

# Operations Management

<b>Topic</b>
Intro to Operations
Products and Services
Quality and Inventory
Operational Systems
Operational Management

# Introduction to Operations

## Introduction to Operations Management

- Operations: Sequence of processes
- Operations Management: The management system of the sequence

### History/Evolution of Operations

- Industrial Revolution
  - 1.0: Water and Steam
  - 2.0: Electricity
  - 3.0: Automation
  - 4.0: Technological Advancement
- Scientific Management
  - Introduction of Efficiency
  - Present Evolution: Safety, Quality, Efficiency
- HR Management (Human Element of Job Design)
- Decision Models & Management Science
  - Use of models and formulas in management theory
  - Statistical sampling
- Influence of Japanese Manufacturers

### Operations Today

- Tech Management
- Global Competition
- Working with fewer resources
- Revenue Management
- Agility
- Automation
- Real-Time Analytics
- AI

### 11 Pillars of Technological Advancement

1. Autonomous Robot
2. Big Data
3. Supply Chain
4. Additive/Subtractive Manufacturing
5. Cloud
6. Business Models
7. AI
8. Cybersecurity
9. IOT
10. Horizontal/Vertical Integration
11. Simulation/AR

### Industries

1. Primary: Getting Raw Materials
2. Secondary: Manufacturing
3. Tertiary: Provide a Service
4. Quaternary: R&D

### Value Chains

#### Vertical

- Sales
- Services (IT & Shared Services)
- Product Development (R&D),
- Supply Chain (Purchasing, Manufacturing, Logistics)
- Corporate Functions (Finance, Tax, Legal)

#### Horizontal

- Supplier Network (Suppliers, Cooperation Partners)
- Company's Internal Operations (Planning, Purchasing, Manufacturing, Logistics)
- Customer Network

# Operations Process Management

Process: 1+ actions that transform inputs into outputs

- Supply Chain: Sequence of activities/organizations involved in producing and delivering
- Transformation Process
  - Feedback: Measurements taken at various points in the transformation process
  - Control: The comparison of feedback against previously established standards to determine if corrective action is needed
- Good-Service Continuum: Products are typically neither purely service-based/goods-based

## Categories

- Upper-Management Processes: These govern the operation of the entire organization.
- Operational Processes: These are core processes that make up the value stream.
- Supporting Processes: These support the core processes

## Variation

- Variety of goods or services being offered: The greater the variety of goods and services offered, the greater the variation in production or service requirements.
- Structural variation in demand: These are generally predictable. They are important for capacity planning.
- Random variation: Natural variation that is present in all processes. Generally, it cannot be influenced by managers.
- Assignable variation: Variation that has identifiable sources. This type of variation can be reduced or eliminated by analysis and corrective action.

## Operation Function Overlap

### Marketing/Sales

- Demand Data
- Product/Service Design
- Competitor Analysis
- Lead Time Data

### Finance

- Budgeting
- Economic Analysis of Investment Proposals
- Provision of Funds

## Competitiveness, Strategy, and Productivity

Cold Hard Fact: Better Quality, Higher Productivity, Lower Costs, and the ability to respond quickly to customer needs

### Competitiveness

- How well the organization responds to customer needs and wants
- How effectively an organization meets the needs and wants of customers

## Competitive Advantage

- Cost Advantage
- Differentiation Advantage
- Network Advantage
- Importance
- Strategies

## Competitive Strategy

- Cost Leadership: Compete by reducing financial outlays
- Differentiation: Creating a unique differentiator
- Focus: Focusing on a narrow segment

## Operation Influences on Competitiveness

- Product/Service Design
- Cost
- Location
- Quality
- Quick Response
- Flexibility
- Inventory Management
- Supply Chain Management
- Service
- Managers/Workers

## Marketing Influences on Competitiveness

- Identifying consumer wants/needs
- Price and quality
- Advertising and promotion

## Why Do Organizations Fail?

- Neglecting Operations Strategy
- Failing to take advantage of strengths and opportunities, and/or failing to recognize competitive threats
- Too much emphasis on short-term financial performance at the expense of R&D
- Too much emphasis on product and service design and not enough on process design/improvement
- Neglecting investments in capital and human resources
- Failing to establish good internal communication
- Failing to meet customer needs/wants

## Hierarchical Planning

1. Mission
2. Goal
3. Organizational Strategies
4. Functional Strategies
5. Tactics
6. Procedures

## Strategy

- Systematic Plan (Roadmap) to achieve goals and hit milestones
- A plan for achieving organizational goals
- Preferred timeline 1 year to 18 months
- Tactics: The methods and actions taken to accomplish strategies; The “how to” part of the process
- Operations: The actual “doing” part of the process

## Formulation

### Effective strategy formulation requires taking into account

- Core competencies: The special attributes or abilities that give an organization a competitive edge
- Environmental scanning (SWOT)

### Successful strategy formulation also requires taking into account:

- Order qualifiers: Characteristics that customers perceive as minimum standards of acceptability for a product/service to be considered as a potential for purchase
- Order winners: Characteristics of an organization's goods/services that cause it to be perceived as better than the competition

## Types of Strategies

- Supply Chain Strategy: How the organization should work with suppliers and policies relating to customer relationships and sustainability
- Sustainability Strategy: Work with governmental regulations and interest groups to achieve sustainability goals
- Global Strategy: Work with international suppliers/producers and also with countries where the products and services are sold
- Operations Strategy: The approach, consistent with the organization's strategy, that is used to guide the operations function
- Quality-based Strategy: A strategy that focuses on quality in all phases of an organization
- Time-based Strategies: Strategies that focus on the reduction of the time needed to accomplish tasks
- Agile operations: A strategic approach for competitive advantage that emphasizes the use of flexibility to adapt and prosper in an environment of change
- Balanced Scorecard: A top-down management system that organizations can use to clarify their vision and strategy and transform them into action

## Productivity

- A measure of the effective use of resources, usually expressed as the ratio of output to input
- Effective use of resources
- Direct impact on competitiveness
- Efficiency is a narrower concept that pertains to getting the most out of a fixed set of resources.

## Productivity Measures

Tracking an operating unit's performance over time; Judging the performance of an entire industry/country (Ratios)

## Improving Productivity

1. Develop productivity measures for all operations
2. Determine critical (bottleneck) operations
3. Develop methods for productivity improvements
4. Establish reasonable goals
5. Make it clear that management supports and encourages productivity improvement
6. Measure and publicize improvements
7. Don't confuse productivity with efficiency

## Effects on Productivity

- Methods
- Capital
- Technology
- Management
- Quality

# Forecasting

Smart Factory Model → Robotic Processing cost is lowering 6-8% each year

## What is Forecasting?

- Statement about the future value of a variable of interest
- Estimating informed decisions
- Includes Quality, Quantity, and Finances
- Predicting what's in the future and possibly expected

## Aspects of Forecasts

- Expected level of demand: May be a function of some structural variation
- Accuracy: Related to the potential size of the forecast error

## Forecasting in Business Organizations

- Accounting: Cost Estimates, Profit Projections, Cash Management
- Finance: Replacement Needs, Timing, and Amount of funding/borrowing needs
- HR: Hiring, Recruitment, Training, Layoff planning
- Marketing: Pricing, Promotions
- MIS: Internet Services, New/Revised IS
- Operations: Schedules, Capacity Planning, Workloads, Inventory Planning
- Product/service design: Designing New/Revising Products/Services

## Uses

### Plan the use of the system

Generally involves short-/medium-range plans

- Inventory management
- Workforce levels
- Purchasing
- Production
- Budgeting
- Scheduling

### Plan the system

Generally involves long-range plans

- Types of products/services to offer
- Facility and equipment levels
- Facility location

## Features Common to All Forecasts

- Techniques assume that some underlying causal system that existed in the past will persist into the future
- Forecasts are not perfect
- Forecasts for groups of items are more accurate than those for the individual items
- Forecast accuracy decreases as the forecasting horizon increases

## Elements of Good Forecasts

- Timely
- Accurate
- Reliable
- Expressed in meaning units
- Documented - In writing
- Simple to use/understand
- Cost-effective

## Forecasting Process

1. Determine the purpose of the forecast
2. Establish a time horizon
3. Obtain, clean, and analyze appropriate data
4. Select a technique
5. Make a forecast
6. Monitor errors

## Approaches

### Quantitative

Relies on hard data

Time-Series: Time-ordered sequence of observations taken at regular time intervals

- Naïve: Uses a single previous value of a time series as the basis for a forecast
- Averaging: Handles step changes or gradual changes in the level of a series - Moving average; Weighted moving average; Exponential smoothing

### Qualitative

- Human Factors
- Personal Factors
- Hunches/Intuition-Based
- Executive Opinions
- Salesforce Opinions
- Consumer Surveys

## Disruptions

- Trends: A long-term upward or downward movement in data
- Seasonality: Short-term, fairly regular variations related to the calendar or time of day
- Cycles: Wavelike variations lasting more than one year
- Irregular Variations: Due to unusual circumstances that do not reflect typical behavior
- Random Variations: Residual variation that remains after all other behaviors have been accounted for

# Product/Service Design and Planning

## Product/Service Design

- The essence of an organization is the goods/services it offers
- Product/Service design or redesign should be closely tied to strategy
- Poka-yoke: Mistake-Proofing/Error Prevention

### What Does Product & Service Design Do?

Activities and responsibilities of product and service design include:

1. Translate customer “needs and wants” into product and service requirements
2. Refine existing products and services
3. Develop new products and services
4. Formulate quality goals
5. Formulate cost targets
6. Construct and test prototypes
7. Document specifications
8. Translate product and service specifications into process specifications
9. Involve inter-functional collaboration

### Key Questions When Designing

1. Is there a demand for it?
  - Market size
  - Demand profile
2. Can we do it?
  - Manufacturability - Capability to produce an product
  - Serviceability - Capability to provide a service
3. What level of quality is appropriate?
  - Customer expectations
  - Competitor quality
  - Fit with current offering
4. Does it make sense from an economic standpoint?
  - Liability issues, ethical considerations, sustainability issues, costs, and profits

### Reasons to Design/Redesign

The driving forces for product and service design or redesign are market opportunities or threats:

- Economic
- Social/Demographic
- Political/Liability/Legal
- Competitive
- Cost
- Availability
- Technological

## Idea Generation

### Research and Development (R&D)

Efforts to increase innovation

- Basic research: Has the objective of advancing the state of knowledge about a subject
- Applied research: Has the objective of achieving commercial applications
- Development: Converts the results of applied research into useful commercial applications

### Supply-Chain

Ideas can come from anywhere in the supply chain:

- Customers
- Suppliers
- Distributors
- Employees
- Maintenance and repair personnel

### Competitors

- By studying how a competitor operates and its products and services, many useful ideas can be generated
- Reverse engineering: Dismantling and inspecting a competitor's product to discover product improvements

## Design Considerations

- Legal Considerations: Product liability/Uniform Commercial Code
- Ethical Considerations
  - Designers are often under pressure to speed up the design process and cut costs
  - These pressures force trade-off decisions
- Human Factors: Safety/Liability
- Cultural Factors: Colors, preferred food, product labels
- Global design: Design teams can be in different countries
- Sustainability
  - Using resources in ways that do not harm ecological systems that support human existence
  - Cradle-to-grave assessment (life-cycle analysis)
  - End-of-life programs
  - The 3-Rs: Reduce, Reuse, Recycle

## Capacity Planning

Strategy always comes into play when planning for the future

### Capacity

Upper limit or ceiling on the load that an operating unit can handle. Needs include: Equipment, Space, Employee Skills

### Goal

To achieve a match between the long-term supply capabilities of an organization and the predicted level of long-term demand

- Overcapacity: Operating costs that are too high
- Undercapacity: Strained resources and possible loss of customers

## Questions

### Key questions

- What kind of capacity is needed?
- How much is needed to match demand?
- When is it needed?

### Related questions

- How much will it cost?
- What are the potential benefits and risks?
- Are there sustainability issues?
- Should capacity be changed all at once, or through several smaller changes?
- Can the supply chain handle the necessary changes?

## Capacity Decisions

1. Impact the ability of the organization to meet future demands
2. Affect operating costs
3. They are a major determinant of initial cost
4. Often involve long-term commitment of resources
5. Can affect competitiveness
6. Affect the ease of management
7. Have become more important and complex due to globalization
8. Need to be planned for in advance due to their consumption of financial and other resources

## Defining and Measuring Capacity

Measure capacity in units that do not require updating: Why is measuring capacity in dollars problematic?

Two useful definitions of capacity

- Design capacity: The maximum output rate or service capacity an operation, process, or facility is designed for
- Effective capacity: Design capacity minus allowances such as personal time and maintenance

## Steps to Capacity Planning

1. Estimate future capacity requirements
2. Evaluate existing capacity and facilities; identify gaps
3. Identify alternatives for meeting requirements
4. Conduct financial analyses
5. Assess key qualitative issues
6. Select the best alternative for the long term
7. Implement the alternative chosen
8. Monitor results

## Resolving Constraint Issues

1. Identify the most pressing constraint
2. Change the operation to achieve maximum benefit, given the constraint
3. Make sure other portions of the process are supportive of the constraint
4. Explore and evaluate ways to overcome the constraint
5. Repeat the process until the constraint levels are at acceptable levels

# Quality Management and Control

## Quality

The ability of a product or service to consistently meet or exceed customer expectations

- For a decade or so, quality was an important focal point in business. After a while, this emphasis began to fade as other concerns took precedence
- There has been a recent resurgence in attention to quality given recent experiences with the costs and adverse attention associated with highly visible quality failures

### Dimensions of Service Quality

- Convenience – the availability and accessibility of the service
- Reliability – ability to perform a service dependably, consistently, and accurately
- Responsiveness – willingness to help customers in unusual situations and to deal with problems
- Time – the speed with which the service is delivered
- Assurance – knowledge exhibited by personnel and their ability to convey trust and confidence
- Courtesy – the way customers are treated by employees
- Tangibles – the physical appearance of facilities, equipment, personnel, and communication materials
- Consistency – the ability to provide the same level of good quality repeatedly
- Expectancy – meet (or exceed) customer expectations

### Dimensions of Product Quality

- Performance – main characteristics of the product
- Aesthetics – appearance, feel, smell, taste
- Special features – extra characteristics
- Conformance – how well the product conforms to design specifications
- Reliability – consistency of performance
- Durability – the useful life of the product
- Perceived quality – indirect evaluation of quality
- Serviceability – handling of complaints or repairs
- Consistency – quality doesn't vary

## Quality Management

### Assessing Service Quality

- Audit service to identify strengths and weaknesses
- In particular, look for discrepancies between:
  1. Customer expectations and management perceptions of those expectations
  2. Management perceptions, customer expectations, and service quality specifications
  3. Service quality and service actually delivered
  4. Service actually delivered and what is communicated about the service to customers
  5. Customers' expectations of the service provider and their perceptions of provider delivery

### Determinants of Quality

- Quality of Design: Intention of designers to include or exclude features in a product or service
- Quality of Conformance: The degree to which goods or services conform to the intent of the designers
- Ease-of-use and User Instructions: Increase the likelihood that a product will be used for its intended purpose and in such a way that it will continue to function properly and safely
- After-the-sale Service: Taking care of issues and problems that arise after the sale

## Responsibility for Quality

- Top management
- Design
- Procurement
- Production/operations
- Quality assurance
- Packaging and shipping
- Marketing and sales
- Customer service

Everyone in the organization has some responsibility for quality, but certain areas of the organization are involved in activities that make them key areas of responsibility

## Benefits of Good Quality

- Enhanced reputation for quality
- Ability to command premium prices
- Increased market share
- Greater customer loyalty
- Lower liability costs
- Fewer production or service problems
- Lower production costs
- Higher profits

## Consequences of Poor Quality

- Loss of business
- Liability
- Productivity
- Costs

## Costs of Quality

- Appraisal Costs: Costs of activities designed to ensure quality or uncover defects
- Prevention Costs: All TQ training, TQ planning, customer assessment, process control, and quality improvement costs to prevent defects from occurring
- Failure Costs: Costs incurred by defective parts/products or faulty services
  - Internal Failure Costs: Costs incurred to fix problems that are detected before the product/service is delivered to the customer
  - External Failure Costs: All costs incurred to fix problems that are detected after the product/service is delivered to the customer

## Quality and the Supply Chain

Business leaders are increasingly recognizing the importance of their supply chains in achieving their quality goals

Requires:

- Measuring customer perceptions of quality
- Identifying problem areas
- Correcting these problems

Supply chain quality management can benefit from a collaborative relationship with suppliers

- Helping suppliers with quality assurance efforts
- Information sharing on quality-related matters

## Total Quality Management (TQM)

A philosophy that involves everyone in an organization in a continual effort to improve quality and achieve customer satisfaction

- Continuous Improvement: Philosophy that seeks to make never-ending improvements to the process of converting inputs into outputs (Kaizen: Japanese word for continuous improvement)
- Quality at the Source: The philosophy of making each worker responsible for the quality of his or her work (“Do it right” and “If it isn’t right, fix it”)

## Elements

- Continuous improvement
- Competitive benchmarking
- Employee empowerment
- Team approach
- Decision based on fact, not opinion
- Knowledge of tools
- Supplier quality
- Champion
- Quality at the source
- Suppliers are partners in the process

## Approach

1. Find out what the customer wants
2. Design a product or service that meets or exceeds customer wants
3. Design processes that facilitate doing the job right the first time
4. Keep track of results
5. Extend these concepts throughout the supply chain
6. Top management must be involved and committed

## Obstacles

- Lack of company-wide definition of quality
- Lack of strategic plan for change
- Lack of customer focus
- Poor intra-organizational communication
- Lack of employee empowerment and leadership
- View of quality as a “quick fix”
- Emphasis on short-term financial results
- Inordinate presence of internal politics and “turf” issues
- Lack of strong motivation
- Lack of time to devote to quality initiatives

