Costs Associated with Inventories:

Inventory management is quite critical for the companies as it includes substantial costs, especially in material intensive manufacturing concerns. Following are the costs that are associated with inventories:

1. Cost of purchasing the inventory – the price that is settled with the supplier, after deducting the trade discounts and rebates.

2. Cost of ordering the inventory – such as clerical costs of preparing the material requisition, purchase order, receiving and handling shipments and preparing receiving report, communicating in case of quantity/ quality errors or delay in receipt of shipment, and accounting for the shipment and the payment.

Annual Ordering Cost = Number of orders per annum x cost per order
(Number of orders = Annual demand / order size)

3. Cost of holding the inventory – such as interest cost on borrowings for purchase of inventory, insurance cost, warehouse and storage cost, handling cost and cost of obsolescence, deterioration of inventory and opportunity cost of holding the stocks.

Annual Holding Cost = Holding Cost per unit x Average Inventory
[Average Inventory=(Opening quantity of stock + Closing quantity of stock)/2]

Companies put substantial efforts to determine the expected market demand on the basis of which purchasing and manufacturing plans are made in order to achieve a point of inventory at which the cost is minimized. The mathematicians have therefore derived quantitative models to determine the level of stock to be maintained at which the price is minimal (known as optimum stock level).

Example:

Ore Limited (OL) is a manufacturer of sports bicycles. The company buys tyres from a local vendor. Following data, relating to a pair of tyres, has been extracted from OL's records:

Following data, relating to a pair of tyres, has been extracted from OL's records:

Cost (per unit)	**Rs.**
Storage cost based on average inventory	80
Insurance cost based on average inventory	60
Store keeper's salary (included in absorbed overheads)	8
Cost incurred on final quality check at the time of delivery	10

Other relevant details are as follows:
i. The purchase price is Rs. 900 per pair.
ii. The annual demand for tyres is 200,000 pairs.
iii. The ordering cost per order is Rs. 8,000.
iv. The delivery cost per order is Rs. 3,000.
v. Recently the vendor has offered a quantity discount of 3% on orders of a minimum of 5,000 pairs.

Required:
Using the above data, calculate the following:

a) Annual Ordering Cost
b) Average inventory

c) Annual Holding cost
d) Total Cost of Inventory

Answer:

a) Annual Ordering Cost, can be calculated as follows:
Annual Ordering Cost = Number of orders per annum x cost per order Number of orders = Annual demand / order size = 200,000/5000 = 40 orders per annum
Cost per Order = Ordering Cost + Delivery Cost = Rs. 8,000 + Rs. 3,000 = 11,000
Therefore, the annual ordering cost = 40 x 11,000 = Rs. 440,000

b) To calculate Average inventory, following calculations would be required:
Average Inventory = (Opening quantity of stock + Closing quantity of stock) / 2 (0+5000)/2 = 2,500 pairs

c) Annual Holding cost, to be calculated as follows:
Annual Holding Cost = Holding Cost per unit x Average Inventory Holding cost per unit:

Storage cost based on average inventory =	80
Insurance cost based on average inventory =	60
Total (relevant) holding cost per unit =	140
Annual Holding Cost = 140 x 2,500	350,000

d) Total Cost of Inventory would be Total Cost of Inventory:

Purchase cost (net of discount) =	900 x 200,000 x 97% = 174,600,000
Annual Ordering Cost = (a)	440,000
Annual Holding Cost = (c)	350,000
Total Cost of Inventory per annum =	175,390,000

Objective of inventory control

The overall objective of inventory control is, therefore, to maintain inventory levels so that the total of the following costs is minimised.

- Holding costs
- Stockout costs
- Ordering costs

ECONOMIC ORDER QUANTITY (EOQ)

The economic order quantity is a company's optimal order quantity for minimizing its total costs related to ordering, receiving, and holding inventory.

The optimum order will be determined by those costs that are affected by either:

- the quantity of stocks held or
- the number of orders placed.

If more units are ordered at one time, fewer orders will be required per year. This will result in reduction in ordering costs.
As seen in above example, if order size is 10,000 units, the number of orders will be 200,000 / 10,000 = 20 orders which will reduce the ordering cost to Rs. 220,000.

