: An operator turns out 70 jobs in 20 hrs. This time includes the time for setting the machine and the actual turning time per price.
Setting time is 40 min
Turning time/price = 15 min.

15. The standard time for turning out 70 jobs is
(A) 55 min (B) 385 min
(C) 1050 min (D) 1090 min.

16. The operator efficiency is
(A) 82.5% (B) 85.8%
(C) 90.8% (D) 93.5%.

Direction for questions 17 to 20: A firm produces a component which is sold in the market at a price of ₹8/unit. The fixed cost is ₹8000 per month, the variable cost being ₹3/unit produced.

17. The break even quantity is
(A) 2000 units (B) 1800 units
(C) 1700 units (D) 1600 units.

18. If the firm produces 1000 units per month, the loss incurred is
(A) ₹3000 (B) ₹2500
(C) ₹2000 (D) ₹1800.

19. To get a profit of ₹3000, the quantity to be produced is
(A) 2000 (B) 2200
(C) 2400 (D) 2500.

20. In a business situation, the demand forecast for the next year is 60. But during this year, the forecast demand was 62 units, whereas the actual demand came out to be 58. If exponential smoothing method was adopted for forecasting, the smoothing constant was
(A) $\alpha = 0.3$ (B) $\alpha = 0.4$
(C) $\alpha = 0.5$ (D) $\alpha = 0.6$.

Practice Problems 2

1. Secular trend means
(A) A steadily increasing or decreasing trend
(B) A seasonal trend
(C) An unpredictable trend
(D) A trend indicating no variation.

2. Delphi method of forecasting is applicable
(A) when previous data from the market are available
(B) when a study about a product already in the market is required
(C) when a new product is launched in the market
(D) the market is highly competitive.

3. Routing is the process of
(A) preparing the timetable for production
(B) determining the flow of material during the process
(C) instructing the procedure of production
(D) making a guideline for action.

4. Loading with respect to production planning and control means

(A) Instructing the workmen to start working
(B) Changing the shop work order to work load on individuals
(C) Loading the facility efficiently with raw materials
(D) Maximum utilisation of the available facility.

5. Among the following steps, the controlling activity is
(A) scheduling (B) routing
(C) dispatching (D) expediting.

6. In production planning and control, the function dispatching means
(A) the process of dispatching the raw material
(B) the process of dispatching the finished product
(C) giving instructions to start work
(D) issue tools for the operations.

7. The preplanning of inventory and workforce at the broadest level is known as
(A) aggregate planning (B) long – range planning
(C) scheduling (D) requiring.

8. Two machines *K* and *L* are purchased for ₹1.5 lakhs and 1 lakh, respectively. The interest on the investment is 12% each. The equipments operate 3600 hrs a day. Production rate of *K* is 8 units/hr and that of *L* is 6 unit/hr. Operating cost of *K* is ₹12/hr and that of *L* is ₹19/hr. The machine preferred for regular production is
(A) *K* (B) *L*
(C) both are alike (D) data is insufficient.

9. A firm introduces a new product in the market at a price of ₹80/unit. The investment is ₹12000 and the cost for a unit produced is ₹50. If the firm produces 800 units, the profit margin is (₹).
(A) 18000 (B) 14000 (C) 12000 (D) 10000

10. The demand for a product during the years 1995, 1996, 1997, 1998 and 1999 are 12, 13, 11, 10, 12 units, respectively. The demand for the year 2000 is
(A) 14 (B) 13.8 (C) 12.6 (D) 10.7.

11. An equipment is purchased for ₹25000. Its scrap value after 10 years of use is ₹5000. The rate of depreciation in percentage is
(A) 14.86 (B) 13.72 (C) 13.21 (D) 12.62

12. A machine is purchased for ₹50000 and its useful life is 25 years. The scrap value at the end of life is ₹10000. The percentage reduction in its value at the end of the first year is
(A) 8.3% (B) 7.6% (C) 6.2% (D) 5.8%.

13. The actual demand of a product for the last five months is given as 62, 60, 63, 64, 62. The demand forecast for the 6^{th} month by 3 months moving average analysis is
(A) 64 (B) 63 (C) 62 (D) 61.

14. An assembly line consists of 8 work stations. The task time (in min) at each work station is 45, 65, 50, 85, 90, 70, 75, 65 respectively. The line efficiency of the assembly line is
(A) 75.7% (B) 81.3% (C) 87.8% (D) 92.5%.

15. A manufacturing unit observes that the forecast and actual sales of its product during the month of Jan 2013 were 128 and 118 units, respectively. Taking an exponential smoothing constant of 0.4, the forecast sales during Feb 2013 would be
(A) 130 (B) 124 (C) 122 (D) 120.

16. Gannt chart gives the information about
(A) the utilisation of man power
(B) the number of jobs to be completed
(C) the quantity of material flow into the process
(D) the production schedule.

17. For the production of a component, a standard machine tool and an automatic machine tool are considered. The following details are obtained.

