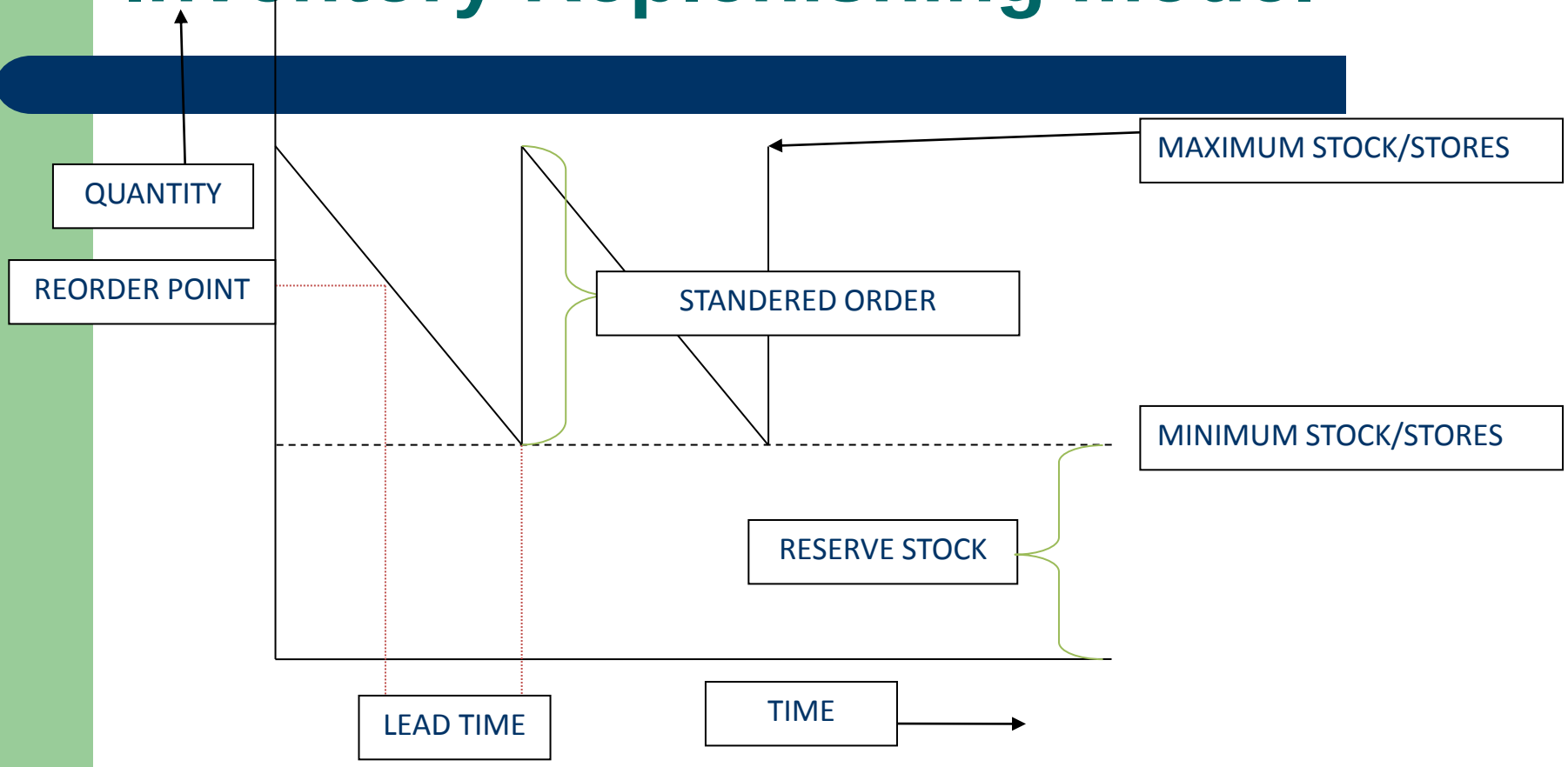
MATERIALS MANAGEMENT

INVENTORY

What Is Inventory?

- Stock of items kept to meet future demand
- **Inventory-**A physical resource that a firm holds in stock with the intent of selling it or transforming it into a more valuable state.
- **Inventory System**- A set of policies and controls that monitors levels of inventory and determines what levels should be maintained, when stock should be replenished, and how large orders should be

Inventory Replenishing model



Classification of inventories according to the function they perform

- **Anticipation Inventory**
  - created ahead of a peak selling season, a promotion program, vacation shutdown, or possibly the threat of a strike.
  - They are built up to help level production and to reduce the costs of changing production rates.

- **Fluctuation Inventory (Safety Stock/buffer stock/reserve stock)**
  - Is held to cover random unpredictable fluctuations in supply and demand or lead time.
  - Safety stock is carried to protect against this possibility.
  - Its purpose is to prevent disruptions in manufacturing or deliveries to customers.

- **Lot-Size Inventory**
  - Items purchased or manufactured in quantities greater than needed immediately create lot-size inventories.
  - This is to take advantage of quantity discounts; to reduce shipping, clerical, and setup costs; and in cases where it is impossible to make or purchase items at the same rate that they will be used or sold.
- **Transportation Inventory (**pipeline or movement inventories)
  - exist because of the time needed to move goods from one location to another such as from a plant to a distribution center or a customer.
  - The average amount of inventory in transit is:

$$I = \frac{tA}{365}$$

    - where I is the average annual inventory in transit, t is transit time in days, and A is annual demand.
  - Notice that the transit inventory does not depend upon the shipment size but on the transit time and the annual demand.
  - The only way to reduce the inventory in transit, and its cost, is to reduce the transit time.

- **Hedge Inventory**
  - Some products such as minerals and commodities—for example, grains or animal products—are traded on a worldwide market.
  - The price for these products fluctuates according to world supply and demand.
  - If buyers expect prices to rise, they can purchase **hedge inventory** when prices are low.

- **Maintenance, Repair, and Operating Supplies (MROs)**
  - support general operations and maintenance but that do not become directly part of a product.
  - include maintenance supplies, spare parts,and consumables such as cleaning compounds, lubricants, pencils, and erasers.

Two Forms of Demand

- Dependent
  - Demand for items used to produce final products
  - Tires stored at a Goodyear plant are an example of a dependent demand item
- Independent
  - Demand for items used by external customers
  - Cars, appliances, computers, and houses are examples of independent demand inventory

NEED

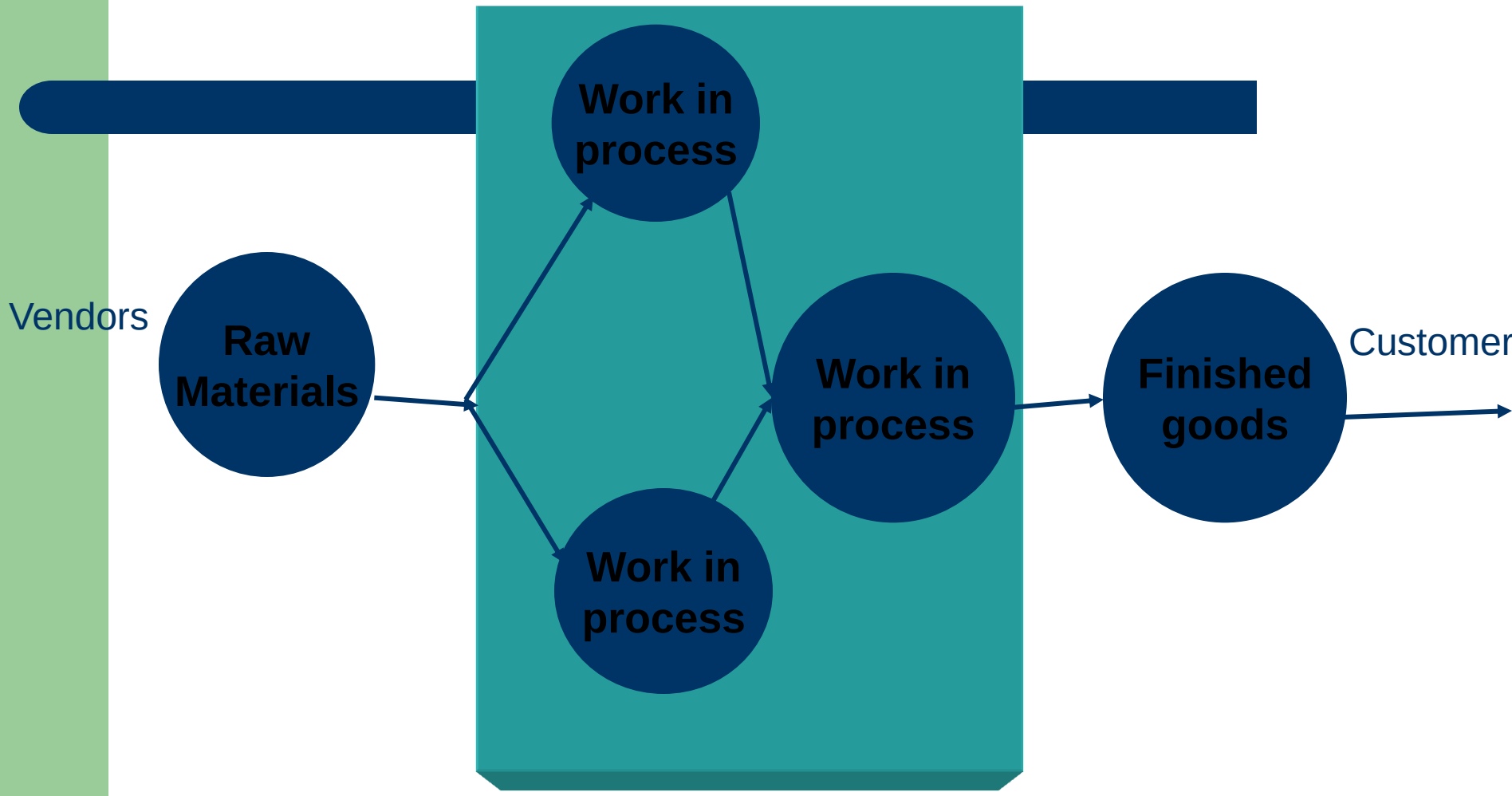
- Inventory enables a constant rate of production for the firm, even if
  - Source of supply are not too reliable,
  - Due to power shortage,
  - Transport or labour problems.

