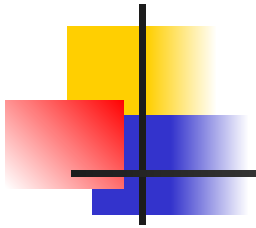
Chapter 3 - Product Design & Process Selection



Operations Management

by

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Learning Objectives

- Define product design and explain its strategic impact on organizations
- Describe steps to develop a product design
- Using break-even analysis as a tool in selecting between alternative products
- Identify different types of processes and explain their characteristics

Learning Objectives – con't

- Understand how to use a process flowchart
- Understand how to use process performance metrics
- Understand current technology advancements and how they impact process and product design
- Understand issues impacting the design of service operations

Product Design & Process Selection - defined

Product design – the process of defining all of the companies product characteristics

- Product design must support product manufacturability (the ease with which a product can be made)
- Product design defines a product's characteristics of:

•appearance,
•materials,
•dimensions,
•tolerances, and
•performance standards.

Process Selection – the development of the process necessary to produce the designed product.

Design of Services versus Goods

- Service design is unique in that the service and entire service concept are being designed
  - must define both the service and concept
    - Physical elements, aesthetic & psychological benefits
      - e.g. promptness, friendliness, ambiance
  - Product and service design must match the needs and preferences of the targeted customer group

The Product Design Process

Idea development: all products begin with an idea whether from:

- customers,
- competitors or
- suppliers

Reverse engineering: buying a competitor's product

Product Design Process

- Idea developments selection affects
  - Product quality
  - Product cost
  - Customer satisfaction
  - Overall **manufacturability** – the ease with which the product can be made

The Product Design Process

Step 1 - Idea Development - Someone thinks of a need and a product/service design to satisfy it: customers, marketing, engineering, competitors, benchmarking, reverse engineering

Step 2 - Product Screening - Every business needs a formal/structured evaluation process: fit with facility and labor skills, size of market, contribution margin, break-even analysis, return on sales

Step 3 – Preliminary Design and Testing - Technical specifications are developed, prototypes built, testing starts

Step 4 – Final Design - Final design based on test results, facility, equipment, material, & labor skills defined, suppliers identified

Product Screening Tool – Break-Even Analysis

- Computes the quantity of goods company needs to sell to cover its costs

$$Q_{BE} = F/ (SP - VC)$$

  - Q_{BE} – Break even quantity
  - F – Fixed costs
  - SP – selling price/unit
  - VC – Variable cost

Product Screening Tool – Break-Even Analysis con't

- Break-even analysis also includes calculating
  - Total cost – sum of fixed and variable cost

    $$\text{Total cost} = F + (VC)*Q$$

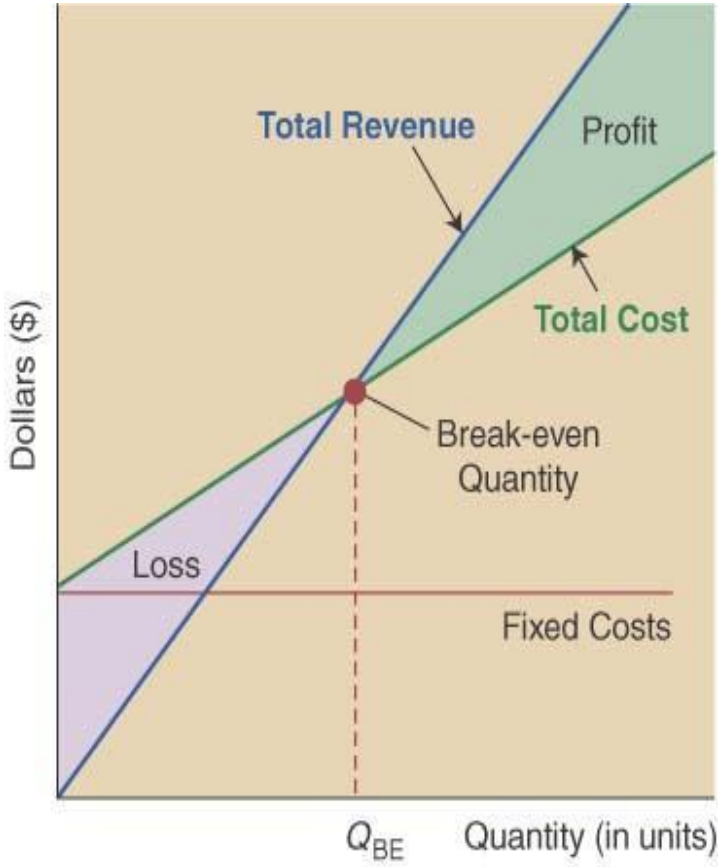
  - Revenue – amount of money brought in from sales

    $$\text{Revenue} = (SP) * Q$$

Q = number of units sold

Break-Even Analysis: Graphical Approach

- Compute quantity of goods that must be sold to break-even
- Compute total revenue at an assumed selling price
- Compute fixed cost and variable cost for several quantities
- Plot the total revenue line and the total cost line
- Intersection is break-even
- Sensitivity analysis can be done to examine changes in all of the assumptions made



Break-Even Example:

A company is planning to establish a chain of movie theaters. It estimates that each new theater will cost approximately $1 Million. The theaters will hold 500 people and will have 4 showings each day with average ticket prices at $8. They estimate that concession sales will average $2 per patron. The variable costs in labor and material are estimated to be $6 per patron. They will be open 300 days each year. What must average occupancy be to break-even?

