Economic Order Quantity (*EOQ*) (Reorder Quantity)

The *EOQ* is the optimum or the most favourable quantity which should be purchased each time the purchases are to be made. The *EOQ* is one where the costs of carrying inventory is equal or almost equal to the cost of not carrying inventory (cost of placing orders). Also at *EOQ* level, the total of these two costs is minimum.

The cost of carrying the inventory is the real out-of-pocket cost associated with having inventory on hand, such as warehouse charges, insurance, heat, light, and losses due to spoilage, breakage, pilferage. Another opportunity cost, which is not the out-of-pocket cost, is important and should be considered, i.e., cost incurred (capital used) in purchasing the inventory. If funds have been borrowed to finance the inventory purchase, interest payments on borrowed funds will be the direct cost. Carrying or holding costs of inventory are explicit as well as implicit. That is, some costs are readily ascertained from accounting records while others require extensive study to estimate them because they are not expressly stated. Insurance on inventory is an explicit cost while the cost of funds invested in inventory are implicit costs. Generally, inventory carrying costs are considered to be proportional to the value of inventory carried.

The costs of not carrying adequate inventory arise because of frequent placing of order at short intervals. This includes costs, such as extra purchasing, handling and transportation costs, higher price due to small order quantities, frequent stock-outs resulting in disruption of production schedules, overtime and extra set up time, loss of sales and customer goodwill, etc.

The costs of carrying the inventory, and ordering costs change in the reverse order. The costs of placing the order decrease as the size of the order increase since with a bigger size of order, the number of the order will be lower. However, simultaneously the costs of carrying the inventory will go up because purchases have been made in large quantities. It may be possible to have a point which provides the lowest total cost and this point (ideal size) is known as the *EOQ*. This equilibrium can be determined mathematically as follows:

$$EOQ = \sqrt{\frac{2 \times U \times O}{IC}}$$

where U = Annual usage in units
O = Cost of placing an order
I = Per cent cost of carrying inventory
C = Cost per unit of material

Assume

Annual usage units = 6,000
Cost of placing an order = Rs 30
Carrying cost as a per cent of inventory = 20%
Cost per unit of material = Rs 5

Then,

$$EOQ = \sqrt{\frac{2 \times 6{,}000 \times 30}{5 \times 20\%}}$$

$$= \sqrt{3{,}60{,}000}$$

$$= 600 \text{ units}$$

In the above example, the *EOQ* is 600 units. That is, ten orders per year are needed. At the level of 600 units, the ordering costs and the carrying costs are equal and also the total cost is at minimum as it is clear from Table 3.1.

Table 3.1 Table Showing Economic Order Quantity

Annual usage	Orders per year	Units per order	Average inventory (units)	Value per order (Rs)	Average inventory amount (Rs)	Order cost	Carrying cost (20%)	Total cost (Rs)
6,000 units	1	6,000	3,000	30,000	15,000	20	3,000	3020
	2	3,000	1,500	15,000	7,500	40	1,500	1540
	3	2,000	1,000	10,000	5,000	60	1,000	1060
	4	1,500	750	7,500	3,750	120	750	870
	5	1,200	600	6,000	3,000	150	600	750
	6	1,000	500	5,000	2,500	180	500	680
	7	857	429	4,285	2,142	210	428	638
	8	750	375	3,750	1,875	240	376	616
	9	667	334	3,335	1,668	270	334	604
	10	600	300	3,000	1,500	300	300	600
	11	545	273	2,725	1,363	330	272	602
	12	500	250	2,500	1,250	360	250	610

Table 3.1 shows that quantities of other orders resulting in more or less than ten orders per year are not so economical as they involve higher total costs.

The *EOQ* formula is sometimes expressed in the following manner which is not in any way different from the formula explained earlier.

$$EOQ = \sqrt{\frac{2U \times P}{S}}$$

where U = Annual demand or consumption or purchased quantity (in units)

P = Cost of placing an order

S = Annual cost of carrying inventory per unit (Storage and interest)

The ordering costs, holding costs, total costs and *EOQ* can be shown graphically also as displayed in Fig. 3.4.

When to Order (Reorder Level)

The *EOQ* determines how much to buy at a particular time. But the question "when to buy" is equally important for business firms. This question is easy to answer only if we know the lead time—the time interval between placing an order and receiving delivery—and know the *EOQ*, and are certain of the consumption pattern during lead time. The order point or re-order level is a point or quantity level at which if materials in stores reach, the order for supply of materials must be placed. This point automatically initiates a new order. The order point is calculated from three factors:

1. The expected usage.
2. The time interval between initiating an order and its receipt, referred to as the lead time.
3. The minimum inventory, or safety stock.

