Inventory Management

Unit - III

Inventory is a stock of Item kept by an organization to meet internal or external customer demand. Virtually every type of organization maintains some form of inventory. Department stores carry inventories of all the retail items they sell; a nursery has inventories of different plants, trees & flowers; a rental car agency has inventories of cars.

Types of Inventories

1. Raw Material
2. Purchased parts & supplies
3. Labor
4. In-Process (partially completed) products
5. component parts
6. Working capital
7. Tools, machinery & equipment
8. finished goods.

The purpose of Inventory Management is to determine the amount of inventory to keep in stock - i.e

✓ How much to order

✓ When to order.

so that the sum of all the inventory cost (carrying + ordering + shortage) be minimiz[ed]

Objectives / Advantages of Inventory control

i) It ensures adequate supply of materials, stores, stocks etc. There is no shortage of any item at any stage of production.

ii) It reduces investment in inventories, inventory costs & losses due to obsolescence.

iii) Materials are made available at the most economical rates.

iv) delays & interruptions in production due to non-availability of materials do not occour

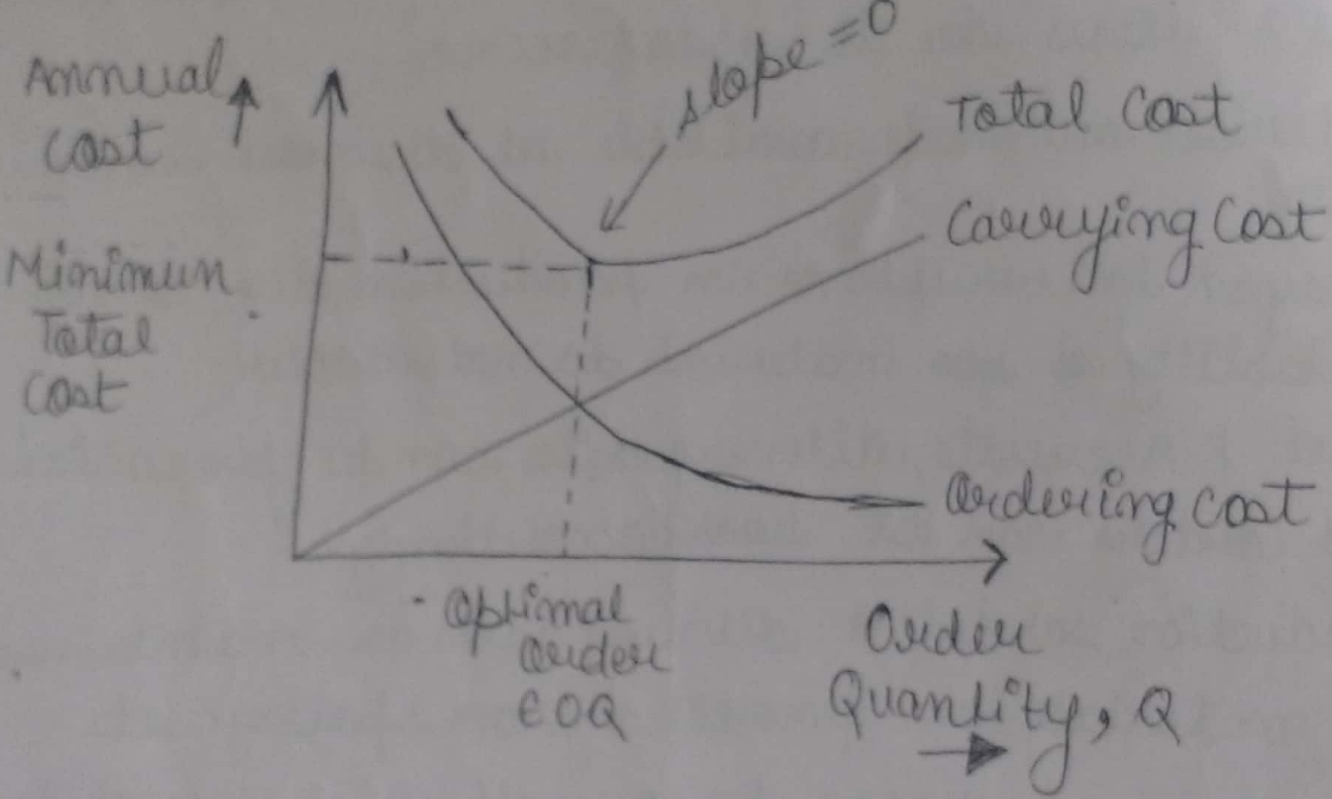
v) Exact & Accurate delivery dates can be forecasted and orders can be booked accordingly.

vi) Production schedule & delivery dates are maintained.

vii) The materials are protected from spoilage etc.

viii) There is an increase in overall efficiency of the orgn.