However, when fewer orders are placed, larger average stocks must be maintained which leads to increase in holding costs that is (10,000 / 2) x 140 = 700,000.

Hence the total relevant cost (ordering cost + holding cost) shall become Rs. 920,000 that is Rs. 130,000 higher than the one calculated at 5,000 units (i.e. 440,000+350,000=790,000).

Therefore, an optimum level must be determined at which the total relevant cost is minimized. This optimum level is called **Economic Order Quantity (EOQ).**

Assumptions of EOQ:

EOQ model is valid only as per the following assumptions:

1. The holding cost per unit will be constant.
2. The average inventory is equal to one half of the order quantity as the stock is consumed at a constant rate throughout the period. (discussed in above sections)
3. The cost per order is constant.
4. There are no quantity discounts available.
5. The demand for its inputs and outputs can be predicted with perfect certainty.

Example:

A company uses 5000 pieces of raw materials per annum, the cost of each being sh. 20, the cost per order is sh. 80 and the cost of storage is 10% of the value of the item. Calculate EOQ and the total cost of stock.

Solution

D = 5000

Co= 80

C=20

Ch = 10% x 20 =2

Therefore EOQ = $\sqrt{\frac{2DCo}{Ch}}$ EOQ = $\sqrt{\frac{2x5000x80}{2}}$ = 632.46 EOQ = 632 pieces

Total cost of inventory =Total ordering cost + Total holding cost

Where:

a. **Total Ordering cost-**This is the cost incurred in getting an order to the firm facility storage. They include Cost of telephone charges, cost of issuing the purchase order offloading and inspection of goods etc.

Ordering cost=No of orders x cost per order

Nb: Number of orders= $\frac{\text{Annual demand(D)}}{\text{Quantity(Q)}}$

So, **Ordering cost** = $\frac{D}{Q}$ X Co

= $\frac{5000}{632}$ X 80

=632.91

b. **Total Holding cost** -This is the cost incurred as a result of maintaining inventory items in a firm.

They include: Cost of insurance of goods

Security cost on the goods Storekeepers' salaries etc.

Holding cost=Average stock x Holding cost per unit

= $\frac{Q}{2}$ X Ch

= $\frac{632}{2}$ x 2 = 632.91

Total cost = Total Ordering cost + Total Holding cost (Where discounts are not provided)

= $\frac{D}{Q}$ X Co + $\frac{Q}{2}$ X Ch =632.91+632.91=1265.82

Note that the total cost line is at a minimum for an order quantity of 500 units and occurs at the point where the ordering cost curve and holding cost curve intersect. The EOQ is therefore found at the point where holding costs equal ordering costs.

Example

Rana Manufacturers require 1,500 units of an item per month. The cost of each unit is Rs. 27. The cost per order is Rs. 150 and material carrying charge works out to 20% of the average material. What is EOQ?

By putting values in formula EOQ would be

$$\sqrt{\frac{(2\times 18{,}000\times 150)}{5.40}} = 1{,}000 \text{ units}$$

(b) Calculation of Annual ordering and holding cost, is given below:

Annual cost Rupees Ordering cost (18,000/ 1,000 x 150)	2,700
Holding cost (1,000 / 2 x 5.40)	2,700
Total Ordering & Holding Cost	**5,400**

Quantity Discounts affecting the decision of order size:

As per above assumptions, it is assumed that no quantity discounts exist. However, sometimes the suppliers offer discounts on bulk purchases. In such a case, the EOQ model can only be used when the total cost including purchase price after taking into account the discounts is more than the cost at EOQ. This means, the entity shall evaluate both the options and determine which option gives the lesser cost.

Following steps should be followed in order to calculate EOQ in case of bulk discounts.

i. Calculate EOQ (Ignoring discounts)
ii. Calculate Annual Inventory Cost including purchase cost at above EOQ level.
iii. Calculate Annual Inventory Cost at each discount level including purchase cost.
iv. Compare annual inventory costs calculated in above II and III, and determine EOQ level at a point where total inventory cost is minimum.