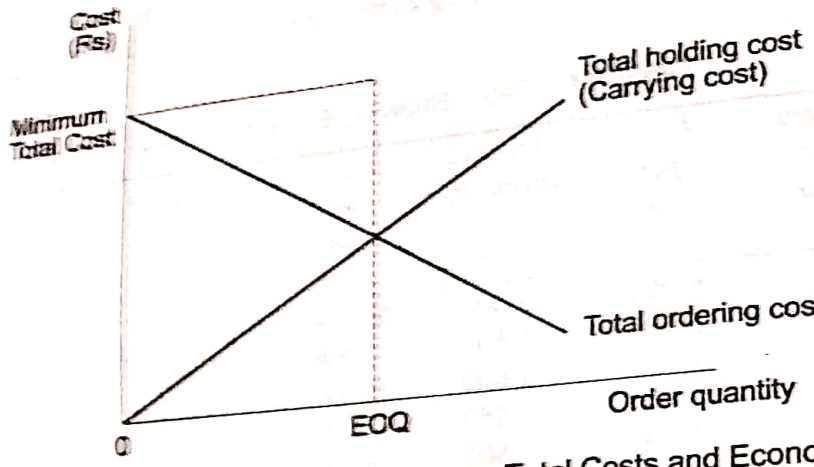

Fig. 3.4 Behaviour of Carrying Costs, Ordering Costs, Minimum Total Costs and Economic Order Quantity

For example, if daily usage is 400 units of material which have a lead time of 20 days and the safety (minimum) stock is 500 units, the order point will be calculated as follows:

Daily consumption × lead time = 400 × 20	=	8,000
Add safety stock	=	500
Order point units		8,500

The order point is determined after considering the worst possible expected conditions. This only ensures that the minimum stock will always remain in the inventory and will not be used atleast in the short-run. However, situations may arise where there will be stock-out and thus, the order point may not be an absolutely accurate forecasting.

Determination of Safety or Minimum Stock Level

It is advisable to carry a reserve or safety stock to prevent stock-out. The safety stock should be used only in abnormal circumstances, and the working stock in ideal or normal conditions. Therefore, for normal working conditions, the stock should not be allowed to fall below the safety limit, kept only for emergencies. If the usage pattern is known with certainty, and the lead time is also known accurately, then no safety stock would be needed. However, if either usage or lead time is subject to variation then it is necessary for a business firm to maintain safety stock levels equal to the difference between the expected usage over lead time and the maximum usage over lead time that the firm feels is necessary for cost minimization. The safety stock level can be computed by using the following formula:

Safety stock level = Ordering level – (Average rate of consumption × Re-order period)

Or

Safety stock level = (Maximum rate of consumption – Average rate of consumption) × Lead time

That is,

= (425 – 400) × 20 days

= 500 units

Maximum Stock Level

The maximum level ensures that the stocks will not exceed this limit although there may be low demand for materials or quick delivery from the suppliers. Maximum stock level can be computed as follows:

Maximum stock level = EOQ + Minimum stock

Or

Maximum stock level = Re-order level + EOQ – (Minimum consumption × Minimum re-order period)

Danger level

Generally the danger level of stock is indicated below the safety or minimum stock level. Sometimes, depending on the practices of the firm and circumstances prevailing, the danger level is determined between reorder level and minimum level. In the second case (danger level being between reorder level and minimum level), the firm can only take steps to ensure that materials ordered will arrive in time.

Average stock level

Average stock level is computed in the following manner:

$$= \frac{\text{Minimum + Maximum stock}}{2}$$

Or

$$= \frac{\text{Minimum level + Re-order quantity}}{2}$$

The following example further illustrates the different stock levels.

Maximum usage (units)	650 per day
Minimum usage (units)	300 per day
Normal usage (units)	500 per day
Economic order quantity (units)	75000
Re-order period—lead time	25 to 30 days
Minimum level (units) (10 days at normal usage)	5000

The different stock levels will be as follows:

Re-order level = Normal usage × Normal lead time + Minimum level

= (500 × 30) + 5000

= 20000 units

Maximum level = Re-order level + EOQ – Minimum quantity used in re-order period

= 20,000 + 75000 – (300 × 25)

= 87500 units

$$\text{Average level} = \frac{\text{Maximum + Minimum}}{2}$$

$$= \frac{87500 + 5000}{2}$$

= 46250 units

After placing an order, if usage goes above average or if the lead time is longer than expected, then the stock will fall below minimum. However, stock will not be exhausted, so long as the maximum usage and maximum re-order periods are not exceeded. In the above example, maximum usage during the lead time would cause an extra 4500 units (30 days × 150 units) to be consumed. Therefore, in this situation, the purchasing officer should try to chase supplies to ensure that delivery promises are kept.

The different stock levels, as found in the above example, are displayed in Fig. 3.5.

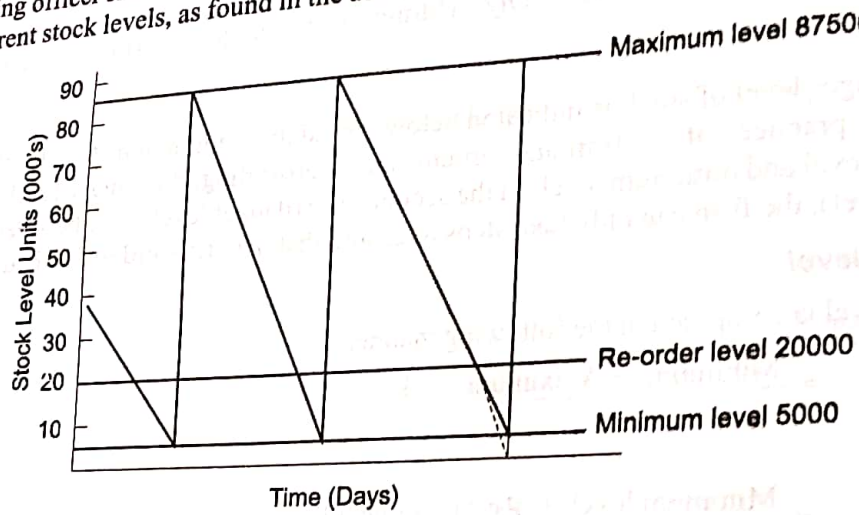

Fig. 3.5 Stock Levels

Example 3.1

In a company weekly minimum and maximum consumption of material *A* are 25 and 75 units respectively. The re-order quantity as fixed by the company is 300 units. The material is received within 4 to 6 weeks from issues of supply order. Calculate minimum level and maximum level of material *A*.

