# *Chapter 6*

# *Inventory Control Models*

**To accompany**
***Quantitative Analysis for Management*, *Eleventh Edition*, *Global Edition***
**by Render, Stair, and Hanna**
**Power Point slides created by Brian Peterson**

# *Learning Objectives*

**After completing this chapter, students will be able to:**

1. **Understand the importance of inventory control and ABC analysis.**
2. **Use the economic order quantity (EOQ) to determine how much to order.**
3. **Compute the reorder point (ROP) in determining when to order more inventory.**
4. **Handle inventory problems that allow quantity discounts or non-instantaneous receipt.**

# *Learning Objectives*

**After completing this chapter, students will be able to:**

5. **Understand the use of safety stock.**
6. **Describe the use of material requirements planning in solving dependent-demand inventory problems.**
7. **Discuss just-in-time inventory concepts to reduce inventory levels and costs.**
8. **Discuss enterprise resource planning systems.**

# *Chapter Outline*


6.1 Introduction
6.2 Importance of Inventory Control
6.3 Inventory Decisions
6.4 Economic Order Quantity: Determining How Much to Order
6.5 Reorder Point: Determining When to Order
6.6 EOQ Without the Instantaneous Receipt Assumption
6.7 Quantity Discount Models
6.8 Use of Safety Stock

# Introduction

- Inventory is an expensive and important asset to many companies.
- Inventory is any stored resource used to satisfy a current or future need.
- Common examples are raw materials, work-in-process, and finished goods.
- Most companies try to balance high and low inventory levels with cost minimization as a goal.
  - Lower inventory levels can reduce costs.
  - Low inventory levels may result in stockouts and dissatisfied customers.

# *Introduction*

- **All organizations have some type of inventory control system.**
- **Inventory planning helps determine what goods and/or services need to be produced.**
- **Inventory planning helps determine whether the organization produces the goods or services or whether they are purchased from another organization.**
- **Inventory planning also involves demand forecasting.**