## Criticisms

- Overzealous advocates may pursue TQM programs blindly, focusing attention on quality
- Programs may not be linked to the strategies of the organization in a meaningful way
- Quality-related decisions may not be tied to market performance
- Failure to carefully plan a program before embarking on it can lead to false starts, employee confusion, and meaningless results
- Organizations sometimes pursue continuous improvement
- Quality efforts may not be tied to results

## Plan-Do-Study-Act (PDSA) Cycle

### Plan

- Begin by studying and documenting the current process
- Collect data on the process or problem
- Analyze the data and develop a plan for improvement
- Specify measures for evaluating the plan

### Do

- Implement the plan, document any changes made, and collect data for analysis

### Study

- Evaluate the data collection during the do phase
- Check results against goals formulated during the plan phase

### Act

- If the results are successful, standardize the new method and communicate it to the relevant personnel
- Implement training for the new method
- If unsuccessful, revise the plan and repeat the process

## Process Improvement

A systematic approach to improving a process

- Map the process
  - Collect information about the process and identify each step in the process
  - Prepare a flowchart that accurately depicts the process
- Analyze the process
  - Ask critical questions about the process
  - Ask specific questions about each step in the process
- Redesign the process

## Six Sigma

A business process for improving quality, reducing costs, and increasing customer satisfaction

- Statistically: Having no more than 3.4 defects per million
- Conceptually: Program designed to reduce defects; Requires the use of certain tools and techniques

## Principles

- Reduction in variation is an important goal
- The methodology is data-driven; it requires data validation
- Outputs are determined by inputs
- Only a critical few inputs have a significant impact on outputs

## DMAIC

- Define: Set the context and objectives for improvement (What, When, Where, Who, and Why)
- Measure: Determine the baseline performance and capability of the process
- Analyze: Use data and tools to understand the cause-and-effect relationships of the process
- Improve: Develop the modifications that lead to a validated improvement of the process
- Control: Establish plans and procedures to ensure that improvements are sustained

## Quality Cycles

Groups of workers who meet to discuss ways of improving products or processes

- Less structured and more informal than teams involved in continuous improvement
- Quality circle teams have historically had relatively little authority to make any but the most minor changes

## Benchmarking Process

1. Identify a critical process that needs improvement
2. Identify an organization that excels in this process
3. Contact that organization
4. Analyze the data
5. Improve the critical process

# Quality Control

## What is Quality Control?

- A process that evaluates output relative to a standard and takes corrective action when output doesn't meet standards
  - If results are acceptable, no further action is required
  - Unacceptable results call for correction action
- Inspection alone is not sufficient to achieve a reasonable level of quality
  - Most organizations rely upon some inspection and a great deal of process control to achieve an acceptable level of quality

## Inspection

An appraisal activity that compares goods or services to a standard

### Typical Inspection Points

- Raw materials and purchased parts
- Finished products
- Before a costly operation
- Before an irreversible process
- Before a covering process

### Inspection Issues

- How much to inspect and how often
- At what points in the process to inspect
- Whether to inspect in a centralized or on-site location
- Whether to inspect attributes or variables

## Off-site or On-site Inspection

Effects on cost and level of disruption are a major issue in selecting centralized vs. on-site inspection

### Off-Site

- Specialized tests that may best be completed in a lab
- More specialized testing equipment
- More favorable testing environment

### On-Site

- Quicker decisions are rendered
- Avoid introduction of extraneous factors
- Quality at the source

## Statistical Process Control (SPC)

Quality control seeks quality of conformance; A product or service conforms to specifications

A tool used to help in this process:

- Statistical evaluation of the output of a process
- Helps us to decide if a process is "in control" or if corrective action is needed

## Process Variability

Two basic questions concerning variability:

- Issue of process control: Are the variations random? If nonrandom variation is present, the process is said to be unstable.
- Issue of process capability: Given a stable process, is the inherent variability of the process within a range that conforms to performance criteria?

## Variation

- Random (common cause) variation: Natural variation in the output of a process, created by countless minor factors
- Assignable (special cause) variation: A variation whose cause can be identified; A nonrandom variation

## Sampling and Sampling Distribution

- SPC involves periodically taking samples of process output and computing sample statistics:
  - Sample means
  - The number of occurrences of some outcome
- Sample statistics are used to judge the randomness of process variation

## Control Process

- Sampling and corrective action are only a part of the control process
- Steps required for effective control:
  - Define: What is to be controlled?
  - Measure: How will measurement be accomplished?
  - Compare: There must be a standard of comparison
  - Evaluate: Establish a definition of out of control
  - Correct: Uncover the cause of nonrandom variability and fix it
  - Monitor: Verify that the problem has been eliminated

## Control Charts: The Voice of the Process

A time-ordered plot of representative sample statistics obtained from an ongoing process (e.g. sample means), used to distinguish between random and nonrandom variability

### Control Charts for Variables

Variables generate data that are measured

- Mean control charts (“x-bar” charts): Used to monitor the central tendency of a process
- Range control charts (R charts): Used to monitor the process dispersion

### Control Limits

- The dividing lines between random and nonrandom deviations from the mean of the distribution
- Upper and lower control limits define the range of acceptable variation

## Errors

### Type I Error

- Concluding a process is not in control when it actually is
- The probability of rejecting the null hypothesis when the null hypothesis is true
- Manufacturer’s risk

### Type II Error

- Concluding a process is in control when it is not
- The probability of failing to reject the null hypothesis when the null hypothesis is false
- Consumer’s risk

## Control Charts for Attributes

Attributes generate data that is counted.

### c-chart

A control chart used to monitor the number of defects per unit

Use only when the number of occurrences per unit of measure can be counted; non-occurrences cannot be counted.

- Scratches, chips, dents, or errors per item
- Cracks or faults per unit of distance
- Breaks or tears per unit of area
- Bacteria or pollutants per unit of volume
- Calls, complaints, failures per unit of time

### p-chart

A control chart used to monitor the proportion of defectives in a process

- When observations can be placed into two categories
  - Good or bad
  - Pass or fail
  - Operate or don't operate
- When the data consists of multiple samples of several observations each

## Managerial Considerations

- At what points in the process to use control charts
- What size samples to take
- Sample frequency
- What type of control chart to use: Variables & Attributes

## Run Tests

- Even if a process appears to be in control, the data may still not reflect a random process
- Analysts often supplement control charts with a run test
  - Run test: A test for patterns in a sequence
  - Run: A sequence of observations with a certain characteristic

## Process Capability

Once a process has been determined to be stable, it is necessary to determine if the process is capable of producing output that is within an acceptable range.

- Tolerances or Specifications: Range of acceptable values established by engineering design or customer requirements
- Process Variability: Natural or inherent variability in a process
- Process Capability: The inherent variability of process output (process width) relative to the variation allowed by the design specification (specification width)

## Limitations of Capability Measures

There are several risks of using capability measures:

- The process may not be stable
- The process output may not be normally distributed
- The process is not centered, but  $C_p$  is used

# Inventory Management

## Inventory

Inventories are a vital part of business: (1) necessary for operations, and (2) contribute to customer satisfaction

- A stock or store of goods
- Raw materials used in production as well as the goods produced that are available for sale.

## Independent-demand Items

- Items that are ready to be sold or used
- Inventory is a very important asset for any company

## Business Concepts

- Service Inventory
- Perishable Inventory
- Obsolete Inventory
- Consignment Inventory
- Safety Stock
- Service Parts
- Backordered Inventory
- Seasonal Inventory
- Excess Inventory
- Cycle Inventory
- Transit Inventory

## Basic Types

- Raw materials and purchased parts
- Work-in-process (WIP)
- Finished goods inventories or merchandise
- Tools and supplies
- Maintenance and repairs (MRO) inventory
- Goods-in-transit to warehouses or customers (pipeline inventory)

## Inventory Functions

Inventories serve a number of functions, such as:

1. To meet anticipated customer demand
2. To smooth production requirements
3. To decouple operations
4. To protect against stockouts
5. To take advantage of order cycles
6. To hedge against price increases
7. To permit operations
8. To take advantage of quantity discounts

## Effective Inventory Management

1. A system keep track of inventory
2. A reliable forecast of demand
3. Knowledge of lead time and lead time variability
4. Reasonable estimates of Costs
  - Holding costs
  - Ordering costs
  - Shortage costs
5. A classification system for inventory items

## Objectives of Inventory Control

Inventory management has two main concerns:

1. Level of customer service: Having the right goods available in the right quantity in the right place at the right time
2. Costs of ordering and carrying inventories: The overall objective of inventory management is to achieve satisfactory levels of customer service while keeping inventory costs within reasonable bounds

## Inventory Costs

- Purchase cost: The amount paid to buy the inventory
- Holding (carrying) costs: Cost to carry an item in inventory for a length of time, usually a year
- Ordering costs: Costs of ordering and receiving inventory
- Setup costs: The costs involved in preparing equipment for a job; Analogous to ordering costs:
- Shortage costs: Costs resulting when demand exceeds the supply of inventory; often unrealized profit per unit

## ABC Classification System

Classifying inventory according to some measure of importance and allocating control efforts accordingly

- A items (very important): 10 to 20 percent of the number of items in inventory and about 60 to 70 percent of the annual dollar value
- B items (moderately important)
- C items (least important): 50 to 60 percent of the number of items in inventory but only about 10 to 15 percent of the annual dollar value

## Cycle Counting Management

Cycle Counting: A physical count of items in inventory

- How much accuracy is needed?
- When should cycle counting be performed?
- Who should do it?
- A items:  $\pm 0.2$  percent
- B items:  $\pm 1$  percent
- C items:  $\pm 5$  percent

## Economic Production Quantity (EPQ)

The batch mode is widely used in production. In certain instances, the capacity to produce a part exceeds its usage (demand rate).

### Assumptions

- Only one item is involved
- Annual demand requirements are known
- Usage rate is constant
- There are no quantity discounts
- Usage occurs continually, but production occurs periodically
- The production rate is constant
- Lead time is known and constant

## When to Reorder (Reorder point)

When the quantity on hand of an item drops to this amount, the item is reordered.

### Determinants

- The rate of demand
- The lead time
- The extent of demand and/or lead time variability
- The degree of stockout risk acceptable to management

### Under Uncertainty

- Demand or lead time uncertainty creates the possibility that demand will be greater than available supply
- To reduce the likelihood of a stockout, it becomes necessary to carry safety stock

## Safety Stock

Stock that is held in excess of expected demand due to variable demand and/or lead time

- As the amount of safety stock carried increases, the risk of stockout decreases: This improves customer service level
- Service level: The probability that demand will not exceed supply during lead time ( $100\% - \textit{stockout risk}$ )

### How Much to Order: FOI

Fixed-Order-Interval (FOI) model: Orders are placed at fixed time intervals

Reasons for using the FOI model:

- Supplier's policy may encourage its use
- Grouping orders from the same supplier can produce savings in shipping costs
- Some circumstances do not lend themselves to continuously monitoring inventory position

### How Much Safety Stock?

The amount of safety stock that is appropriate for a given situation depends upon:

1. The average demand rate and average lead time
2. Demand and lead time variability
3. The desired service level

## Single-Period Model

- Model for ordering of perishables and other items with limited useful lives
- The goal of the single-period model is to identify the order quantity that will minimize the long-run excess and shortage costs
- Demand problems can be categorized by whether they follow a continuous or discrete distribution

# Operational Systems

## MRP and ERP

Computer-Based Information Systems Implemented in Business Applications

### MRP

#### Material Requirements Planning

- A computer-based information system that translates master schedule requirements for end items into time-phased requirements for subassemblies, components, and raw materials.
- MRP Processing: Takes the end item requirements specified by the master schedule and “explodes” them into time-phased requirements for assemblies, parts, and raw materials offset by lead times
- The MRP is designed to answer three questions: (1) What is needed? (2) How much is needed? (3) When is it needed?

#### Inputs

- Master Schedule: Primary input in MRP, specifies end items to be produced, their quantities, and required timing, and should extend at least to the cumulative lead time, which is the total sequential lead time from raw material ordering to final assembly completion
- Inventory Records: time-bucketed information on each item's status, including gross requirements, scheduled receipts, expected on-hand amounts, and details like stock changes, canceled orders, supplier, lead time, and lot size policy
- Bill of Materials (BOM): Comprehensive list of all assemblies, subassemblies, parts, and raw materials required for a single product unit, visually represented by a product structure tree, and often optimized through low-level coding to ensure all component occurrences are at their lowest common level

#### Outputs

- Primary: Planned orders, Order releases, and Changes
- Secondary: Performance-control reports, Planning reports, and Exception reports

#### Development

- The MRP is based on the product structure tree diagram (from BOM)
- Requirements are determined level by level, starting from the end item and working downwards, where the timing and quantity of each parent item dictate those of its children, which then become the parents for the next level
- Pegging is the process of identifying parent items that create a specific set of material requirements for a given item, a concept central to dependent demand in Supply Chain Management

#### Updating The System

An MRP is not a static document because it continuously evolves with new orders, altered existing orders (quantity changes, delays, missed deliveries), and the completion status of various orders; these updates are managed either periodically by a Regenerative System or continuously by a Net-Change System.

#### Other MRP Considerations

- Lot Sizing Rules (Lot-for-Lot (L4L) Ordering, Economic Order Quantity (EOQ), Fixed Period Ordering)
- Safety Stock
- MRP in Service

## **Benefits**

### **Enables Managers to Easily**

- Determine the quantities of each component for a given order size
- Know when to release orders for each component
- Be alerted when items need attention

### **Additional benefits**

- Low levels of in-process inventories
- The ability to track material requirements
- The ability to evaluate capacity requirements
- A means of allocating production time
- The ability to easily determine inventory usage via backflushing
- Exploding an end item's BOM to determine the quantities of the components that were used to make the item

## **Requirements**

Implementing an effective MRP system requires

- A computer and the necessary software to handle computations and maintain records
- Accurate and up-to-date (Master schedules, Bills of materials, Inventory records)
- Integrity of data files

## **Difficulties**

- Consequences of Inaccurate Data: Missing parts, Ordering incorrect numbers of items, and Inability to stay on schedule
- Other problems include assumptions of constant lead times, products being produced differently from the Bill of Materials (BOM), failure to alter a BOM when customizing a product, and inaccurate forecasts.

## **MRP II**

### **Manufacturing Resources Planning (MRP II)**

- Expanded approach to production resource planning, involving other areas of the firm in the planning process and enabling capacity requirements planning
- Most MRP II systems have the capability of performing simulations to answer a variety of "what if" questions so they can gain a better appreciation of available options and their consequences
- Closed-loop MRP II systems incorporate feedback loops to evaluate proposed material plans against available capacity through a process called capacity requirements planning; if a plan is not feasible, it must be revised.

## **CRP**

### **Capacity Requirements Planning**

The process of determining short-range capacity requirements.

- Inputs: Planned-order releases for the MRP; Current shop loading; Routing information; Job time
- Outputs: Load reports (Department or work center reports that compare known and expected future capacity requirements with projected capacity availability)

# ERP

## Enterprise Resource Planning

- The next step in an evolution that began with MRP and evolved into MRPII
- Typically has an MRP core
- Provides a system to capture and make data available in real time to decision-makers and other users throughout an organization
- Composed of a collection of integrated modules

## Project Organization (Implementation)

- The “Big Bang”: ERP implementation involves simultaneously replacing all legacy systems with a single ERP system across an entire company, making it the most ambitious and challenging method
- Franchising Strategy: ERP implementation involves installing independent ERP systems in each business unit while linking common processes, making it suitable for large or diverse companies with limited shared processes across units
- Slam Dunk: ERP implementation approach dictates process design by focusing on a few key processes, making it more suitable for smaller companies anticipating growth into an ERP system

## Considerations

- How can ERP improve a company’s business performance?
- How long will an ERP implementation project take?
- How will ERP affect current business processes?
- What is the ERP total cost of ownership?
- What are the hidden costs of ERP ownership?

# JIT and Lean Operations

- Lean: A flexible system of operation that uses considerably fewer resources than a traditional system. Tend to achieve: Greater productivity; Lower costs; Shorter cycle times; Higher quality
- Just In Time (JIT): A highly coordinated processing system in which goods move through the system, and services are performed, just as they are needed

## Lean System Characteristics

- Waste reduction
- Continuous improvement
- Use of teams
- Work cells
- Visual controls
- High quality
- Minimal inventory
- Output only to match demand
- Quick changeovers
- Small lot sizes
- Lean culture

## Lean System Principles

Five principles embody the way lean systems function

1. Identify customer values
2. Focus on processes that create value
3. Eliminate waste to create “flow”
4. Produce only according to customer demand
5. Strive for perfection

## Key Benefits

- Reduced waste
- Lower costs
- Increased quality
- Reduced cycle time
- Increased flexibility
- Increased productivity

## Critical Risks

- Increased stress on workers
- Fewer resources are available if problems occur
- Supply chain disruptions can halt operations

## Lean Operations

- Ultimate Goal: Achieve a balanced system (One that achieves a smooth, rapid flow of materials and/or work through the system)
- Supporting Goals: The degree to which lean's ultimate goal is achieved depends upon how well its supporting goals are achieved (Eliminate disruptions, Make the system flexible, Eliminate waste, Especially excess inventory)

## Waste

The eight sources of waste in lean systems, representing unproductive resources, are: excess inventory, overproduction, waiting time, unnecessary transporting, processing waste, inefficient work methods, product defects, and underused people.

## Building Blocks

The building blocks of a Lean system are Product Design, Process Design, Personnel/Organizational, and Manufacturing Planning and Control (MPC).