(CA Inter, May 1995)

Solution Minimum Level = Re-order level – (Average Rate of Consumption × Average Re-order Period)

= 450 units – (50 units × 5 weeks) = 200 units.

Maximum level = Re-order Level + Re-order Quantity – (Min. Rate of Consumption × Min. Re-order Period)

= 450 units + 300 units – (25 units × 4 weeks)

= 650 units.

Working Note:

Re-order Level = Maximum Usage per Period × Maximum Re-order Period

= 75 units × 6 weeks = 450 units.

Example 3.2

About 50 items are required every day for a machine. A fixed cost of Rs. 50 per order is incurred for placing an order. The inventory carrying cost per item amount to Re. 0.02 per day. The lead period is 32 days. Compute:

(i) Economic Order Quantity
(ii) Re-order level

(CA Inter, Nov. 1996)

Solution

Annual Consumption (U) = 50 items × 365 days
= 18,250 units

Ordering Cost (P) = Rs. 50

Inventory Carrying cost per item per annum (S) = Re 0.02 × 365 = Rs. 7.30

(i) Economic Order Quantity $= \sqrt{\frac{2U \times P}{S}}$

$= \sqrt{\frac{2 \times 18{,}250 \times \text{Rs. } 50}{\text{Rs. } 7.30}}$

= 500 units

(ii) Re-order Level = Maximum Usage per day × Maximum Lead Time
= 50 units per day × 32 days
= 1,600 items

Example 3.3

From the following information calculate Economic Order Quantity, and the number of orders to be placed in one quarter of the year:

(i)	Quarterly consumption of materials	2,000 kg.
(ii)	Cost of placing one order	Rs 50
(iii)	Cost Per unit	Rs 40
(iv)	Storage and carrying Cost	8% on average inventory

(B. Com. (Hons), Delhi 1997)

Solution

$$EOQ = \sqrt{\frac{2U \times P}{S}}$$

Where:

U = Annual Consumption
S = Storage cost per unit per annum

Anual usage of materials = 2000 kg × 4 = 8000 kg

Cost of placing order = Rs. 50

Annual storage or carrying cost of one unit $= \frac{40 \times 8}{100} = 3.2$

$$EOQ = \sqrt{\frac{2 \times 8000 \times 50}{3.2}}$$

$$= \sqrt{\frac{8{,}00{,}000}{3.2}}$$

$= \sqrt{2,50,000} = 500$ kg

No. of orders per quarter = 2000 kg ÷ 500 kg = 4

Example 3.4

If the minimum stock level and average stock level of raw-material *A* are 4,000 and 9,000 units respectively, find out its 'Re-order quantity'. *(CA Inter, May 1997)*

Solution

Minimum Stock Level of Material *A* = 4,000 units

Average Stock Level of Material *A* = 9,000 units

Average Stock Level = Minimum Stock level + 1/2 Re-order Quantity

or 1/2 Reorder Quantity = 9,000 units – 4,000 units

= 5,000 units

or Re-order quantity = 10,000 units.

Example 3.5

From the details given below, calculate:

(i) Re-ordering Level
(ii) Maximum Level
(iii) Minimum Level
(iv) Danger Level

Cost of placing a purchase order is Rs. 20

Number of units to be purchased during the year is 5,000.

Purchase price per unit inclusive of transportation cost is Rs. 50.

Annual cost of storage per unit is Rs. 5

Details of lead time: Average 10 days, Maximum 15 days, Minimum 6 days. For emergency purchases 4 days.

Rate of Consumption: Average : 15 units per day, Maximum : 20 units *(CA Inter, May 1996)*

Solution

(i) Re-ordering Level (*ROL*) = Maximum Usage per day × Maximum Re-order period

= 20 units per day × 15 days

= 300 units

(ii) Maximum Level (*WN* 1 and 2) = *ROL* + *ROQ* – (Min. Rate of Consumption × Min. Re-order Period)

= 300 units + 200 units – (10 units per day × 6 days)

= 440 units.

(iii) Minimum Level = *ROL* – (Average rate of consumption × Average reorder period)

= 300 units – (15 units per day × 10 days)

= 150 units.

(iv) Danger Level = Average consumption × Lead time for emergency purchases

= 15 units per day × 4 days

= 60 units.

Working Notes:

1. $ROQ = \sqrt{\frac{2U \times P}{S}} = \sqrt{\frac{2 \times 5000 \text{ units} \times \text{Rs } 20}{\text{Rs } 5}}$

$= 200$ units

Where: ROQ = Reorder Quantity
U = Annual Consumption
P = Cost per order
S = Storage Cost per unit

2. Average Rate of Consumption

$$= \frac{\text{Minimum Rate of Consumption } (x) + \text{Maximum Rate of Consumption}}{2}$$

$$15 \text{ units per day} = \frac{x + 20 \text{ units per day}}{2}$$

or $x = 10$ units per day.

Example 3.6

G. Ltd. produces a product which has a monthly demand of 4,000 units. The product requires a component X which is purchased at Rs. 20. For every finished product, one unit of component is required. The ordering cost is Rs. 120 per order and the holding cost is 10% p.a.