Inventory Costs



Inventory Costs

re are 3 basic Costs associated with inventory; arrying / holding cost ; ordering costs and shortage cost.

<u>Carrying Costs</u> are these costs of holding the inventory. These costs vary with the level of inventory and occasionally with the length of time an item is held; that is, the greater the level of inventory over a period of time, the higher the carrying costs. Carrying costs can include the cost of losing the use of funds tied up in inventory; direct storage costs such as rents, heating, cooling, lighting, security, refrigeration, record keeping and transportation; interest on loans used to purchase inventory; dpreical; obsolescence as markets for products in inventory diminishes; product deterioration and spoilage; breakage; taxes & pilferage.

Carrying costs are normally specified in two ways. The usual way is to calculate total carrying costs by summing-up all individual costs mentioned above on per unit and per time basis. eg Rs 10/unit/year. The other way is to express as a percentage of the value of an item or as a percentage of average inventory value. eg. 10% of the value.

<u>Ordering Costs</u> are associated with replenishing the stock of inventory being held. These are normally expressed as a dollar amount per order and are independent of the order size. Ordering costs vary with the number of orders made - as the no. of order increases, the orderi costs increases. Costs incurred each time an order is made can include requisition & purchase orders,

transportation and shipping, receiving, inspection, handling can storage and accounting & auditing of

Ordering costs generally react inversely to carrying costs. As the size of orders increases, fewer orders are required, reducing ordering costs. However, ordering larger amounts results in higher inventory levels and higher carrying costs. In general, as the order size increases, ordering costs decreases & carrying costs increases.

Shortage Costs / Stockout Costs: occours when customer demand cannot be met because of insufficient inventory. If these shortages result in a permanent loss of sales, shortage costs include the lost of profits. Shortages can also cause customer dissatisfaction and a loss of goodwill that can result in permanent loss of customer and future sales. In some instances, the inability to meet customer demand or lateness in meeting demand results in penalities in the form of price discounts or rebates. When demand is internal, a shortage can cause work stoppages in the prodn process & create delays, resulting in downtime costs and the costs of lost production (including indirect and direct production costs).

Costs resulting from lost sales because demand cannot be met are more difficult to determine than carrying or ordering costs. Therefore, shortage costs are frequently subjective estimates & sometimes are educated guess.

Shortages occour because of carrying inventory is costly. As a result, shortage costs have an inverse relationship to carrying costs – as the amount of inventory on hand increases, the carrying costs increase where as shortage cost decreases.

Inventory Control Systems

An Inventory control system controls the level of inventory by determining how much to order (the level of replenishment) & when to order. There are two basic types of inventory systems:-

A continious (or fixed-order-quantity) system (Q)

A Periodic (or fixed-time-period) system. (P)

In a continious system, an order is placed for the same constant amount whenever the inventory on hand decreases to a certain level, whereas in a periodic system an order is placed for a variable amount after specific regular intervals.

I) Continious Inventory Systems

In a continious inventory system (also reffered to as a perpetual system and a fixed-order-quantity) a continual record of the inventory level is maintained whenever the inventory on hand decreases to a predetermined level, reffered to as Reorder point, a new order is placed to replenish the stock of inventory. The order that is placed is for a fixed amount that minimizes the total inventory costs. This amount is called the Economic Order Quantity.

A positive feature of a continious system is that the inventory level is continiously monitored, so management always knows the inventory level/status. This is advantageous for critical items such as replacement parts or raw materials & supplies. However, maintaining a continiual record of the amount of inventory on hand can also be costly.

Example of continious Inventory system is the computerized checkout system with a laser sc used by many supermarkets and retail stores. The laser scanner reads the bar code from the produ packet; the transaction is instantly recorded, & the inventory level updated. Such a system is not only quick & accurate it also provides management with continiously updated information on the status of inventory levels.