## Preventive Maintenance and Housekeeping

- Preventive Maintenance: Maintaining equipment in good operating condition and replacing parts that have a tendency to fail before they actually do fail
- Housekeeping: Maintaining a workplace that is clean and free of unnecessary materials. It involves the following 5 behaviors to make the workplace effective (Sort, Straighten, Sweep, Standardize, Self-discipline)

## Lean Tools

- 5W2H: A method of asking questions about a process that includes what, why, where, when, who, how, and how much
- Value Stream Mapping: A visual tool to systematically examine the flows of materials and information; Its purpose is to help identify waste and opportunities for improvement
- Six Sigma: Lean and Six Sigma are complementary process improvement approaches, with Lean optimizing process velocity by eliminating waste and Six Sigma enhancing quality by reducing variation, together achieving efficient and high-quality process flow
- Value-Added Analysis: Method used to identify and categorize activities within a process based on their contribution to the final product or service from the customer's perspective

## Transitioning to Lean Systems

1. Make sure top management is committed and that they know what will be required
2. Decide which parts will need the most effort to convert
3. Obtain the support and cooperation of workers
4. Begin by trying to reduce setup times while maintaining the current system
5. Gradually convert operations, begin at the end and work backwards
6. Convert suppliers to JIT
7. Prepare for obstacles

## Obstacles to Conversion

1. Management may not be fully committed or willing to devote the necessary resources to conversion
2. Workers/management may not be cooperative
3. It can be difficult to change the organizational culture to one consistent with the lean philosophy
4. Suppliers may resist

# Operational Management

## Supply Chain Management (SCM)

The strategic coordination of business functions within a business organization and throughout its supply chain for the purpose of integrating supply and demand management.

- **Supply Chain:** The sequence of organizations—their facilities, functions, and activities—that are involved in producing and delivering a product or service (value chains)
- **SCM Managers:** People at various organizational levels are responsible for managing supply and demand both within and across businesses, involving the planning and coordination of activities (sourcing and procurement of materials and services, transformation activities, and logistics)
- **Logistics:** The part of a supply chain involved with the forward and reverse flow of goods, services, cash, and information

### Facilities

The sequence of the supply chain begins with basic suppliers and extends all the way to the final customer (Warehouses, Factories, Processing/Distribution centers, Retail outlets, Offices)

### Functions and Activities

The key functions and activities involved in supply chain management include forecasting, purchasing, inventory management, information management, quality assurance, scheduling, production and delivery, and customer service.

### Key Aspects of SCM

- **Goal:** Match supply to demand as effectively and efficiently as possible
- **Key Issues:** Determining appropriate outsourcing levels, managing procurement and suppliers, fostering strong customer relationships, and having the capability to quickly identify and respond to problems

### Flow Management

- **Product and Service Flow:** Involves movement of goods and services from suppliers to customers as well as handling customer service needs and product returns
- **Information Flow:** Involves sharing forecasts and sales data, transmitting orders, tracking shipments, and updating order status
- **Financial Flow:** Involves credit terms, payments, consignment, and title ownership arrangements

### Trends

Trends include measuring supply chain ROI, “greening” the supply chain, re-evaluating outsourcing, integrating IT, adopting lean principles, managing risks, adopting blockchain technology, establishing transparency, and adopting new delivery methods.

### Outsourcing

- **Benefits:** Lower prices from reduced labor costs, allowing organizations to focus on core strengths, converting fixed to variable costs, freeing up capital, shifting risks to suppliers, leveraging supplier expertise, and easier international expansion
- **Risks:** Inflexibility from longer lead times, higher transportation costs, cultural and language barriers, potential job and control loss, reduced productivity, loss of business knowledge, intellectual property concerns, and increased supply chain management effort

## Supply Chain Risks

- Supply Chain Disruption: Natural disasters, Supplier problems
- Quality Issues: Another form of disruption that may disrupt supplies and lead to product recalls, liability claims, and negative publicity
- Loss of Control of Sensitive Information: If suppliers divulge sensitive information to competitors, it can weaken a firm's competitive position

## Risk Management

Involves identifying risks, assessing their likelihood of occurring and their potential impact and then developing strategies for addressing those risks.

- Effective strategies for managing potential problems often involve a combination of risk avoidance, risk reduction, and risk sharing
- The key elements for a resilient supply chain include thoroughly knowing your suppliers, providing comprehensive supply chain visibility, and developing robust event-response capabilities

## Global Supply Chains

- Products are sold globally and Product design often uses inputs from around the world
- Some manufacturing and service activities are outsourced to countries where labor and/or materials costs are lower
- Complexities: Language and cultural differences; Currency fluctuations; Political instability; Increasing transportation costs and lead times

## ERP and Supply Chain Management

Supply Chain Management that integrates ERP is a formal approach to effectively plan and manage all the resources of a business enterprise. (Supplier Relationship Management, Performance Management, and Sales and Order Fulfillment)

## Dealing with Ethical Issues

Dealing with ethical issues in the supply chain involves developing an ethical code of behavior, monitoring activities, choosing reputable suppliers, incorporating labor standard compliance in contracts, and swiftly addressing any problems that arise.

## Small Business Concerns

Small business concerns often include optimizing inventory management to achieve reduced risks, especially when engaging in international trade.

## Management Responsibilities

- Legal: Being knowledgeable about laws and regulations of the countries where supply chains exist; Obeying laws and operating to conform to regulations
- Economic: Supplying products and services to meet demand as efficiently as possible
- Ethical: Conducting business in ways that are consistent with the moral standards of society
- Strategic: Certain strategic responsibilities have a major impact on the success of both supply chain management and the business itself
- Operational Efficiency: Meticulous scheduling, precise receiving, value-added transforming, timely order fulfilling, proactive managing inventory, efficient shipping, comprehensive information sharing, and diligent controlling
- Tactical: Accurate forecasting, strategic sourcing, detailed operations planning, effective managing inventory, optimized transportation planning, and robust collaborating

## Procurement

The purchasing department is responsible for obtaining the materials, parts, supplies, and services needed to produce a product or provide a service.

The Goal of Procurement: Develop and implement purchasing plans for products and services that support operations strategies

### Duties of Purchasing

- Identifying sources of supply
- Negotiating contracts
- Maintaining a database of suppliers
- Obtaining goods and services
- Managing suppliers

### The Purchasing Cycle

1. Purchasing receives the requisition
2. Purchasing selects a supplier
3. Purchasing places the order with a vendor
4. Monitoring orders
5. Receiving orders

### Centralized Purchasing

- Lower prices by combining orders
- Better service from suppliers due to larger volumes
- Better handling of special items

### Decentralized Purchasing

- Departments know their needs better
- Quicker response time
- Dealing with local suppliers may save money

## Supplier Management

Supplier management encompasses vendor analysis, conducting supplier audits, achieving supplier certification, cultivating strong supplier relationship management, and forging supplier/strategic partnerships.

## Logistics

Logistics refers to the movement of materials, services, cash, and information within a supply chain, encompassing movements within a facility, incoming and outgoing shipments, ensuring items get to the right location, tracking goods via methods like RFID, and utilizing services such as third-party logistics (3-PL).

## Creating an Effective Supply Chain

It begins with strategic sourcing - Analyzing the procurement process to lower costs by reducing waste and non-value-added activities, increase profits, reduce risks, and improve supplier performance.

- Needs: Trust, effective communication, information velocity, supply chain visibility, robust event management capability, and clear performance metrics
- Challenges: Barriers to integrating organizations, gaining top management buy-in, dealing with trade-offs, addressing the unique needs of small businesses, managing variability and uncertainty, and optimizing response time

## Trade-Offs

Supply chain management often involves navigating various trade-offs, such as the lot-size-inventory trade-off, the inventory-transportation cost trade-off, the lead time-transportation costs trade-off, the product variety-inventory trade-off, and the cost-customer service trade-off.

# Project Management (PM)

- **Projects:** Unique, one-time operations designed to accomplish a specific set of objectives in a limited time frame
- **Project Manager:** Ultimately responsible for the success or failure of the project

## Nature of Projects

- Projects go through a series of stages – a life cycle
- Projects bring together people with a diversity of knowledge and skills, most of whom remain associated with the project for less than its full life
- Organizational structure affects how projects are managed

## Project Management Decisions

Project success depends upon making key managerial decisions over a sequence of steps:

- Deciding which projects to implement
- Selecting the project manager
- Selecting the project team
- Planning and designing the project
- Managing and controlling project resources
- Deciding if and when a project should be terminated

## Project Life Cycle

1. Initiating (Discovery)
2. Planning
3. Executing
4. Monitoring and Controlling
5. Closing

## Behavioral Issues

Behavioral problems can be created or exacerbated by Decentralized decision making, Stress of achieving project milestones on time and within budget, and Surprises.

The team must be able to function as a unit

- Interpersonal and coping skills are very important
- Conflict resolution and negotiation can be an important part of a project manager's job

## Avoiding Problems

Many problems can be avoided or mitigated by:

- Effective team selection
- Leadership
- Motivation
- Maintaining an environment of Integrity, Trust, and Professionalism
- Being supportive of team efforts

## Project Champion

A person who promotes and supports a project

- Usually resides within the organization
- Facilitate the work of the project by 'talking up' the project to other managers who might be asked to share resources with the project team as well as employees who might be asked to work on parts of the project
- The project champion can be critical to the success of a project

## Work Breakdown Structure (WBS)

A hierarchical listing of what must be done during a project

Establishes a logical framework for identifying the required activities for the project

1. Identify the major elements of the project
2. Identify the major supporting activities for each of the major elements
3. Break down each major supporting activity into a list of the activities that will be needed to accomplish it

## PERT and CPM

PERT (program evaluation and review technique) and CPM (critical path method) are two techniques used to manage large-scale projects

By using PERT or CPM, managers can obtain:

- A graphical display of project activities
- An estimate of how long the project will take
- An indication of which activities are most critical to timely project completion
- An indication of how long any activity can be delayed without delaying the project

## PERT Advantages

Among the most useful features of PERT:

1. It forces the manager to organize and quantify available information and to identify where additional information is needed
2. It provides a graphic display of the project and its major activities
3. It identifies activities that should be closely watched, and activities that have slack time

## Network Diagram

Diagram of project activities that shows sequential relationships by use of arrows and nodes

- Activity on arrow (AOA): Network diagram convention in which arrows designate activities
- Activity on node (AON): Network convention in which nodes designate activities
  - Activities: Project steps that consume resources and/or time
  - Events: The starting and finishing of activities

## Project Time Lines

- Deterministic: Time estimates that are fairly certain
- Probabilistic: Time estimates that allow for variation

## Early Start, Early Finish

Finding ES and EF involves a forward pass through the network diagram

### Early start (ES)

The earliest start time (ES) for an activity, assuming preceding activities also start as early as possible, is the Early Finish (EF) of its single preceding activity, or the largest EF of all preceding activities if there are multiple.

### **Early finish (EF)**

The earliest time an activity can finish (EF) is adding its earliest start time (ES) to its expected duration (t). ( $EF = ES + t$ )

### **Late Start, Late Finish**

Finding LS and LF involves a backward pass through the network diagram

#### **Late Start (LS)**

The latest time an activity can start (LS) without delaying the project is calculated by subtracting its expected duration from its latest finishing time (LF). ( $LS = LF - t$ )

#### **Late Finish (LF)**

The latest time an activity can finish (LF) without delaying the project is determined by the Latest Start (LS) of its single leaving activity, or for nodes with multiple leaving activities, it's the smallest LS among those leaving activities.

### **Slack**

Slack can be computed in one of two ways:  $Slack = LS - ES$  or  $LF - EF$

Critical Path: Indicated by the activities with zero slack

#### **Using Slack Times**

Knowledge of slack times provides managers with information for planning the allocation of scarce resources

- Control efforts will be directed toward those activities that might be most susceptible to delaying the project
- Activity slack times are based on the assumption that all of the activities on the same path will be started as early as possible and not exceed their expected time
- If two activities are on the same path and have the same slack, this will be the total slack available to both

### **Probabilistic Time Estimates**

The beta distribution is generally used to describe the inherent variability in time estimates

The probabilistic approach involves three time estimates:

- Optimistic time ( $t_o$ ): The length of time required under optimal conditions
- Pessimistic time ( $t_p$ ): The length of time required under the worst conditions
- Most likely time ( $t_m$ ): The most probable length of time required

### **Knowledge of Path Statistics**

Knowledge of expected path times and their standard deviations enables managers to compute probabilistic estimates about project completion such as:

- The probability that the project will be completed by a certain time
- The probability that the project will take longer than its expected completion time

## **Project Completion Time**

To accurately determine project completion probability by a specified time, calculate and multiply the probabilities of all project paths finishing within that timeframe, as relying solely on the critical path is risky.

## **Assumption: Independence**

The assumption that path duration times are independent of each other, requiring independent activity times where each activity is on only one path, is typically met if only a few activities in a large project are shared across multiple paths.

## **Simulation**

When activity times cannot be assumed to be independent, simulation is often used

Repeated sampling involves making numerous passes through a project network, randomly selecting activity times in each pass to determine project duration, then compiling these durations into a frequency distribution from which probabilistic completion time estimates are made.

## **Time-Cost Trade-Offs**

- Activity time estimates are made for a given level of resources
- It may be possible to reduce the duration of a project by injecting additional resources

## **Crashing**

- Shortening activity durations: Typically, involves the use of additional funds to support additional personnel or more efficient equipment, and the relaxing of some work specifications
- The project duration may be shortened by increasing direct expenses, thereby realizing savings in indirect project costs

## **Sources of Error**

1. The project network may be incomplete
2. Precedence relationships may not be correctly expressed
3. Time estimates may be inaccurate
4. There may be a tendency to focus on critical path activities to the exclusion of other important project activities
5. Major risk events may not be on the critical path

## **Risk Management**

- Risks are an inherent part of project management
- Risks relate to the occurrence of events that have undesirable consequences such as Delays, Increased costs, and Inability to meet technical specifications

## **Good Risk Management Involves**

- Identifying as many risks as possible
- Analyzing and assessing those risks
- Working to minimize the probability of their occurrence
- Establishing contingency plans and budgets for dealing with any that do occur

# Chapter 1

## Introduction to Operations Management

# Operations Management (OM)

- **Video 1: OM** (7-8-6m)

[What is Operations Management? | Rowtons Training by Laurence Gartside \(youtube.com\)](#)

[2 Foundations for Improving your Operations | Rowtons Training by Laurence Gartside \(youtube.com\)](#)

[What is Operation Management? | Duties and Responsibilities in Operation Management \(youtube.com\)](#)

- 1) V1: What are business operations? Name few inputs & outputs mentioned?
- 2) V1: Explain KPIs and Visual Management from OM perspective?
- 3) V2: What are key sets of tasks involved in OM ?
- 4) V2: OM requires what and why?
- 5) V2: Explain the nature of OM?
- 6) V2: What are the duties and responsibilities in OM?
- 7) V2: Explain Product Design and Forecasting?
- 8) V2: Explain Supply Chain Management (SCM) and Explain Delivery Management?
- 9) V2: Name the 5-benefits of OM?
- 10) V2: Explain any 2 benefits of OM

- **Video 2: Ideal Skills** (12m)

[Ideal Skills of an Operations Manager | Simplicity Consultancy \(youtube.com\)](#)

- 1) What are the benefits of OM skills?
- 2) Name any 5-categories of Organizational Business Talents?

- **Group Discussion 1: [50-points]**

# Historical Evolution of OM

- Industrial Revolution
- Scientific management
- Human relations movement
- Decision models and management science
- Influence of Japanese manufacturers

# Industrial Revolution

- **Pre-Industrial Revolution**
  - **Craft production** - System in which highly skilled workers use simple, flexible tools to produce small quantities of customized goods
- **Some key elements of the industrial revolution**
  - Began in England in the 1770s
  - Division of labor - Adam Smith, 1776
  - Application of the “rotative” steam engine, 1780s
  - Cotton gin and interchangeable parts - Eli Whitney, 1792
- **Management theory and practice did not advance appreciably during this period**

# Scientific Management

- **Movement was led by efficiency engineer, Frederick Winslow Taylor**
  - Believed in a “science of management” based on observation, measurement, analysis and improvement of work methods, and economic incentives
  - Management is responsible for planning, carefully selecting and training workers, finding the best way to perform each job, achieving cooperation between management and workers, and separating management activities from work activities
  - Emphasis was on maximizing output

# Human Relations Movement

- The human relations movement emphasized the importance of the human element in job design
  - Lillian Gilbreth – applications of psychology
  - Elton Mayo – Hawthorne studies on worker motivation, 1930
  - Abraham Maslow – motivation theory, 1940s; hierarchy of needs, 1954
  - Frederick Herzberg – Two Factor Theory, 1959
  - Douglas McGregor – Theory X and Theory Y, 1960s
  - William Ouchi – Theory Z, 1981

# Decision Models & Management Science

- F.W. Harris – mathematical model for inventory management, 1915
- Dodge, Romig, and Shewart – statistical procedures for sampling and quality control, 1930s
- Tippett – statistical sampling theory, 1935
- Operations Research (OR) Groups – OR applications in warfare
- George Dantzig – linear programming, 1947

# Influence of Japanese Manufacturers

- **Refined and developed management practices that increased productivity**
  - Credited with fueling the “quality revolution”
  - Just-in-Time production

# Table 1.5

## Historical summary of Operations Management

Approximate Date	Contribution/Concept	Originator
1776	Division of labor	Adam Smith
1790	Interchangeable parts	Eli Whitney
1911	Principles of scientific management	Frederick W. Taylor
1911	Motion study, use of industrial psychology	Frank and Lillian Gilbreth
1912	Chart for scheduling activities	Henry Gantt
1913	Moving assembly line	Henry Ford
1915	Mathematical model for inventory ordering	F. W. Harris
1930	Hawthorne studies on worker motivation	Elton Mayo
1935	Statistical procedures for sampling and quality control	H. F. Dodge, H. G. Romig, W. Shewhart, L.H.C. Tippett
1940	Operations research applications in warfare	Operations research groups
1947	Linear programming	George Dantzig
1951	Commercial digital computers	Sperry Univac, IBM
1950s	Automation	Numerous
1960s	Extensive development of quantitative tools	Numerous
1960s	Industrial dynamics	Jay Forrester
1975	Emphasis on manufacturing strategy	W. Skinner
1980s	Emphasis on flexibility, time-based competition, lean production	T. Ohno, S. Shingo, Toyota
1980s	Emphasis on quality	W. Edwards Deming, J. Juran, K. Ishikawa
1990s	Internet, supply chain management	Numerous
2000s	Applications service providers and outsourcing	Numerous
	Social media, YouTube, and others	Numerous

# Industrial Revolution

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- **What are the four types of industry?**
  - **Primary industry** involves getting raw materials e.g. mining, farming and fishing.
  - **Secondary industry** involves manufacturing e.g. making cars and steel.
  - **Tertiary industries** provide a service e.g. teaching and nursing.
  - **Quaternary industry** involves research and development industries e.g. IT.