Types of Inventory

- Raw materials
- Purchased parts and supplies
- Work-in-process (partially completed) products (WIP)
- Items being transported
- Tools and equipment

Common Construction Materials

Types of Inventory



- **SYMTOMES OF POOR INVENTORY MANAGEMENT**

  - Excessive material down time due to material shortage,
  - Periodic lack of adequate storage space,
  - Widely varying costs of inventory losses,
  - Continuous growing inventory quantities,
  - Inability to meet delivery schedule, and
  - Uneven production.

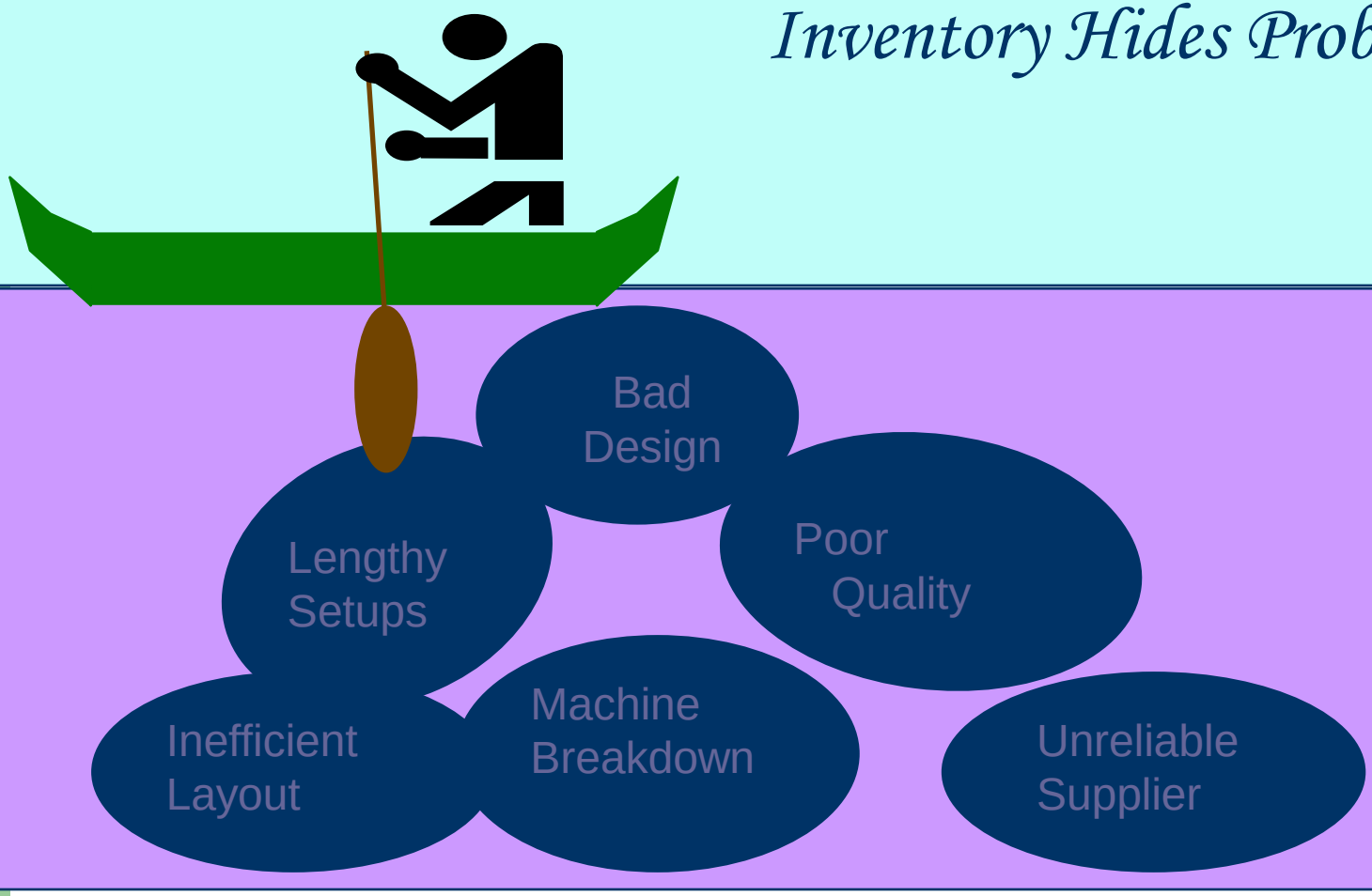
Reasons To Hold Inventory

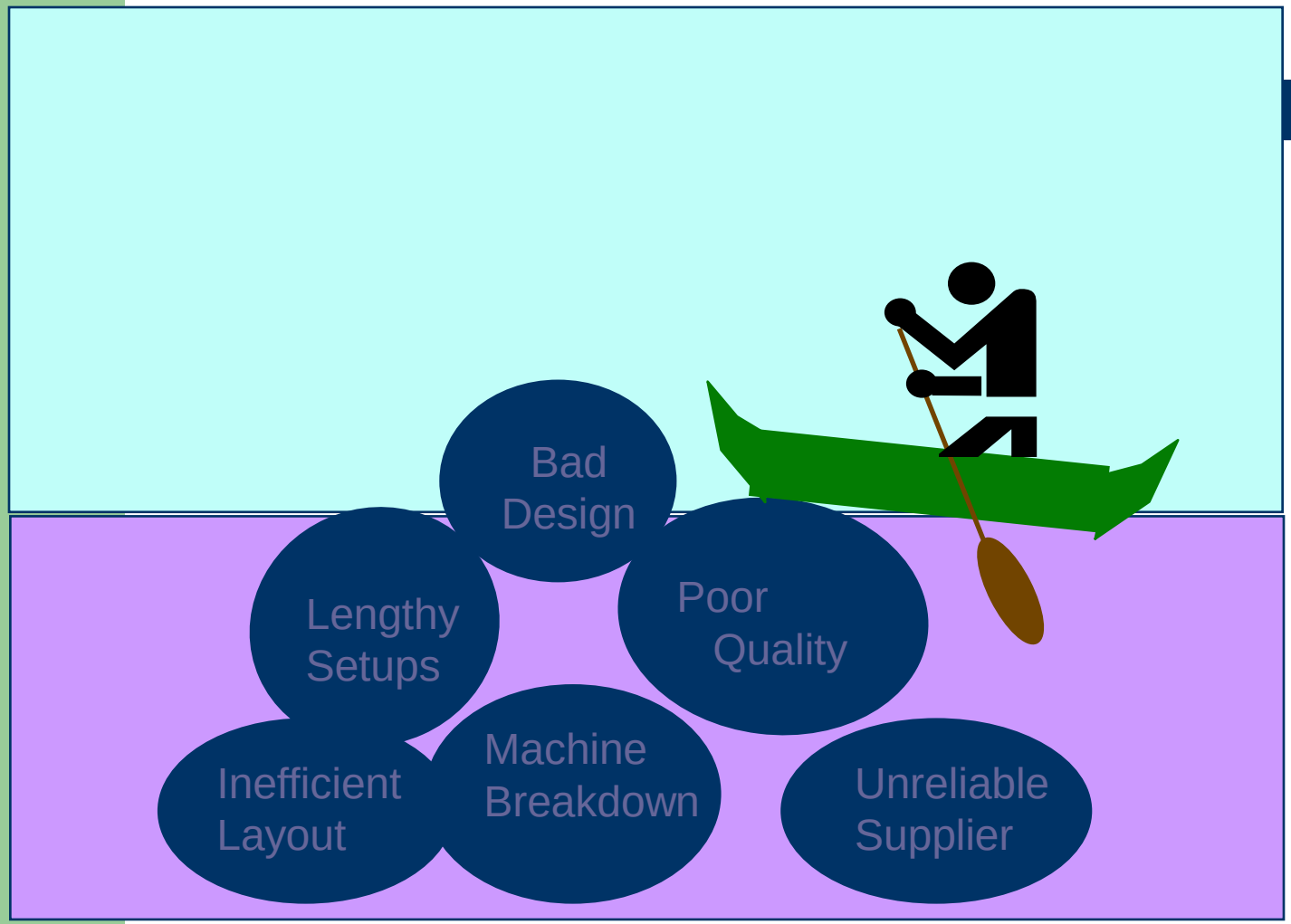
- Meet variations in customer demand:
  - Meet unexpected demand
  - Smooth seasonal or cyclical demand
- Pricing related:
  - Temporary price discounts
  - Hedge against price increases
  - Take advantage of quantity discounts
- Process & supply surprises
  - Internal – upsets in parts of or our own processes
  - External – delays in incoming goods
- Transit

Reasons To NOT Hold Inventory

- Carrying cost
  - Financially calculable
- Takes up valuable factory space
  - Especially for in-process inventory
- Inventory covers up “problems” …
  - That are best exposed and solved