Example:

Entity G uses 105 units of an item of inventory every week. These cost Rs.150 per unit. They are stored in special storage units and the variable costs of holding the item is Rs.4 per unit each year plus 2% of the inventory's cost.

a) If placing an order for this item of material costs Rs.390 for each order, the optimum order quantity to minimize annual costs would be calculated as follows. It is assumed that there are 52 weeks in each year.

   The annual holding cost per unit of inventory = Rs.4 + (2% × Rs.150) = Rs.7.

   Annual demand = 52 weeks × 105 units = 5,460 units.

$$\text{EOQ} = \sqrt{\frac{(2\times 390\times 5{,}460)}{5.40}} = 780 \text{ units}$$

b) Now suppose that the supplier offers a discount of 1% on the purchase price for order sizes of 2,000 units or more.

   The order size to minimize total annual costs would require following calculations.

   A discount on the price is available for order sizes of 2,000 units or more, which is above the EOQ.

The order size that minimizes cost is therefore either the EOQ or the minimum order size to obtain the discount, which is 2,000 units.

Annual costs	Order size 780 units	Order size 2,000 units
	Rs.	Rs.
Purchases		
(5,460 × Rs.150): ((5,460 × Rs.150 × 99%)	819,000	810,810
Holding costs	2,730	6,970
(Rs.7 × 780/2): (Rs.6.97 × 2,000/2)		
Ordering costs	2,730	1,065
(Rs.390 × 5,460/780): (Rs.390 × 5,460/2,000)		
Total costs	824,460	818,875

Conclusion: The order size that will minimize total annual costs is 2,000 units

Example

W Co. is retailer of barrels. The company has an annual demand of 30,000 barrels. The barrel cost Rs. 12 each. Fresh supplies can be obtained immediately, with ordering and transport costs amounting to Rs. 200 per order. The annual cost of holding one barrel in stock is estimated to be Rs. 1.20 per year.

A 2% discount is available on orders of at least 5,000 barrels and 2.5% discount is available if the order quantity is 7,500 barrel or above

Step-I Calculation of EOQs (Ignoring discounts)

Holding cost per barrel per year = Rs. 1.20

Cost per order = Rs. 200

Annual demand = 30,000 barrels

$$EOQ = \sqrt{\frac{2 \times 200 \times 30{,}000}{1.20}} = 3{,}162 \text{ barrels}$$

Step II Calculation of annual inventory cost at Q= 3,162

Annual costs	Order size 3,162 barrels
	Rs.
Purchases (30,000 x 12)	360,000
Ordering cost (30,000/3,162 x 200)	1,898
Holding cost (3,162/2 x 1.20)	1,897
Total Inventory Cost	**363,795**

Step III Calculation of annual inventory cost at each discount level

Annual costs	Order size 5,000 barrels	Order size 7,500 barrels
	Rs.	Rs.
Purchases (30,000 x 12 x 98%) / (30,000 x 12 x 97.5%)	352,800	351,000
Ordering cost (30,000/5,000 x 200) / (30,000/7,500 x 200)	1,200	800
Holding costs (5,000/2 x 1.20) / (7,500/2 x 1.20)	3,000	4,500
Total Inventory cost	**357,000**	**356,300**

The optimal order size should be 7,500 barrels as at this level, annual inventory cost is minimum.

Example:

Raveen Shah Enterprises produces Product Y and its monthly demand is 2,000 units. 2.5 kg of material K is required to produce one unit of Product Y. Cost of placing an order is Rs. 150 and purchase price of Material K is Rs. 80 per Kg. Average holding cost is 8% of purchase price. Recently, vendor offers discount of 2% at minimum purchase quantity of 5,000 kg and 3% at minimum purchase quantity of 10,000 kg.

