Inventory Management

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Inventory

- ☑ One of the most expensive assets of many companies representing as much as 50% of total invested capital
- ☑ Operations managers must balance inventory investment and customer service

Types of Inventory

- ☑ ***Raw material***
  - ☑ ***Purchased but not processed***
- ☑ ***Work-in-process***
  - ☑ ***Undergone some change but not completed***
  - ☑ ***A function of cycle time for a product***
- ☑ ***Maintenance/repair/operating (MRO)***
  - ☑ ***Necessary to keep machinery and processes productive***
- ☑ ***Finished goods***
  - ☑ ***Completed product awaiting shipment***

Holding, Ordering, and Setup Costs

- ☑ ***Holding costs* - the costs of holding or "carrying" inventory over time**
- ☑ ***Ordering costs* - the costs of placing an order and receiving goods**
- ☑ ***Setup costs* - cost to prepare a machine or process for manufacturing an order**

Holding Costs

- *Housing costs (including rent or depreciation, operating costs, taxes, insurance)*

- *Material handling costs (equipment lease or depreciation, power, operating cost)*

- *Labor cost*

- *Investment costs (borrowing costs, taxes, and insurance on inventory)*

- *Pilferage, space, and obsolescence*

Table 12.1

Inventory Models for Independent Demand

Need to determine when and how much to order

- ☑ ***Basic economic order quantity***
- ☑ ***Production order quantity***
- ☑ ***Quantity discount model***

Basic EOQ Model

Important assumptions

1. *Demand is known, constant, and independent*
2. *Lead time is known and constant*
3. *Receipt of inventory is instantaneous and complete*
4. *Quantity discounts are not possible*
5. *Only variable costs are setup and holding*
6. *Stockouts can be completely avoided*