Break-Even Example Calculations

- **Break-Even Point**

  Total revenues = Total costs @ break-even point Q

  Selling price*Q = Fixed cost + variable cost*Q

  ($8+$2)Q= $1,000,000 + $6*Q

  Q = **250,000 patrons (42% occupancy)**

- **What is the gross profit if they sell 300,000 tickets**

  Profit = Total Revenue – Total Costs

  P = $10*300,000 – (1,000,000 + $6*300,000)

  P = **$200,000**

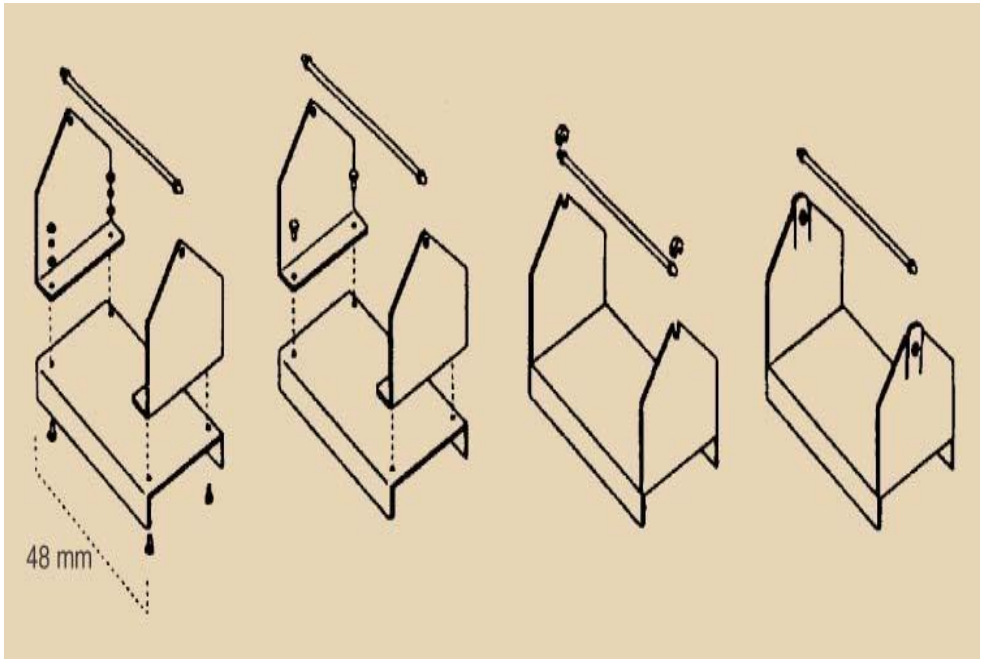
- **If concessions only average $.50/patron, what is break-even Q now? (sensitivity analysis)**

  ($8.50)Q = 1,000,000 - $6*Q

  Q = **400,000 patrons (67% occupancy)**

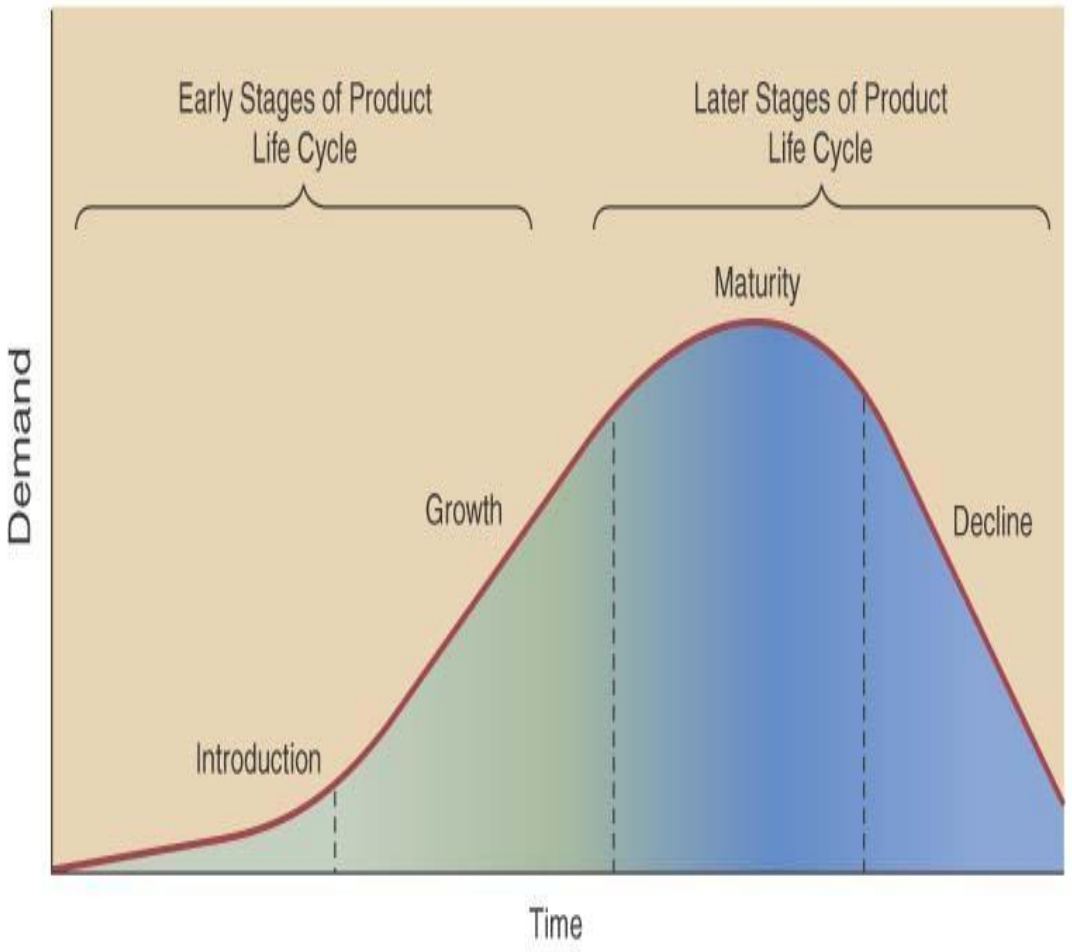
Factors Impacting Product Design

- Must **Design for Manufacturing** – **DFM**
- **Guidelines to produce a product easily and profitably**
  - **Simplification - Minimize parts**
  - **Standardization**
    - **Design parts for multiply applications**
  - **Use modular design**
  - **Simplify operations**