You are required to calculate:

(i) Economic order quantity.

(ii) If the minimum lot size to be supplied is 4,000 units, what is the extra cost, the company has to incur?

(iii) What is the minimum carrying cost, the company has to incur? *(CA Inter, May 1999)*

Solution

(i) *Computation of Economic Ordering Quantity*

$$EOQ = \sqrt{\frac{2U \times P}{S}}$$

Where U = Annual Consumption
P = Cost of Placing an Order
S = Storage Cost per unit per annum

$$= \sqrt{\frac{2 \times 48{,}000 \text{ units} \times \text{Rs. } 120}{10\% \times \text{Rs. } 20}} = \sqrt{5{,}76{,}000}$$

$= 2{,}400$ units.

(ii) *Extra cost incurred by the company*

Total cost when order size is 4000 units

= Total Ordering Cost + Total Carrying Cost
= 12 orders × 120 + 4,000 × 1/2 × 20 × 10/100
= Rs. 1,440 + Rs. 4,000 = Rs. 5,440

Total cost when order size is 2400 units
Total Cost = 20 orders × Rs. 120 + 2,400 × 1/2 × 20 × 10/100
= Rs. 2,400 + Rs. 2,400 = Rs. 4,800

Extra Cost incurred by the company = Rs. 5,440 – Rs. 4,800 = Rs. 640

(iii) *Minimum Carrying Cost*

The carrying or storage cost depends upon the size of the order. It will be minimum when the order size is least.

In the question the two order sizes are 2,400 units and 4,000 units. Hence, 2,400 units is the least of the two order sizes. At this order size carrying cost will be minimum.

The minimum carrying cost in this case will be as under:

Minimum Carrying Cost = 1/2 × 2,400 units × 10/100 × Rs. 20 = Rs. 2,400

Example 3.7

ZEE is product manufactured out of three raw materials M, N and Q. Each unit of ZEE requires 10 kgs, 8 kgs. and 6 kgs. of M, N and Q respectively. The re-order levels of M and N are 15,000 kgs and 10,000 kg. respectively while the minimum-level of Q is 2,500 kg. The weekly production of ZEE varies from 300 to 500 units, while the weekly average production is 400 units. You are required to compute

(i) the minimum stock level of *M*.
(ii) the maximum stock level of *N*, and
(iii) the re-order level of *Q*.

The following additional data are given:

	M	*N*	*Q*
Re-order Quantity (in kgs.)	*20,000*	*15,000*	*20,000*
Delivery (in weeks)			
Minimum	2	4	3
Average	3	5	4
Maximum	4	6	5

(ICWA Inter, Dec. 1995)

Solution

(i) Minimum Stock Level of *M*

= Re-order Level – (Average Usage × Average Delivery Time)
= 15,000 kgs – (400 units of Zee × 10 kgs. per unit × 3 weeks)
= 15,000 – 12,000 = 3,000 kgs.

(ii) Maximum Stock Level of *N*

= Re-order Level + Re-order Quantity – (Minimum Usage × Minimum Re-order Period)
= 10,000 kgs + 15,000 kgs. – (300 × 8 × 4) kgs.
= 15,400 kgs.

(iii) Re-order Level of *Q*

= Maximum Re-order period × Maximum Usage
= 5 × 500 × 6
= 15,000 kgs.

Example 3.8

M/s Tubes Ltd. are the manufacturers of picture tubes for T.V. The following are the details of their operation during 1997:

Average monthly market demand	2,000 Tubes
Ordering cost	Rs. 100 per order
Inventory carrying cost	20% per annum
Cost of tubes	Rs. 500 per tube
Normal usage	100 tubes per week
Minimum usage	50 tubes per week
Maximum usage	200 tubes per week
Lead time to supply	6-8 weeks

Compute from the above:

1. Economic Order Quantity. If the supplier is willing to supply quarterly 1,500 units at a discount of 5%, is it worth accepting?
2. Maximum level of stock.
3. Minimum level of stock.
4. Reorder level.

(CA Inter, May 1998)

Solution

1. $$EOQ = \sqrt{\frac{2UP}{S}}$$

Where U = Annual usage of tubes

= Normal usage per week × 52 weeks

= 100 tubes × 52 weeks = 5,200 tubes.

P = Ordering cost per order = Rs. 100 per order.

S = Inventory carrying cost per unit per annum.

20% × Rs. 500 = Rs. 100 per unit per annum.

$$EOQ = \sqrt{\frac{2 \times 5{,}200 \text{ units} \times \text{Rs. } 100}{\text{Rs } 100}} = 102 \text{ tubes (approx.)}$$

Evaluation of offer. If the supplier is willing to supply 1,500 units at a discount of 5%:

(i) Total Cost When order size is 1500 units

= Cost of 5,200 Units + Ordering Cost + Carrying Cost

$$= 5{,}200 \text{ units} \times \text{Rs. } 475 + \frac{5{,}200 \text{ units}}{1{,}500 \text{ units}} \times \text{Rs. } 100 + \frac{1}{2} \times 1{,}500 \text{ units} \times 20\% \times \text{Rs. } 475$$

= Rs. 24,70,000 + Rs. 346.67 + Rs. 71,250

= Rs. 25,41,596.67

(ii) Total Cost (when order size is 102 units):

$$= 5{,}200 \text{ units} \times \text{Rs. } 500 + \frac{5{,}200 \text{ units}}{102 \text{ units}} \times \text{Rs. } 100 + \frac{1}{2} \times 102 \text{ units} \times 20\% \times \text{Rs. } 500$$

= Rs. 26,00,000 + Rs. 5,098.03 + Rs. 5,100

= Rs. 26,10,198.03

The above calculation shows the total cost under quarterly supply of 1,500 units with 5% discount is lower than that when order size is 102 units. Therefore, the offer should be accepted. However, while accepting this offer consideration of capital blocked on order size of 1,500 units per quarter has been ignored.