Inventory Usage Over Time

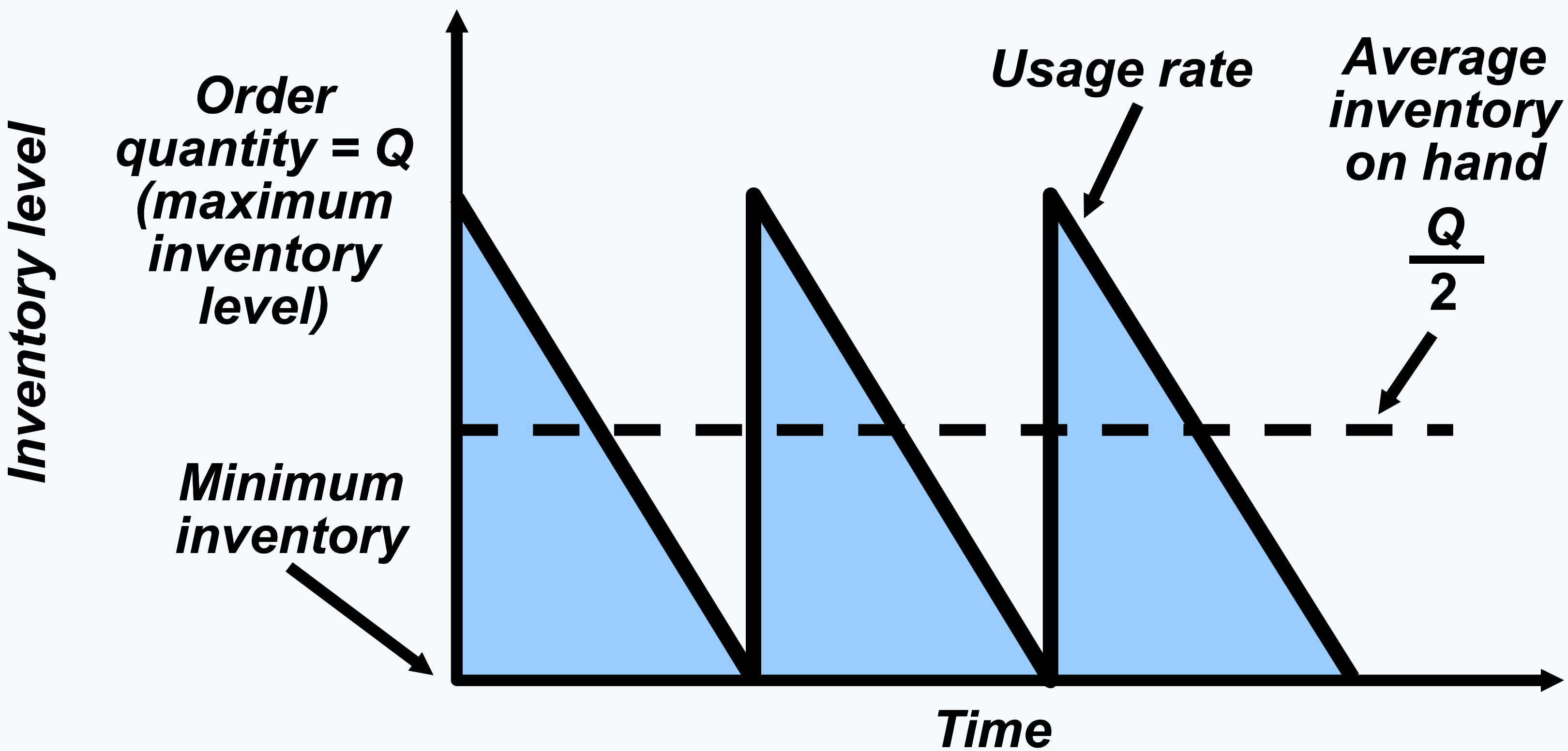

Figure 12.3

Minimizing Costs

Objective is to minimize total costs

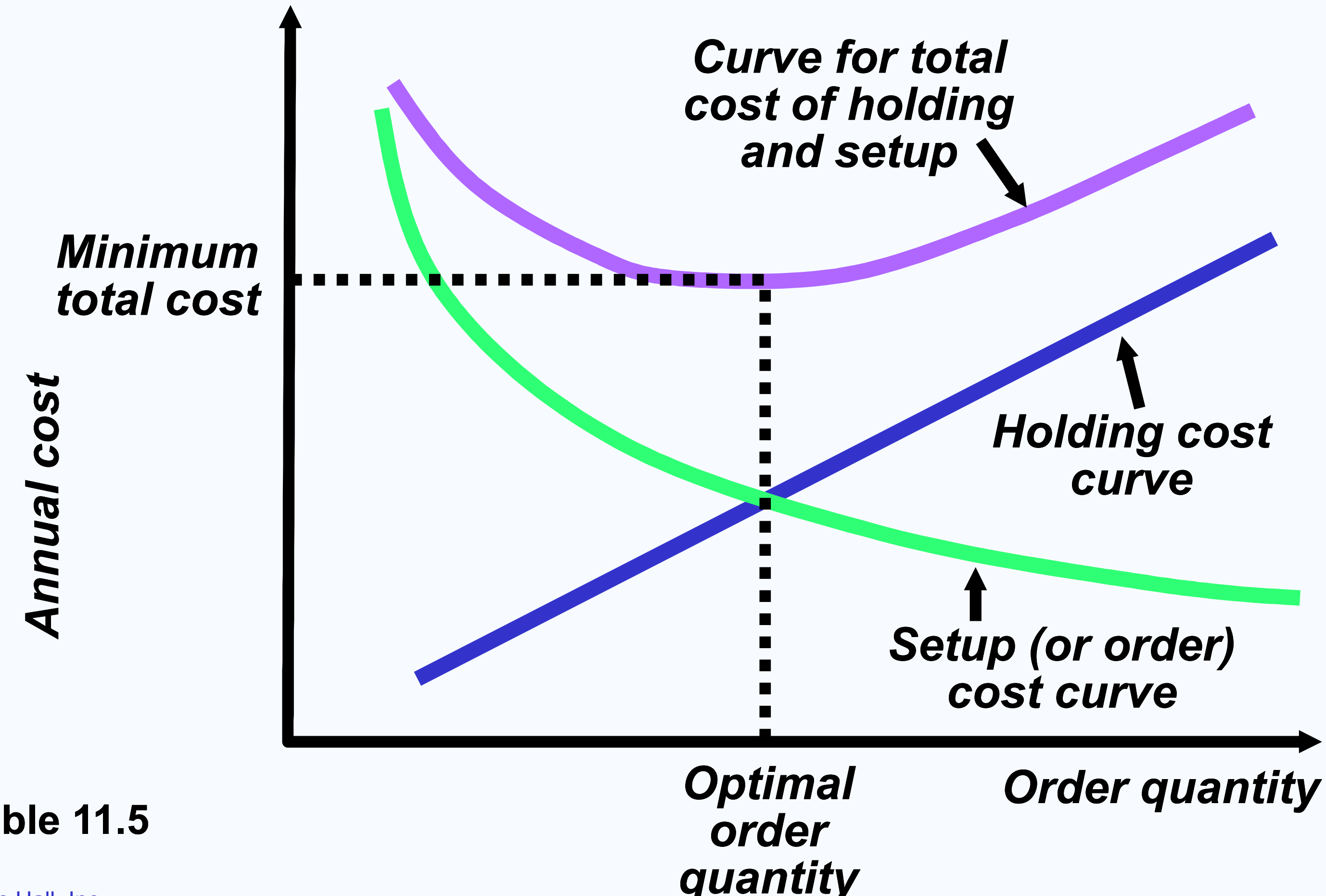

Table 11.5

The EOQ M

Annual setup cost = $\frac{D}{Q}S$

Q = Number of pieces per order
*Q** = Optimal number of pieces per order (EOQ)
D = Annual demand in units for the Inventory item
S = Setup or ordering cost for each order
H = Holding or carrying cost per unit per year

Annual setup cost = (Number of orders placed per year) x (Setup or order cost per order)

$$= \left(\frac{\text{Annual demand}}{\text{Number of units in each order}}\right)\left(\begin{array}{c}\text{Setup or order}\\ \text{cost per order}\end{array}\right)$$

$$= \left(\frac{D}{Q}\right)(S)$$

The EOQ M

$$\textit{Annual setup cost} = \frac{D}{Q}S$$

$$\textit{Annual holding cost} = \frac{Q}{2}H$$

Q = *Number of pieces per order*
*Q** = *Optimal number of pieces per order (EOQ)*
D = *Annual demand in units for the Inventory item*
S = *Setup or ordering cost for each order*
H = *Holding or carrying cost per unit per year*

Annual holding cost = (*Average inventory level*)
x (*Holding cost per unit per year*)

$$= \left(\frac{\textit{Order quantity}}{2}\right)(\textit{Holding cost per unit per year})$$

$$= \left(\frac{Q}{2}\right)(H)$$

The EOQ Model