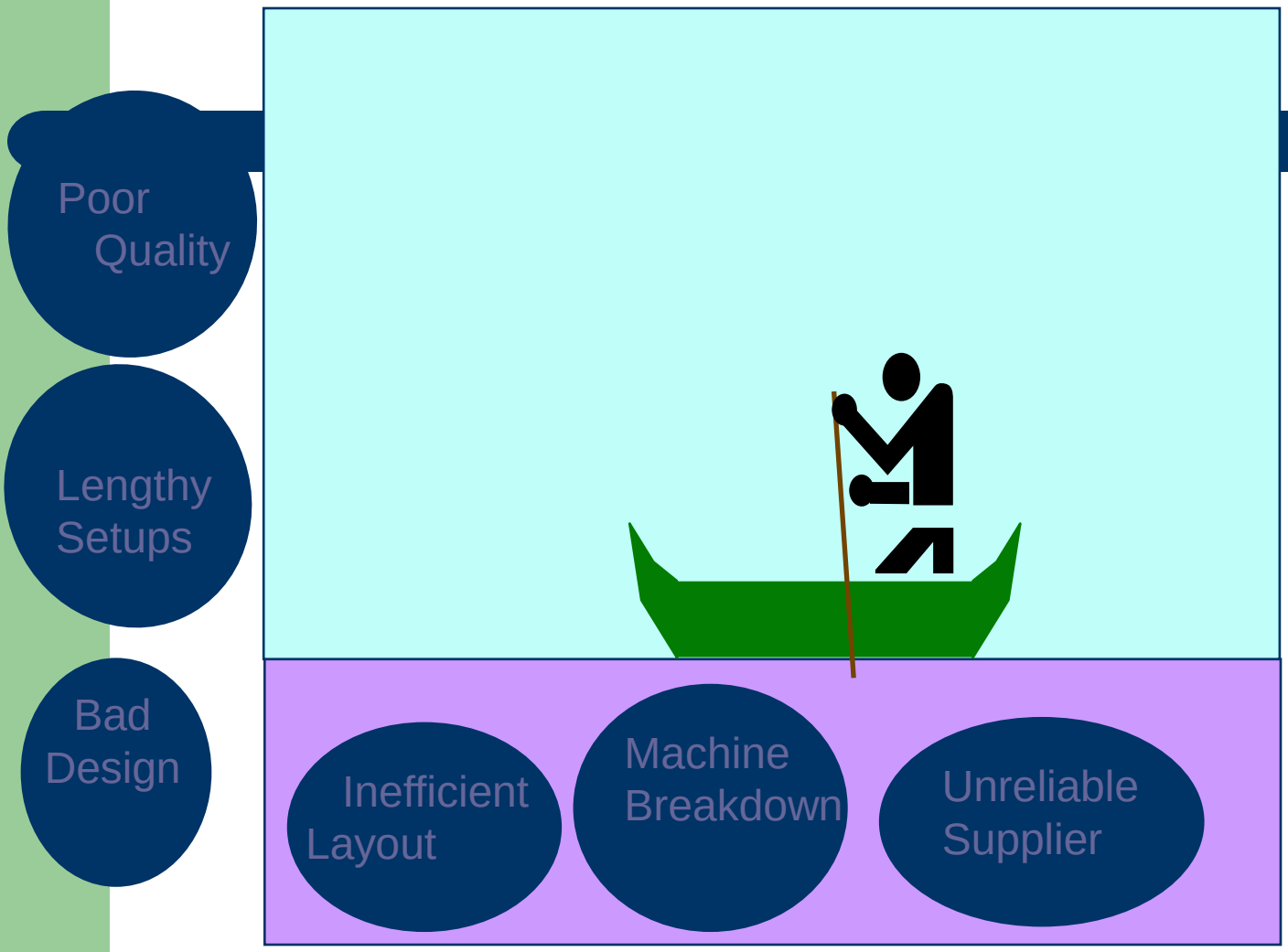
Inventory Hides Problems





To Expose Problems:

Reduce Inventory Levels



Remove Sources of Problems and Repeat the Process

- **Systems Approach**:

  - This approach states that inventory should be managed by developing and then following proper systems.

Aim of systems approach is to reduce the size of inventories without destroying their effectiveness.

Steps to be taken:

- Better fore-casting,
- Fewer variety,
- Centralized inventories,
- Finding reliable sources of suppliers, who will supply items of right quality in right place, in right time with right cost,
- Effective follow up,
- Control through reporting system at regular frequency,
- Effective budgetary control.

Value through Inventory

- **Quality** - inventory can be a “buffer” against poor quality; conversely, low inventory levels may force high quality
- **Speed** - *location* of inventory has gigantic effect on speed
- **Flexibility** - location, level of anticipatory inventory both have effects
- **Cost** - direct: purchasing, delivery, manufacturing

  indirect: holding, stock out.

INVENTORY CONTROL

- It can be defined as

  "Systematic location, storage and recording of goods/materials in such a way that desired degree of services can be made to operations department at minimum ultimate cost"

- Inventory control is the means by which materials of the correct quality and quantity is made available as and when required with due regards to economy in storage, ordering cost and working capital.

NEED

- Inventory control is necessary to maintain reserve stock of goods that will ensure manufacturing according to production plans at lowest possible cost.

- Also to avoid losses such as:

  - Excess Purchase,
  - Lack of material for production,
  - Loss of sales due unavailability of finished goods.

OBJECTIVES

- The fundamental objective of a good inventory control system is to be able to determine what to order, when to order, how much to order, and how much to carry in stock so as to gain economy in purchasing, storing, manufacturing and selling.

Amplified objectives

- Continuity of productive operations :
  - Every attempt should be made to ensure continuity of productive operations through an uniform flow of materials and eliminate the possibility of stock-outs.
- 2. Effective use of capital
  - The system should enable the management to make an effective use of its capital. The investment in inventories should be kept at minimum consistent with the operating sales and financial requirements of the firm.
- 3. Reduction of administrative workload :
  - The administrative workload on the purchasing, receiving, inspection, stores, accounts and other related departments should be bearest minimum.

FUNCTIONS

- To run the stores effectively,
  - This includes – Layout, storing, utilization of storage space and receiving and issuing procedures.
- To ensure timely availability of materials and avoid building up of stock levels,
- Technical responsibility for the state of materials,
  - This includes- methods of storing, maintenance, deterioration and absolance.
- Stock control systems,
  - This includes- physical stock verification, recording and ordering policies and purchase procedures.

- Maintenance of specified raw materials,
  - Sufficient stock of inventory should be maintained to full fill the demand.
- Protecting inventory from losses due to improper handling, storing and theft of goods,
- Pricing all materials supplied to the shop as to estimate materials cost.

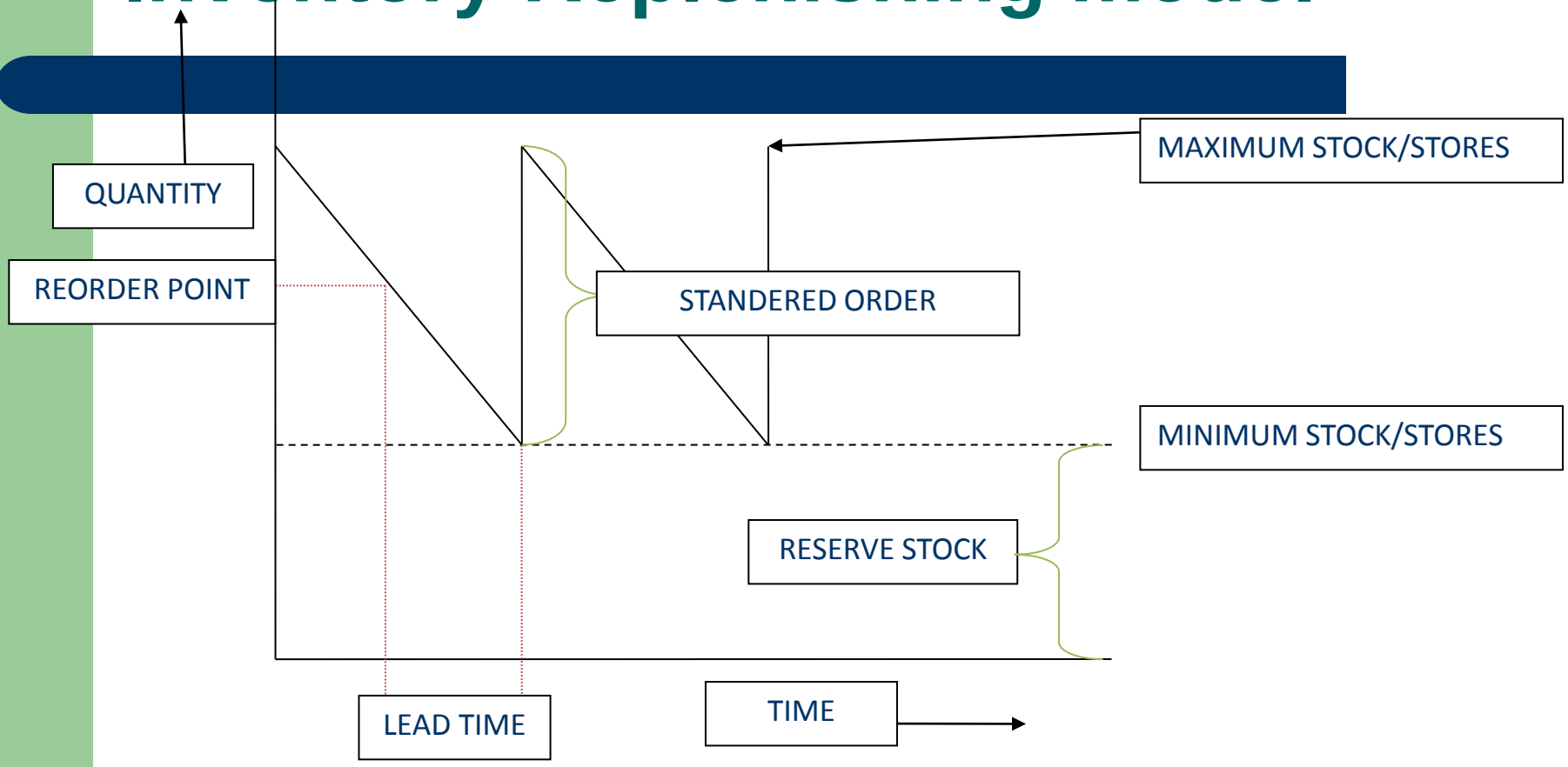
ADVANTAGES

- It creates buffer between input and out put,
- It ensures against delay in delivery,
- It allows for possible increase in out put,
- It allows advantage of quantity discounts,
- It ensures against scarcity of material in the market,
- It utilizes the benefit of price fluctuations,
- It avoids inventory build-up.