	Std μ/c	Automatic μ/c
Time of arrangement	45 min	1.5 hrs
μ/c time per price	35 min	12 min
Production cost	₹300/hrs	₹850/hrs

The break even lot size above which the automatic machine is economical is
(A) 320 units (B) 215 units
(C) 202 units (D) 186 units.

18. A product is priced at the rate of ₹250. The labour and material cost amounts to ₹125 per unit produced. If the fixed cost is ₹50000, the break even value in ₹ is
(A) ₹75000 (B) ₹100000
(C) ₹115000 (D) ₹125000.

Direction for questions 19 to 21: A plant produces an item and sells at a price of ₹7 per unit. The fixed cost per month is ₹6000, variable cost being ₹2/unit produced.

19. The break even volume is (per month)
(A) 1200 (B) 1500 (C) 1800 (D) 2000.

20. If 1400 units are produced in a month, the profit is (₹)
(A) ₹1800 (B) ₹1200 (C) ₹1000 (D) ₹800.

21. The number of units to be produced per month to achieve a profit of ₹4000 is
(A) 2500 units (B) 2000 units
(C) 1500 units (D) 1250 units.

Direction for questions 22 to 24: It is observed that by purchasing one machine, the range of production could be 0 ~ 300 units, if two machines are purchased it will be in the range 301 ~ 600 and if three machines are purchased it may become 601 ~ 900. The fixed cost for 1, 2 and 3 machines is ₹12000, ₹15000 and ₹21000 respectively, and the variable cost remains constant at ₹20/units. The revenue obtainable/unit is ₹50.

22. If the projected demand is between 600 and 650, the number of machines to be purchased is
(A) 1 machine (B) 2 machines
(C) 3 machines (D) 2 or 3 machines.

23. If 3 machines are purchased to meet the demand of 650 units, the loss incurred is
(A) ₹2000 (B) ₹1500 (C) ₹1200 (D) ₹1000.

24. When a demand of 600 is met, in the case of two machines, the profit is
(A) ₹1000 (B) ₹1500 (C) ₹2000 (D) ₹3000.

25. Sales forecast for the next year as per exponential smoothing method is 90 units. But during the current year, there is a discrepancy between the forecast sales volume (86) and actual sales volume (96 units). Then, the exponential smoothing constant is
(A) 0.3 (B) 0.4 (C) 0.5 (D) 0.6.

26. In a production set up, the break even value of production is ₹81250. The fixed cost is ₹25000. The cost of labour and material per unit of production was estimated to be ₹45/unit produced. The selling price of the product per unit is
(A) 85 (B) 70 (C) 65 (D) 60.

27. A steel plant of a design capacity of 75000 tons of ingot has a plant utilisation factor of 72%. If the efficiency of the plant is 90%, the effective capacity of the plant is
(A) 72000 tonnes (B) 70000 tonnes
(C) 65000 tonnes (D) 60000 tonnes.

28. A firm operates for 6 days a week on two shift basis (8 hr shift.) The percentage utilisation of time is 70% for a system efficiency of 85%. The output of the firm in terms of hours is (there are 12 machines of the same capacity)
(A) 686 hrs (B) 712 hrs
(C) 760 hrs (D) 810 hrs.

29. The following activities constitute a work cycle.

Activities	Time required
1. Cutting	5.00 min
2. Polishing	25 min
3. Finishing	30 min
4. Loading	55 min

The output of the plant in an 8 hrs shift is
(A) 2 units (B) 3 units
(C) 4 units (D) 5 units.

30. The percentage depreciation of a machining is 12%. Its salvage value after use for 15 years is ₹400. The cost price of the machining is (₹)
(A) 29500 (B) 27230
(C) 25120 (D) 22500

Previous Years' Questions

1. For a product, the forecast and the actual sales for December 2002 were 25 and 20 respectively. If the exponential smoothing constant (α) is taken as 0.2, the forecast sales for January 2003 would be **[2004]**
(A) 21 (B) 23 (C) 24 (D) 27

2. A standard machine tool and an automatic machine tool are being compared for the production of a component. The following data refers to the two machines. **[2004]**

	Standard machine tools	Automatic machine tool
Setup time	30 min	2 hrs
Machining time per piece	22 min	5 min
Machine rate	₹200/hr	₹800/hr

The breakeven production batch size above which the automatic machine tool will be economical to use will be
(A) 4 (B) 5 (C) 24 (D) 225

3. The sales of a product during the last four years were 860, 880, 870 and 890 units. The forecast for the fourth year was 876 units. If the forecast for the fifth year, using simple exponential smoothing, is equal to the forecast using a three period moving average, the value of the exponential smoothing constant α is **[2005]**
(A) $\frac{1}{7}$ (B) $\frac{1}{5}$ (C) $\frac{2}{7}$ (D) $\frac{2}{5}$

4. A component can be produced by any of the four processes I, II, III and IV. Process I has a fixed cost of ₹20 and a variable cost of ₹3 per piece. Process II has a fixed cost of ₹50 and variable cost of ₹1 per piece. Process III has a fixed cost of ₹40 and variable cost of ₹2 per piece. Process IV has a fixed cost of ₹10 and variable cost of ₹4 per piece. If the company wishes to produce 100 pieces of the component, from the economic point of view, it should choose **[2005]**
(A) Process I (B) Process II
(C) Process III (D) Process IV.