$$\text{Annual setup cost} = \frac{D}{Q}S$$

$$\text{Annual holding cost} = \frac{Q}{2}H$$

Q = *Number of pieces per order*
*Q** = *Optimal number of pieces per order (EOQ)*
D = *Annual demand in units for the Inventory item*
S = *Setup or ordering cost for each order*
H = *Holding or carrying cost per unit per year*

Optimal order quantity is found when annual setup cost equals annual holding cost

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

*Solving for Q**

$$2DS = Q^2H$$

$$Q^2 = 2DS/H$$

$$Q^* = \sqrt{2DS/H}$$

An EOQ Example

Determine optimal number of needles to order
D = 1,000 *units*
S = $10 *per order*
H = $.50 *per unit per year*

$$Q^* = \sqrt{\frac{2DS}{H}}$$

$$Q^* = \sqrt{\frac{2(1{,}000)(10)}{0.50}} = \sqrt{40{,}000} = 200 \text{ units}$$

An EOQ Example

Determine optimal number of needles to order

D = 1,000 *units*

S = $10 *per order*

H = $.50 *per unit per year*

Q^* = 200 *units*

$$\text{Expected number of orders} = N = \frac{\text{Demand}}{\text{Order quantity}} = \frac{D}{Q^*}$$

$$N = \frac{1{,}000}{200} = 5 \text{ orders per year}$$

An EOQ Example

Determine optimal number of needles to order

D = 1,000 *units*

S = \$10 *per order*

H = \$.50 *per unit per year*

Q^* = 200 *units*

N = 5 *orders per year*

$$\text{Expected time between orders} = T = \frac{\text{Number of working days per year}}{N}$$