Factors In Product Life Cycle

- **Product life cycle – series of changing product demand**
- **Consider product life cycle stages**
  - **Introduction**
  - **Growth**
  - **Maturity**
  - **Decline**
- **Facility & process investment depends on life cycle**



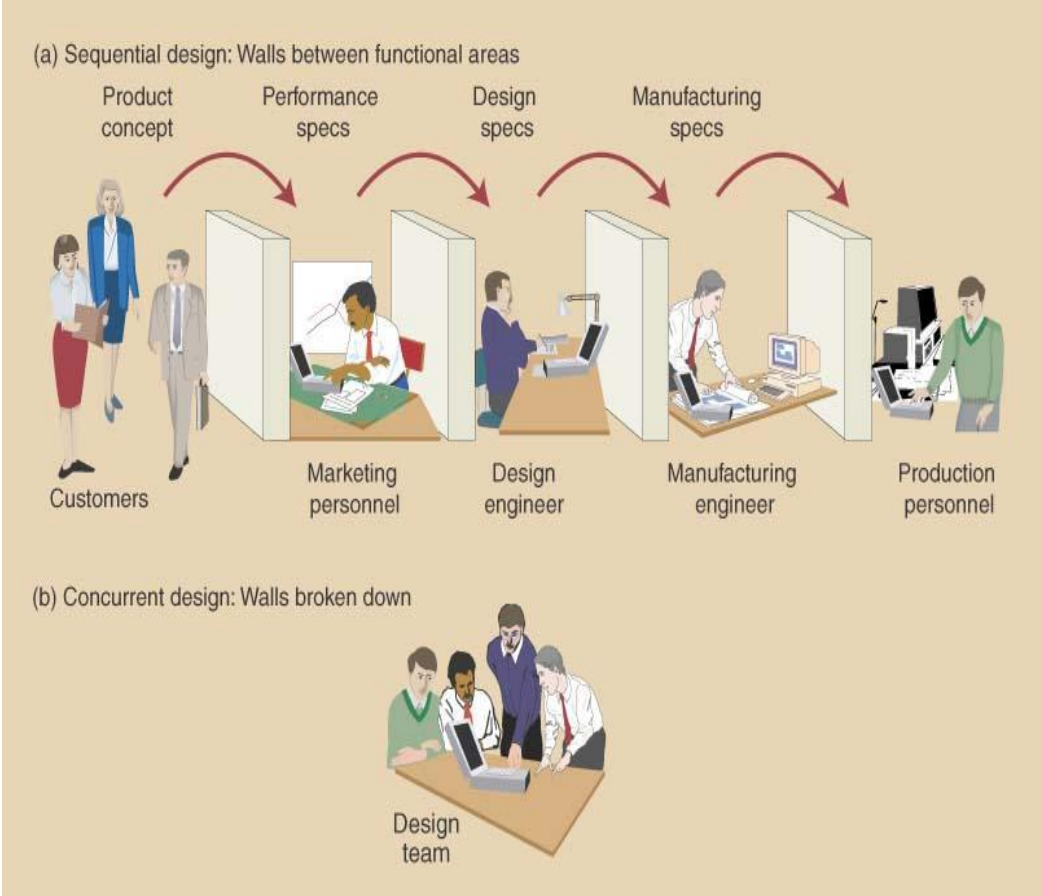
Concurrent Engineering

Old "over-the-wall" sequential design process should not be used

- Each function did its work and passed it to the next function

Replace with a Concurrent Engineering process

- All functions form a design team that develops specifications, involves customers early, solves potential problems, reduces costs, & shortens time to market



Remanufacturing

Uses components of old products in the production of new ones and has:

- Environmental benefits
- Cost benefits

Good for:

- Computers, televisions, automobiles

Types of Processes

- Intermittent processes:
  - Processes used to produce a variety of products with different processing requirements in lower volumes. (such as healthcare facility)
- Repetitive processes:
  - Processes used to produce one or a few standardized products in high volume. (such as a cafeteria, or car wash)

Process Selection

- Product design considerations must include the process
- Differences between Intermittent & Repetitive Ops:
  (1) the amount of product volume produced, and
  (2) the degree of product standardization.