# INDUSTRY 4.0: 3<sup>rd</sup> Industrial Revolution

Late 18<sup>th</sup> century  
Industry 1.0

Late 19<sup>th</sup> century  
Industry 2.0

1970s to 2000s  
Industry 3.0



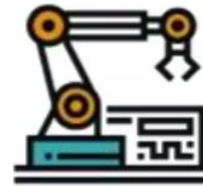
## 1st Industrial Revolution WATER & STEAM

Steam and water power  
replace human and animal power  
with machines.



## 2nd Industrial Revolution ELECTRICITY

Electricity, internal combustion  
engines, airplanes, telephones,  
cars, radio, and mass production.



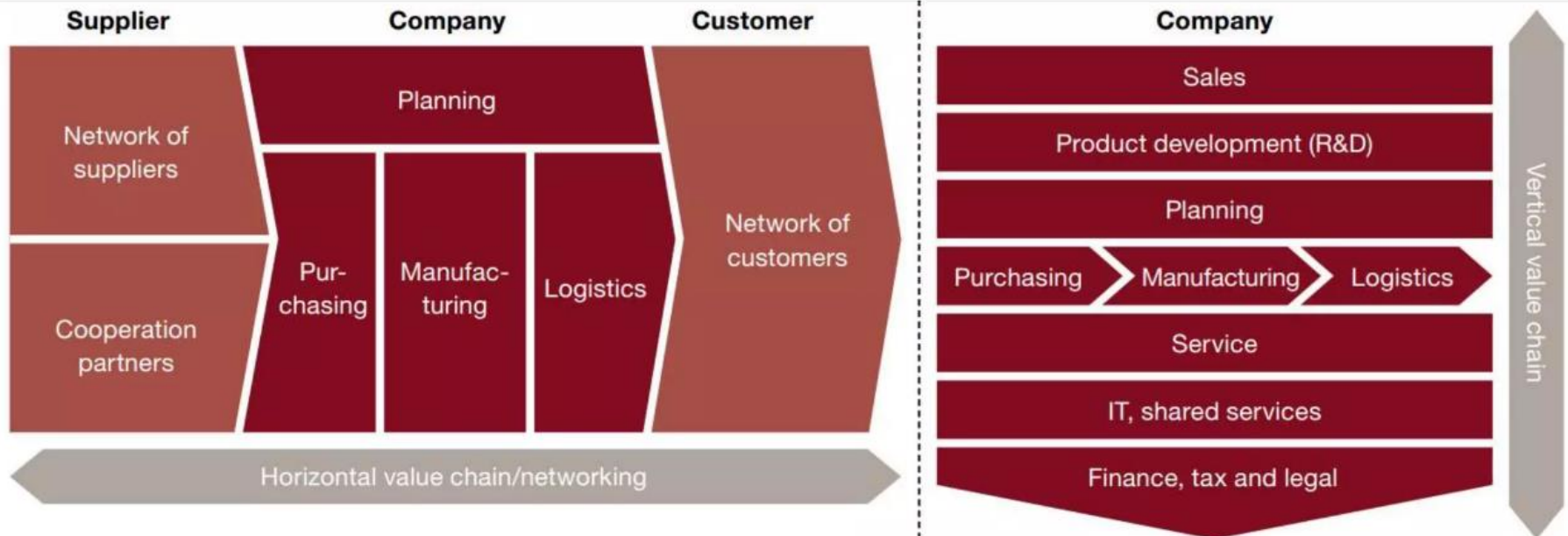
## 3rd Industrial Revolution AUTOMATION

Electronics, the internet and IT  
used to further the automation  
of mass production.



- Computation and data analysis technologies
- Electronics, Internet & IT
- Automation & Mass production

# Industry 4.0 requires comprehensive digitization of the horizontal and vertical value chains



Some of improvements may result from the digitization of processes and value chains:

- Focusing on core areas in the individual value chain
- Reduction of redundancies in processes
- Minimizing quality losses
- Making processes more flexible and coherent

# Operations Today

- Technology Management
- Global competition
- Working with fewer resources
- Revenue management
- Agility
- Automation
- Real-Time Analytics
- Artificial Intelligence (0 – 60%)

# Key Issues for Operations Managers Today

- Economic conditions
- Innovating
- Quality problems
- Risk management
- Cyber-security
- Competing in a global economy

# Operations Management

- **What is operations?**
  - The part of a business organization that is responsible for producing goods or services
- **How can we define operations management?**
  - The management of systems or processes that create goods and/or provide services

# Good or Service?

**Goods** are physical items that include raw materials, parts, subassemblies, and final products

- Automobile
- Computer
- Oven
- Shampoo

**Services** are activities that provide some combination of time, location, form or psychological value

- Air travel
- Education
- Haircut
- Legal counsel
- <https://www.youtube.com/watch?v=nG5-52a5lRo>

# Supply Chain

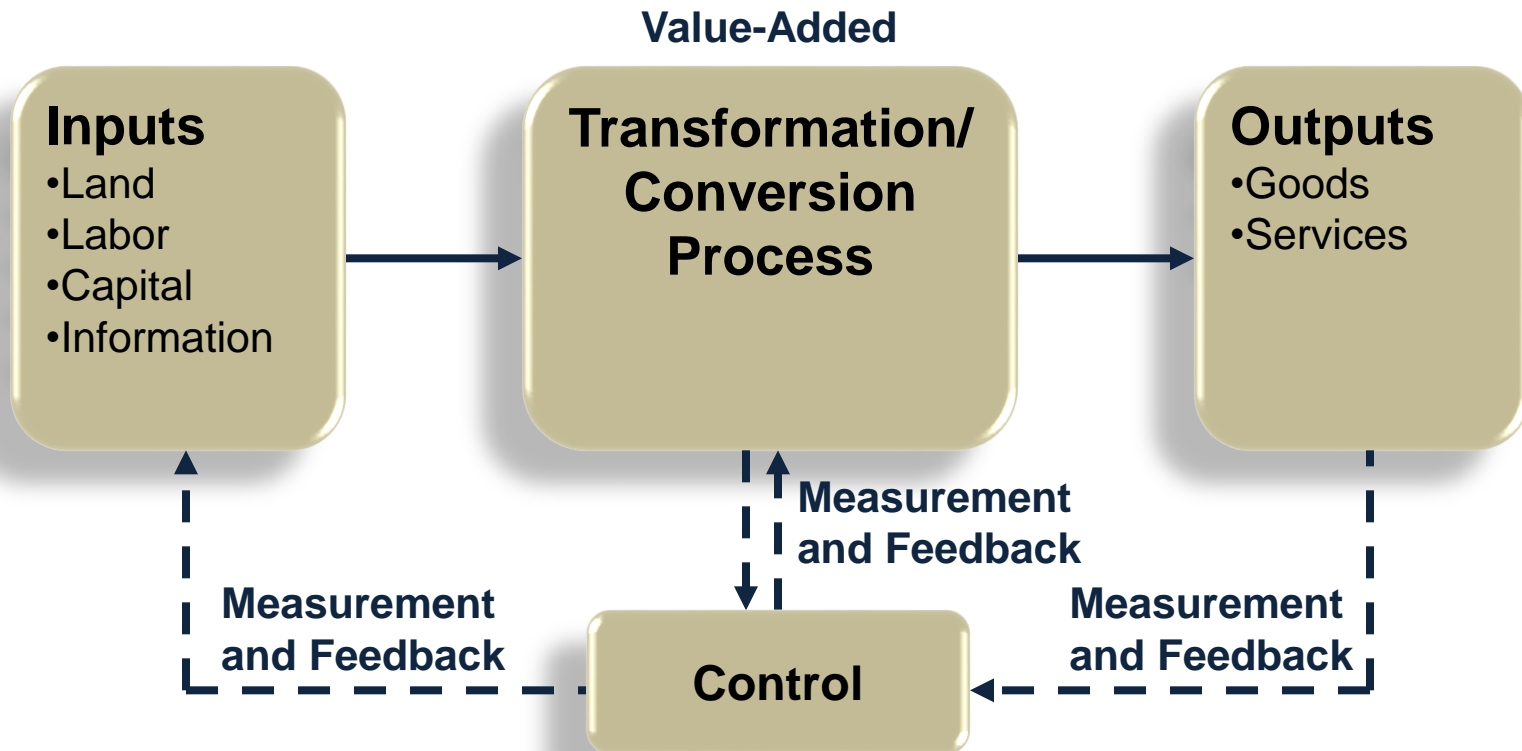
**Supply chain** – a sequence of activities and organizations involved in producing and delivering a good or service

<https://www.youtube.com/watch?v=Lpp9bHtPANO>

<https://www.youtube.com/watch?v=tdZOjBODtE4>



# The Transformation Process

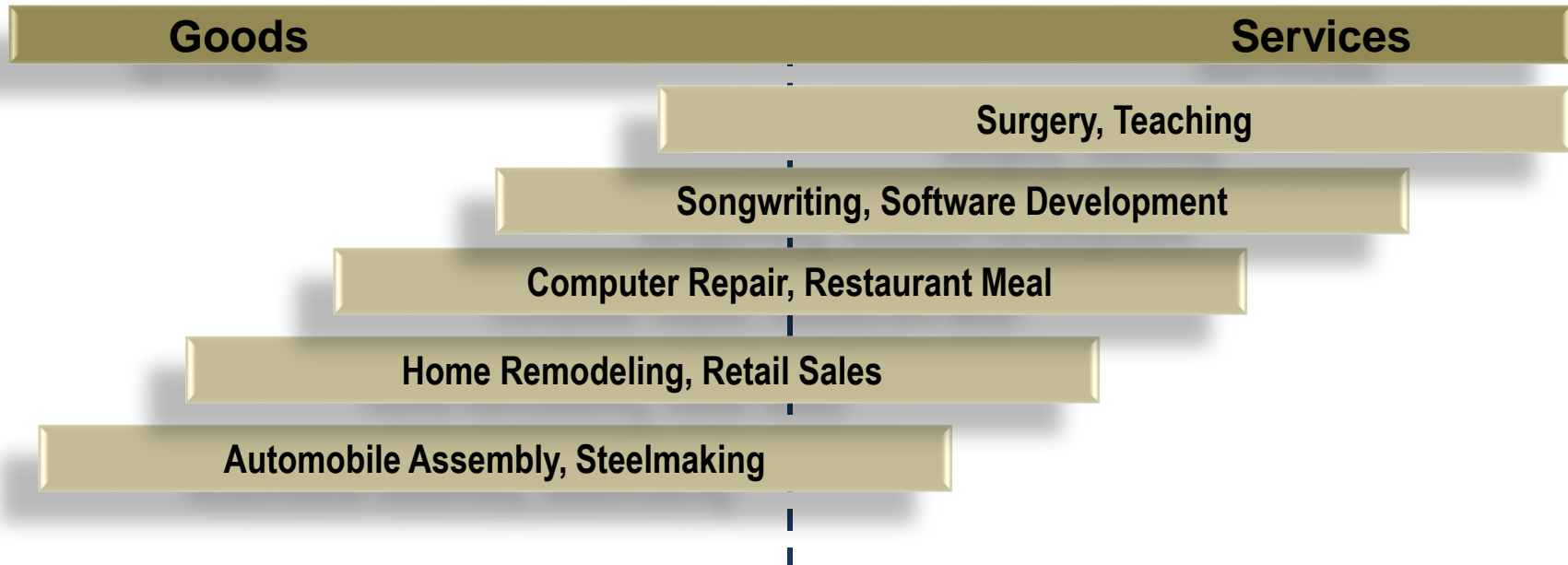


**Feedback** = Measurements taken at various points in the transformation process

**Control** = The comparison of feedback against previously established standards to determine if corrective action is needed

# Goods-Service Continuum

Products are typically neither purely service- or purely goods-based



# Table 1.2

## Illustrations of the transformation process

	Inputs	Processing	Output
Food Processor	Raw vegetables	Cleaning	Canned vegetables
	Metal sheets	Making cans	
	Water	Cutting	
	Energy	Cooking	
	Labor	Packing	
	Building	Labeling	
	Equipment		
Hospital	Doctors, nurses	Examination	Treated patients
	Hospital	Surgery	
	Medical supplies	Monitoring	
	Equipment	Medication	
	Laboratories	Therapy	

# Table 1.3

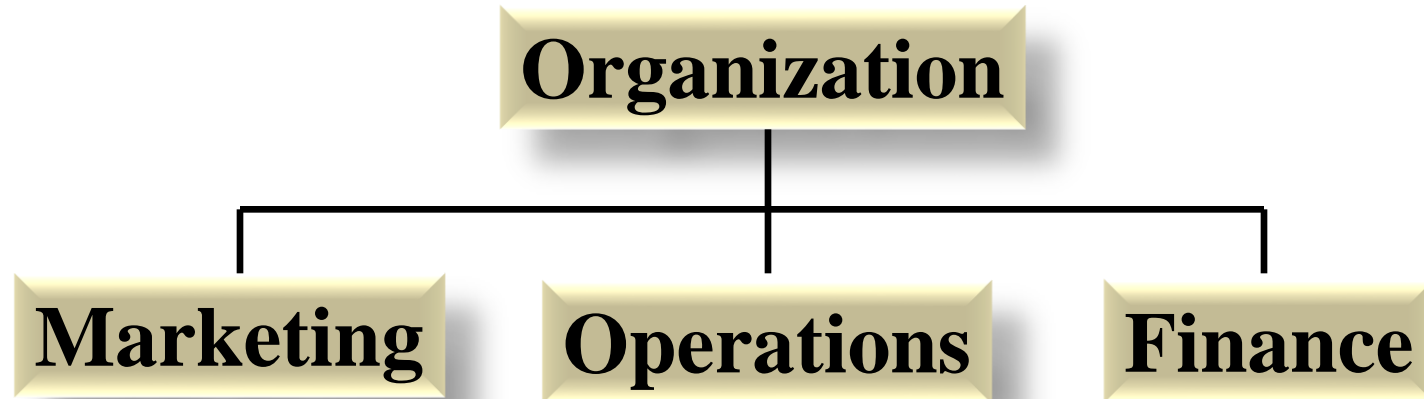
## Typical differences between production of goods and provision of services

Characteristic	Goods	Services
Output	Tangible	Intangible
Customer contact	Low	High
Labor content	Low	High
Uniformity of input	High	Low
Measurement of productivity	Easy	Difficult
Opportunity to correct problems before delivery	High	Low
Inventory	Much	Little
Wages	Narrow range	Wide range
Patentable	Usually	Not usually

# Why Study Operations Management?

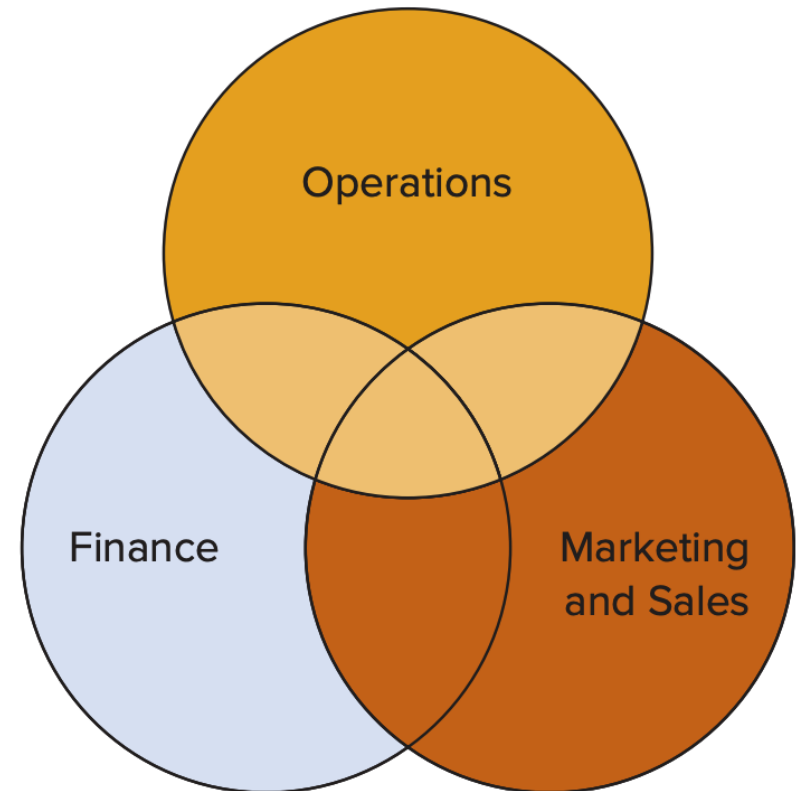
- **Every aspect of business affects or is affected by operations**
- **Many service jobs are closely related to operations**
  - Financial services
  - Marketing services
  - Accounting services
  - Information services
- **Through learning about operations and supply chains you will have a better understanding of:**
  - The world you live in
  - The global dependencies of companies and nations
  - Reasons that companies succeed or fail
  - The importance of working with others

# Basic Functions of the Business Organization



# Function Overlap

- **Finance & operations**
  - Budgeting
  - Economic analysis of investment proposals
  - Provision of funds
- **Marketing & operations**
  - Demand data
  - Product and service design
  - Competitor analysis
  - Lead time data



# OM and Supply Chain Career Opportunities

- Operations manager (Industry 4.0 / Modern Age – Analyst applies to all with multiple variants)
- Supply chain manager
- Production analyst
- Schedule coordinator
- Production manager
- Industrial engineer
- Purchasing manager
- Inventory manager
- Quality manager

# OM-Related Professional Societies

- APICS - The Association for Operations Management  
[Association for Operations Management \(APICS\) | The Manufacturing Institute](#)
- American Society for Quality (ASQ)  
[Excellence Through Quality | ASQ](#)
- Institute for Supply Management (ISM)  
[Home \(ismworld.org\)](#)
- Institute for Operations Research and Management Science (INFORMS)  
[IOL Home - INFORMS](#)
- The Production and Operations Management Society (POMS)  
[Welcome to Production and Operations Management Society | Production and Operations Management Society \(poms.org\)](#)
- The Project Management Institute (PMI)  
[Project Management Institute | PMI](#)
- Council of Supply Chain Management Professionals (CSCMP)  
[cscmp.org](#)

# Process Management

**Process** - one or more actions that transform inputs into outputs

## Three Categories of Business Processes:

### Upper-management processes

These govern the operation of the entire organization.