2. *Maximum Level of Stock*
   = Re-order level + Re-order quantity – (Min. usage × Min. Re-order period)
   = 1,600 units + 102 units – 50 units × 6 weeks
   = 1,402 units.

3. *Minimum Level of Stock*
   = Re-order level – (Normal usage × Average Re-order period)
   = 1,600 units – 100 units × 7 weeks = 900 units.

4. *Reorder Level*
   = Maximum Consumption × Maximum Re-order Period
   = 200 units × 8 weeks
   = 1,600 units.

Example 3.9

Shagoon India Ltd. provides the following information in respect of material X

Supply period	:	5 to 15 days
Rate of Consumption:		
Average	:	15 units per day
Maximum	:	20 units per day
Yearly	:	5,000 units

Ordering costs are Rs. 20 per order.
Purchase price per unit is Rs. 50.
Storage costs are 10% of unit value.

Compute:
(i) Reorder Level
(ii) Minimum Level
(iii) Maximum Level

(B. Com. (Hons), Delhi 1998)

Solution

(i) Re-ordering Level = Maximum Usage per period × Maximum Re-order per period
= 20 units per day × 15 days
= 300 units

(ii) Maximum Level = *ROL* + *ROQ* – (Min. Rate of Consumption × Min. Re-order Period)
= 300 units + 200 units – (10 units per day × 5 days)
= 450 units

(iii) Minimum Level = *ROL* – (Average Rate of Consumption × Average Re-order Period)
= 300 units – (15 units per day × 10 days)
= 150 units

Working Notes:

1. $$ROQ = \sqrt{\frac{2U \times P}{S}} = \sqrt{\frac{2 \times 5000 \text{ units} \times \text{Rs. } 20}{\text{Rs. } 5}} = 200 \text{ units}$$

where: ROQ = Reorder Quantity
U = Annual Consumption
P = Cost per order
S = Storage cost per unit

2. Average Rate of Consumption

$$= \frac{\text{Minimum Rate of Consumption } (x) + \text{Maximum Rate of Consumption}}{2}$$

$$15 \text{ units per day} = \frac{x + 20 \text{ units per day}}{2}$$

or $x = 10$ units per day.

Example 3.10

Materials X and Y are used as follows:

Minimum usage – 50 units each per week.
Maximum usage – 150 units each per week.
Normal usage – 100 units each per week.

Ordering quantities $X = 600$ units
$Y = 1000$ units

Delivery period $X = 4$ to 6 weeks
$Y = 2$ to 4 weeks

Calculate for each material : (a) Minimum level; (b) Maximum level; and (c) Order level.

Solution

Material X

Ordering level = maximum usage × Maximum delivery period
= 150 × 6
= 900 units

Minimum level = Ordering level – (Normal usage × Normal delivery period)
= 900 – (100 × 5)
= 900 – 500
= 400 units

Maximum level = (Ordering level + Ordering quantity) – (Minimum usage × Minimum delivery period)
= 900 + 600 – (50 × 4)
= 1500 – 200
= 1300 units

Material Y

Ordering level = Maximum usage × Maximum delivery period
= 150 × 4
= 600 units

Minimum level = Ordering level – (Normal usage × Normal delivery period)
= 600 – (100 × 3)
= 600 – 300
= 300 units

Maximum level = (Ordering level + Ordering quantity) – (Minimum usage × Minimum delivery period)
= 600 + 1000 – (50 × 2)
= 1600 – 100
= 1500 units

Notes: Normal period of delivery has been computed as follows:

$$\text{Material } X = \frac{(4+6)}{2} = 5 \text{ weeks}$$

$$\text{Material } Y = \frac{(2+4)}{2} = 3 \text{ weeks}$$

Example 3.11

From the following data, calculate the economic order quantity and the re-order point for Part Z:

Working days in a year	200
Safety stock	400 units
Lead time	10 days
Order costs	Rs 300 per order
Holding cost	15% of cost
Annual consumption	10,000 units
Cost per unit	Rs 10

Solution

$$EOQ = \sqrt{\frac{2U \times P}{S}}$$

$$\sqrt{\frac{2 \times 10{,}000 \times \text{Rs } 300}{15\% \times 10}} = \sqrt{\frac{6{,}000{,}000}{1.5}} = \sqrt{4000000} = 2000 \text{ units}$$

Trial and error calculation to arrive at the above answer:

Times ordered	4	5	6
Order size (units)	2,500	2,000	1,666
Average stock (units)	1,250	1,000	833
Holding costs (Rs)	1,875	1,500	1,250
Order costs (Rs)	1,200	1,500	1,800
	Rs 3,075	Rs 3,000	Rs 3050

Holding cost has been calculated as follows:
Average stock units × Cost per unit × 15%
Economic order quantity : 2,000 units, order 5 times per annum.