5. A moving average system is used for forecasting weekly demand. $F_1(t)$ and $F_2(t)$ are sequences of forecasts with parameters m_1 and m_2 respectively, where m_1 and $m_2 (m_1 > m_2)$ denote the numbers of weeks over which the moving averages are taken. The actual demand shows a step increase from d_1 to d_2 at a certain time. Subsequently **[2008]**

(A) neither $F_1(t)$ nor $F_2(t)$ will catch up with the value d_2
(B) both sequences $F_1(t)$ and $F_2(t)$ will reach d_2 in the same period
(C) $F_1(t)$ will attain the value d_2 before $F_2(t)$
(D) $F_2(t)$ will attain the value d_2 before $F_1(t)$.

6. Which of the following forecasting methods take a fraction of forecast error into account for the next period forecast? **[2009]**
(A) simple average method
(B) moving average method
(C) weighted moving average method
(D) exponential smoothening method.

7. The demand and forecast for February are 12000 and 10275, respectively. Using single exponential smoothening method (smoothening coefficient = 0.25), forecast for the month of March is **[2010]**
(A) 431 (B) 9587
(C) 10706 (D) 11000.

8. Which one of the following is NOT a decision taken during the aggregate production planning stage? **[2012]**
(A) Scheduling of machines
(B) Amount of labour to be committed
(C) Rate at which production should happen
(D) Inventory to be carried forward.

9. In simple exponential smoothing forecasting, to give higher weightage to recent demand information, the smoothing constant must be close to **[2013]**
(A) –1 (B) zero (C) 0.5 (D) 1.0.

10. In exponential smoothening method, which one of the following is true? **[2014]**
(A) $0 \le \alpha \le 1$ and high value of α is used for stable demand
(B) $0 \le \alpha \le 1$ and high value of α is used for unstable demand
(C) $\alpha \ge 1$ and high value of α is used for stable demand
(D) $\alpha \le 0$ and high value of α is used for unstable demand.

11. The actual sales of a product in different months of a particular year are given below: **[2014]**

September	October	November	December	January	February
180	280	250	190	240	?

The forecast of sales, using the 4-months moving average method, for the month of February is _____

12. For a canteen, the actual demand for disposable cups was 500 units in January and 600 units in February. The forecast for the month of January was 400 units. The forecast for the month of March considering smoothing coefficient as 0.75 is _____. **[2015]**

13. During the development of a product, an entirely new process plan is made based on design logic, examination of geometry and tolerance information. This type of process planning is known as: **[2015]**
(A) Retrieval (B) Generative
(C) Variant (D) Group technology based

14. Sales data of a product is given in the following table:

Month	January	February	March	April	May
Number of units sold	10	11	16	19	25

Regarding forecast for the month of June, which one of the following statements is TRUE? **[2015]**
(A) Moving average will forecast a higher value compared to regression.
(B) Higher the value of order N, the greater will be the forecast value by moving average.
(C) Exponential smoothing will forecast a higher value compared to regression.
(D) Regression will forecast a higher value compared to moving average.

15. A manufacturer has the following data regarding a product. **[2015]**
Fixed cost per month = ₹50,000
Variable cost per unit = ₹200
Selling price per unit = ₹300
Production capacity = 1500 units per month
If the production is carried out at 80% of the rated capacity, then the monthly profit (in ₹) is _____.

16. The demand for a two-wheeler was 900 units and 1030 units in April 2015 and May 2015, respectively. The forecast for the month of April 2015 was 850 units. Considering a smoothing constant of 0.6, the forecast for the month of June 2015 is: **[2016]**
(A) 850 units
(B) 927 units
(C) 965 units
(D) 970 units

Answer Keys

Exercises

Practice Problems 1

1. C	**2.** B	**3.** A	**4.** B	**5.** A	**6.** B	**7.** C	**8.** B	**9.** B	**10.** D
11. A	**12.** C	**13.** A	**14.** C	**15.** D	**16.** C	**17.** D	**18.** A	**19.** B	**20.** C

Practice Problems 2

1. A	**2.** C	**3.** B	**4.** B	**5.** D	**6.** C	**7.** A	**8.** B	**9.** C	**10.** D
11. A	**12.** C	**13.** B	**14.** A	**15.** B	**16.** D	**17.** B	**18.** B	**19.** A	**20.** C
21. B	**22.** B	**23.** B	**24.** D	**25.** B	**26.** C	**27.** D	**28.** A	**29.** C	**30.** B

Previous Years' Questions

1. C	**2.** D	**3.** C	**4.** B	**5.** D	**6.** D	**7.** C	**8.** A	**9.** D	**10.** B

11. 239 to 241 **12.** 568 to 570 **13.** B **14.** D **15.** 68,000 to 72,000 **16.** D