### Operational processes

These are core processes that make up the value stream.

### Supporting processes

These support the core processes.

# Supply & Demand

Operations &  
Supply Chains

Sales & Marketing

Supply  $>$  Demand

Wasteful  
Costly

Supply  $<$  Demand

Opportunity Loss  
Customer  
Dissatisfaction

Supply  $=$  Demand

Ideal

LO 1.5

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# Process Variation

<b>Four Sources of Variation:</b>	
<b>Variety of goods or services being offered</b>	The greater the variety of goods and services offered, the greater the variation in production or service requirements.
<b>Structural variation in demand</b>	These are generally predictable. They are important for capacity planning.
<b>Random variation</b>	Natural variation that is present in all processes. Generally, it cannot be influenced by managers.
<b>Assignable variation</b>	Variation that has identifiable sources. This type of variation can be reduced, or eliminated, by analysis and corrective action.

Variations can be disruptive to operations and supply chain processes. They may result in additional costs, delays and shortages, poor quality, and inefficient work systems.

# Scope of Operations Management

The scope of operations management ranges across the organization.

**The operations function includes many interrelated activities such as:**

- Forecasting
- Capacity planning
- Locating facilities
- Facilities and layout
- Scheduling
- Managing inventories
- Assuring quality
- Motivating employees
- And more . . .

# Role of the Operations Manager

The Operations function consists of all activities *directly* related to producing goods or providing services.

A primary function of the operations manager is to guide the system by decision making.

- System design decisions
- System operation decisions

# System Design Decisions

- **System design**
  - Capacity
  - Facility location
  - Facility layout
  - Product and service planning
  - Acquisition and placement of equipment
- These are typically strategic decisions that
  - usually require long-term commitment of resources
  - determine parameters of system operation

# System Operation Decisions

- **System operation**
  - These are generally tactical and operational decisions
    - Management of personnel
    - Inventory management and control
    - Scheduling
    - Project management
    - Quality assurance
  - Operations managers spend more time on system operation decision than any other decision area
    - They still have a vital stake in system design

# OM Decision Making

- **Most operations decisions involve many alternatives that can have quite different impacts on costs or profits**
- **Typical operations decisions include:**
  - *What:* What resources are needed, and in what amounts?
  - *When:* When will each resource be needed? When should the work be scheduled? When should materials and other supplies be ordered?
  - *Where:* Where will the work be done?
  - *How:* How will the product or service be designed? How will the work be done? How will resources be allocated?
  - *Who:* Who will do the work?

# General Approach to Decision Making

- **Modeling is a key tool used by all decision makers**
  - *Model* - an abstraction of reality; a simplification of something
  - Common features of models:
    - They are simplifications of real-life phenomena
    - They omit unimportant details of the real-life systems they mimic so that attention can be focused on the most important aspects of the real-life system
  - Physical Model – miniature airplane
  - Schematic Model – drawing of a city
  - Mathematical Model – Inventory optimization

# Understanding Models

- **Keys to successfully using a model in decision making**
  - What is its purpose?
  - How is it used to generate results?
  - How are the results interpreted and used?
  - What are the model's assumptions and limitations?

# Benefits of Models

1. Generally easier to use and less expensive than dealing with the real system
2. Require users to organize and sometimes quantify information
3. Increase understanding of the problem
4. Enable managers to analyze “What if?” questions
5. Serve as a consistent tool for evaluation and provide a standardized format for analyzing a problem
6. Enable users to bring the power of mathematics to bear on a problem

# Model Limitations

- Quantitative information may be emphasized at the expense of qualitative information
- Models may be incorrectly applied and the results misinterpreted
  - This is a real risk with the widespread availability of sophisticated, computerized models placed in the hands of uninformed users
- The use of models does not guarantee good decisions

# Quantitative Approaches

- A decision-making approach that frequently seeks to obtain a mathematically optimal solution
  - Supported by computer calculations
  - Often work together with qualitative approaches

# Metrics and Trade-Offs / KPIs

- **Performance metrics**

- All managers use metrics to manage and control operations
  - Profits
  - Costs
  - Quality
  - Productivity
  - Flexibility
  - Inventories
  - Schedules
  - Forecast accuracy

- **Analysis of trade-offs**

- A trade-off is giving up one thing in return for something else
  - Carrying more inventory (an expense) in order to achieve a greater level of customer service

# Systems Perspective

- **System** - a set of interrelated parts that must work together
  - The business organization is a system composed of subsystems
    - Marketing subsystem
    - Operations subsystem
    - Finance subsystem
- **The systems perspective**
  - Emphasizes *interrelationships among subsystems*
  - Main theme is that *the whole is greater than the sum of its parts*
  - The output and objectives of the organization take precedence over those of any one subsystem

# Establishing Priorities

- In nearly all cases, certain issues or items are more important than others
- Recognizing this allows managers to focus their attention to those efforts that will do the most good
  - Pareto Phenomenon - a few factors account for a high percentage of occurrence of some event(s)
    - The critical few factors should receive the highest priority
    - This is a concept that is appropriately applied to all areas and levels of management

# Chapter 2

## Competitiveness, Strategy, and Productivity

# Operations Management (OM)

- **Video 1: Competitiveness** (6-7m)

[What are the three main competitive strategies by Michael Porter 🤨 \(youtube.com\)](#)

[What is Competitive Advantage? \(With Real-World Examples\) | From A Business Professor \(youtube.com\)](#)

- 1) What are Competitive Advantage according to Philip Kotler?
- 2) Explain cost leadership/advantage strategy?
- 3) Explain differentiation advantage strategy?
- 4) Explain focus or network advantage strategy?

- **Extra**

[Tesla competitive advantage \(2020\) : Why Tesla and Apple are so very similar \(youtube.com\)](#)

[How Apple Creates it Competitive Advantage \(youtube.com\)](#)

- **Group Discussion 1: [25-points]**

# A Cold Hard Fact

Better quality, higher productivity, lower costs, and the ability to respond quickly to customer needs are more important than ever, and...

the bar is getting higher

# Chapter Focus

- This chapter focuses on three separate but related ideas that are vitally important to business organizations
  1. Competitiveness
  2. Strategy
  3. Productivity

# Competitiveness

- **Competitiveness:**
  - How effectively an organization meets the wants and needs of customers relative to others that offer similar goods or services
  - Organizations compete through some combination of their marketing and operations functions
    - What do customers want?
    - How can these customer needs best be satisfied?

# Marketing's Influence

- Identifying consumer wants and/or needs
- Pricing and quality
- Advertising and promotion

# Businesses Compete Using Operations

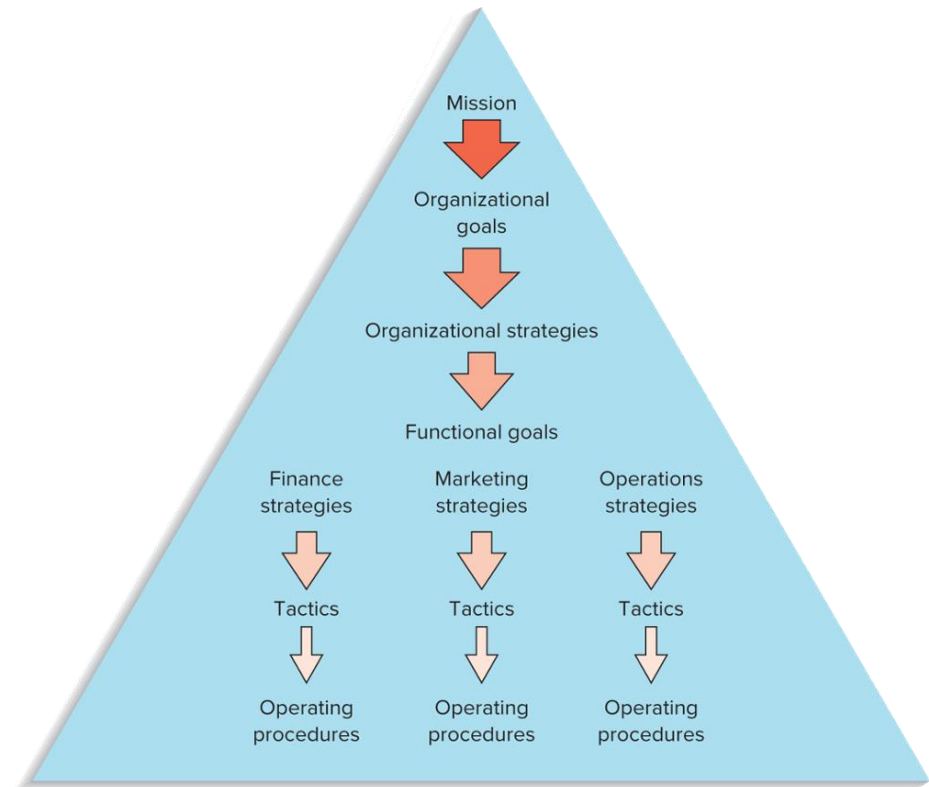
1. Product and service design
2. Cost
3. Location
4. Quality
5. Quick response
6. Flexibility
7. Inventory management
8. Supply chain management
9. Service
10. Managers and workers

# Why Some Organizations Fail

1. Neglecting operations strategy
2. Failing to take advantage of strengths and opportunities and/or failing to recognize competitive threats
3. Too much emphasis on short-term financial performance at the expense of R&D
4. Too much emphasis on product and service design and not enough on process design and improvement
5. Neglecting investments in capital and human resources
6. Failing to establish good internal communications and cooperation
7. Failing to consider customer wants and needs

# Hierarchical Planning

- **Mission**
- **Goals**
- **Organizational strategies**
- **Functional strategies**
- **Tactics**



**FIGURE 2.1**

Planning and decision making are hierarchical in organizations

# Mission

- **Mission**
  - The reason for an organization's existence
- **Mission statement**
  - States the purpose of the organization
  - The mission statement should answer the question of “What business are we in?”

# Mission Statement

**TABLE 2.1**

Selected portions  
of company mission  
statements

<b>Microsoft</b>	To help people and businesses throughout the world to realize their full potential.
<b>Verizon</b>	To help people and businesses communicate with each other.
<b>Starbucks</b>	To inspire and nurture the human spirit—one cup and one neighborhood at a time.
<b>U.S. Dept. of Education</b>	To promote student achievement and preparation for global competitiveness and fostering educational excellence and ensuring equal access.

# Goals

- **The mission statement serves as the basis for organizational goals**
- **Goals**
  - Provide detail and the scope of the mission
    - Goals can be viewed as organizational destinations
  - Goals serve as the basis for organizational strategies

# Strategies

- **Strategy**
  - A plan for achieving organizational goals
    - Serves as a roadmap for reaching the organizational destinations
  - Organizations have
    - *Organizational strategies*
      - Overall strategies that relate to the entire organization
      - Support the achievement of organizational goals and mission
    - *Functional level strategies*
      - Strategies that relate to each of the functional areas and that support achievement of the organizational strategy

# Tactics and Operations

- **Tactics**
  - The methods and actions taken to accomplish strategies
  - The “how to” part of the process
- **Operations**
  - The actual “doing” part of the process

# Core Competencies

- **Core competencies**

The special attributes or abilities that give an organization a *competitive edge*

- To be effective, core competencies and strategies need to be aligned

# Sample Operations Strategies

Organizational Strategy	Operations Strategy	Examples of Companies or Services
Low Price	Low cost	U.S. first-class postage Wal-Mart
Responsiveness	Short processing times On-time delivery	McDonald's restaurants FedEx
Differentiation: High Quality	High performance design and/or high quality processing Consistent quality	Sony TV Coca-Cola
Differentiation: Newness	Innovation	3M, Apple
Differentiation: Variety	Flexibility Volume	Burger King (Have it your way") McDonald's ("Buses Welcome")
Differentiation: Service	Superior customer service	Disneyland IBM
Differentiation: Location	Convenience	Supermarkets; mall stores

# Strategy Formulation

- Effective strategy formulation requires taking into account:
  - Core competencies
  - Environmental scanning
    - SWOT: Strengths, Weaknesses, Opportunities, and Threats
- Successful strategy formulation also requires taking into account:
  - Order qualifiers
  - Order winners

# Strategy Formulation (cont.)

- **Order qualifiers**

- Characteristics that customers perceive as minimum standards of acceptability for a product or service to be considered as a potential for purchase

- **Order winners**

- Characteristics of an organization's goods or services that cause it to be perceived as better than the competition

# Environmental Scanning

- **Environmental scanning is necessary to identify**
  - Internal factors
    - Strengths and weaknesses
  - External factors
    - Opportunities and threats

# Key External Factors

1. Economic conditions
2. Political conditions
3. Legal environment
4. Technology
5. Competition
6. Customers
7. Suppliers
8. Markets

# Key Internal Factors

1. Human resources
2. Facilities and equipment
3. Financial resources
4. Customers
5. Products and services
6. Technology
7. Other

# Mission and Strategies

- **Supply Chain Strategy**
  - How the organization should work with suppliers and policies relating to customer relationships and sustainability
- **Sustainability Strategy**
  - Work with governmental regulations and interest groups to achieve sustainability goals
- **Global Strategy**
  - Work with international suppliers/producers and also with countries where the products and services are sold

# Operations Strategy

- **Operations strategy**
  - The approach, consistent with organization strategy, that is used to guide the operations function

# Strategic OM Decision Areas

Decision Area	What the Decisions Affect
Product and service design	Costs, quality, liability, and environmental issues
Capacity	Cost, structure, flexibility
Process selection and layout	Costs, flexibility, skill level needed, capacity
Work design	Quality of work life, employee safety, productivity
Location	Costs, visibility
Quality	Ability to meet or exceed customer expectations
Inventory	Costs, shortages
Maintenance	Costs, equipment reliability, productivity
Scheduling	Flexibility, efficiency
Supply chains	Costs, quality, agility, shortages, vendor relations
Projects	Costs, new products, services, or operating systems

# Quality-Based Strategies

- **Quality-based strategy**
  - Strategy that focuses on quality in all phases of an organization
    - Pursuit of such a strategy is rooted in a number of factors:
      - Trying to overcome a poor quality reputation
      - Desire to maintain a quality image
      - A desire to catch up with the competition
      - A part of a cost reduction strategy

# Time-Based Strategies

- **Time-based strategies**
  - Strategies that focus on the reduction of time needed to accomplish tasks
    - It is believed that by reducing time, costs are lower, quality is higher, productivity is higher, time-to-market is faster, and customer service is improved

# Time-Based Strategies (cont.)

- **Areas where organizations have achieved time reductions:**
  - Planning time
  - Product/service design time
  - Processing time
  - Changeover time
  - Delivery time
  - Response time for complaints

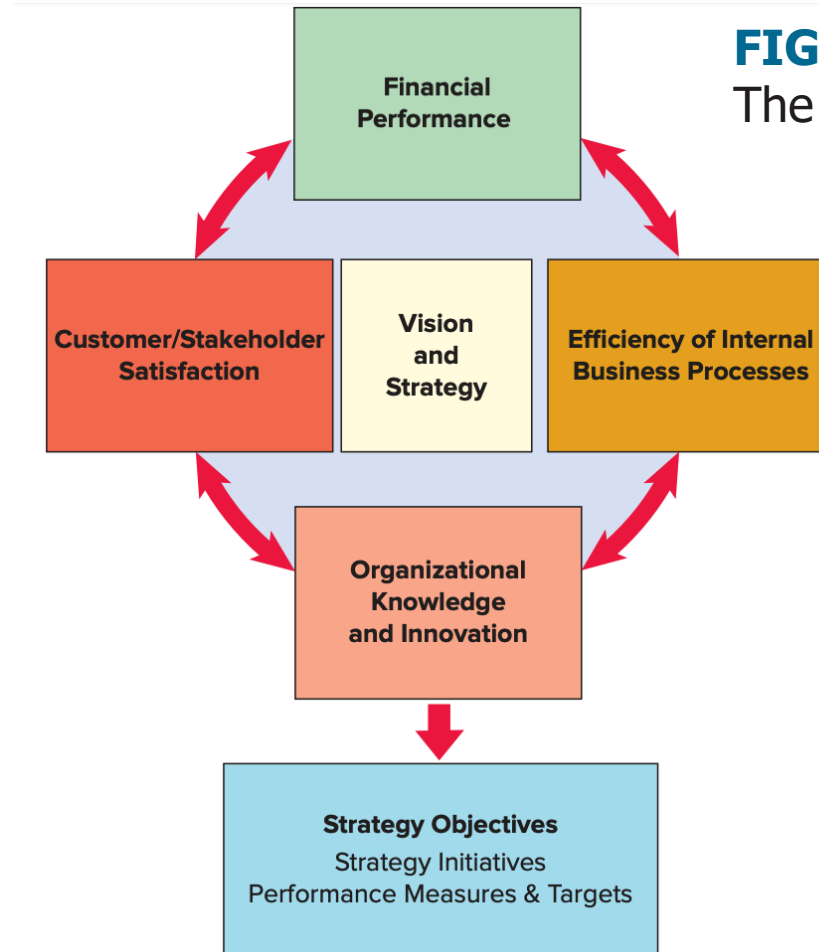
# Agile Operations

- **Agile operations**
  - A strategic approach for competitive advantage that emphasizes the use of flexibility to adapt and prosper in an environment of change
    - Involves the blending of several core competencies:
      - Cost
      - Quality
      - Reliability
      - Flexibility

# The Balanced Scorecard Approach

- A top-down *management system* that organizations can use to clarify their vision and strategy and transform them into action
  - Develop objectives
  - Develop metrics and targets for each objective
  - Develop initiatives to achieve objectives
  - Identify links among the various perspectives
    - Finance
    - Customer
    - Internal business processes
    - Learning and growth
  - Monitor results

# The Balanced Scorecard



**FIGURE 2.2**

The Balanced Scorecard

Source: Adapted from Robert S. Kaplan and David P. Norton, "Using the Balanced Scorecard as a Strategic Management System," *Harvard Business Review* (January-February 1996): 76.