# Introduction

## Inventory planning and control

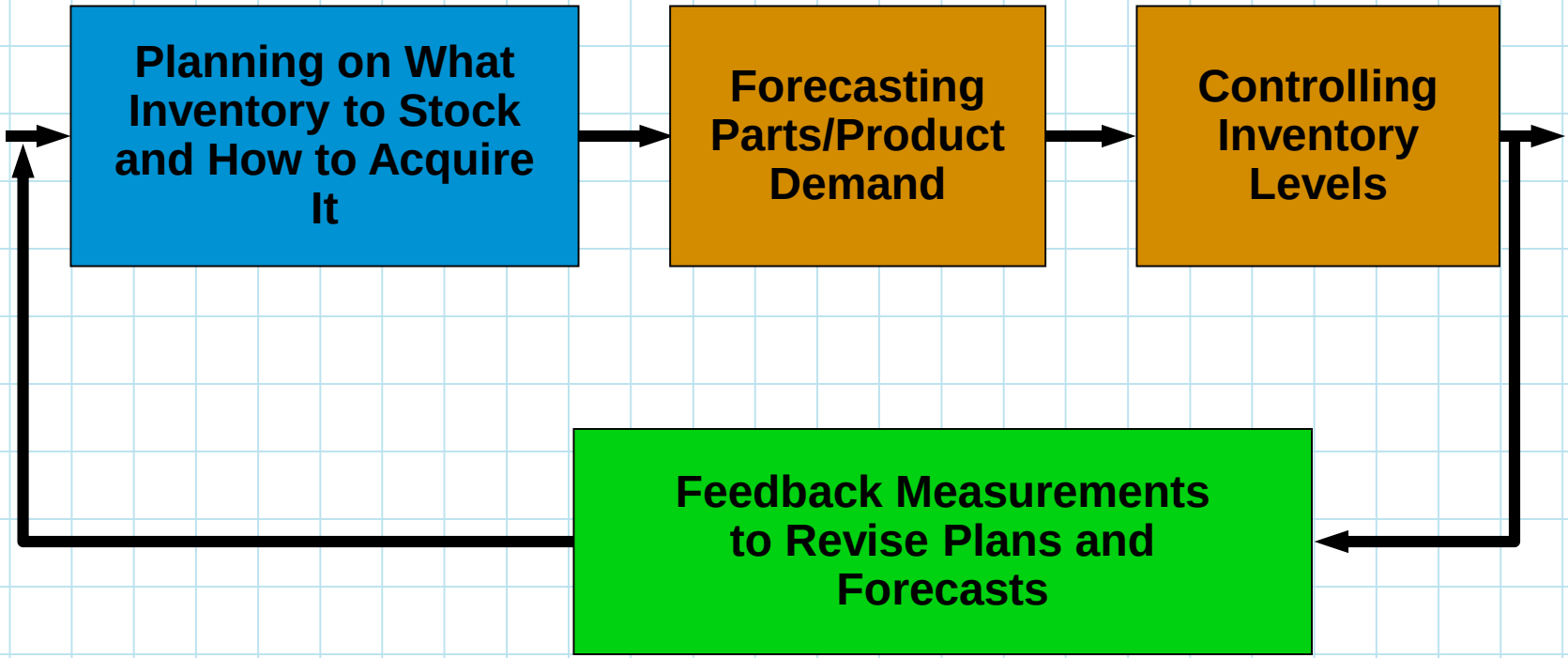


**Figure 6.1**

# *Importance of Inventory Control*

- **Five uses of inventory:**
  - **The decoupling function**
  - **Storing resources**
  - **Irregular supply and demand**
  - **Quantity discounts**
  - **Avoiding stockouts and shortages**
- **Decouple manufacturing processes.**
  - **Inventory is used as a buffer between stages in a manufacturing process.**
  - **This reduces delays and improves efficiency.**

# *Importance of Inventory Control*

- **Storing resources.**
  - **Seasonal products may be stored to satisfy off-season demand.**
  - **Materials can be stored as raw materials, work-in-process, or finished goods.**
  - **Labor can be stored as a component of partially completed subassemblies.**
- **Compensate for irregular supply and demand.**
  - **Demand and supply may not be constant over time.**
  - **Inventory can be used to buffer the variability.**

# *Importance of Inventory Control*

- **Take advantage of quantity discounts.**
  - **Lower prices may be available for larger orders.**
  - **Extra costs associated with holding more inventory must be balanced against lower purchase price.**
- **Avoid stockouts and shortages.**
  - **Stockouts may result in lost sales.**
  - **Dissatisfied customers may choose to buy from another supplier.**

# *Inventory Decisions*

- There are two fundamental decisions in controlling inventory:
  - How much to order.
  - When to order.
- The major objective is to minimize total inventory costs.
- Common inventory costs are:
  - Cost of the items (purchase or material cost).
  - Cost of ordering.
  - Cost of carrying, or holding, inventory.
  - Cost of stockouts.

# Inventory Cost Factors

| ORDERING COST FACTORS | CARRYING COST FACTORS |
|---|---|
| Developing and sending purchase orders | Cost of capital |
| Processing and inspecting incoming inventory | Taxes |
| Bill paying | Insurance |
| Inventory inquiries | Spoilage |
| Utilities, phone bills, and so on, for the purchasing department | Theft |
| Salaries and wages for the purchasing department employees | Obsolescence (Expiration) |
| Supplies, such as forms and paper, for the purchasing department | Salaries and wages for warehouse employees |
| | Utilities and building costs for the warehouse |
| | Supplies, such as forms and paper, for the warehouse |

**Table 6.1**

# *Inventory Cost Factors*

- **Ordering costs are generally independent of order quantity.**
  - **Many involve personnel time.**
  - **The amount of work is the same no matter the size of the order.**
- **Carrying costs generally varies with the amount of inventory, or the order size.**
  - **The labor, space, and other costs increase as the order size increases.**
- **The actual cost of items purchased can vary if there are quantity discounts available.**