Purpose

- How many units to order
- When to order

Inventory Replenishing model



Inventory Costs

- Carrying cost
  - cost of holding an item in inventory
- Ordering cost
  - cost of replenishing inventory
- Shortage cost
  - temporary or permanent loss of sales when demand cannot be met

INVENTORY CONTROL SYSTEMS

SOME COMMONLY ADOPTED INVENTORY POLICIES

Name of the policy	Expansion	Basis of classification	Remarks
VED	Vital, essential and desirable	It is based on the criticality of the item, which are classified in three categories.	Classification depends on the consequences of material stock-out when demanded.
FSN	Fast, slow and normal	It is based on consumption rate of the inventory.	It is helpful in controlling obsolescence.
HML	High, medium and low	It is based on unit price of material.	It is mainly used to control the inventory of purchased material.
XYZ	Value of balance stocks very high	It is used for classifying materials in storage.	Its main use is in review of inventory.
SDE	Scarce, difficult and easy to obtain	It is based on the level of difficulty in the procurement of inventory.	It is useful in lead-time analysis and decision related to the procurement of purchasing strategies.
GOLF	Government, ordinary, local and foreign	It is based on the inventory.	It is useful for decision related to the procurement strategy.
HML	High, medium and low price	It is based on the prices of materials.	It is useful for delegating the purchasing responsibilities.

ABC Analysis is basic analytical management tool which enables top management to concentrate their efforts where the result will be greater

Always Better Control

ABC Prioritization

- Based on “Pareto” concept (80/20 rule) and total usage in dollars (Money) of each item.
- Classification of items as A, B, or C often based on $ (Cost) volume.
- Purpose: set priorities for management attention.

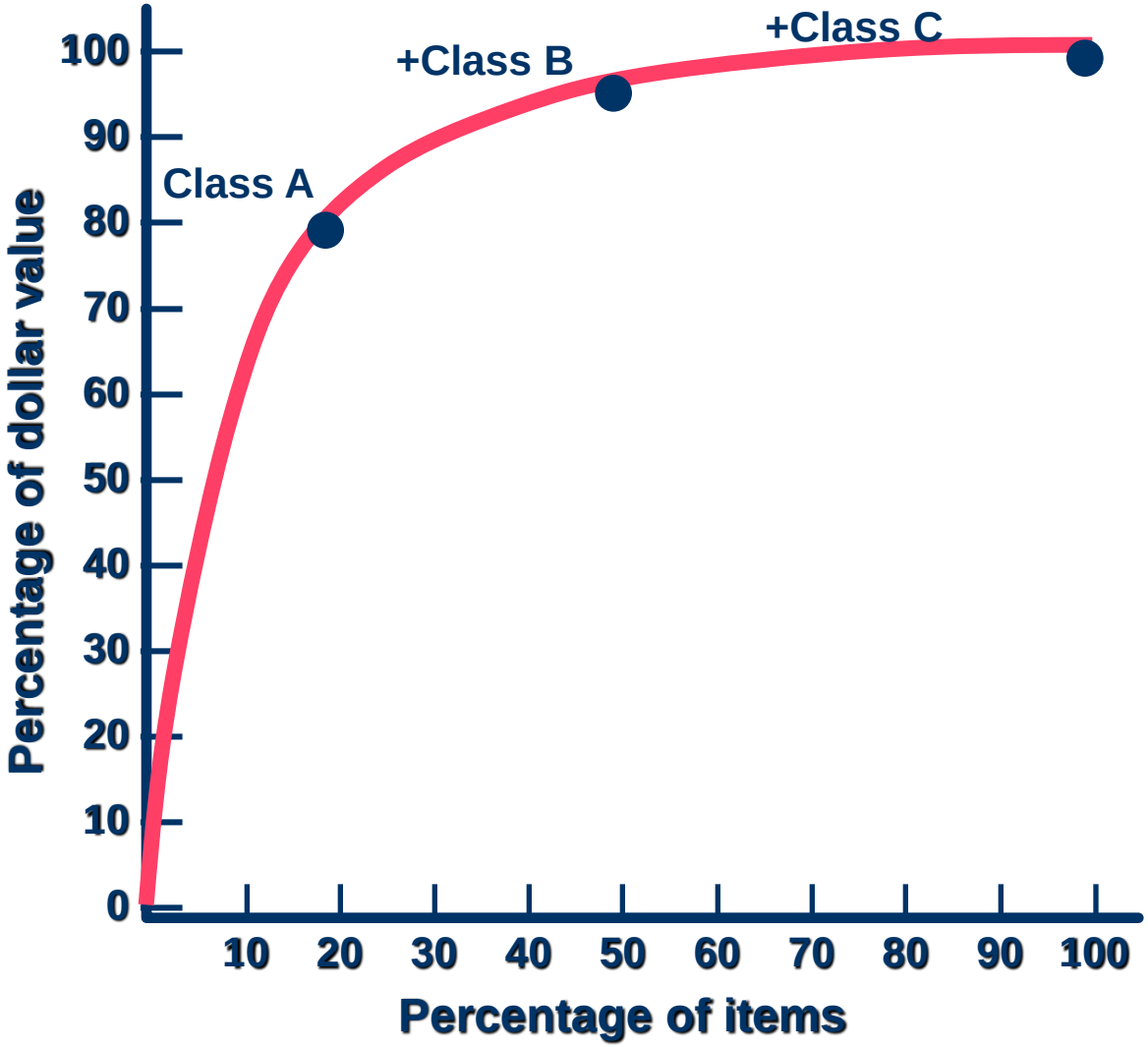
Application Areas

- In materials management, this technique has been applied in areas needing selective control, such as
  - inventory,
  - criticality of items,
  - obsolete stocks,
  - purchasing orders,
  - receipt of materials,
  - inspection,
  - store-keeping, and
  - verification of bills.

Vital Few, Trivial Many

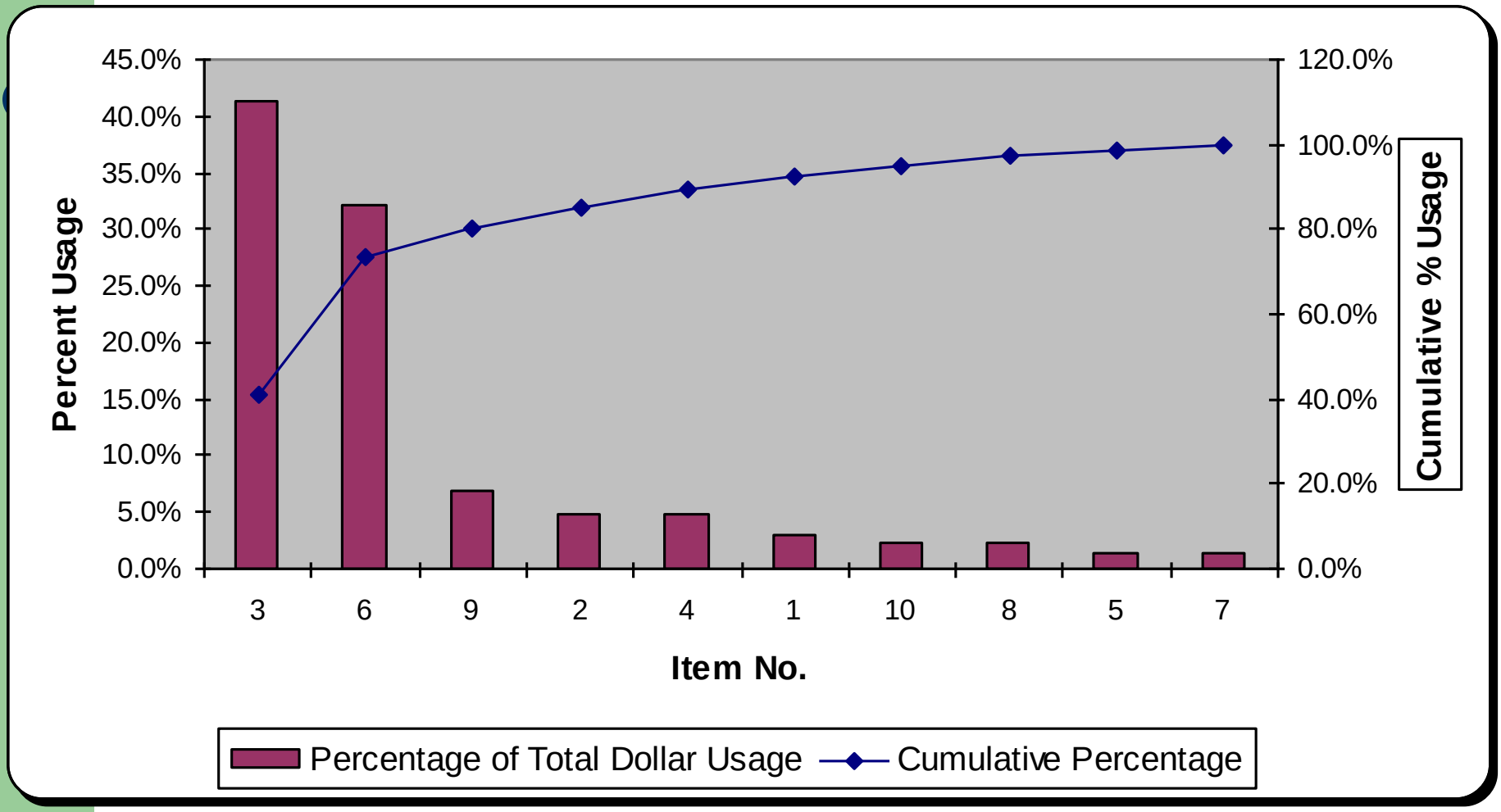
- The annual consumption analysis indicates:
  - less than 10 per cent of the total number of items - will account for a substantial portion of about 75 per cent of the total consumption value, and these few vital items are called A' items which need careful attention of the materials manager.
  - Similarly, a large number of 'bottom' items-over 70 per cent of the total number called the trivial many-account only for about 10 per cent of the consumption value, and are known as the 'C' class.
  - The items that lie between the top and bottom are called the 'B' category items.