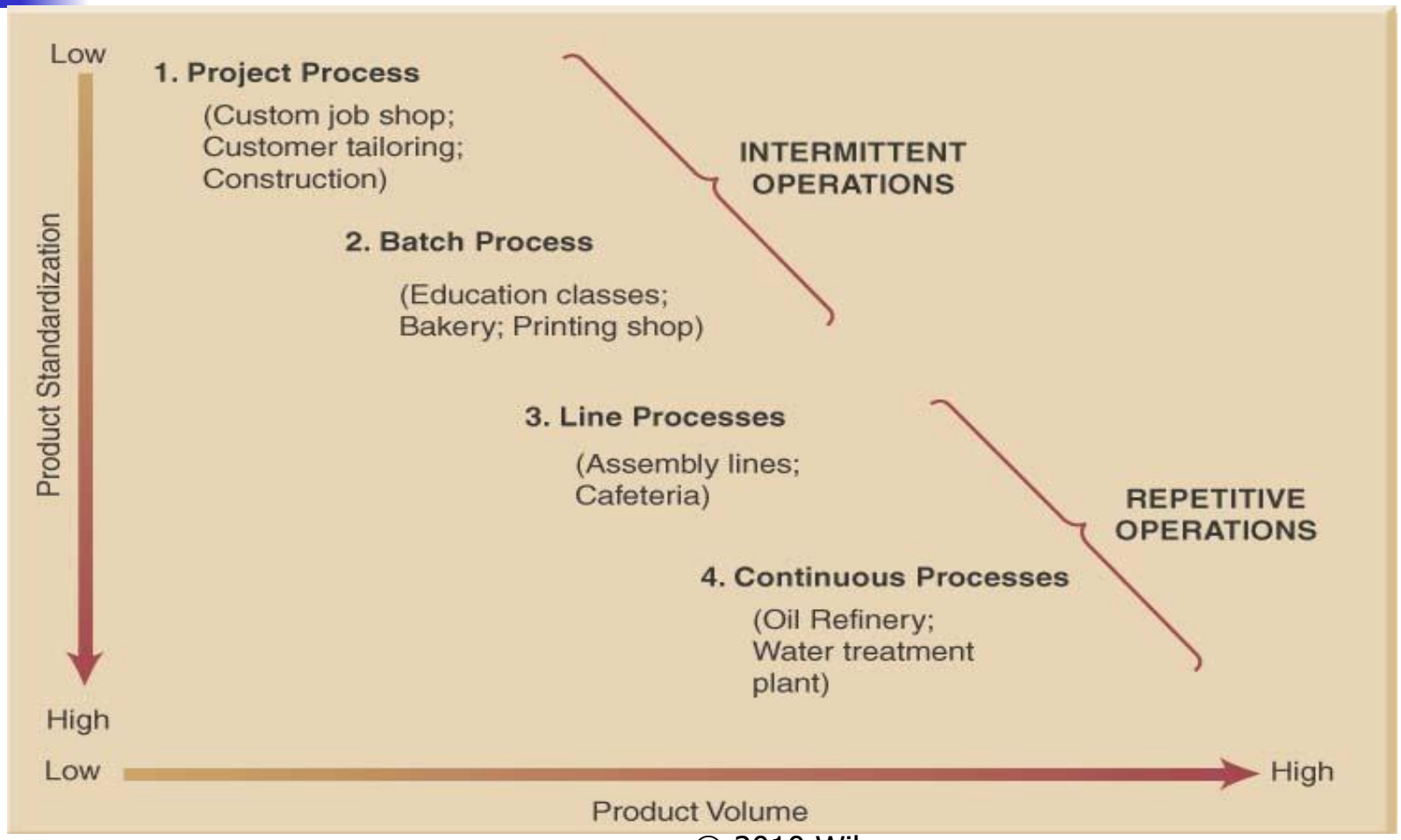
Intermittent and Repetitive Operations

Decision	Intermittent Operations	Repetitive Operations
Product variety	Great	Small
Degree of standardization	Low	High
Organization of resources	Grouped by function	Line flow to accommodate processing needs
Path of products through facility	In a varied pattern, depending on product needs	Line flow
Factor driving production	Customer orders	Forecast of future demands
Critical resource	Labor-intensive operation (worker skills important)	Capital-intensive operation (equipment automation, technology important)
Type of equipment	General-purpose	Specialized
Degree of automation	Low	High
Throughput time	Longer	Shorter
Work-in-process inventory	More	Less

Process Selection Types

- Process types can be:
  - Project process – make a one-at-a-time product exactly to customer specifications
  - Batch process – small quantities of product in groups or batches based on customer orders or specifications
  - Line process – large quantities of a standard product
  - Continuous process – very high volumes of a fully standard product
- Process types exist on a continuum

Underlying Process Relationship Between Volume and Standardization Continuum

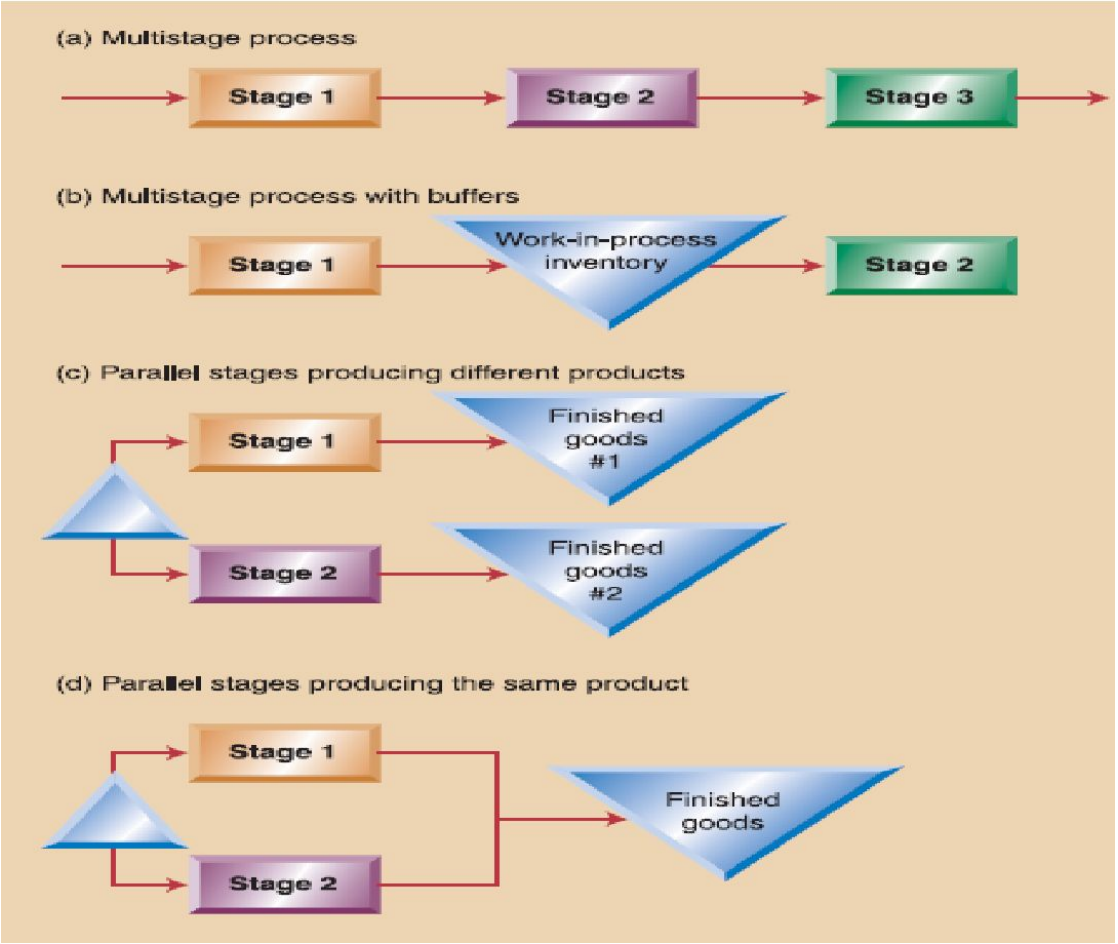


Process Selection Considerations

- **Process selection is based on five considerations**
  1. Type of process; range from intermittent to repetitive or continuous
  2. Degree of vertical integration
  3. Flexibility of resources
  4. Mix between capital & human resources
  5. Degree of customer contact

Process Design Tools

Often stages in the production process can be performed in parallel, as shown here in (c) and (d). The two stages can produce different products (c) or the same product (d).