$$T = \frac{250}{5} = 50 \text{ days between orders}$$

An EOQ Example

Determine optimal number of needles to order

D = 1,000 *units*
S = \$10 *per order*
H = \$.50 *per unit per year*

Q^* = 200 *units*
N = 5 *orders per year*
T = 50 *days*

Total annual cost = Setup cost + Holding cost

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

$$TC = \frac{1{,}000}{200}(\$10) + \frac{200}{2}(\$.50)$$

$$TC = (5)(\$10) + (100)(\$.50) = \$50 + \$50 = \$100$$

Reorder Points

- ☑ EOQ answers the "how much" question
- ☑ The reorder point (ROP) tells when to order

$$ROP = \begin{pmatrix} \text{Demand} \\ \text{per day} \end{pmatrix} \begin{pmatrix} \text{Lead time for a} \\ \text{new order in days} \end{pmatrix}$$

$$= d \times L$$

$$d = \frac{D}{\text{Number of working days in a year}}$$

Reorder Point Curve

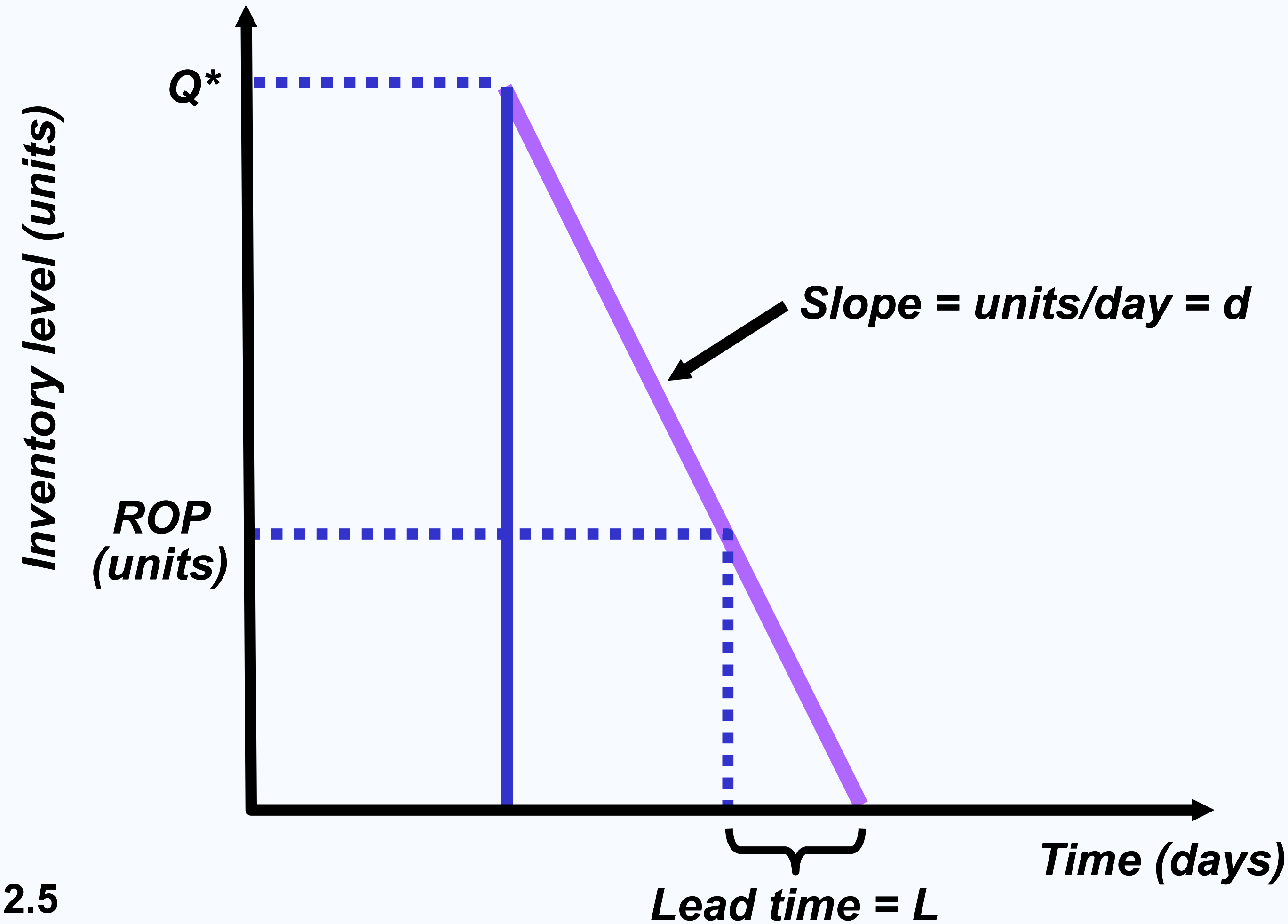

Figure 12.5

Reorder Point Example

Demand **= 8,000** ***DVDs per year***
250 ***working day year***
Lead time for orders is **3** ***working days***