ABC Analysis Example



Item	Annual Usage in Units	Unit Cost	Dollar Usage	Percentage of Total Dollar Usage	Item rearranged	% of dollar usage	Cumulative %	Classification	Annual Usage in Units	Cumulative usage
			$							
1	5,000	1.50	7,500	2.9%	3	41.2%	41.2%	A		
3	10,000	10.50	105,000	41.2%	9	6.9%	80.1%			
4	6,000	2.00	12,000	4.7%	2	4.7%	84.8%			
5	7,500	0.50	3,750	1.5%	4	4.7%	89.5%			
6	6,000	13.60	81,600	32.0%	1	2.9%	92.4%	B		
7	5,000	0.75	3,750	1.5%	10	2.4%	94.8%			
8	4,500	1.25	5,625	2.2%	8	2.2%	97%			
9	7,000	2.50	17,500	6.9%	5	1.5%	98.5%			
10	3,000	2.00	6,000	2.4%	7	1.5%	100%	C		
Total			$ 254,725	100.0%						

ABC Chart


45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Percent Usage
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Cumulative % Usage
3
6
9
2
4
1
10
8
5
7
Item No.
Percentage of Total Dollar Usage
Cumulative Percentage

ADVANTAGES

- This approach helps the materials manager to exercise selective control and focus his attention only on a few items when he is confronted with lakhs of stores items.
- By concentrating on 'A' class items, the materials manager is able to control inventories and show 'visible' results in a short span of time.
- By controlling the 'A' items, and doing a proper inventory analysis, obsolete stocks are automatically pinpointed.

- Many organisations have claimed that ABC analysis has helped in reducing the clerical costs and resulted in better planning and improved inventory turnover.
- ABC analysis has to be resorted to because equal attention to 'A', 'B' and 'C' items will not be worthwhile and would be very expensive.
- Concentrating on all the items is likely to have a diffused effect on all the items, irrespective of the priorities.

Salient Features:

Item type ‘A’

- accurate forecast of quantities needed
- involvement of senior level for purchasing
- ordering is on requirement basis
- enquiries for procurement need to be sent to a large number of suppliers
- strict degree of control is required, preferably monitoring on a weekly basis
- low safely stock is needed

Item type ‘B’

- approximate forecast of quantities needed
- requires involvement of middle level for purchasing
- ordering is on EOQ basis
- enquiries for procurement need to be sent to three to five reliable suppliers
- moderate degree of control required, preferably monitoring on a monthly basis
- moderate safety stock needed

Item type ‘C’

- no need of forecasting; even rough quantity estimate is sufficient
- junior-level staff is authorized to order purchase
- bulk ordering is preferred
- quotations from even two to three reliable suppliers are sufficient
- relatively relaxed degree of control is sufficient, and monitoring can be done on a quarterly basis
- adequate safety stock can be maintained

Mechanics of ABC- Analysis

- Calculate rupee annual issues for each item in inventory by multiplying the unit cost by the number of units issued in a year.
  - It is assumed that the issues and consumption are the same.
- Sort all items by rupee annual issues *in descending sequence.*
- Prepare a list from these ranked items showing item no., unit cost, annual units issued and annual rupee value of units issued.

- Starting at the top of the list, compute a running total, item-by-item issue -value and the rupee consumption value.
- Compute and print for each items the cumulative percentages for the item count and cumulative annual issue value.
- Plot a graph on cumulative value against cumulative per cent of items

Pattern… many organisation show

- 5 per cent to 10 per cent of the top number of items account for about 70 per cent of the total consumption value. These items are called 'A' items.

- 15 per cent to 20 per cent of the number of items account for 20 per cent of the total consumption value. These items are called 'B' items.

- The remaining number of items account for the balance 10 per cent of the total issue value. These items are called 'C' items .

The Basic Principle

- The analysis does not depend upon the unit cost of the items but only on its annual consumption value;
- It does not depend on the importance of the item; and
- The limits for ABC categorization are not uniform but will depend upon the size of the undertaking, its inventory as well as the number of items controlled.

Limitations

- ABC analysis, in order to be fully effective, should be carried out with standardization and codification.
- ABC analysis is based on grading the items according to the importance of performance of an item, that is by V.E.D.- vital, essential and desirable-analysis.
- Some items, though negligible in monetary value, may be vital for running the plant, and constant attention is needed.

- The results of ABC analysis have to be reviewed periodically and updated.
- It is a common experience that a 'C' item, like diesel oil in a firm, will become the most high value item during power crisis.
- However, ABC analysis is a powerful approach in the direction of cost reduction as it helps to control items with a selective approach.

Concluding remarks

Since inventory is “MONEY”, and makes a heavy demand on working capital, special attention is given to inventories.

ECONOMIC ORDER QUANTITY

Inventory Costs

1. Item cost.
2. Carrying costs.
3. Ordering costs.
4. Stock out costs.
5. Capacity-associated costs.

1. Item Cost

- “price paid for a purchased item”
- consists of the cost of the item and any other direct costs associated in getting the item into the plant. (transportation, custom duties, and insurance)

2. Holding costs- (INVENTORY CARRYING COST)

1. **Storage cost** **:** rent, depreciation, insurance, tax, security, personnel, etc;

2. **Capital cost** **:** loss of interest, opportunity cost interest paid;

3. **Risk costs.** The risks in carrying inventory are:
   a. Obsolescence; loss of product value resulting from a model or style change or technological development.
   b. Damage; inventory damaged while being held or moved.
   c. Pilferage; goods lost, strayed, or stolen
   d. Deterioration; inventory that rots or dissipates in storage or whose shelf life is limited.

What does it cost to carry inventory?

- Actual figures vary from industry to industry and company to company.
- Capital costs may vary depending upon interest rates, the credit rating of the firm, and the opportunities the firm may have for investment.
- Storage costs vary with location and type of storage needed.
- Risk costs can be very low or can be close to 100% of the value of the item for perishable goods.
- the possibility of obsolescence with fad or fashion items is high, and the cost of carrying such items is greater.

3. Setup or Ordering costs – (Procurement Cost)

- ***fixed costs associated with the production of a lot internally and placing an order externally with a vendor.***

  - **These are independent of the no. of units ordered.**
  - **Setup costs includes time for setup of jigs/fixture etc.**
  - **Ordering cost includes telephone charges, delivery fee, time required for purchase order, expediting cost.**

- One of the major decision to be taken
  - Involves:

    Investment in the inventory

- Large orders – reduce administrative costs but – increase investment in stock

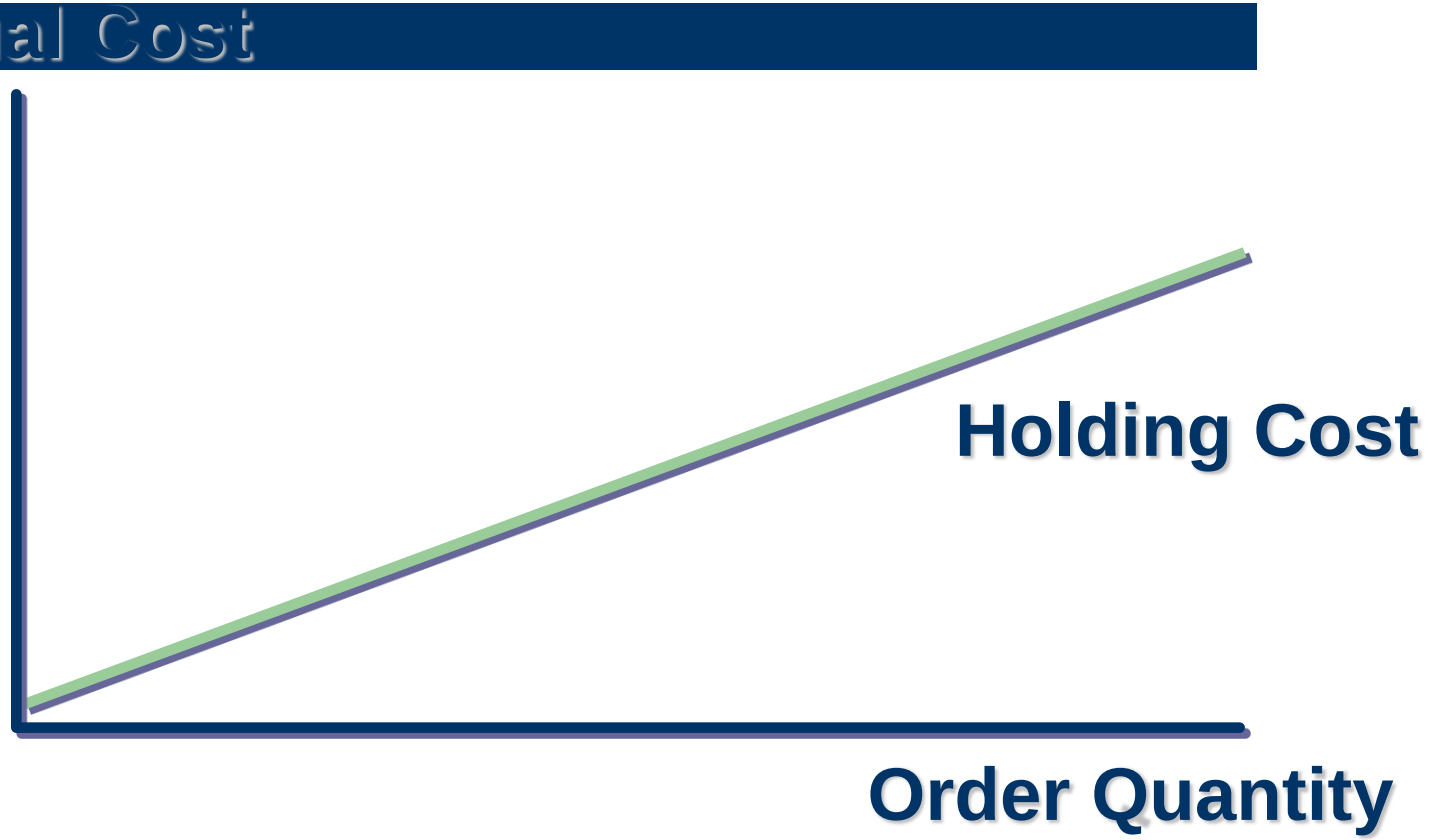
- Small frequent orders – reduce investment but – increases administrative costs

EOQ Assumptions

- Known & constant demand
- Known & constant lead time
- Instantaneous receipt of material
- No quantity discounts
- Only order (setup) cost & holding cost
- No stockouts