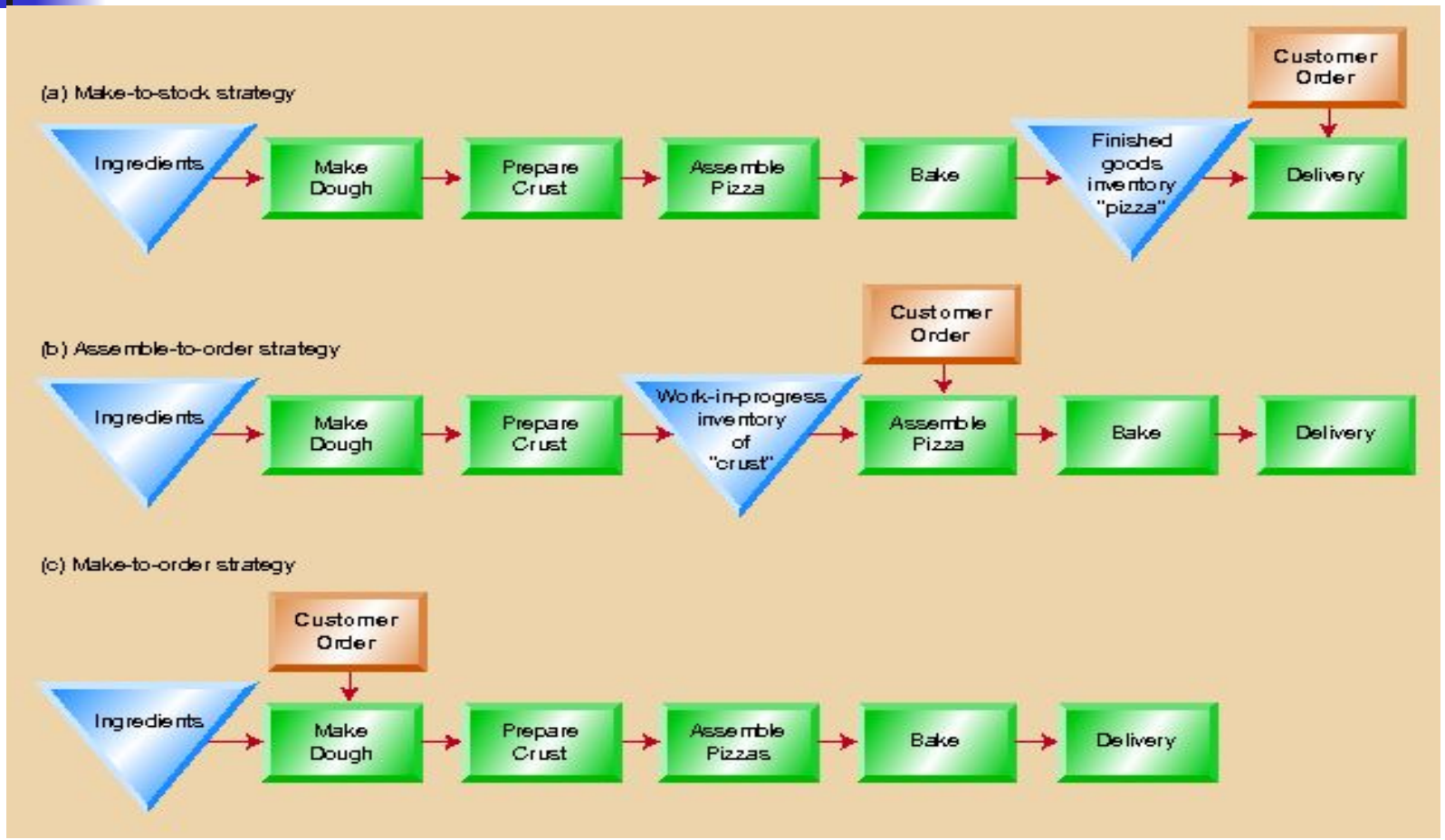


Designing Processes

- Process design tools include
  - Process flow analysis
  - Process flowchart
- Design considerations include
  - Make-to-stock strategy
  - Assemble-to-order strategy
  - Make-to-order strategy

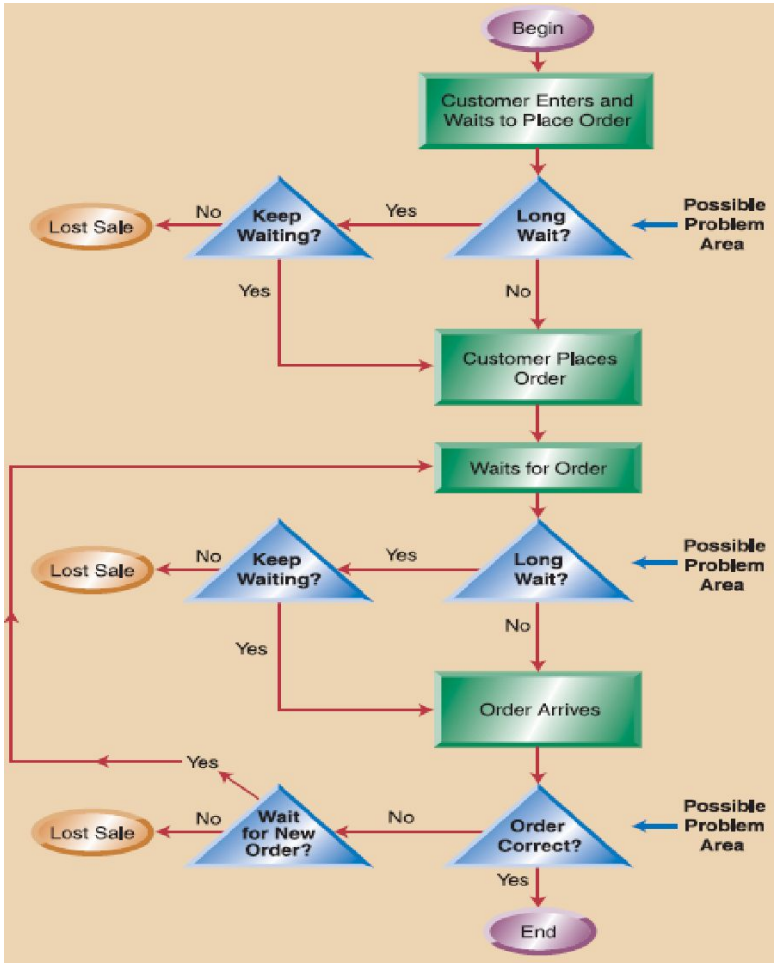
See flowcharts for different product strategies at Antonio's Pizzeria (next slide)