$$d = \frac{D}{\text{Number of working days in a year}}$$

$$= 8{,}000/250 = 32 \textit{ units}$$

$$\text{ROP} = d \times L$$

$$= 32 \textit{ units per day} \times 3 \textit{ days} = 96 \textit{ units}$$

Production Order Quantity Model

- ☑ ***Used when inventory builds up over a period of time after an order is placed***
- ☑ ***Used when units are produced and sold simultaneously***

Production Order Quantity Model

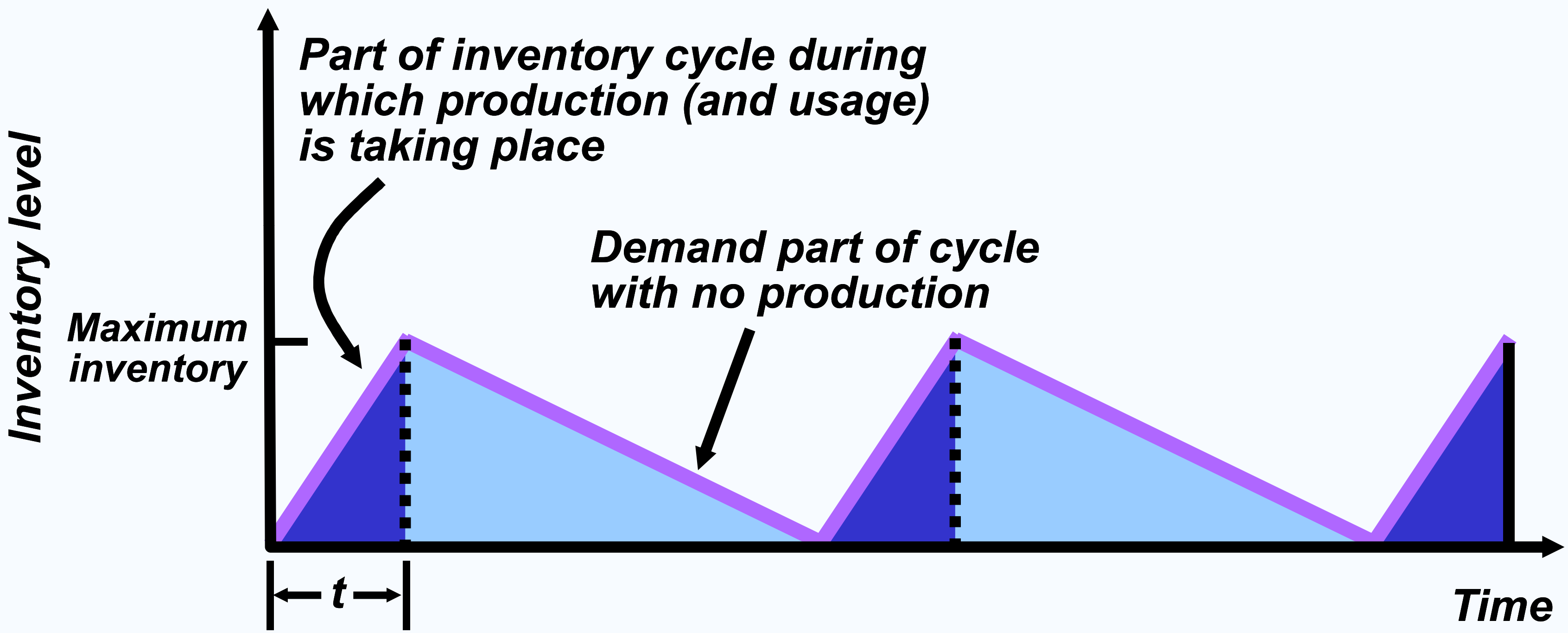

Figure 12.6

Production Order Quantity Model

Q = Number of pieces per order
H = Holding cost per unit per year
D = Annual demand
p = Daily production rate
d = Daily demand/usage rate