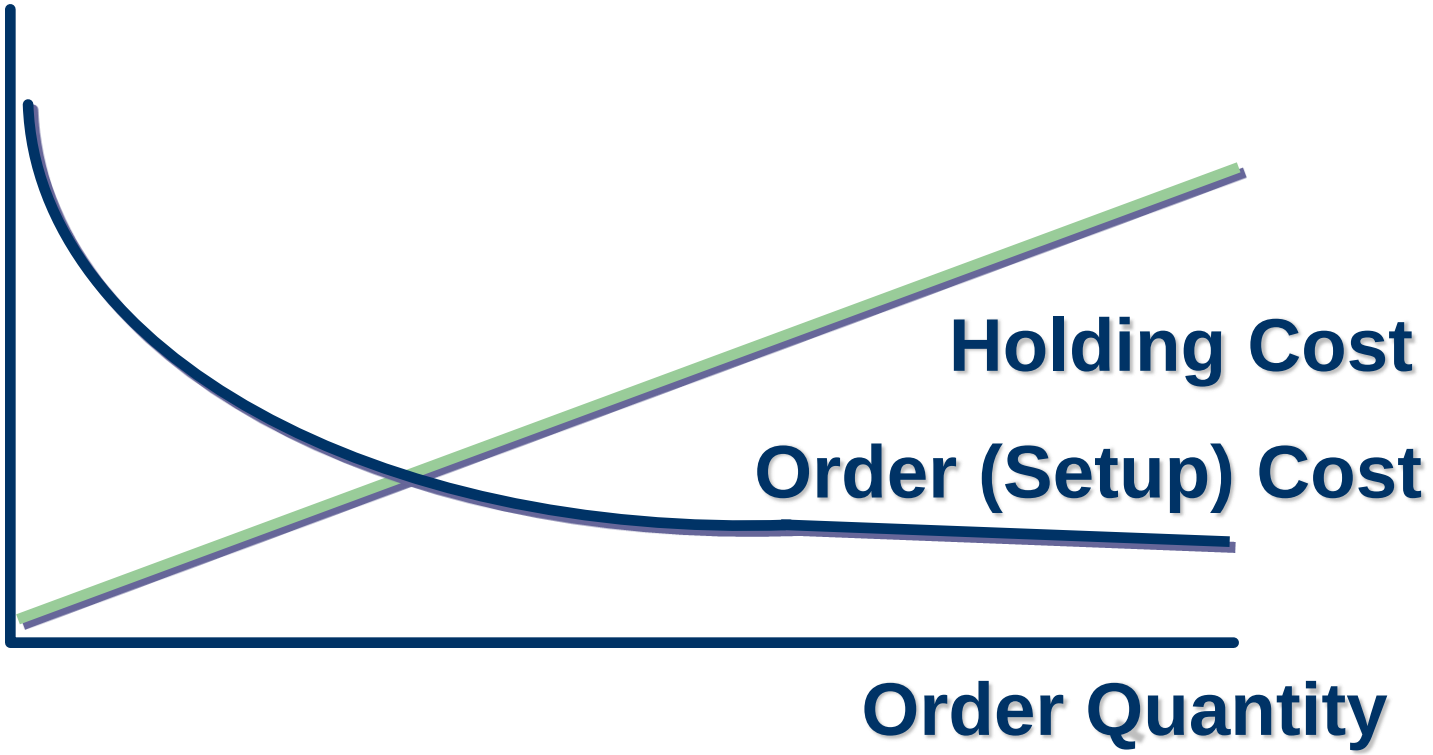
EOQ Model Graphical

EOQ Model

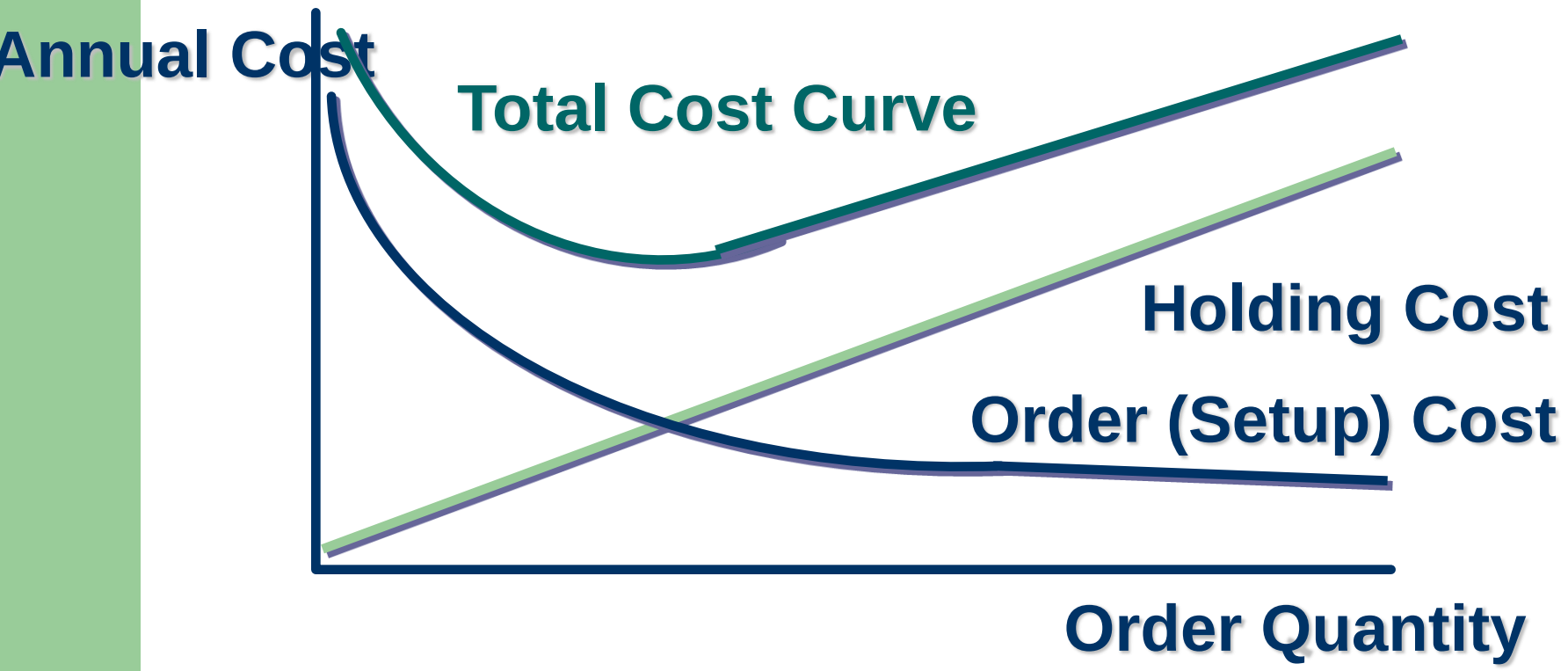


EOQ Model

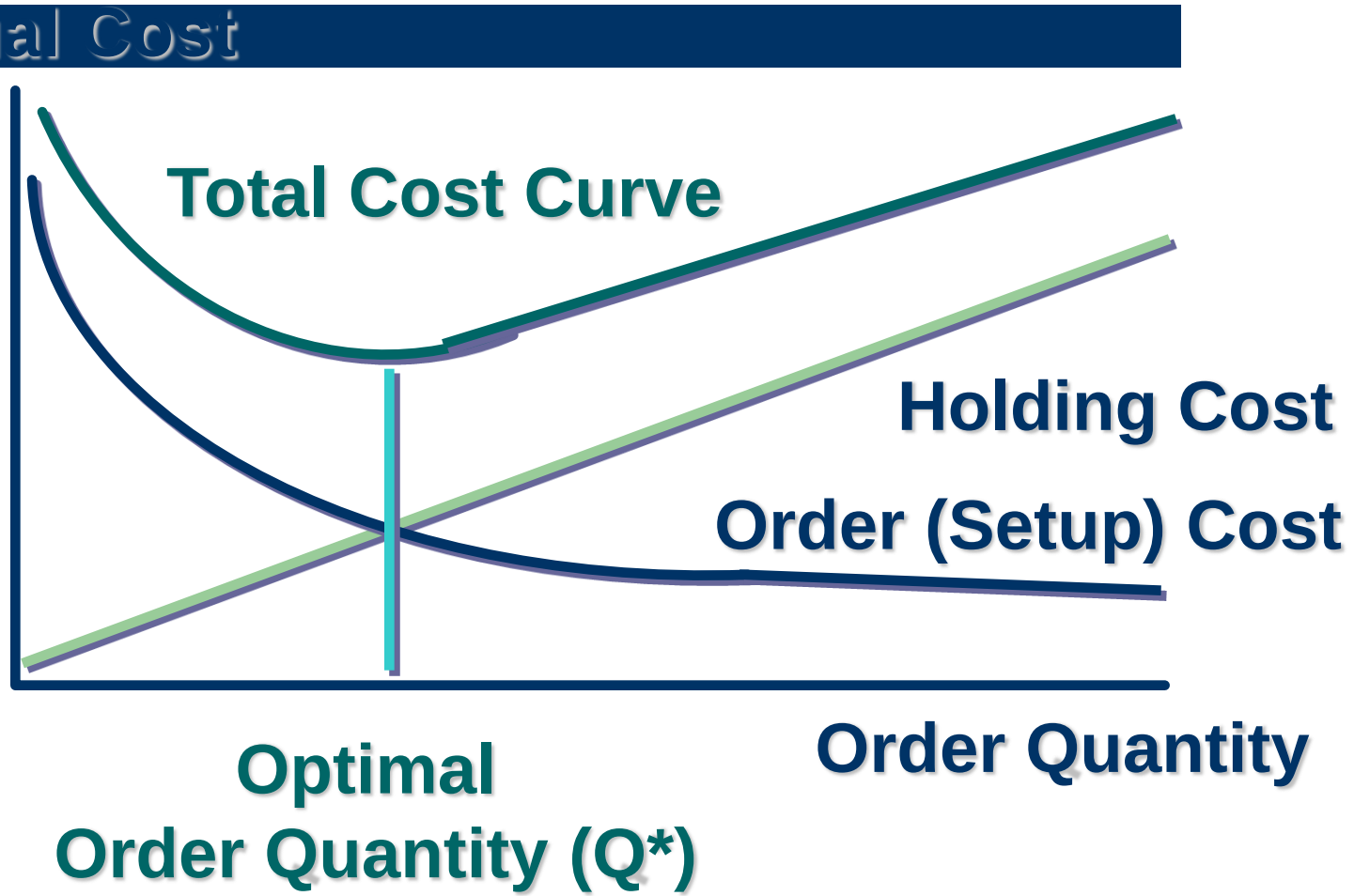
Annual Cost



EOQ Model


Annual Cost
Total Cost Curve
Holding Cost
Order (Setup) Cost
Order Quantity

EOQ Model


Annual Cost
Total Cost Curve
Holding Cost
Order (Setup) Cost
Order Quantity
Optimal
Order Quantity (Q*)

Symbols

- Annual Consumption of the item = S
- Price per unit = C_u
- Procurement cost / order = C_p / C_0
- Inventory carrying cost as % of average inventory investment = i
- Order quantity = q
- Economic Order Quantity = q^0

- Annual procurement cost :
  - No. of orders x procurement cost per order

$$\frac{Annual\ Cunsumption}{order\ Quantity}$$ X procurement cost/per order

$$\frac{s}{q} * c_p$$

Optimising Costs

- Annual Inventory carrying cost:
  - Average inventory investment X inventory carrying cost

$\left[\frac{1}{2}\right] order\ Quantity \times prise\ /unit$ X Inventory carrying cost

$1/2\ [(order\ quantity * price\ /unit)\ ] * inventory\ carrying\ cost]$

$$\frac{q}{2} * c_u * i$$

- TOTAL ANNUAL COST =

$$\frac{s}{q} * c_p + \frac{q}{2} * c_u * i$$

- For the cost to be minimum –

$$\frac{d\,TAc}{dq} = 0$$

$$\frac{-s * c_p}{q^2} + \frac{c_u * i}{2} = 0$$

$$\frac{c_p * s}{q^2} = \frac{c_u * i}{2}$$

$$q = \sqrt{\frac{2c_p * s}{c_u * i}}$$

$$Q = C_u * q = \sqrt{\frac{2s * c_u * c_p}{i}}$$

Q = Cost of EOQ

Optimisation of the model

$$EOQ = \sqrt{\frac{2 * (\text{Annual Consumption \{units\}}) * (\text{procurement cost/order})}{\text{Price / unit} * \text{inventory carrying cost}}}$$

- Let
  - A = Total items consumed per year
  - P = procurement cost per year
  - C= annual inventory carrying cost
  - Q= Economic order quantity

- Then
  - P = Number of orders * cost per order
  - = AP/Q

AN ALTERNATIVE FORMULA

- Inventory carrying cost
  - = Average value of inventory in a year
    - inventory carrying cost /year

= ½ QC

Total cost = AP/Q + QC/2

$$Q2 = 2AP/C$$

$$Q = EOQ = \sqrt{2AP/C}$$

Practical Considerations When Using the EOQ

- **Lumpy demand.**
  - The EOQ assumes that demand is uniform and replenishment occurs all at once.
  - When this is not true, the EOQ will not produce the best results. It is better to use the period-order quantity.
- **Anticipation inventory.**
  - Demand is not uniform, and stock must be built ahead. It is better to plan a buildup of inventory based on capacity and future demand.
- **Minimum order.**
  - Some suppliers require a minimum order. This minimum may be based on the total order rather than on individual items. Often these are C items where the rule is to order plenty, not an EOQ.

- **Transportation inventory.**
  - carriers give rates based on the amount shipped. A full load costs less per ton to ship than a part load.
  - This is similar to the price break given by suppliers for large quantities.
- **Multiples.**
  - Sometimes, order size is constrained by package size. For example, a supplier may ship only in skid-load lots. In these cases, the unit used should be the minimum package size.
- **Order quantities and just-in-time.**
  - The replenishment quantity of an item is adjusted to match the demand of the next operation in the supply chain. This adjustment leads to smaller lot sizes and is often determined by the frequency of shipments to a customer or the size of an easily moved container rather than by calculation.

- Example(ABC Analysis)

  A construction company stores various items in the central stores. The average annual
  consumption and cost per unit of items stored arc given. Classify the items using AŠC analysis.

Name of the item	Average annual consumption (No.)	Average cost per unit (Rs.)
a	5,000	45.00
b	1,000	90.00
c	2,000	225.00
d	4,000	11.25
e	50	300.00
f	6,000	62.50
g	2,000	67.50
h	4,000	18.75
i	50	375.00
j	250	105.00
k	200	187.50
l	50	150.00

Name of the item	Average annual consumption (No.)	Average cost per unit (Rs.)	Average annual cost of consumption (Rs.)	Ranking
a	5,000	45.00	225,000	3
b	1,000	90.00	90,000	5
c	2,000	225.00	450,000	1
d	4,000	11.25	45,000	7
e	50	300.00	15,000	11
f	6,000	62.50	375,000	2
g	2,000	67.50	135,000	4
h	4,000	18.75	75,000	6
i	50	375.00	22,500	10
j	250	105.00	22,500	9
k	200	187.50	37,500	8
l	50	150.00	7,500	12

Rank in descending order of cost	Name of the item	Average annual cost (Rs.)	Annual cost (percentage)	Cumulative cost (%)	Category
1	c	450,000	30	30	A
2	f	375,000	25	55	A
3	a	225,000	15	70	A
4	g	135,000	9	79	B
5	b	90,000	6	85	B
6	h	75,000	5	90	B
7	d	45,000	3	93	C
8	k	37,500	2.5	95.5	C
9	j	26,250	1.75	97.25	C
10	i	18,750	1.25	98.5	C
11	e	15,000	1	99.5	C
12	l	7,500	0.5	100	C

Example 11.1

A shop dealing in construction goods has seven different items in its inventory. The average number of units of each of these items held in the store along with their unit costs is given in Table Q11.1.1. The shopkeeper has decided to employ ABC inventory system. Classify the items in A, B and C categories.