II) Periodic Inventory Systems:

In a periodic inventory system (also reffered to as a fixed-time period system or a periodic review system) the inventory on hand is counted at specific time intervals; for example, ~~an order is placed~~ every week or at the end of each month. After the inventory in stock is determined, an order is placed for an amount that will bring inventory back up to a desired level. In this system the inventory level is not ~~monit~~ monitored at all during the time interval between orders, so it has the advantage of little or no required record keeping. The disadvantage is less direct control. This typically results in larger inventory levels for a ~~specific~~ periodic inventory system than in a continious system to guard against unexpected stockouts early in the fixed period. Such a system also requires that a new order quantity be determined each time a periodic order is made.

An example of a periodic inventory system is a college or university bookstore. Textbooks are normally ordered according to a periodic system, wherein a count of textbooks in stock is made after sessions ends. An order for new textbooks for the next session is then made according to course enrollments for the next term (demand) & the amount remaining in stock.

From the table, the minimum total cost is when three extra reservations are taken. This approach using discrete probability is useful when valid historic data are available. ●

Single-period inventory models are useful for a wide variety of service and manufacturing applications. Consider the following:

1. **Overbooking of airline flights.** It is common for customers to cancel flight reservations for a variety of reasons. Here the cost of underestimating the number of cancellations is the revenue lost due to an empty seat on a flight. The cost of overestimating cancellations is the awards, such as free flights or cash payments, that are given to customers unable to board the flight.
2. **Ordering of fashion items.** A problem for a retailer selling fashion items is that often only a single order can be placed for the entire season. This is often caused by long lead times and limited life of the merchandise. The cost of underestimating demand is the lost profit due to sales not made. The cost of overestimating demand is the cost that results when it is discounted.
3. **Any type of one-time order.** For example, ordering T-shirts for a sporting event or printing maps that become obsolete after a certain period of time.

Multiperiod Inventory Systems

Fixed–order quantity models (Q-models)

Fixed–time period models (P-models)

There are two general types of multiperiod inventory systems: **fixed–order quantity models** (also called the *economic order quantity*, EOQ, and **Q-model**) and **fixed–time period models** (also referred to variously as the *periodic* system, *periodic review* system, *fixed-order interval* system, and **P-model**). Multiperiod inventory systems are designed to ensure that an item will be available on an ongoing basis throughout the year. Usually the item will be ordered multiple times throughout the year where the logic in the system dictates the actual quantity ordered and the timing of the order.

The basic distinction is that fixed–order quantity models are "event triggered" and fixed–time period models are "time triggered." That is, a fixed–order quantity model initiates an order when the event of reaching a specified reorder level occurs. This event may take place at any time, depending on the demand for the items considered. In contrast, the fixed–time period model is limited to placing orders at the end of a predetermined time period; only the passage of time triggers the model.

To use the fixed–order quantity model (which places an order when the remaining inventory drops to a predetermined order point, R), the inventory remaining must be continually monitored. Thus, the fixed–order quantity model is a *perpetual* system, which requires that every time a withdrawal from inventory or an addition to inventory is made, records must be updated to reflect whether the reorder point has been reached. In a fixed–time period model, counting takes place only at the review period. (We will discuss some variations of systems that combine features of both.)

Some additional differences tend to influence the choice of systems (also see Exhibit 14.1):

- The fixed–time period model has a larger average inventory because it must also protect against stockout during the review period, T; the fixed–order quantity model has no review period.
- The fixed–order quantity model favors more expensive items because average inventory is lower.
- The fixed–order quantity model is more appropriate for important items such as critical repair parts because there is closer monitoring and therefore quicker response to potential stockout.
- The fixed–order quantity model requires more time to maintain because every addition or withdrawal is logged.

Exhibit 14.2 shows what occurs when each of the two models is put into use and becomes an operating system. As we can see, the fixed–order quantity system focuses on order