# *Economic Order Quantity*

- **The *economic order quantity* (*EOQ*) model is one of the oldest and most commonly known inventory control techniques.**
- **It is easy to use but has a number of important assumptions.**
- **Objective is to minimize total cost of inventory.**

# Economic Order Quantity

**Assumptions:**

1. **Demand is known and constant.**
2. **Lead time is known and constant.**
3. **Receipt of inventory is *instantaneous.***
4. **Purchase cost per unit is constant throughout the year.**
5. **The only variable costs are the cost of placing an order, *ordering cost*, and the cost of holding or storing inventory over time, *holding* or *carrying cost*, and these are constant throughout the year.**
6. **Orders are placed so that stockouts or shortages are avoided completely.**

# Inventory Usage Over Time

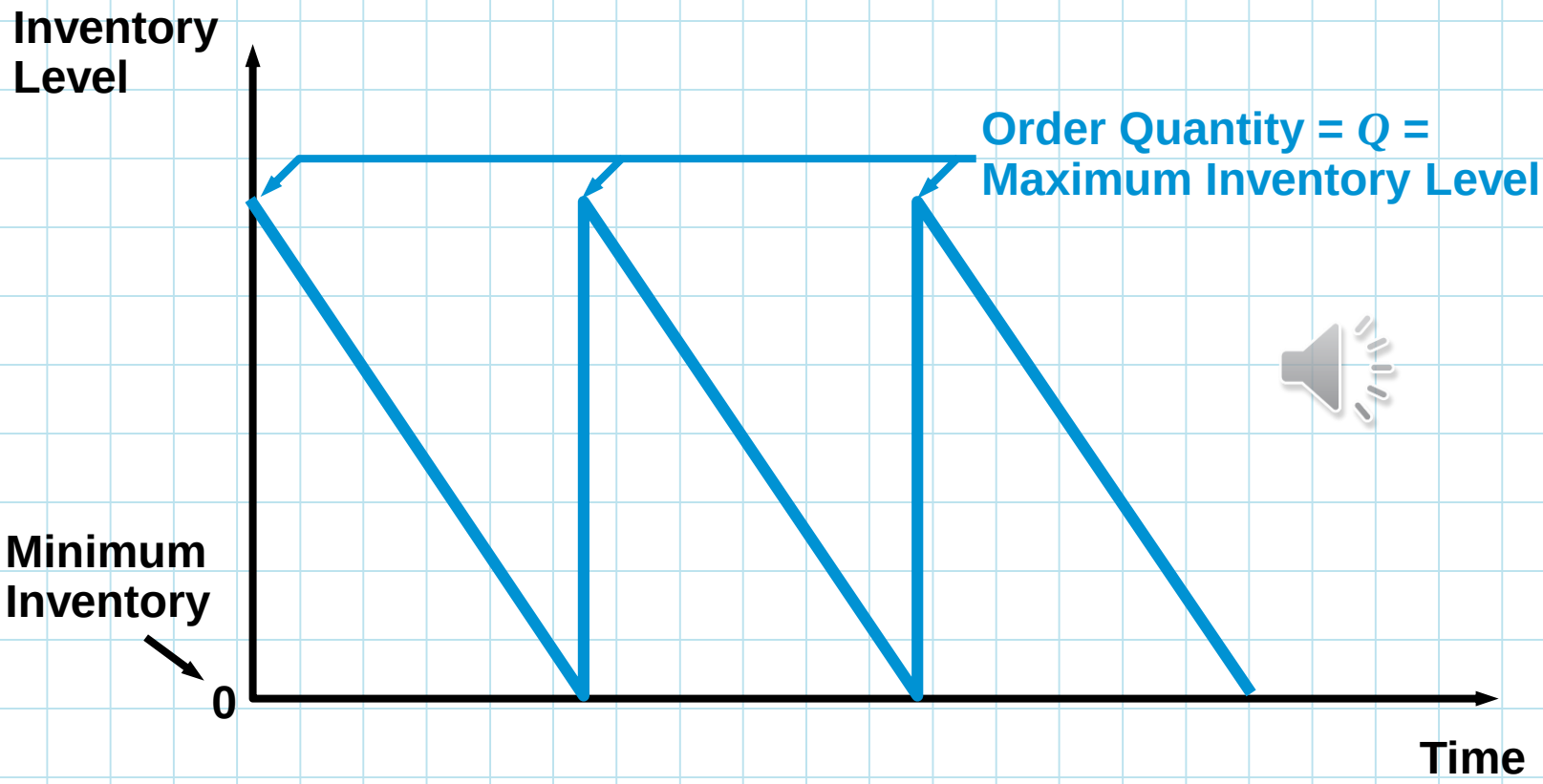


Figure 6.2

# Inventory Costs in the EOQ Situation

## Computing Average Inventory

$$\text{Average inventory level} = \frac{Q}{2}$$

| DAY, Demand=2 | INVENTORY LEVEL | | |
|---|---|---|---|
| | BEGINNING | ENDING | AVERAGE |
| April 1 (order received) | 10 | 8 | 9 |
| April 2 | 8 | 6 | 7 |