Table Q11.1.1 Data for Example 11.1

Item	Average number of units	Average cost per unit in inventory (in Rs.)
1	10,000	121.50
2	10,000	100.00
3	24,000	14.50
4	16,000	19.75
5	60,000	3.10
6	50,000	2.45
7	30,000	0.50

Types of Inventers Control systems

(1) Two-bin system
(2) Maximum-minimum system
(3) Economic order quantity (EOQ) system
(4) Fixed order quantity and variable cycle or Q system
(5) Fixed cycle and variable quantity or P system
(6) Replenishment system or S,s policy
(7) Ordering with quantity discounts

(1) *Two-bin System*

- The order is placed when first bin is empty.
- The order will arrive at the time just before the second bin is empty.
- It is a deterministic system where rate of consumption is known and the time of ordering is also known.

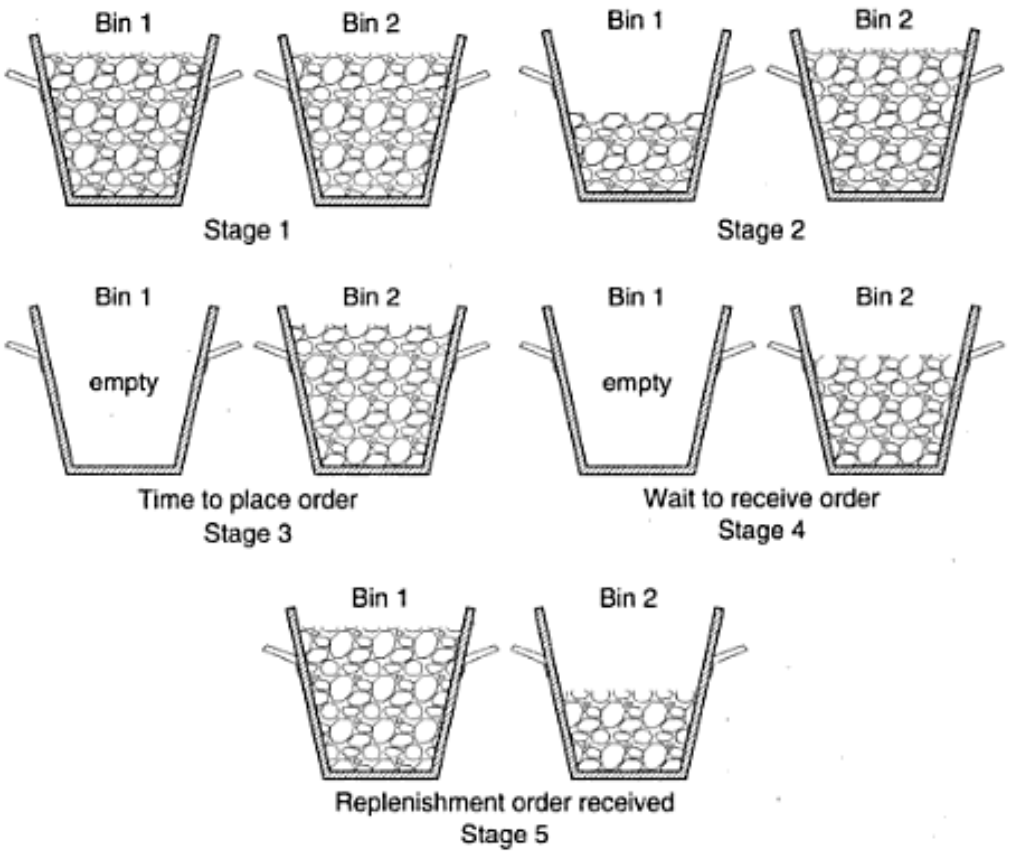


Figure 11.5 Schematic representation of different stages in Two bin system

(2) *Maximum-Minimum System*

- In this system-maximum and minimum level of inventory stored are fixed.
- The order is placed when the inventory level touches a particular quantity.
- Re-ordering is done after a period of review.
- If maximum amount in the store is 500 units and 50 units is safety stock. The order is placed when inventory level reaches 50 units.
- The disadvantages of the system are
  - (*i*) If the stock consumption fluctuates rapidly, the change in the maximum and minimum level is difficult.
  - (*ii*) If periodic review can not be done, the shortages or overstock may be there.
  - (*iii*) The control is necessary to keep records of inventories and maximum and minimum levels which can be altered based on demand changes and rate of consumption.

(3) *Economic Order Quantity (EOQ) System*

- This system is used to economize the cost of inventory control.
- In this system, inventory is zero when order is received.
- Order is placed such that all the materials ordered as EOQ is consumed.
- This method of inventory control is normally used to store valuable and essential items in the store.

(4) *Fixed Order Quantity and Variable Cycle System (Q System)*

- quantity ordered every time is fixed and the number of cycle for which orders are placed and cycle time may vary.
- It is also called *reorder point* or *Q system*.
- The items are purchased as per need and consumption rate.
- When the demand changes, rapidly the reorder point reduces or cycle time isreduced and number of orders placed are increased as the order quantity Q is fixed.

(5) *Fixed Cycle and Variable Quantity (P) System*

- This is also called Periodic Review System.
- period of review is fixed as three, six or twelve months.
- Quantity ordered change as per demand or rate of consumption.

(6) *Replenishment System or S,s policy*

- This is a major system of inventory control,
- When the supplier puts the restriction on minimum order quantity, the variable order quantity is decided based on S,s policy i.e., maximum level of inventory is S and minimum safety stock is s.
- The replenishment level is in between S and s values.
- Order quantity is decided as.

  = Q1 – I, where Q1 is replenishment level and I is inventory on hand.
- accurate information of inventory levels and rate of consumption must be available before the orders are placed.

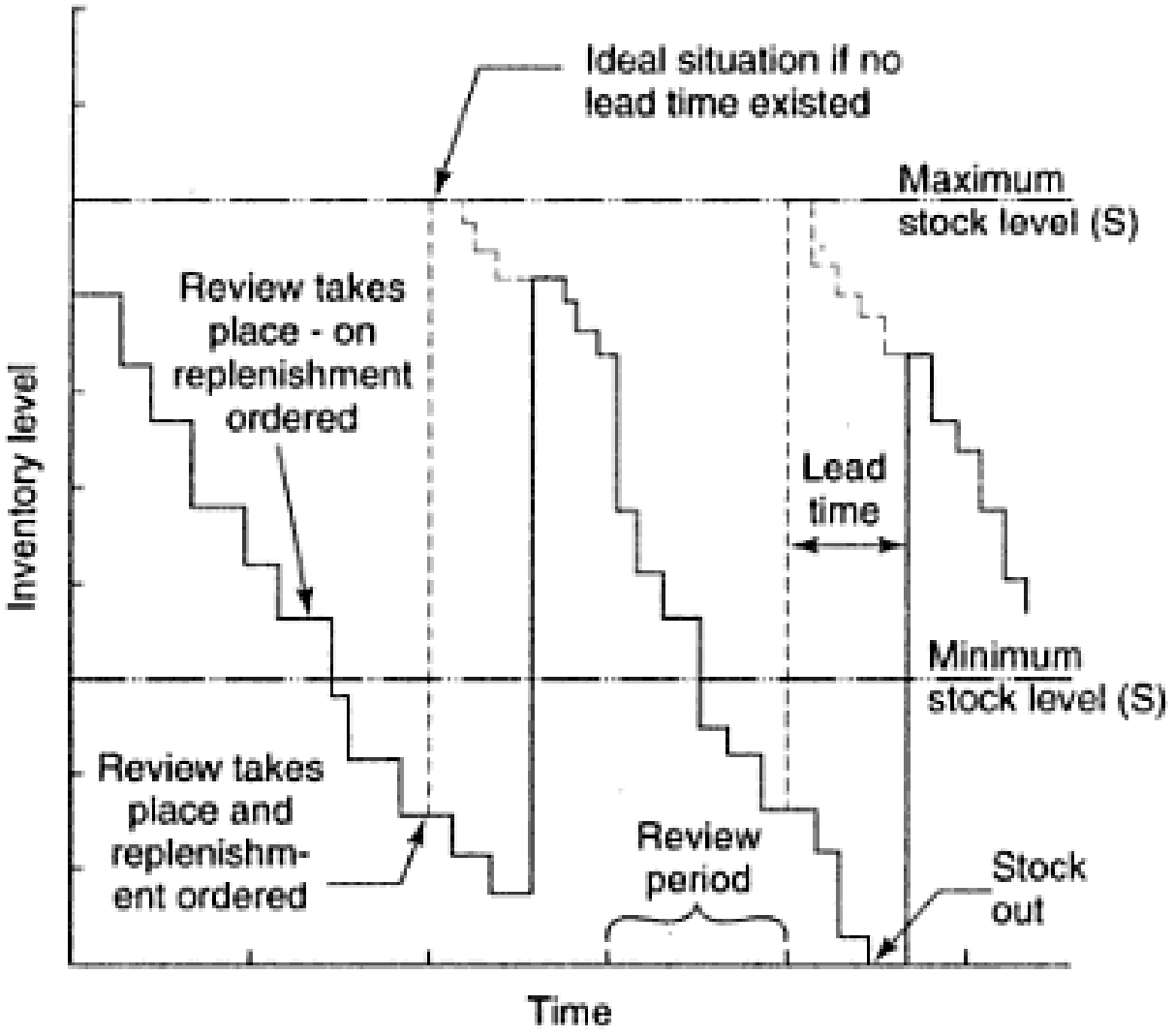


Figure 11.4 Typical stock balance under (s,S) policy

(7) *Ordering when Quantity are Available*

- Different discounts are offered on different purchase quantities and frequency of purchase.