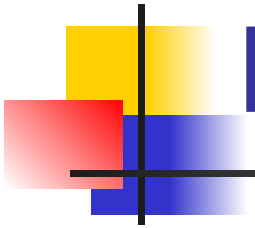
Flowchart for Different Product Strategies at Antonio's Pizzaria



Process Flowchart of Customer Flow at Antonio's Pizzeria

A basic process performance metric is **throughput time**. A lower throughput time means that more products can move through the system. One goal of process improvement is to reduce *throughput time*.





Process Performance Metrics

Process performance metrics – d**efined**:

Measurement of different process characteristics that tell us how a process is performing

- Determining if a process is functioning properly is required
- Determination requires measuring performance

Process Performance Metrics

Measure	Definition
1. Throughput time	Average amount of time product takes to move through the system.
2. Process velocity $= \frac{\text{Throughput time}}{\text{Value-added time}}$	A measure of wasted time in the system.
3. Productivity $= \frac{\text{Output}}{\text{Input}}$	A measure of how well a company uses its resources.
4. Utilization $= \frac{\text{Time a resource used}}{\text{Time a resource available}}$	The proportion of time a resource is actually used.
5. Efficiency $= \frac{\text{Actual output}}{\text{Standard output}}$	Measures performance relative to a standard.

Linking Product Design & Process Selection

- Product design and process selection are directly linked
- Type of product selected defines type of operation required
- Type of operation available defines broader organizational aspects such as
  - Equipment required
  - Facility arrangement
  - Organizational structure

Linking Design & Process Selection

- **Organizational Decisions appropriate for different types of operations**

Decision	Intermittent Operations	Repetitive Operations
Product design	Early stage of product life cycle	Later stage of product life cycle
Competitive priorities	Delivery, flexibility, and quality	Cost and quality
Facility layout	Resources grouped by function	Resources arranged in a line
Product strategy	Make-to-order/assemble-to-order	Make-to-stock
Vertical integration	Low	High

Linking Product Design & Process Selection con't

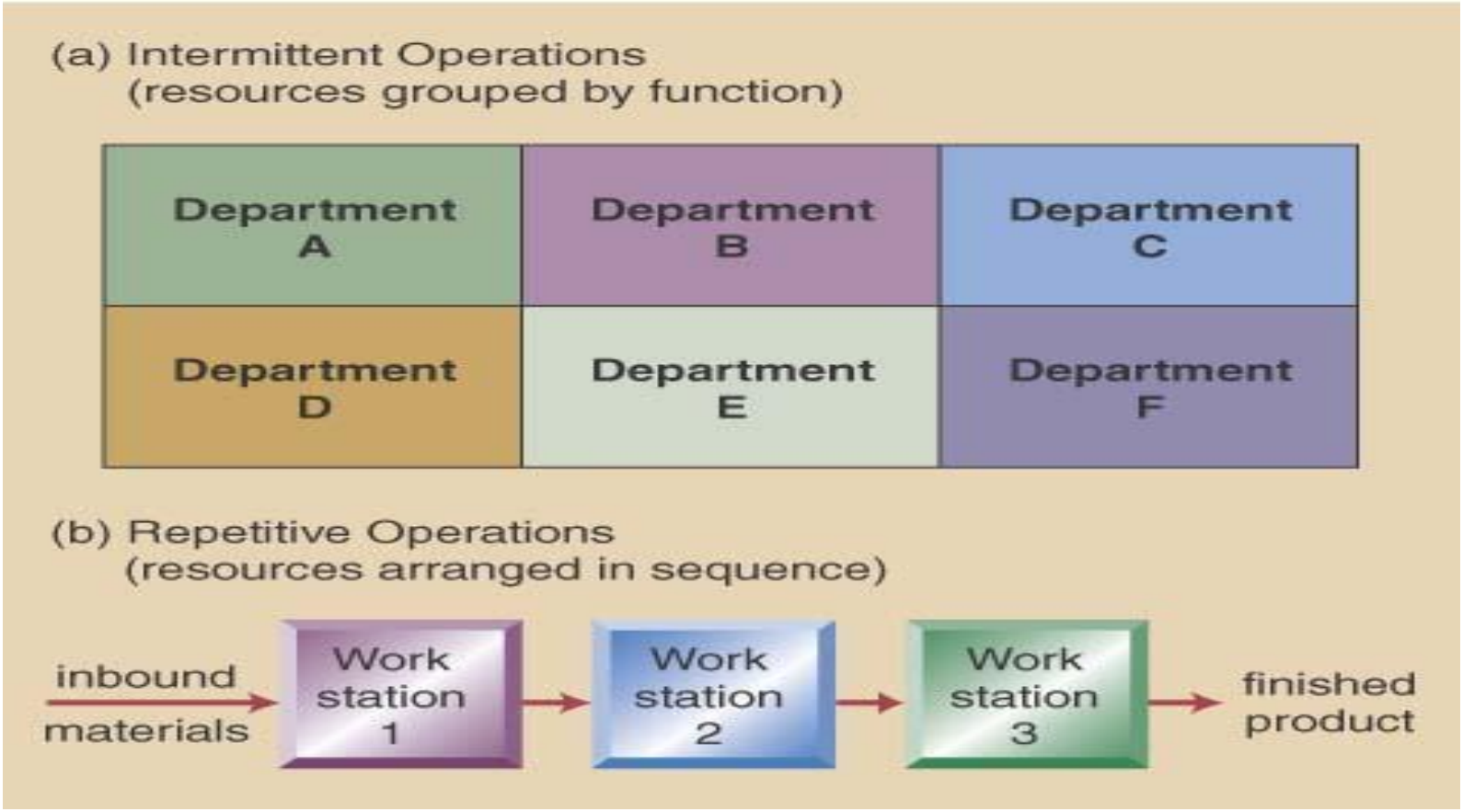
Product Design Decisions:

Intermittent and repetitive operations typically focus on producing products in different stages of the product life cycle. Intermittent is best for early in product life; repetitive is better for later when demand is more predicable.

Linking Product Design & Process Selection, con't

- Competitive Priorities: decisions of how a company will compete in the marketplace. Intermittent operations are typically less competitive on cost than repetitive operations. (Think "off the rack" vs. custom tailored clothing.)

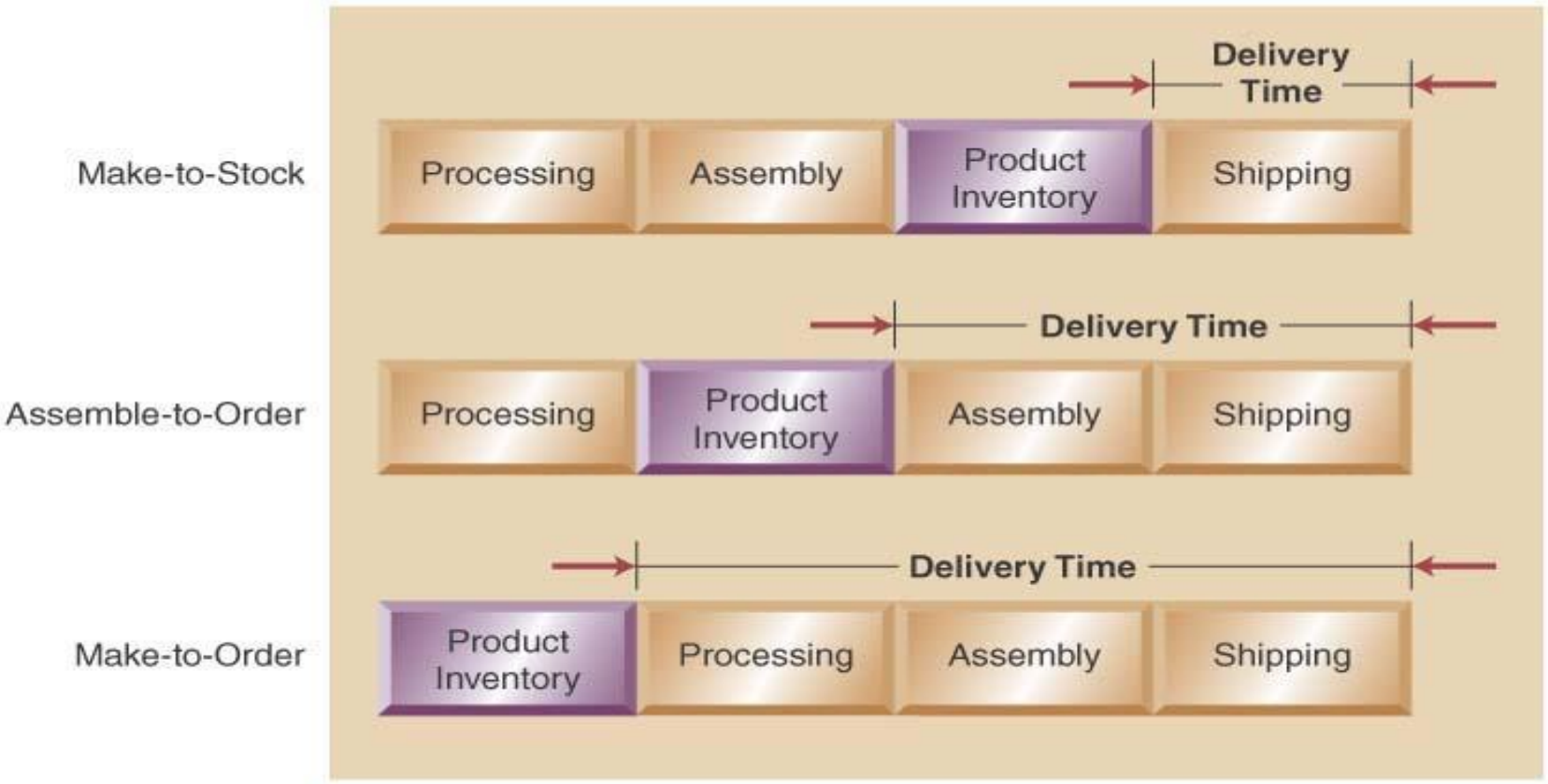
Intermittent VS. Repetitive Facility Layouts



Product and Service Strategy

- Type of operation is directly related to product and service strategy
- Three basic strategies include
  1. Make-to-stock; in anticipation of demand
  2. Assemble-to-order; built from standard components on order
  3. Make-to-order; produce to customer specification at time of order

Product and Service Strategy Options



Degrees of Vertical Integration & Make or Buy

- ***Vertical integration*** **refers to the degree a firm chooses to do processes itself- raw material to sales**
  - Backward Integration means moving closer to primary operations
  - Forward Integration means moving closer to customers