In order to calculate EOQ following steps are used:

In order to calculate EOQ following steps are used:

Step-I Calculation of EOQs (Ignoring discounts)

Holding cost per unit per year = Rs. 6.40 (80 x 8%)

Cost per order = Rs. 150

Annual demand = 60,000 kg (2,000 x 12 x 2.5)

$$EOQ = \sqrt{\frac{2 \times 150 \times 60{,}000}{6.40}} = 1{,}677 \text{ kg}$$

Step II Calculation of annual inventory cost at Q= 1,677

Annual costs	Order size 1,677 Kg
	Rs.
Purchases (60,000 x 80)	4,800,000
Ordering cost (60,000/1,677 x 150)	5,367
Holding cost (1,677/2 x 6.40)	5,366
Total Inventory Cost	**4,810,733**

Step III Calculation of annual inventory cost at each discount level

Annual costs	Order size 5,000 Kg	Order size 10,000 Kg
	Rs.	Rs.
Purchases (60,000 x 80 x 98%) / (60,000 x 80 x 97%)	4,704,000	4,656,000
Ordering cost (60,000/5,000 x 150) / (60,000/10,000 x 150)	1,800	900
Holding costs (5,000/2 x 80 x 8% x 98%) / (10,000/2 x 80 x 8% x 97%)	15,680	31,040
Total Inventory cost	**4,721,480**	**4,687,940**

The optimal order size should be 10,000 kg as at this level, annual inventory cost is minimum.

Inventory control levels

Inventory control levels can be calculated in order to maintain inventories at the optimum level. The three critical control levels are reorder level, minimum level and maximum level.
Based on an analysis of past inventory usage and delivery times, inventory control levels can be calculated and used to maintain inventory at their optimum level.

Reorder level

When inventories reach this level, an order should be placed to replenish inventories. The reorder level is determined by consideration of the following.

- The maximum rate of consumption
- The maximum lead time

The maximum lead time is the time between placing an order with a supplier, and the inventory becoming available for use.

Formula to Learn:

Reorder level = maximum usage × maximum lead time
Minimum level = reorder level – (average usage × average lead time)
Maximum level = reorder level + reorder quantity – (minimum usage × minimum lead time)
Average inventory = safety inventory + ½ reorder quantity
Safety Stock Level = (Maximum usage x Maximum Lead time) - (Average usage x Average Lead time)

Question

A large retailer with multiple outlets maintains a central warehouse from which the outlets are supplied. The following information is available for Part Number SF525.

Average usage	350 per day
Minimum usage	180 per day
Maximum usage	420 per day
Lead time for replenishment	11-15 days
Reorder quantity	6,500 units
Reorder level	6,300 units

Required:

a) Based on the data above, what is the maximum level of inventory?
b) Based on the data above, what is the approximate number of Part Number SF525 carried as buffer inventory?

Answer:

(a) Maximum inventory level = reorder level + reorder quantity – (min usage × min lead time)
= 6,300 + 6,500 – (180 × 11)
= 10,820

(b) Buffer inventory = minimum level
Minimum level = reorder level – (average usage × average lead time)
= 6,300 – (350 × 13) = 1,750.

Question

A component has a safety inventory of 500, a reorder quantity of 3,000 and a rate of demand which varies between 200 and 700 per week. What is average inventory?

Average inventory = safety inventory + ½ reorder quantity
= 500 + (0.5 × 3,000)
= 2,000

Question. 2

XY Enterprises produces product that requires two components X and Y and relevant data for each type of components are given as below:

Description	
Normal usage in kg for each component per week	500
Minimum usage in kg for each component per week	250
Maximum usage in kg for each component per week	750
Re order quantity	X: 4,000 kg Y: 6,000 kg
Re order period	X: 4-6 weeks Y: 2-3 weeks

Required. Compute re order level, safety stock level and average stock level for each component of material.

Solution.

For each component of material, re order level, safety stock level and average stock level is calculated as under:

Re-order level = Average usage per week x Average lead time per week

Component	Kg
Component X (500 x 5)	2,500
Component Y (500 x 2.5)	1,250

Safety stock level = (Maximum usage x Maximum lead time) - (Average usage x Average lead time)

Component	Kg
Component X [(750 x 6) - (500 x 5)]	2,000
Component Y [(750 x 3) - (500 x 2.5)]	1,000

Average stock level = EOQ/2 + Safety stock level

Component	Kg
Component X (4,000/2) + 2,000	4,000
Component Y (6,000/2) + 1,000	4,000