Re-order point:

Daily consumption X lead time $(10,000 \div 200) \times 10 =$	500
Add safety stock	400
Re-order point	900 Units

Holding cost has been calculated as follows :
Average stock units × cost per unit × 15%

Example 3.12

Eats Ltd. supply a number of products to bakers and confectioners. One of their products consists of packets of cake decorations. The cake decorations are sold in packets of twelve decorations for Rs 20 per packet. The demand for the cake decorations is very constant and has over a long period of time been at the rate of 2,000 packets per month. The packets cost Eats Ltd. Rs 10 each from the manufacturer and a lead time of four days is required from date of order to date of delivery. Ordering costs are Rs 1.20 per order and the holding or carrying cost is 10 per cent per annum.

(a) Calculate the following:
  (i) the economic order quantity:
  (ii) the number of orders to be placed per annum:
  (iii) the total cost of buying and carrying cake decorations per annum.

(b) Assume that the present stock level is 200 packets and that no buffer stocks are kept. When must the next order be given to the supplier? (For purposes of your calculation one year consists of 360 days).

(c) There are certain major difficulties often experienced by firms in seeking to use the EOQ Formula. List them briefly.

Solution

(a) (i) Economic order quantity $= \sqrt{\frac{2U \times P}{S}}$

$$\sqrt{\frac{2 \times 24,000 \times 1.20}{0.10 \times 10}} = \sqrt{\frac{57,600}{1}} = 240 \text{ units}$$

(ii) Number of orders to be placed per annum

$$\frac{\text{Annual usage}}{EOQ} = \frac{24,000}{240} = 100 \text{ orders}$$

(iii)

Cost of buying 100 orders × Rs 1.20	Rs 120
Cost of holding = average stock × holding cost per unit = 120 units × Re 1	Rs 120
Total cost of buying and holding cake decorations per annum	Rs 240

(b) $\frac{200}{2,000} = \frac{1}{10}$th of a month or 3 days supply.

With a lead time of four days the order must be placed tomorrow without fail.

(c) Difficulties often experienced by firms in seeking to use the *EOQ* formula are difficulty of estimating, with accuracy, such items as the annual demand for stock items, the cost of ordering and the cost of carrying. Also the *EOQ* formula makes the assumption that stock is used at a constant rate throughout the year. This may not be so.

Example 3.13

The Purchase Department of your organisation has received an offer of quantity discounts on its orders of materials as under:

Price per tonne Rs	*Tonnes*
1,200	Less than 500
1,180	500 and less than 1,000
1,160	1,000 and less than 2,000
1,140	2,000 and less than 3,000
1,120	3,000 and above.

The annual requirement for the material is 5,000 tonnes. The ordering cost per order is Rs 1,200 and the carrying cost is estimated at 20% per annum.

You are required to compute the most economic order quantity presenting the information in a tabular form.

(B. Com. (Hons), Delhi 2001)

Solution

Ordering quantity (Tonnes)	*Price per tonne (Rs)*	*Purchasing cost of 5,000 tonnes (Rs)*	*Ordering cost (Rs)*	*Inventory carrying (Rs)*	*Total cost (Rs)*
EOQ		*5,000 × Per order delivery cost*	$\frac{5,000 \times 1,200}{\text{Ordering quantity}}$	$\frac{EOQ}{2} \times$ *price per tonne* $\times 20\%$	
400	1,200	60,00,000	15,000	48,000	60,63,000
500	1,180	59,00,000	12,000	59,000	59,71,000
1,000	1,160	58,00,000	6,000	1,16,000	59,22,000
2,000	1,140	57,00,000	3,000	2,28,000	59,31,000
3,000	1,120	56,00,000	2,000	3,36,000	59,38,000

The above table shows that most economical purchase level is at a level where the ordering quantity is 1,000 tonnes, since at this level the total cost (i.e. inventory carrying cost and ordering cost) is the minimum.

Example 3.14

Shriram Enterprises manufactures a special product "ZED". The following particulars were collected for the year 2002:

(a) Monthly demand of ZED 1,000 units.
(b) Cost of placing an order Rs 100.
(c) Annual carrying cost per unit Rs 15.
(d) Normal usage 50 units per week.
(e) Minimum usage 25 units per week.

(f) Maximum usage 75 units per week.
(g) Re-order period 4 to 6 weeks.

Compute from the above

1. Re-order quantity
2. Re-order level
3. Minimum level
4. Maximum level
5. Average stock level

(ICWA Inter)

Solution

1. Re-order quantity (of units used)

$$= \sqrt{\frac{2U \times P}{S}}$$

where U = Annual demand of input units

P = Cost of placing an order

S = Annual carrying cost per unit

$$= \sqrt{\frac{2 \times 2{,}600 \times \text{Rs. } 100}{\text{Rs. } 15}} = \sqrt{34667}$$

= 186 units (approx.)