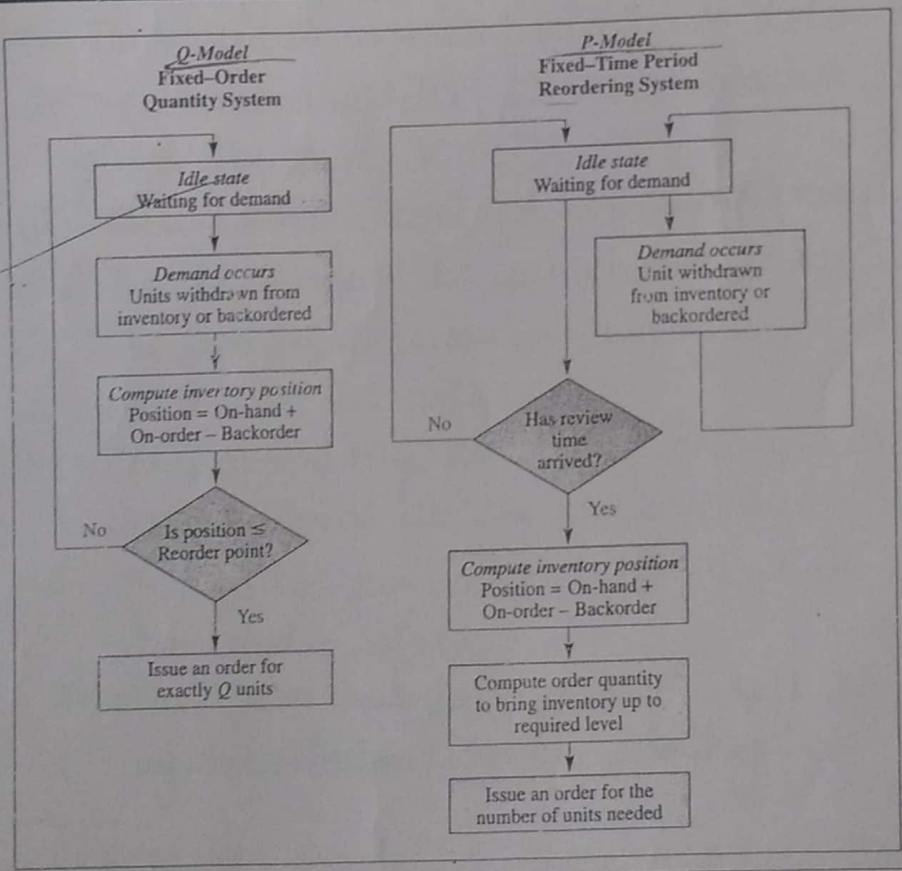
EXHIBIT 14.1

Fixed–Order Quantity and Fixed–Time Period Differences

FEATURE	Q-MODEL FIXED–ORDER QUANTITY MODEL	P-MODEL FIXED–TIME PERIOD MODEL
Order quantity	Q—constant (the same amount ordered each time)	q—variable (varies each time order is placed)
When to place order	R—when inventory position drops to the reorder level	T—when the review period arrives
Recordkeeping	Each time a withdrawal or addition is made	Counted only at review period
Size of inventory	Less than fixed–time period model	Larger than fixed–order quantity model
Time to maintain	Higher due to perpetual recordkeeping	
Type of items	Higher-priced, critical, or important items	

EXHIBIT 14.2

Comparison of Fixed–Order Quantity and Fixed–Time Period Reordering Inventory Systems



quantities and reorder points. Procedurally, each time a unit is taken out of stock, the withdrawal is logged and the amount remaining in inventory is immediately compared to the reorder point. If it has dropped to this point, an order for Q items is placed. If it has not, the system remains in an idle state until the next withdrawal.

In the fixed–time period system, a decision to place an order is made after the stock has been counted or reviewed. Whether an order is actually placed depends on the inventory position at that time.

Inventory Control Models

Deterministic Models

These items are based on the assumption that the demand as well as the lead-time of an item are known with certainity (i.e. deterministic) can be determined. In these models, the stock is replenished as soon as the stock reaches the point of exhaustion because of the assumptions underlying them. Under such idealistic situations there is no need to maintain any extra stock because the supplies are assumed to arrive the moment the stock level reduces to zero. Hence, there are no stock-outs.

The various assumptions in deterministic models are

i) The demand of the item is known exactly for a given period of time.

ii) Orders are received instantaneously.

iii) The items can be purchased freely i.e w/o restrictions

iv) The cost of placing an order is fixed. It does not vary with the lot size.

v) The inventory carrying charges are directly proportional to the order quantity.

vi) The price per unit is fixed & is independent of the order size.

vii) The item has fairly long shelf life. There is no fear of deterioration or spoilage.

Probabilistic Model :- These models take into account the variations in demand & lead time of an item.

Economic Order Quantity (EOQ) :

In a continious, or fixed order quantity, system when inventory reaches a specific level, reffered to as the reorder point, a fixed amount is ordered. The most widely used and traditional means for determining how much to order in a continious system is the EOQ i.e Economic Quantity order model.