$$\text{Setup cost} = (D/Q)S$$

$$\text{Holding cost} = 1/2\, HQ[1 - (d/p)]$$

$$(D/Q)S = 1/2\, HQ[1 - (d/p)]$$

$$Q^2 = \frac{2DS}{H[1 - (d/p)]}$$

$$Q^* = \sqrt{\frac{2DS}{H[1 - (d/p)]}}$$

Production Order Quantity Example

D = 1,000 *units*
S = \$10
H = \$0.50 *per unit per year*

p = 8 *units per day*
d = 4 *units per day*

$$Q^* = \sqrt{\frac{2DS}{H[1 - (d/p)]}}$$

$$Q^* = \sqrt{\frac{2(1{,}000)(10)}{0.50[1 - (4/8)]}} = \sqrt{80{,}000}$$

= 282.8 *or* 283 *hubcaps*

Quantity Discount Models

- ☑ ***Reduced prices are often available when larger quantities are purchased***
- ☑ ***Trade-off is between reduced product cost and increased holding cost***

Total cost = Setup cost + Holding cost + Product cost

$$TC = \frac{D}{Q}S + \frac{QH}{2} + PD$$

Quantity Discount Models

A typical quantity discount schedule

Discount Number	*Discount Quantity*	*Discount (%)*	*Discount Price (P)*
1	0 *to* 999	*no discount*	$5.00
2	1,000 *to* 1,999	4	$4.80
3	2,000 *and over*	5	$4.75

Table 12.2

Quantity Discount Models

Steps in analyzing a quantity discount

1. For each discount, calculate Q*
2. If Q* for a discount doesn't qualify, choose the smallest possible order size to get the discount
3. Compute the total cost for each Q* or adjusted value from Step 2
4. Select the Q* that gives the lowest total cost

Quantity Discount Example

Calculate Q* for every discount

$$Q^* = \sqrt{\frac{2DS}{IP}}$$

$$Q_1^* = \sqrt{\frac{2(5{,}000)(49)}{(.2)(5.00)}} = 700 \textit{ cars order}$$

$$Q_2^* = \sqrt{\frac{2(5{,}000)(49)}{(.2)(4.80)}} = 714 \textit{ cars order}$$

$$Q_3^* = \sqrt{\frac{2(5{,}000)(49)}{(.2)(4.75)}} = 718 \textit{ cars order}$$

Quantity Discount Example

$$Q^* = \sqrt{\frac{2DS}{IP}}$$

Calculate Q* for every discount

$$Q_1^* = \sqrt{\frac{2(5{,}000)(49)}{(.2)(5.00)}} = 700 \textit{ cars order}$$

$$Q_2^* = \sqrt{\frac{2(5{,}000)(49)}{(.2)(4.80)}} = \cancel{714} \textit{ cars order}$$

$$1{,}000 \text{ — } \textit{adjusted}$$

$$Q_3^* = \sqrt{\frac{2(5{,}000)(49)}{(.2)(4.75)}} = \cancel{718} \textit{ cars order}$$

$$2{,}000 \text{ — } \textit{adjusted}$$

Quantity Discount Example

…

$$TC_{Q=700} = \frac{5{,}000}{700} \times 49 + \frac{700}{2} \times 0.2 \times 5.00 + 5.00 \times 5000 = \$25{,}700$$

$$TC_{Q=1000} = \frac{5{,}000}{1000} \times 49 + \frac{1000}{2} \times 0.2 \times 4.80 + 4.80 \times 5000 = \boxed{\$24{,}725}$$

$$TC_{Q=2000} = \frac{5{,}000}{2000} \times 49 + \frac{2000}{2} \times 0.2 \times 4.75 + 4.75 \times 5000 = \$24{,}822.50$$

Quantity Discount Example

Discount Number	Unit Price	Order Quantity	Annual Product Cost	Annual Ordering Cost	Annual Holding Cost	Total
1	$5.00	700	$25,000	$350	$350	$25,700
2	$4.80	1,000	$24,000	$245	$480	$24,725
3	$4.75	2,000	$23.750	$122.50	$950	$24,822.50

Table 12.3

Choose the price and quantity that gives the lowest total cost

Buy* 1,000 *units at* $4.80 *per unit