- **A firm's *Make-or-Buy* choices should be based on the following considerations:**
  - Strategic impact
  - Available capacity
  - Expertise
  - Quality considerations
  - Speed
  - Cost (fixed cost + variable cost)$_{make}$ = Cost (fixed cost + Variable cost)$_{buy}$

Technology Decisions

Information Technology

- Simplify first then apply appropriate technology
  - ERP, GPS, RFID
  - Automation
  - Automated Material Handling: Automated guided vehicles (AGV), Automated storage & retrieval systems (AS/RS)
  - Flexible Manufacturing Systems (FMS)
  - Robotics & Numerically-Controlled (NC) equipment

E-manufacturing

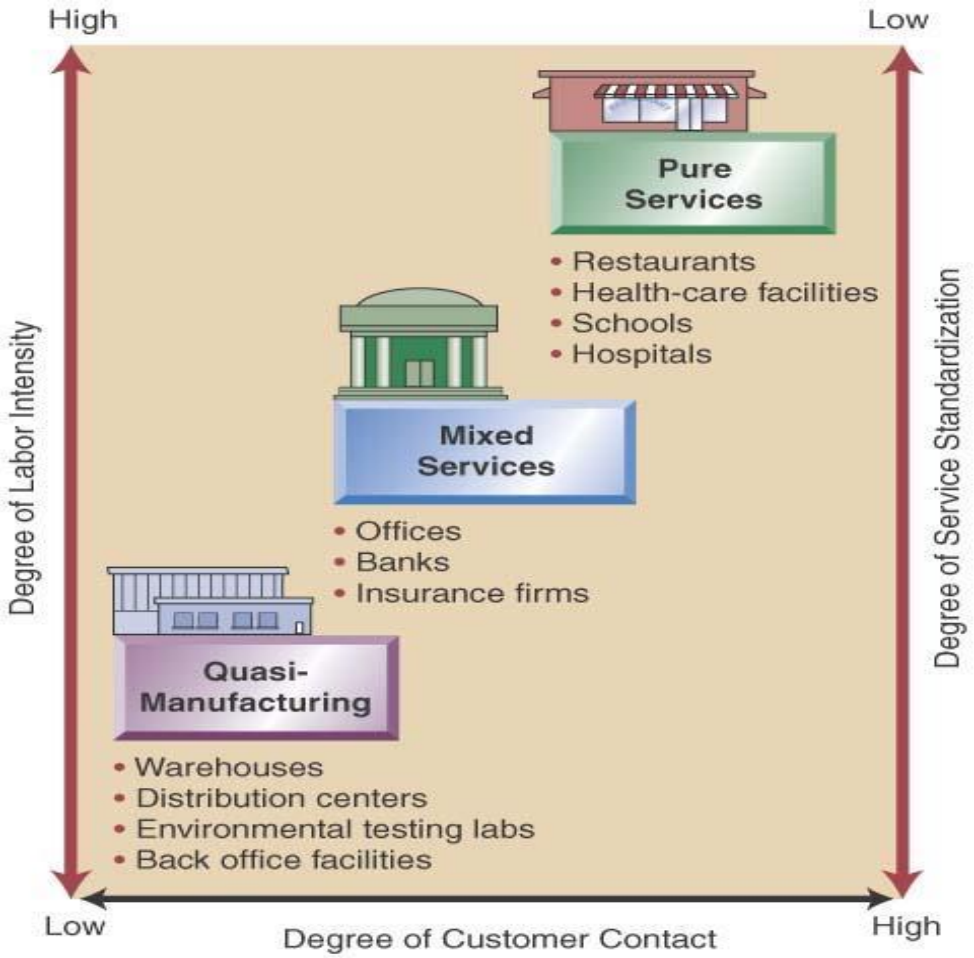
- Web-based environment creates numerous business opportunities to include;
  - Product design collaboration
  - Process design collaboration
- Computer-aided design – uses computer graphics to design new products
- Computer-integrated manufacturing – integration of product design, process planning, and manufacturing using an integrated computer system

Designing Services: How do they Differ from Manufacturing?

- Services are different from manufacturing as they;
  - Produce intangible products
  - Involve a high degree of customer contact
- Type of service is classified according to degree of customer contact

Designing Services

- **Service Characteristics**
  - Pure services
  - Quasi-Manufacturing
  - Mixed services
- **Service Package**
  - The physical goods
  - The sensual benefits
  - The psychological benefits
- **Differing designs**
  - Substitute technology for people
  - Get customer involved
  - High customer attention



Product Design and Process Selection Across the Organization

- Strategic and financial of product design and process selection mandates operations work closely across the organization
  - Marketing is impacted by product that is produced
  - Finance is integral to the product design and process selection issues due to frequent large financial outlays

Product Design and Process Selection Across the Organization – con't

- Strategic and financial of product design and process selection mandates operations work closely across the organization
  - Information services has to be developed to match the needs of the production process
  - Human resources provides important input to the process selection decisions for staffing needs

Chapter 3 Highlights

- Product design is the process of deciding on the unique characteristics and features of a company's product Process selection is the development of the process necessary to produce the product being designed.
- Steps in product include idea generation, product screening, preliminary design and testing, and final design
- Break-even analysis is a tool used to compute the amount of goods that have to be sold just to cover costs.
- Production processes can be divided into two broad categories: intermittent and repetitive operation project to batch to line to continuous

Chapter 3 Highlights con't

- Product design and process selection decisions are linked
- Process flow charts is used for viewing the flow of the processes involved in producing the
- Different types of technologies can significantly enhance product and process design. These include automation, automated material handling devices, CAD, NC, FMS, and CIM
- Designing services have more complexities than manufacturing, because service produce an intangible product and typically have a high degree of customer contact.

Chapter 3 Homework Hints

- 4.a. Calculate break-even point.
  - b. Primarily decisions at the company's plant(s).
- 8.a. Calculate/graph break-even point.
  - b. Calculate profit given revenue and cost data.
  - c. Compare profits given sales estimate differences based on the 2 prices.
  - d. Primarily factors at the company's plant(s).