The function of EOQ model is to determine the optimal order size that minimizes total inventory costs.

The Basic EOQ Model

The basic model is a formula for determining the optimal order size that minimizes the sum of carrying costs and ordering costs. The model formula is derived under a set of simplifying and restrictive assumptions, as follows,

i) Demand is known with certainty & is constant over time.
ii) No shortages are allowed.
iii) Lead time for the receipt of order is constant
iv) The order quantity is received all at once.

The basic model describes the continious inventory order cycle system inherent in the EOQ model.

FIXED-ORDER QUANTITY MODELS

Fixed-order quantity models attempt to determine the specific point, R, at which an order will be placed and the size of that order, Q. The order point, R, is always a specified number of units. An order of size Q is placed when the inventory available (currently in stock and on order) reaches the point R. **Inventory position** is defined as the on-hand plus on-order minus backordered quantities. The solution to a fixed-order quantity model may stipulate something like this: When the inventory position drops to 36, place an order for 57 more units.

inventory position

The simplest models in this category occur when all aspects of the situation are known with certainty. If the annual demand for a product is 1,000 units, it is precisely 1,000—not 1,000 plus or minus 10 percent. The same is true for setup costs and holding costs. Although the assumption of complete certainty is rarely valid, it provides a good basis for our coverage of inventory models.

Exhibit 14.3 and the discussion about deriving the optimal order quantity are based on the following characteristics of the model. These assumptions are unrealistic, but they represent a starting point and allow us to use a simple example.

- Demand for the product is constant and uniform throughout the period.
- Lead time (time from ordering to receipt) is constant.
- Price per unit of product is constant.
- Inventory holding cost is based on average inventory.
- Ordering or setup costs are constant.
- All demands for the product will be satisfied. (No backorders are allowed.)

Tutorial: EOQ

The "sawtooth effect" relating Q and R in Exhibit 14.3 shows that when the inventory position drops to point R, a reorder is placed. This order is received at the end of time period L, which does not vary in this model.

In constructing any inventory model, the first step is to develop a functional relationship between the variables of interest and the measure of effectiveness. In this case, because we are concerned with cost, the following equation pertains:

$$\text{Total annual cost} = \text{Annual purchase cost} + \text{Annual ordering cost} + \text{Annual holding cost}$$

or

$$TC = DC + \frac{D}{Q}S + \frac{Q}{2}H \qquad [14.2]$$

where

TC = Total annual cost
D = Demand (annual)
C = Cost per unit
Q = Quantity to be ordered (the optimal amount is termed the *economic order quantity*—EOQ—or Q_{opt})
S = Setup cost or cost of placing an order
R = Reorder point
L = Lead time
H = Annual holding and storage cost per unit of average inventory (often holding cost is taken as a percentage of the cost of the item, such as $H = iC$, where i is the percent carrying cost)

On the right side of the equation, DC is the annual purchase cost for the units, $(D/Q)S$ is the annual ordering cost (the actual number of orders placed, D/Q, times the cost of each order, S), and $(Q/2)H$ is the annual holding cost (the average inventory, $Q/2$, times the cost per unit for holding and storage, H). These cost relationships are graphed in Exhibit 14.4.

FIXED-ORDER QUANTITY MODELS

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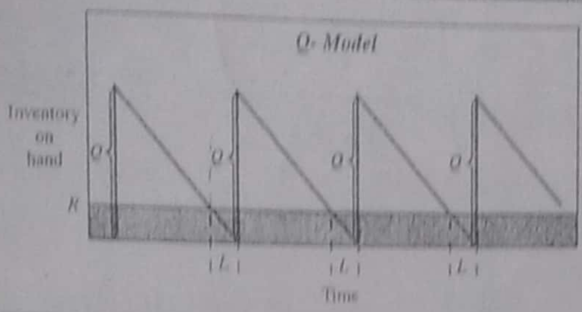
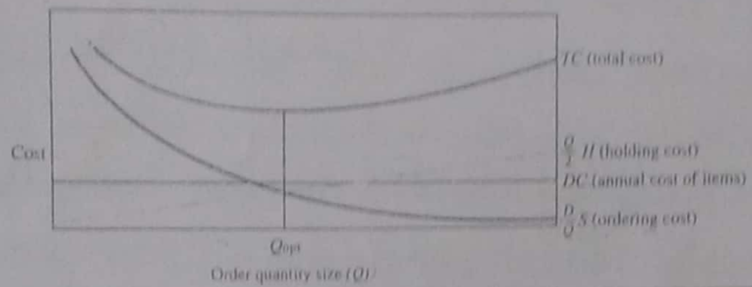
Exhibit 14.3