| April 3 | 6 | 4 | 5 |
| April 4 | 4 | 2 | 3 |
| April 5 | 2 | 0 | 1 |

Maximum level April 1 = 10 units
Total of daily averages = 9 + 7 + 5 + 3 + 1 = 25
Number of days = 5
Average inventory level = 25/5 = 5 units

Table 6.2

# Inventory Costs in the EOQ Situation

**Mathematical equations can be developed using:**

$Q$ = number of pieces to order
EOQ = $Q^*$ = optimal number of pieces to order
$D$ = annual demand in units for the inventory item
$C_o$ = ordering cost of each order
$C_h$ = holding or carrying cost per unit per year

$$\text{Annual ordering cost} = \left(\begin{array}{c}\text{Number of}\\ \text{orders placed}\\ \text{per year}\end{array}\right) \times \left(\begin{array}{c}\text{Ordering}\\ \text{cost per}\\ \text{order}\end{array}\right)$$

$$= \frac{D}{Q}C_o$$

# Inventory Costs in the EOQ Situation

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$D$ = annual demand in units for the inventory item
$C_o$ = ordering cost of each order
$C_h$ = holding or carrying cost per unit per year

$$\text{Annual holding cost} = \left(\text{Average inventory}\right) \times \left(\text{Carrying cost per unit per year}\right)$$