# Productivity

- **Productivity**
  - A measure of the effective use of resources, usually expressed as the ratio of output to input
- **Productivity measures are useful for**
  - Tracking an operating unit's performance over time
  - Judging the performance of an entire industry or country

# Why Productivity Matters

- High productivity is linked to higher standards of living
  - As an economy replaces manufacturing jobs with lower productivity service jobs, it is more difficult to maintain high standards of living
- Higher productivity relative to the competition leads to competitive advantage in the marketplace
  - Pricing and profit effects
- For an industry, high relative productivity makes it less likely it will be supplanted by foreign industry

# Productivity Measures

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

$$\text{Partial Measures} \quad \frac{\text{Output}}{\text{Single Input}}; \quad \frac{\text{Output}}{\text{Labor}}; \quad \frac{\text{Output}}{\text{Capital}}$$

$$\text{Multifactor Measures} \quad \frac{\text{Output}}{\text{Multiple Inputs}}; \quad \frac{\text{Output}}{\text{Labor + Machine}}; \quad \frac{\text{Output}}{\text{Labor + Capital + Energy}}$$

$$\text{Total Measure} \quad \frac{\text{Goods or services produced}}{\text{All inputs used to produce them}}$$

# Operations Management (OM)

- **Video 1: Productivity** (3-4m)

[What is Productivity? How to calculate Productivity? Purpose of improving Productivity, Part 1 \(youtube.com\)](#)

[Factors affecting Productivity, productivity part 2 \(youtube.com\)](#)

- 1) What is productivity?
- 2) Name few “Inputs” and “Outputs”?
- 3) What is the purpose of improving productivity for management?
- 4) What is the purpose of improving productivity for workers?
- 5) List the factors affecting productivity

- **Extra**

[What is Productivity | Productivity Definition Related to Lean and Management \(youtube.com\)](#)

[What is Productivity? \(youtube.com\)](#)

- **Group Discussion 1: [25-points]**

## Table 2.8

### Some examples of partial productivity measures

#### **Labor productivity**

Units of output per labor hour

Units of output per shift

Value-added per labor hour

Dollar value of output per labor hour

#### **Machine productivity**

Units of output per machine hour

Dollar value of output per machine hour

#### **Capital productivity**

Units of output per dollar input

Dollar value of output per dollar input

#### **Energy productivity**

Units of output per kilowatt-hour

Dollar value of output per kilowatt-hour

# Productivity Calculation Example

Units produced:	5,000
Standard price:	\$30/unit
Labor input:	500 hours
Cost of labor:	\$25/hour
Cost of materials:	\$5,000
Cost of overhead:	2× labor cost

***What is the multifactor productivity?***

# Solution

$$\begin{aligned}\text{Multifactor Productivity} &= \frac{\text{Output}}{\text{Labor} + \text{Material} + \text{Overhead}} \\ &= \frac{5,000 \text{ units} \times \$30/\text{unit}}{(500 \text{ hours} \times \$25/\text{hour}) + \$5,000 + (2(500 \text{ hours} \times \$25/\text{hour}))} \\ &= \frac{\$150,000}{\$42,500} \\ &= 3.5294\end{aligned}$$

# Productivity Growth

$$\text{Productivity Growth} = \frac{\text{Current productivity} - \text{Previous productivity}}{\text{Previous productivity}} \times 100\%$$

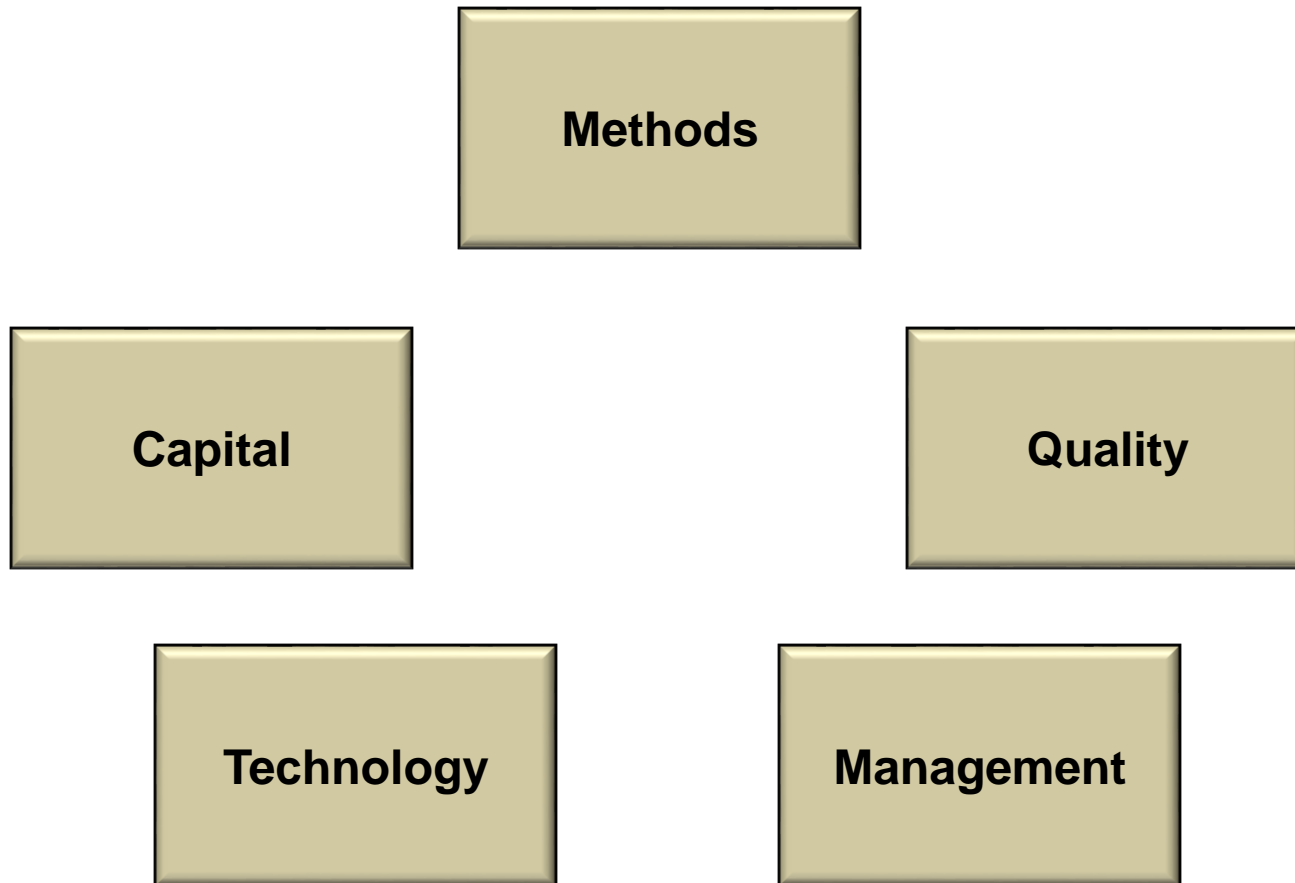
Example: Labor productivity on the ABC assembly line was 25 units per hour in 2014. In 2015, labor productivity was 23 units per hour. What was the productivity growth from 2014 to 2015?

$$\text{Productivity Growth} = \frac{23 - 25}{25} \times 100\% = -8\%$$

# Service Sector Productivity

- Service sector productivity is difficult to measure and manage because
  - It involves intellectual activities
  - It has a high degree of variability
- A useful measure related to productivity is ***process yield***
  - Where products are involved
    - Ratio of output of good product to the quantity of raw material input
  - Where services are involved, process yield measurement is often dependent on the particular process:
    - Ratio of cars rented to cars available for a given day
    - Ratio of student acceptances to the total number of students approved for admission

# Factors Affecting Productivity



# Recent Technological factors affecting productivity

- Drones
- GPS devices
- Smartphones
- 3D printers
- Radio frequency ID tags (RFID)
- Medical imaging
- Artificial intelligence

# Improving Productivity

1. Develop productivity measures for all operations
2. Determine critical (bottleneck) operations
3. Develop methods for productivity improvements
4. Establish reasonable goals
5. Make it clear that management supports and encourages productivity improvement
6. Measure and publicize improvements
7. Don't confuse *productivity* with *efficiency*

# Numerical Problem 1

- A catering company prepared and served 350 meals at an anniversary celebration last week using 8 workers. The week before, 2 workers prepared and served 230 meals at a wedding reception.

a1. Calculate the labor productivity for each event.

a2. For which event was the labor productivity higher?

Anniversary or Wedding?

# Numerical Problem 3-17

- The manager of a crew that installs carpeting has tracked the crew's output over the past several weeks, obtaining these figures:

Week	Crew	Yards Installed
1	2	100
2	4	67
3	3	97
4	5	47
5	6	67
6	7	56

a. Compute the labor productivity for each of the weeks.

b. Which crew size works best?

# Numerical Problem 5-17

- Compute the multifactor productivity measure for each of the weeks shown for production of chocolate bars. Assume 40-hour weeks and an hourly wage of \$16. Overhead is 1.5 times weekly labor cost. Material cost is \$9 per pound.

Week	Output (Units)	Workers	Materials (lbs)
1	32000	5	470
2	37000	6	520
3	28000	6	480
4	38000	7	580

# Numerical Problem 7-17

- A company that makes shopping carts for supermarkets and other stores recently purchased some new equipment that reduces the labor content of the jobs needed to produce the shopping carts. Prior to buying the new equipment, the company used 6 workers, who together produced an average of 70 carts per hour. Workers receive \$13 per hour, and machine cost was \$50 per hour. With the new equipment, it was possible to transfer one of the workers to another department, and equipment cost increased by \$11 per hour, while output increased by 5 carts per hour.
  - a. Compute labor productivity under each system. Use carts per worker per hour as the measure of labor productivity.
  - b. Compute the multifactor productivity under each system. Use carts per dollar cost (labor plus equipment) as the measure.
  - c. Comment on the changes in productivity according to the two measures.

# Chapter 3

## Forecasting

# Chapter 3: Key Activities Today

1. Basic Theory: Forecasting
2. Videos:
  - a) **Case Study: Nestle**
    - Discussion (Group of 4-6 Students) [20-points]
  - b) **Case Study: Aviation Spairliner**
    - Discussion (Group of 4-6 Students) [20-points]
  - c) **Statistical Methods & Predictive Analytics**
    - Discussion (Group of 4-6 Students. 20]
3. Numerical Problems (Refer Excel Sheet in Canvas)

# Forecast

- **Forecast – a statement about the future value of a variable of interest**
  - We make forecasts about such things as weather, demand, and resource availability
  - Forecasts are important to making informed decisions

$$y_c = a + bx$$

# Two Important Aspects of Forecasts

- **Expected level of demand**
  - The level of demand may be a function of some structural variation such as trend or seasonal variation
- **Accuracy**
  - Related to the potential size of forecast error

# Forecasts in Business Organizations

- **Accounting.** New product/process cost estimates, profit projections, cash management.
- **Finance.** Equipment/equipment replacement needs, timing and amount of funding/borrowing needs.
- **Human resources.** Hiring activities, including recruitment, interviewing, and training; layoff planning, including outplacement counseling.
- **Marketing.** Pricing and promotion, e-business strategies, global competition strategies.
- **MIS.** New/revised information systems, internet services.
- **Operations.** Schedules, capacity planning, work assignments and workloads, inventory planning, make-or-buy decisions, outsourcing, project management.
- **Product/service design.** Revision of current features, design of new products or services.

# Forecast Uses

- **Plan the system**
  - Generally involves long-range plans related to:
    - Types of products and services to offer
    - Facility and equipment levels
    - Facility location
- **Plan the use of the system**
  - Generally involves short- and medium-range plans related to:
    - Inventory management
    - Workforce levels
    - Purchasing
    - Production
    - Budgeting
    - Scheduling

# Features Common to All Forecasts

1. Techniques assume some underlying causal system that existed in the past will persist into the future
2. Forecasts are not perfect
3. Forecasts for groups of items are more accurate than those for individual items
4. Forecast accuracy decreases as the forecasting horizon increases

# Forecasts Are Not Perfect

- Forecasts are not perfect:
  - Because random variation is always present, there will always be some residual error, even if all other factors have been accounted for.

# Elements of a Good Forecast

## The forecast

- Should be *timely*
- Should be *accurate*
- Should be *reliable*
- Should be expressed in *meaningful units*
- Should be *in writing*
- Technique should be *simple to understand and use*
- Should be *cost-effective*

# Steps in the Forecasting Process

1. Determine the purpose of the forecast
2. Establish a time horizon
3. Obtain, clean, and analyze appropriate data
4. Select a forecasting technique
5. Make the forecast
6. Monitor the forecast errors

# Nestle DSD (Direst Store Delivery): Video

[https://www.youtube.com/watch?v=CBLk4\\_oYQnI](https://www.youtube.com/watch?v=CBLk4_oYQnI)

## Group Discussion Questions:

- 1) What were the challenges for demand planning?
- 2) What were the business issues with the existing forecasting system they had?
  - 1) Growth, channels, portfolio, cost reduction, service exptn.,
- 3) What were the forecasting related issues they were facing?
- 4) List their criteria for a good forecasting demand?
- 5) Name and explains the Vendor's (sas) demand planning tool?
- 6) What other departments were benefitted from their DPW?

Group Discussion: 20-points

# Forecasting Approaches

- **Qualitative forecasting**

- Qualitative techniques permit the inclusion of *soft* information such as:
  - Human factors
  - Personal opinions
  - Hunches / intuition based
- These factors are difficult, or impossible, to quantify

- **Quantitative forecasting**

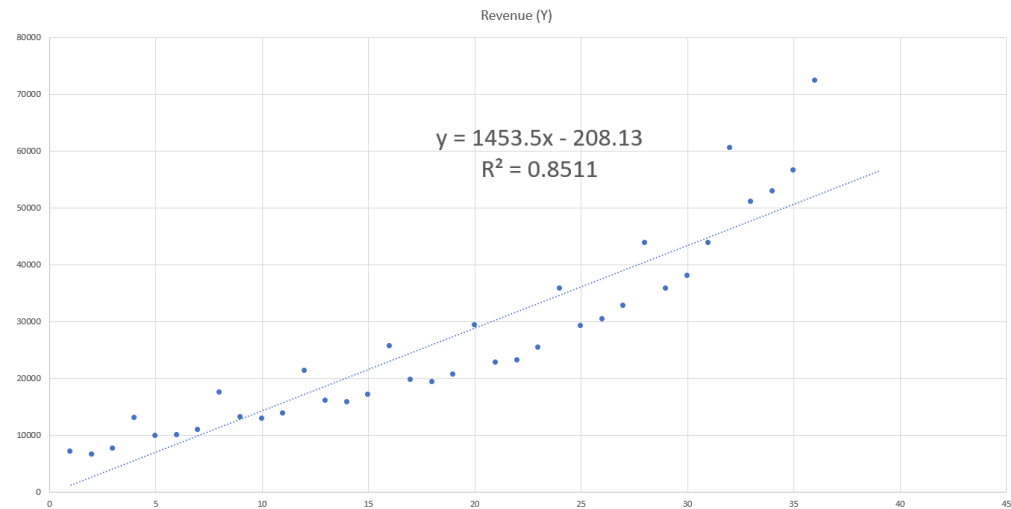
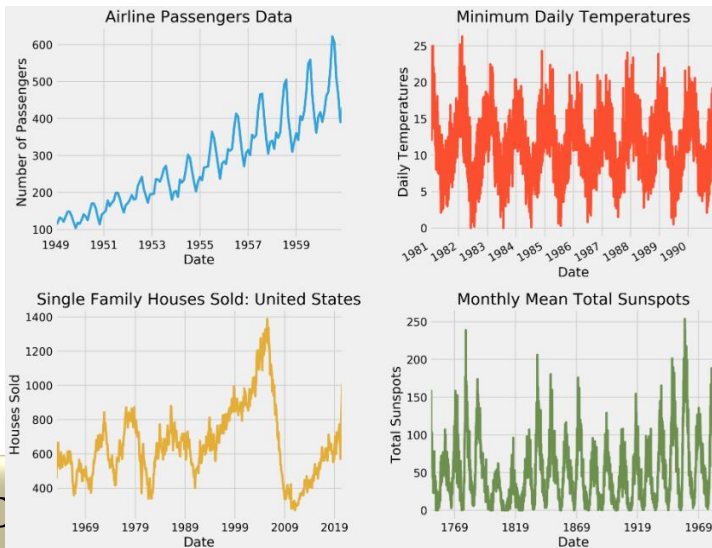
- These techniques rely on *hard* data
- Quantitative techniques involve either the projection of historical data or the development of associative methods that attempt to use *causal variables* to make a forecast

# Qualitative Forecasts

- Forecasts that use subjective inputs such as opinions from consumer surveys, sales staff, managers, executives, and experts
  - **Executive opinions**
    - A small group of upper-level managers may meet and collectively develop a forecast
  - **Salesforce opinions**
    - Members of the sales or customer service staff can be good sources of information due to their direct contact with customers and may be aware of plans customers may be considering for the future
  - **Consumer surveys**
    - Since consumers ultimately determine demand, it makes sense to solicit input from them
    - Consumer surveys typically represent a *sample* of consumer opinions
  - **Other approaches**
    - Managers may solicit opinions from other managers or staff people or outside experts to help with developing a forecast.
    - The Delphi method is an iterative process intended to achieve a consensus