2. Re-order level = Maximum re-order period × Maximum usage
   = 6 weeks × 75 units
   = 450
3. Minimum level = Re-order level – (Normal usage × Average re-order period)
   = 450 units – (50 units × 5 weeks)
   = 450 units – 250 units = 200 units
4. Maximum level = Re-order level + Re-order quantity – (Minimum usage × Minimum order period)
   = 450 units + 186 units – (25 units × 4 weeks)
   = 536 units.
5. Average stock level = 1/2 (Minimum stock level + Maximum stock level)
   = 1/2 (200 units + 536 units)
   = 368 units

Working Notes:

U = Annual demand of input units for 12,000 units of 'ZED'.
= 52 weeks × Normal usage of input units per week.
= 52 weeks × 50 units of input per week

= 2,600 units

Example 3.15

A company uses three raw materials *A*, *B* and *C* for a particular product for which the following data apply:

Raw material	Usage per unit of product kg	Re-order quantity (kg)	Price per kg	Delivery (in weeks) Min.	Av.	Max.	Re-order level (kgs)	Minimum level (kgs)
A	10	10,000	0.10	1	2	3	8,000	
B	4	5,000	0.30	3	4	5	4,750	
C	6	10,000	0.15	2	3	4		2,000

Weekly production varies from 175 to 225 units, averaging 200 units of the said product. What would be the following quantities:

(i) Minimum stock of *A*?
(ii) Maximum stock of *B*?
(iii) Re-order level of *C*?
(iv) Average stock level of *A*?

(CA Inter)

Solution

(i) Minimum stock of *A*
Re-order level – (Average rate of consumption × Average time required to obtain fresh delivery)
= 8,000 – (2,000 × 2) = 4,000 kg

(ii) Maximum stock of *B*
Re-order level – (Minimum consumption × Minimum re-order period + Re-order quantity)
= 4,750 – (4 × 175 × 3) + 5,000
= 9,750 – 2,100 = 7,650 kg

(iii) Re-order level of *C*
Maximum re-order period × Maximum usage = 4 × 1,350 = 5,400 kg
Or
Re-order level of *C* = Minimum stock of *C* + (Average rate of consumption × Average time required to obtain fresh delivery)
= 2,000 + [200 × 6 × 3] kg = 5,600 kg

(iv) Average stock level of *A*

$$= \frac{\text{Minimum stock} + \text{Maximum stock}}{2} = \frac{4{,}000 + 16{,}250}{2}$$

= 10,125 kg

Working Note:

Maximum stock of *A* = *ROL* + *ROQ* – (Min. consumption × Min. re-order period)
= 8000 kg + 10000 – [(175 × 10) × 1]
= 16250 kg

Example 3.16

XYZ Company buys in lots of 500 boxes which is a 3 months supply. The cost per box is Rs 125 and the ordering cost is Rs 150. The inventory carrying cost is estimated at 20% of unit value. What is the total annual cost of the existing inventory policy? How much could be saved by employing the economic order quantity?

Solution

(i) Ordering Cost

	Rs
4 orders in a year @ Rs 150 each order	600
Carrying cost of average inventory $\frac{500}{2}$ = 250 units × 20% × 125 =	6250
Total annual cost of existing inventory policy	6850

(ii) Economic Order Quantity (*EOQ*)

$$= \sqrt{\frac{2U \times P}{S}}$$

$$= \sqrt{\frac{2 \times 2000 \times 150}{20\% \text{ of Rs } 125}}$$

$$= \sqrt{\frac{6,00,000}{25}}$$

= 155 units

(iii) Ordering Cost

$$= \frac{2000}{155} = 12.90 \text{ or } 13 \text{ orders approx.}$$

13 orders are to be placed at Rs 150 each	1950.00
carrying cost of average inventory $= \frac{155}{2} \times \frac{20}{100} \times 125$	1937.50
Total annual cost	3887.50

Saving in annual cost if *EOQ* is adopted

Rs 6850 – Rs 3887.50 = Rs 2962.50

Example 3.17

The following information in an inventory problem is available:

Annual demand	2400 units
Unit price (Rs)	2.40
Ordering cost (Rs)	4.00
Storage cost (Rs)	2% per year
Interest rate	10% p.a.
Lead time	1/2 month

Calculate *EOQ*, Re-order level and total annual inventory cost. How much does the total inventory cost vary if the unit price is changed to Rs 5? *(ICWA Inter)*

Solution

Inventory carrying cost = 10% + 2% = 12% p.a.

Carrying cost per unit p.a. = 12% of Rs. 2.40 = Rs 0.288

$$EOQ = \sqrt{\frac{2U \times P}{S}} = \sqrt{\frac{2 \times 2400 \times 4}{0.288}} = \sqrt{66667} = 258 \text{ units}$$

ROL = 1/2 month × 2400/12 = 100 units

	Rs
Total Annual Inventory Cost:	
Cost of 2400 units at Rs 2.40	5760.00
Ordering cost 2400/258 = 9.3 orders	
Approximately 10 orders at Rs 4	40.00
Carrying cost of average inventory of 258 units	
$= \frac{258}{2} = 129$ units	
i.e., 129 units × Rs 0.288	37.15
Total Annual Inventory Cost	5837.15

Unit Price Rs 5

$$EOQ = \sqrt{\frac{2 \times 2400 \times 4}{12\% \text{ of } 5.00}} = \sqrt{32000} = 179 \text{ units}$$

	Rs
Total Annual Inventory Cost:	
Cost of 2400 units at Rs 5 each	12,000
Ordering cost 24000/179 = 13.4 orders	
Or 14 orders at Rs 4 each	56.00
Carrying cost 179/2 × 0.60	53.70
Total annual inventory cost	12109.70

Difference = Rs 12109.70 – 5837.15
= Rs 6272.55

Example 3.18

A Ltd. is committed to supply 24,000 bearings per annum to *B* Ltd. on a steady basis. It is estimated that it costs 10 paise as inventory holding cost per bearing per month and that the set-up cost per run of bearing manufacture is Rs. 324.