$$= \frac{Q}{2} C_h$$

# Inventory Costs in the EOQ Situation

## Total Cost as a Function of Order Quantity

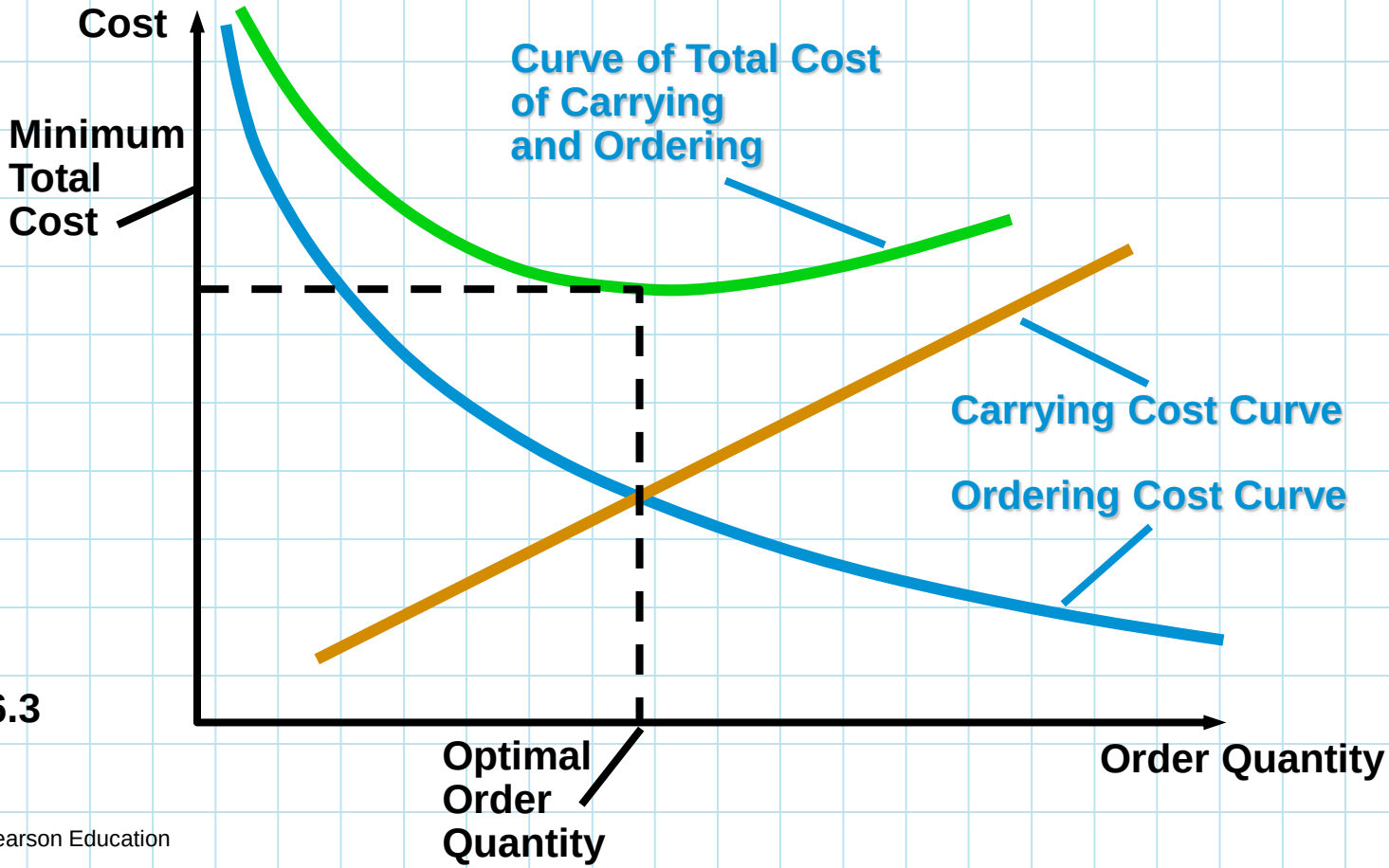


Figure 6.3

# Finding the EOQ

**According to the graph, when the EOQ assumptions are met, total cost is minimized when annual ordering cost equals annual holding cost.**

$$\frac{D}{Q}C_o = \frac{Q}{2}C_h$$

**Solving for $Q$**

$$2DC_o = Q^2C_h$$

$$\frac{2DC_o}{C_h} = Q^2$$

$$\sqrt{\frac{2DC_o}{C_h}} = Q = \text{EOQ} = Q^*$$

# Economic Order Quantity (EOQ) Model

## Summary of equations:

$$\text{Annual ordering cost} = \frac{D}{Q}C_o$$

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

$$\text{EOQ} = Q^* = \sqrt{\frac{2DC_o}{C_h}}$$

# *Sumco Pump Company*

- **Sumco Pump Company sells pump housings to other companies.**
- **The firm would like to reduce inventory costs by finding optimal order quantity.**
  - **Annual demand = 1,000 units**
  - **Ordering cost = $10 per order**
  - **Average carrying cost per unit per year = $0.50**

# First Calculate the Q*

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

# Sumco Pump Company

**Total annual cost = Order cost + Holding cost**

$$TC = \frac{D}{Q}C_o + \frac{Q}{2}C_h$$

$$= \frac{1{,}000}{200}(10) + \frac{200}{2}(0.5)$$

$$= \$50 + \$50 = \$100$$