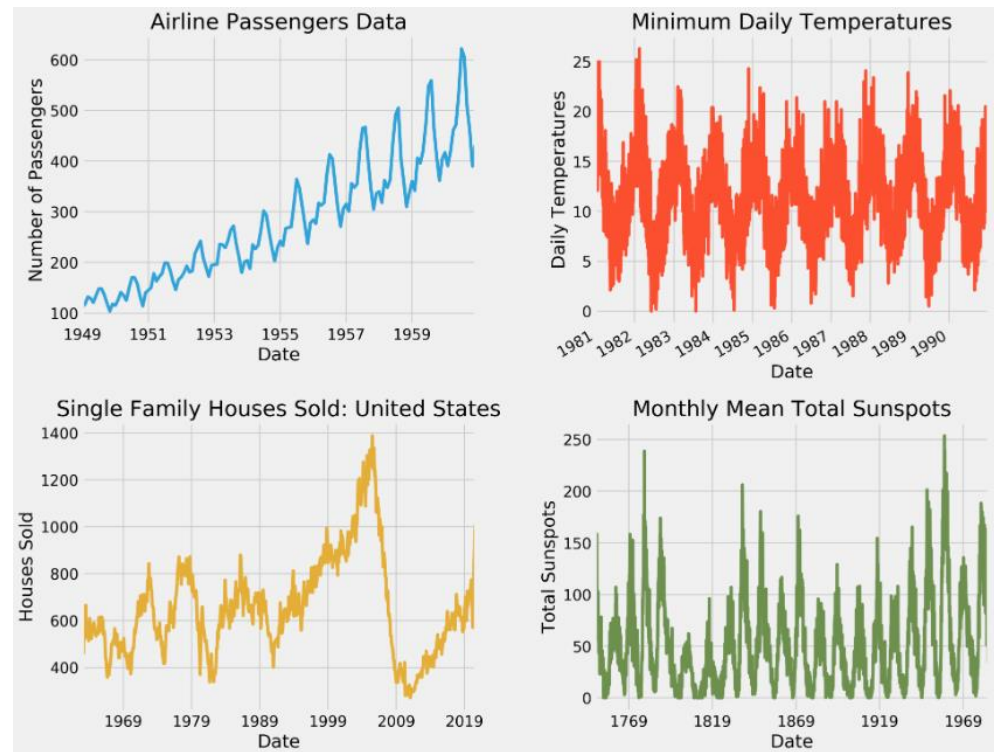
# Quantitative forecasting : Time-Series

- Forecasts that project patterns identified in recent time-series observations
  - **Time-series** – a time-ordered sequence of observations taken at regular time intervals
- Assume that future values of the time-series can be estimated from past values of the time-series



# Time-Series Behaviors

- Trend
- Seasonality
- Cycles
- Irregular variations
- Random variation



# Trends and Seasonality

- **Trend**

- A long-term upward or downward movement in data
  - Population shifts
  - Changing income

- **Seasonality**

- Short-term, fairly regular variations related to the calendar or time of day
- Restaurants, service call centers, and theaters all experience seasonal demand

# Cycles and Variations

- **Cycle**

- Wavelike variations lasting more than one year
  - These are often related to a variety of economic, political, or even agricultural conditions

- **Irregular variation**

- Due to unusual circumstances that do not reflect typical behavior
  - Labor strike
  - Weather event

- **Random Variation**

- Residual variation that remains after all other behaviors have been accounted for

# Probabilistic Forecasting for Aviation: Spairliners case study: Video

<https://www.youtube.com/watch?v=dhr3vYmFRVY>

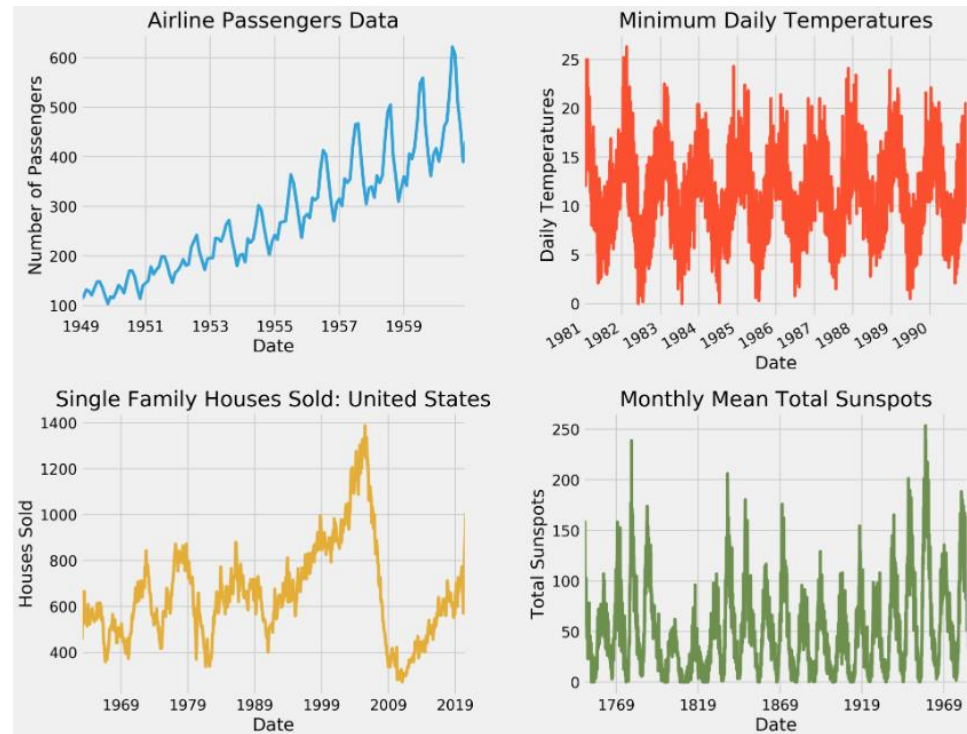
## Group Discussion Questions:

- 1) What is Spairliners Co.? What do they do?
- 2) What was the key decision made by their management in 2014? How?
- 3) What were the benefits of the partner Lokad after 2 years?
- 4) Explain: “Probabilistic forecasts” according to Lokad?
- 5) Explain: “Programmatic approach”?

Group Discussion: 20-points

# Time-Series Forecasting - Naïve Forecast

- **Naïve forecast**
  - Uses a single previous value of a time series as the basis for a forecast
    - The forecast for a time period is equal to the previous time period's value
  - Can be used with
    - A stable time series
    - Seasonal variations
    - Trend



# Time-Series Forecasting - Averaging

- These techniques work best when a series tends to vary about an average
  - Averaging techniques smooth variations in the data
  - They can handle step changes or gradual changes in the level of a series
  - Techniques
    1. Moving average
    2. Weighted moving average
    3. Exponential smoothing

# Moving Average

- Technique that averages a number of the most recent actual values in generating a forecast

$$F_t = \text{MA}_n = \frac{\sum_{i=1}^n A_{t-i}}{n} = \frac{A_{t-n} + \dots + A_{t-2} + A_{t-1}}{n}$$

where

$F_t$  = Forecast for time period  $t$

$\text{MA}_n$  =  $n$  period moving average

$A_{t-i}$  = Actual value in period  $t - i$

$n$  = Number of periods in the moving average

## Moving Average (cont.)

- As new data become available, the forecast is updated by adding the newest value and dropping the oldest and then re-computing the average
- The number of data points included in the average determines the model's sensitivity
  - Fewer data points used—more responsive
  - More data points used—less responsive

# Weighted Moving Average

- The most recent values in a time series are given more weight in computing a forecast
  - The choice of weights,  $w$ , is somewhat arbitrary and involves some trial and error

$$F_t = w_t(A_t) + w_{t-1}(A_{t-1}) + \dots + w_{t-n}(A_{t-n})$$

where

$w_t$  = weight for period  $t$ ,  $w_{t-1}$  = weight for period  $t-1$ , etc.

$A_t$  = the actual value for period  $t$ ,  $A_{t-1}$  = the actual value for period  $t-1$ , etc.

# Linear Trend

- A simple data plot can reveal the existence and nature of a trend
- Linear trend equation

$$F_t = a + bt$$

where

$F_t$  = Forecast for period  $t$

$a$  = Value of  $F_t$  at  $t = 0$

$b$  = Slope of the line

$t$  = Specified number of time periods from  $t = 0$

# Estimating Slope and Intercept

- Slope and intercept can be estimated from historical data

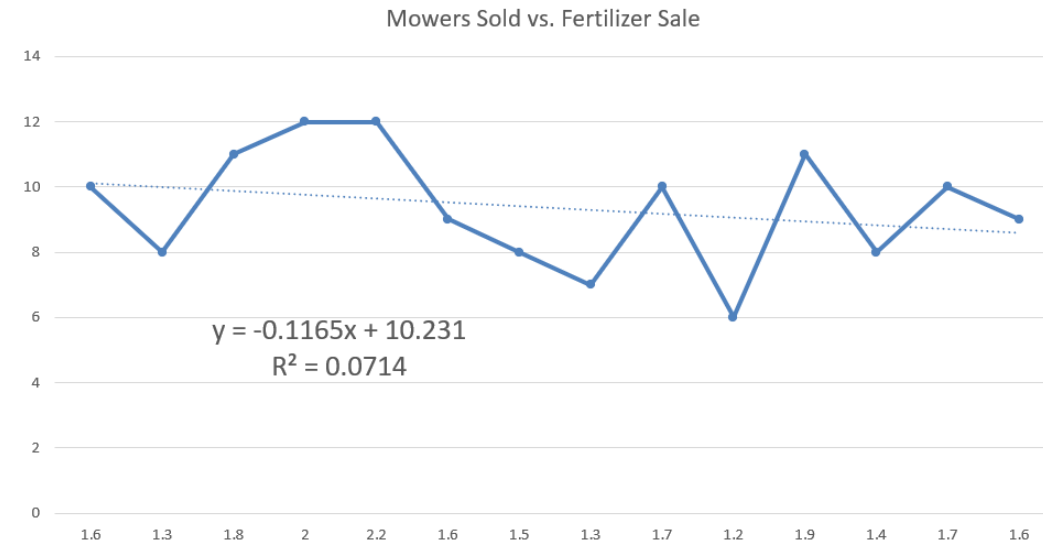
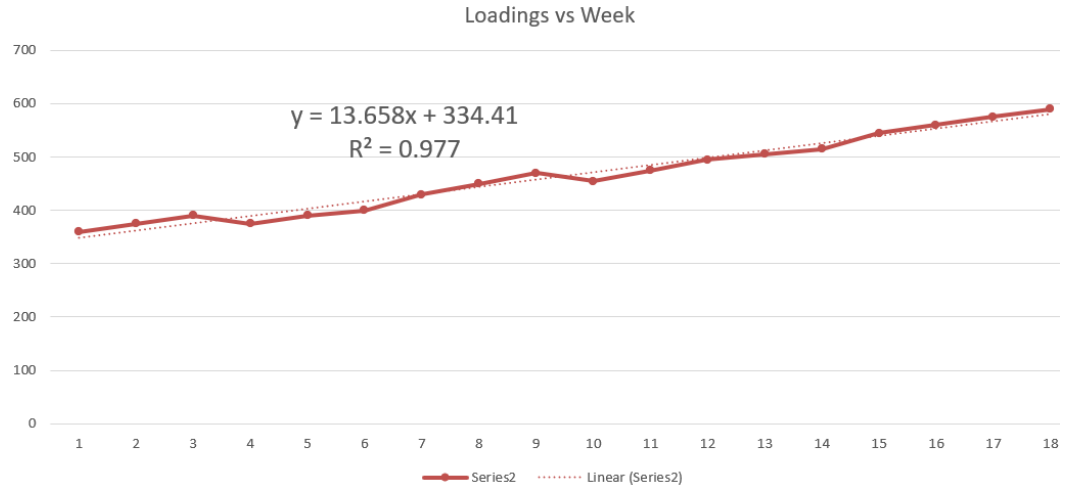
$$b = \frac{n \sum ty - \sum t \sum y}{n \sum t^2 - (\sum t)^2}$$

$$a = \frac{\sum y - b \sum t}{n} \text{ or } \bar{y} - b \bar{t}$$

where

$n$  = Number of periods

$y$  = Value of the time series



# Techniques for Seasonality

- Seasonality – regularly repeating movements in series values that can be tied to recurring events
  - Expressed in terms of the amount that actual values deviate from the average value of a series
  - Models of seasonality
    - Additive
      - Seasonality is expressed as a quantity that gets added to or subtracted from the time-series average in order to incorporate seasonality
    - Multiplicative
      - Seasonality is expressed as a percentage of the average (or trend) amount which is then used to multiply the value of a series in order to incorporate seasonality

# Seasonal Relatives

- **Seasonal relatives**

- The seasonal percentage used in the multiplicative seasonally adjusted forecasting model

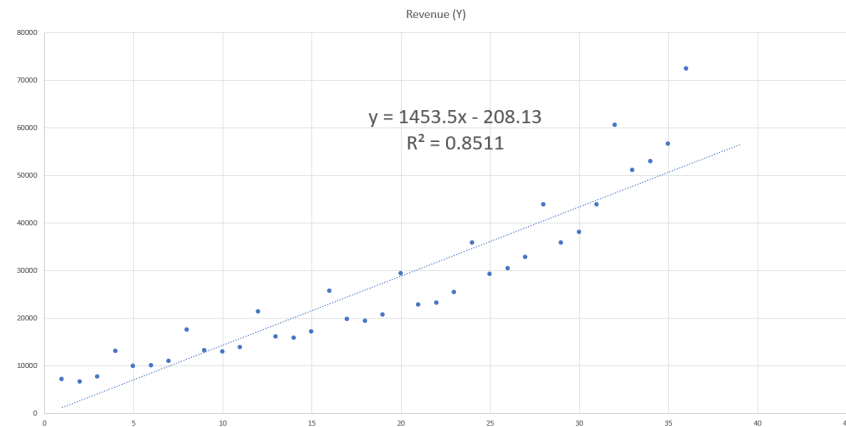
- **Using seasonal relatives**

- To *deseasonalize* data

- Done in order to get a clearer picture of the nonseasonal (e.g., trend) components of the data series
- Divide each data point by its seasonal relative

- To *incorporate seasonality* in a forecast

1. Obtain trend estimates for desired periods using a trend equation
2. Add seasonality by multiplying these trend estimates by the corresponding seasonal relative



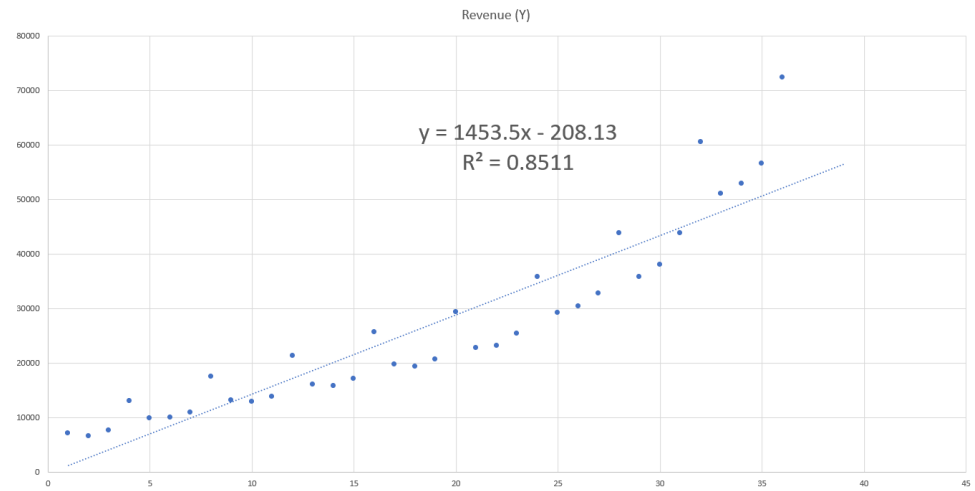
# Associative Forecasting Techniques

- Associative techniques are based on the development of an equation that summarizes the effects of predictor variables
  - **Predictor variables** – variables that can be used to predict values of the variable of interest
    - Home values may be related to such factors as home and property size, location, number of bedrooms, and number of bathrooms

# Simple Linear Regression

- **Regression** – a technique for fitting a line to a set of data points
  - Simple linear regression – the simplest form of regression that involves a linear relationship between two variables
    - The object of simple linear regression is to obtain an equation of a straight line that minimizes the sum of squared vertical deviations from the line (i.e., the *least squares criterion*)

$$y_c = a + bx$$



# Least Squares Line

$$y_c = a + bx$$

where

$y_c$  = Predicted (dependent) variable

$x$  = Predictor (independent) variable

$b$  = Slope of the line

$a$  = Value of  $y_c$  when  $x = 0$  (i.e., the height of the line at the  $y$  intercept)

and

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

$$a = \frac{\sum y - b \sum x}{n} \text{ or } \bar{y} - b\bar{x}$$

where

$n$  = Number of paired observations

# Correlation Coefficient

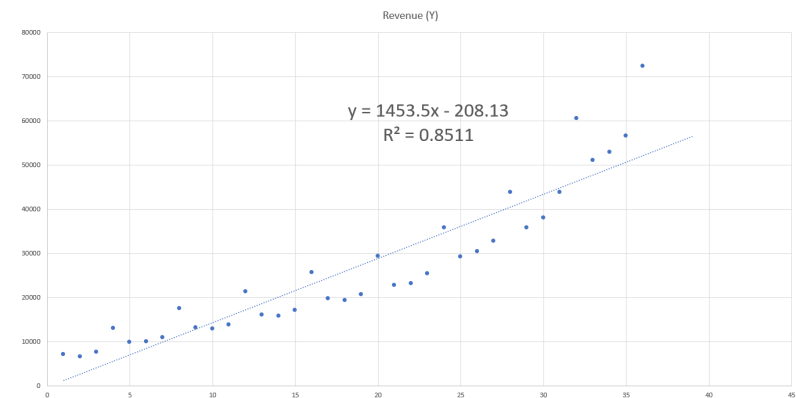
- **Correlation,  $r$**

- A measure of the strength and direction of relationship between two variables
- Ranges between -1.00 and +1.00

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2} \sqrt{n(\sum y^2) - (\sum y)^2}}$$

- **$r^2$ , square of the correlation coefficient**

- A measure of the percentage of variability in the values of  $y$  that is “explained” by the independent variable
- Ranges between 0 and 1.00



# Simple Linear Regression Assumptions

1. Variations around the line are random
2. Deviations around the average value (the line) should be normally distributed
3. Predictions are made only within the range of observed values

# Issues to Consider:

- Always plot the line to verify that a linear relationship is appropriate
- The data may be time-dependent
  - If they are
    - use analysis of time series
    - use time as an independent variable in a multiple regression analysis
- $r^2$  value close to 1.0 indicate a strong correlation between variables.