(i) What should be the optimum run size for bearing manufacture?
(ii) What would be the interval between two consecutive optimum runs?
(iii) Find out the minimum inventory cost per annum.

Solution: *(CA Inter, Nov. 2000)*

(i) *Optimum run size for bearing manufacture*

$$= \sqrt{\frac{2 \times \text{Annual supply of bearings} \times \text{Set-up cost per production run}}{\text{Annual holding cost per bearing}}}$$

$$= \sqrt{\frac{2 \times 24{,}000 \text{ bearings} \times \text{Rs. } 324}{12 \text{ months} \times 0.10\text{P.}}} = \sqrt{12960000}$$

= 3600 bearings

(ii) *Interval between two consecutive optimum runs*

$$= \frac{12 \text{ months}}{\text{Number of production runs per annum}} = \frac{12 \text{ months}}{\left(\frac{\text{Annual production}}{\text{Optimum run size}}\right)}$$

$$= \frac{12 \text{ months}}{\left(\frac{24{,}000 \text{ bearings}}{3{,}600 \text{ bearings}}\right)} = \frac{12 \text{ months}}{6.66}$$

= 1.8 months or 55 days approximately

(iii) *Minimum inventory cost per annum*

= Total production run cost + Total carrying cost per annum

$$= \frac{24{,}000 \text{ bearings}}{3{,}600 \text{ bearings}} \times \text{Rs. } 324 + (1/2)\ 3{,}600 \text{ bearings} \times 0.10\ \text{P} \times 12 \text{ months}$$

= Rs. 2,160 + Rs. 2,160

= Rs. 4,320

Example 3.19

PQR Tubes Ltd. are the manufacturers of picture tubes for T.V. The following are the details of their operations during 1999-2000:

Ordering cost	*Rs. 100 per order*
Inventory carrying cost	20% p.a.
Cost of tubes	Rs. 500 per tube
Normal usage	100 tubes per week
Minimum usage	50 tubes per week
Maximum usage	200 tubes per week
Lead time to supply	6–8 weeks

Required:

(i) Economic order quantity. If the supplier is willing to supply quarterly 1,500 units at a discount of 5%, is it worth accepting?

(ii) Re-order level

(iii) Maximum level of stock

(iv) Minimum level of stock

(CA Inter May 2000)

Solution

(b) (i) *Economic order quantity (EOQ)* $= \sqrt{\frac{2u \times P}{S}}$

Here u is the annual requirement of tubes,

P is the ordering cost per order.

S is the inventory carrying cost p.u. p.a.

$$E.O.Q. = \sqrt{\frac{2 \times (100 \text{ tubes} \times 52 \text{ weeks}) \times (\text{Rs. } 100 \text{ per order})}{20\% \times \text{Rs. } 500}}$$

$$E.O.Q. = \sqrt{\frac{2 \times 5{,}200 \text{ tubes} \times \text{Rs. } 100}{\text{Rs. } 100}} = 102 \text{ tubes (approx.)}$$

$(T.C)_{q = 102 \text{ units}}$ = Total purchase cost of 5,200 + Total ordering cost + Total carrying cost

$$= 5{,}200 \text{ units} \times \text{Rs } 500 + \frac{5{,}200 \text{ units}}{102 \text{ units}} \times \text{Rs } 100 + \frac{1}{2} \times 102 \text{ units} \times \text{Rs. } 100$$

$$= \text{Rs } 26{,}00{,}000 + \text{Rs } 5{,}098 + \text{Rs } 5{,}100$$

$$= \text{Rs } 26{,}10{,}198$$

Total cost when the supplier is willing to give a discount of 5% on an order size of 1,500 units will be:

$$(T.C)_{q = 1{,}500 \text{ units}} = 5{,}200 \text{ units} \times \text{Rs } 475 + \frac{5{,}200 \text{ units}}{1{,}500 \text{ units}} \times \text{Rs } 100 + \frac{1}{2} \times 1{,}500 \times 20\% \times \text{Rs } 475$$

$$= \text{Rs } 24{,}70{,}000 + \text{Rs. } 346.66 + \text{Rs } 71{,}250$$

$$= \text{Rs } 25{,}41{,}596.66 \text{ approx.}$$

Decision Since the total cost of inventory when supplier supplies quarterly 1,500 units at a discount of 5% is less than that when the order size is of 102 units. Therefore, it is advisable to accept the offer of 5% discount and save a sum of Rs. 68,601.34 (Rs 26,10,198 – Rs. 25,41.596.66).

Note: In the case of *EOQ* the total ordering cost and the total carrying cost are always equal, but in the above case it is not so because of the approximation made in arriving at the figure of *EOQ*.

(ii) *Re-order level (ROL)*

= Maximum usage × Maximum lead time to supply

= 200 tubes per week × 8 weeks

= 1,600 tubes.

(iii) *Maximum level of stock*

= Re-order level + Re-order quantity – Minimum usage × Minimum lead time to supply

= 1,600 tubes + 102 tubes – 50 tubes × 6 weeks

= 1,402 tubes.

(iv) *Minimum level of stock*

= Re-order level – Normal usage × Average lead time to supply

= 1,600 tubes – 100 tubes × 7 weeks.

= 900 tubes.

STORES ORGANISATION

Efficient storing—after efficient purchasing—is another important step in materials control system. The storekeeper and persons working in stores are primarily responsible for safeguarding the materials and keeping materials and supplies in proper places until required in production. It is difficult to list