Basic Fixed–Order Quantity Model

Exhibit 14.4



Annual Product Costs, Based on Size of the Order

The second step in model development is to find that order quantity Q_{opt} at which total cost is a minimum. In Exhibit 14.4, the total cost is minimal at the point where the slope of the curve is zero. Using calculus, we take the derivative of total cost with respect to Q and set this equal to zero. For the basic model considered here, the calculations are

$$TC = DC + \frac{D}{Q}S + \frac{Q}{2}H$$

$$\frac{dTC}{dQ} = 0 + \left(\frac{-DS}{Q^2}\right) + \frac{H}{2} = 0$$

(14.3) EOQ

$$\boxed{Q_{opt} = \sqrt{\frac{2DS}{H}}}$$

Because this simple model assumes constant demand and lead time, no safety stock is necessary, and the reorder point, R, is simply

(14.4)

$$\boxed{R = \bar{d}L}$$

Reorder point = avg daily

where

$\bar{d}$ = Average daily demand (constant)
L = Lead time in days (constant)

EXAMPLE 14.2: Economic Order Quantity and Reorder Point

Find the economic order quantity and the reorder point, given

Annual demand (D) = 1,000 units
Average daily demand $(\bar{d})$ = 1,000/365
Ordering cost (S) = \$5 per order
Holding cost (H) = \$1.25 per unit per year
Lead time (L) = 5 days
Cost per unit (C) = \$12.50

What quantity should be ordered?

Solution

$$EOQ = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(1000)5}{1.25}} = \sqrt{8000} = \boxed{89.4 \text{ units}}$$

Reorder Point $= \bar{d}L$ = avg daily demand × Lead time

$$= \frac{1000}{365} \times 5 = 13.7 \text{ units}$$

Total Cost

$$= DC + \frac{D}{Q}S + \frac{Q}{2}H$$

$$= 1000(12.50) + \frac{1000}{89} \times 5 + \frac{89}{2}(1.25)$$

$$= \$\,12{,}611.81$$

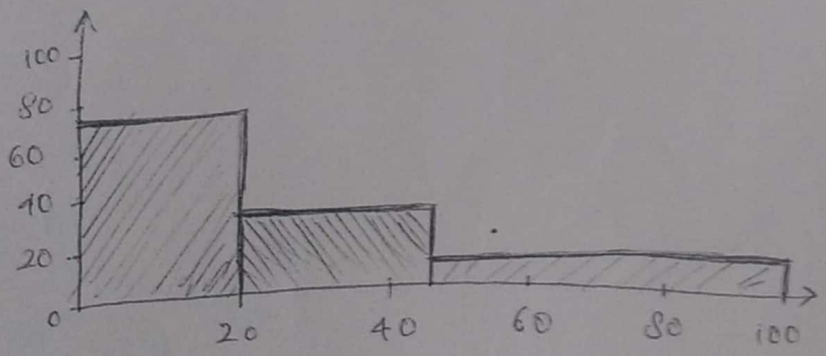
It means, when the inventory position drops to 14, place an order for 89 units.

ABC Inventory Model

In the nineteenth century Vilfreda Pareta, in a study of the distribution of wealth in Milan, found that the 20 percent of the people controlled 80 percent of the wealth. This logic of the few having the greatest importance and the many having little importance has been broadend to include many situations and is termed the "Pareto Principle".

Any inventory system must specify when an order is to be placed for an item and how many units to order. Most inventory control situations involve so many items that it is not practical model and give through treatment to each item. To get around this problem, the ABC classification scheme divide inventory into 3 groups: high dollar value (A)
moderate dollar Value (B)
low dollar Value (C).

Dollar Val Volume is a measure of importance; an item low in cost but high dollar volume can be more important than a high cost item with low dollar volume.



Percentage of total Inventory Value

Percentage of total list of different stock items

The purpose of classifying items into groups is to establish the appropriate degree of control over each item. For eg. on periodic basis class(A) items may be more clearly controlled with weekly ordering, (B) items may be ordered bi-weekly and C items may be ordered monthly or bimonthly.