## Demand forecasting: how predictive analytics helps plan for the future: Video

<https://www.youtube.com/watch?v=NxR-gzjciCI>

### Group Discussion Questions:

- 1) What were the 3-main activities adopted by Master Kong Company to win over the competition? What was the key decision made by their management in 2014? How?
- 2) Traditional statistical methods: Explain? Where used?
- 3) Explain: Trend analysis?
- 4) Drawbacks of using traditional stats when launching new product?
- 5) Explain “data-driven coffee chain” concept by Starbucks?
  - 1) Which data points?
- 6) Explain Predictive analytics in demand forecasting?
- 7) Explain demand sensing?

Group Discussion: 20-points

# Forecast Accuracy and Control

- Allowances should be made for forecast errors
  - It is important to provide an indication of the extent to which the forecast might deviate from the value of the variable that actually occurs
- Forecast errors should be monitored
  - Error = Actual – Forecast
  - If errors fall beyond acceptable bounds, corrective action may be necessary

# Forecast Accuracy Metrics

$$\text{MAD} = \frac{\sum |\text{Actual}_t - \text{Forecast}_t|}{n}$$

MAD weights all errors evenly.  
Smaller MAD value means smaller forecasting error.

---

$$\text{MSE} = \frac{\sum (\text{Actual}_t - \text{Forecast}_t)^2}{n - 1}$$

MSE weights errors according to their squared values

---

$$\text{MAPE} = \frac{\sum \frac{|\text{Actual}_t - \text{Forecast}_t|}{\text{Actual}_t} \times 100}{n}$$

MAPE weights errors according to relative error

Smaller values of MAD, MSE and MAPE means smaller forecasting error.

An analyst must decide between two different forecasting techniques for weekly sales of roller blades: a linear trend equation and the naive approach. The linear trend equation is  $F_t = 127 + 2.1t$ , and it was developed using data from periods 1 through 10. Based on data for periods 11 through 20 as shown in the table, which of these two methods has the greater accuracy if MAD and MSE are used? **(Round your intermediate calculations and final answers to 2 decimal places.)**

<i>t</i>	Units Sold
11	145
12	150
13	148
14	143
15	154
16	149
17	152
18	156
19	158
20	164

$$MAD = \frac{\sum |Actual_t - Forecast_t|}{n}$$

$$MSE = \frac{\sum (Actual_t - Forecast_t)^2}{n - 1}$$

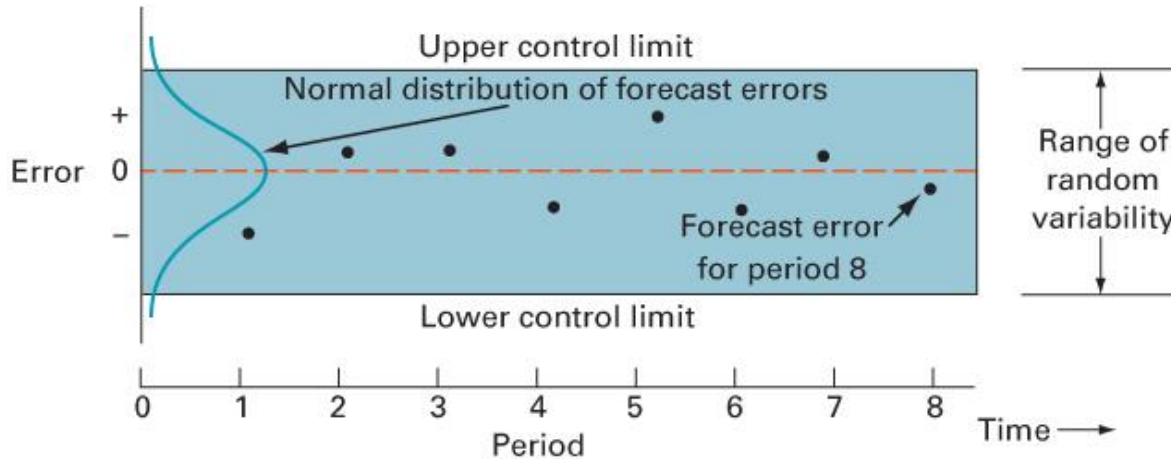
MAD (Naïve)	
MAD (Linear)	
MSE (Naïve)	
MSE (Linear)	

<i>t</i>	Units Sold (Actual)	Linear Method - Forecasted	(A - F)	ABS(A - F)	(A - F)^2	Naïve Forecast	(A - F)	ABS(A - F)	(A - F)^2
11	145								
12	150								
13	148								
14	143								
15	154								
16	149								
17	152								
18	156								
19	158								
20	164								

# Monitoring the Forecast

- Tracking forecast errors and analyzing them can provide useful insight into whether forecasts are performing satisfactorily
- Sources of forecast errors:
  - The model may be inadequate due to
    - a. omission of an important variable
    - b. a change or shift in the variable the model cannot handle
    - c. the appearance of a new variable
  - Irregular variations may have occurred
  - Random variation
- Control charts are useful for identifying the presence of non-random error in forecasts
- Tracking signals can be used to detect forecast bias

# Control Chart Construction



1. Compute the MSE.
2. Estimate of standard deviation of the distribution of errors

$$s = \sqrt{\text{MSE}}$$

3. UCL:  $0 + z\sqrt{\text{MSE}}$

4. LCL:  $0 - z\sqrt{\text{MSE}}$

where  $z$  = Number of standard deviations from the mean

# Choosing a Forecasting Technique

- **Factors to consider**
  - Cost
  - Accuracy
  - Availability of historical data
  - Availability of forecasting software
  - Time needed to gather and analyze data and prepare a forecast
  - Forecast horizon

# Operations Strategy

- The better forecasts are, the more able organizations will be to take advantage of future opportunities and reduce potential risks
  - A worthwhile strategy is to work to improve short-term forecasts
    - Accurate up-to-date information can have a significant effect on forecast accuracy:
      - Prices
      - Demand
      - Other important variables
    - Reduce the time horizon forecasts have to cover
    - Sharing forecasts or demand data through the supply chain can improve forecast quality

# Numerical Problems: 1 (Naïve Method)

A commercial bakery has recorded sales (in dozens) for three products, as shown below:

Day	Blueberry Muffins	Cinnamon Buns	Cupcakes
1	40	18	58
2	41	17	24
3	43	19	30
4	41	19	61
5	49	21	36
6	40	22	29
7	43	24	28
8	49	22	57
9	39	25	25
10	42	26	25
11	45	26	23
12	42	27	62
13	48	29	28
14	43	32	25
15	42	34	22

1. Predict orders for the following day for each of the products using naive method, trend adjusted naïve method, seasonally adjusted naïve method (if seasonal cycles exists).

# Numerical Problems: 2 (Naïve, Moving Avg.)

National Scan, Inc., sells radio frequency inventory tags. Monthly sales for a seven-month period were as follows:

Month	Sales (000)Units
Feb.	18
Mar.	21
Apr.	15
May.	23
Jun.	20
Jul.	26
Aug.	23

Forecast September sales volume using each of the following:

- (1) The naive approach
- (2) A five-month moving average.
- (3) A weighted average using 0.60 for August, 0.10 for July, and 0.30 for June.
- (4) A linear trend equation.

# Numerical Problems: 3 (Linear Trend)

Freight car loadings over an 18-week period at a busy port are as follows:

Week	Number	Week	Number	Week	Number
1	360	7	430	13	505
2	375	8	450	14	515
3	390	9	470	15	545
4	375	10	455	16	560
5	390	11	475	17	575
6	400	12	495	18	590

- Determine a linear trend line for expected freight car loadings.
- Use the above trend equation to predict expected loadings for Weeks 20 & 21.
- The manager intends to install new equipment when the volume exceeds 940 loadings per week. Assuming the current trend continues, in which week (at the earliest) should the loading volume reach that level?

# Numerical Problems: 4 (Linear Trend)

Air travel on Mountain Airlines for the past 18 weeks was:

Week	Passengers	Week	Passengers
1	405	10	440
2	410	11	446
3	420	12	451
4	415	13	455
5	412	14	464
6	420	15	466
7	424	16	474
8	433	17	476
9	438	18	482

- Use an appropriate technique to develop a forecast for the expected number of passengers for the next three weeks.

# Numerical Problems: 5

New car sales for a dealer in Cook County, Illinois, for the past year are shown in the following table, along with monthly indexes (seasonal relatives), which are supplied to the dealer by the regional distributor.

Month	Units Sold	Index	Month	Units Sold	Index
Jan.	647	0.70	Jul.	763	0.90
Feb.	657	0.80	Aug.	783	1.10
Mar.	642	0.60	Sept.	813	1.20
Apr.	742	0.94	Oct.	813	1.20
May	747	0.89	Nov.	823	1.20
Jun.	843	1.00	Dec.	783	1.25

- a. Deseasonalize car sales.
- b. What is your inference based on your findings in part a?
  - the deseasonalized data displays a downward trend.
  - the deseasonalized data displays an upward trend.



# Numerical Problems: 8 (Linear Reg / Correlation Coef.)

The manager of a seafood restaurant was asked to establish a pricing policy on lobster dinners. Experimenting with prices produced the following data:

Average Number Sold per Day, $y$	Price, $x$	Average Number Sold per Day, $y$	Price, $x$
200	\$6.00	155	\$8.25
190	6.50	156	8.50
188	6.75	148	8.75
180	7.00	140	9.00
170	7.25	133	9.25
162	7.50		
160	8.00		

- Write a linear regression equation.
- Determine the correlation coefficient and interpret it.

# Numerical Problems: 9 (Linear Reg / Correlation Coef.)

Lovely Lawns, Inc., intends to use sales of lawn fertilizer to predict lawn mower sales. The store manager estimates a probable six-week lag between fertilizer sales and mower sales. The pertinent data are:

Period	Fertilizer Sales (tons)	Number of Mowers Sold (six-week lag)	Period	Fertilizer Sales (tons)	Number of Mowers Sold (six-week lag)
1	1.6	10	8	1.3	7
2	1.3	8	9	1.7	10
3	1.8	11	10	1.2	6
4	2.0	12	11	1.9	11
5	2.2	12	12	1.4	8
6	1.6	9	13	1.7	10
7	1.5	8	14	1.6	9

- Write a linear regression equation.
- Determine the correlation between the two variables. Does it appear that a relationship exists between these variables will yield good predictions?

# Chapter 4

## Product and Service Design

# Chapter 4: Key Activities Today

## 1) **Video: 1** (Product & Service Design)

- **Discussion** (Group 4-5 Students) [20-points]

## 2) **Video: 2** Product/Service - Netflix transformation through redesign

- **Discussion** (Group 4-5 Students) [20-points]

## 3) **Video: 3** Life Cycle Stages - Coca Cola & Apple

- **Discussion** (Group 4-5 Students) [10-points]

## 5) **Theory: Product & Service Design**

## 6) (Homework) **Video: Case Study [Nordic Service Design]**

- **Banking, Insurance & Wealth Management**

- **Healthcare**

- **Customer Experience**

# Product and Service Design

- **Video 1: Product Design (5-min)**

- <https://www.youtube.com/watch?v=JNzvLWC2cGQ&t=1s>

- Q1) What are products and product design?
- Q2) What are the factors affecting it?
- Q3) Which departments are considered in the PD process? Why?
- Q4) Factors affecting Customer Satisfaction?
- Q5) Factors to make profit?
- Q6) Effect on product cost?
- Q7) Production-Economic factors?

- **Video 2: Service Design (8-min total)**

- [https://www.youtube.com/watch?v=HNOY8GLVy\\_8](https://www.youtube.com/watch?v=HNOY8GLVy_8)

- <https://www.youtube.com/watch?v=rwGcVij6Jzo>

- <https://www.youtube.com/watch?v=BeEUemtdoJQ>

- Q1) What are service and service design?
- Q2) What can service design do to your company?
- Q3) How to make your company's offering more usable, efficient and desirable?
- Q4) List of business categories stated during "Service-Goods Continuum" (e.g. entertainment, professional services, etc)?
- Q5) What do service designers do? How?
- Q6) What are the results?

- **Group Discussion 1: [20-points]**

# Strategic Product and Service “Design”

- The essence of an organization is the goods and services it offers
  - Every aspect of the organization is structured around them
- Product and service “**design**” – or redesign – should be closely tied to an organization’s strategy

## What Does Product & Service Design Do?

Activities and responsibilities of product and service design include:

1. Translate customer “**needs and wants**” into product and service requirements
2. Refine existing products and services
3. Develop new products and services
4. Formulate quality goals
5. Formulate cost targets
6. Construct and test prototypes
7. Document specifications
8. Translate product and service specifications into *process* specifications
9. Involve inter-functional collaboration

# Key Questions

## 1. Is there a demand for it?

- Market size
- Demand profile

## 2. Can we do it?

- **Manufacturability** - the *capability* of an organization to produce an item at an acceptable profit
- **Serviceability** - the *capability* of an organization to provide a service at an acceptable cost or profit

## 3. What level of quality is appropriate?

- Customer expectations
- Competitor quality
- Fit with current offering

## 4. Does it make sense from an economic standpoint?

- Liability issues, ethical considerations, sustainability issues, costs and profits

# Reasons to Design or Re-Design

- The driving forces for product and service design or redesign are market opportunities or threats:
  - Economic
  - Social and demographic
  - Political, liability, or legal
  - Competitive
  - Cost or availability
  - Technological

# Idea Generation for “Design” or “Redesign”

## 1. Supply-Chain Based

- Ideas can come from anywhere in the supply chain:
  - Customers
  - Suppliers
  - Distributors
  - Employees
  - Maintenance and repair personnel

## 2. Competitor Based

- By studying how a competitor operates and its products and services, many useful ideas can be generated
- **Reverse engineering**
  - Dismantling and inspecting a competitor’s product to discover product improvements

## 3. Research Based

- **Research and development (R&D)**
  - Organized efforts to increase scientific knowledge or product innovation
  - **Basic research**
    - Has the objective of advancing the state of knowledge about a subject without any near-term expectation of commercial applications
  - **Applied research**
    - Has the objective of achieving commercial applications
  - **Development**
    - Converts the results of applied research into useful commercial applications

# Legal Considerations

- **Legal considerations**
  - **Product liability**
    - The responsibility a manufacturer has for any injuries or damages caused by a faulty product
    - Some of the concomitant costs
      - Litigation
      - Legal and insurance costs
      - Settlement costs
      - Costly product recalls
      - Reputation effects
  - **Uniform Commercial Code**
    - Under the UCC, products carry an implication of merchantability and fitness

# Ethical Considerations

- **Designers are often under pressure to**
  - Speed up the design process
  - Cut costs
- **These pressures force trade-off decisions**
  - What if a product has bugs?
    - Release the product and risk damage to your reputation
    - Work out the bugs and forego revenue

# Other considerations

- **Human factors**
  - Safety and liability
- **Cultural factors**
  - Colors, preferred food, product labels
- **Global design**
  - Design teams can be in different countries

# Sustainability

- **Sustainability**
  - Using resources in ways that do not harm ecological systems that support human existence
- **Key aspects of designing for sustainability**
  - Cradle-to-grave assessment (life cycle analysis)
  - End-of-life programs
  - The 3-Rs
    - Reduction of costs and materials used
    - Re-using parts of returned products
    - Recycling

# Cradle-to-Grave Assessment

- **Cradle-to-Grave Assessment**
  - *aka* life cycle analysis (LCA)
  - The assessment of the environmental impact of a product or service throughout its useful life
    - Focuses on such factors as
      - Global warming
      - Smog formation
      - Oxygen depletion
      - Solid waste generation
    - LCA procedures are part of the ISO 14000 environmental management procedures

# The three R's

Designers often reflect on three particular aspects of potential cost savings and reducing environmental impact

- Reduce
- Reuse
- Recycle

# Reduce: Costs and Materials

- **Value analysis**

- Examination of the function of parts and materials in an effort to reduce the cost and/or improve the performance of a product
- Common questions used in value analysis
  - Is the item necessary; does it have value; could it be eliminated?
  - Are there alternative sources for the item?
  - Could another material, part, or service be used instead?
  - Can two or more parts be combined?
  - Can specifications be less stringent to save time or money?
  - Do suppliers/providers have suggestions for improvements?
  - Can packaging be improved or made less costly?

# Re-Use: Remanufacturing

- **Remanufacturing**
  - Refurbishing used products by replacing worn-out or defective components
    - Can be performed by the original manufacturer or another company
  - Reasons to remanufacture:
    - Remanufactured products can be sold for about 50% of the cost of a new product
    - The process requires mostly unskilled and semi-skilled workers
    - In the global market, European lawmakers are increasingly requiring manufacturers to take back used products
  - **Design for disassembly (DFD)**
    - Designing a product to that used products can be easily taken apart

# Recycle

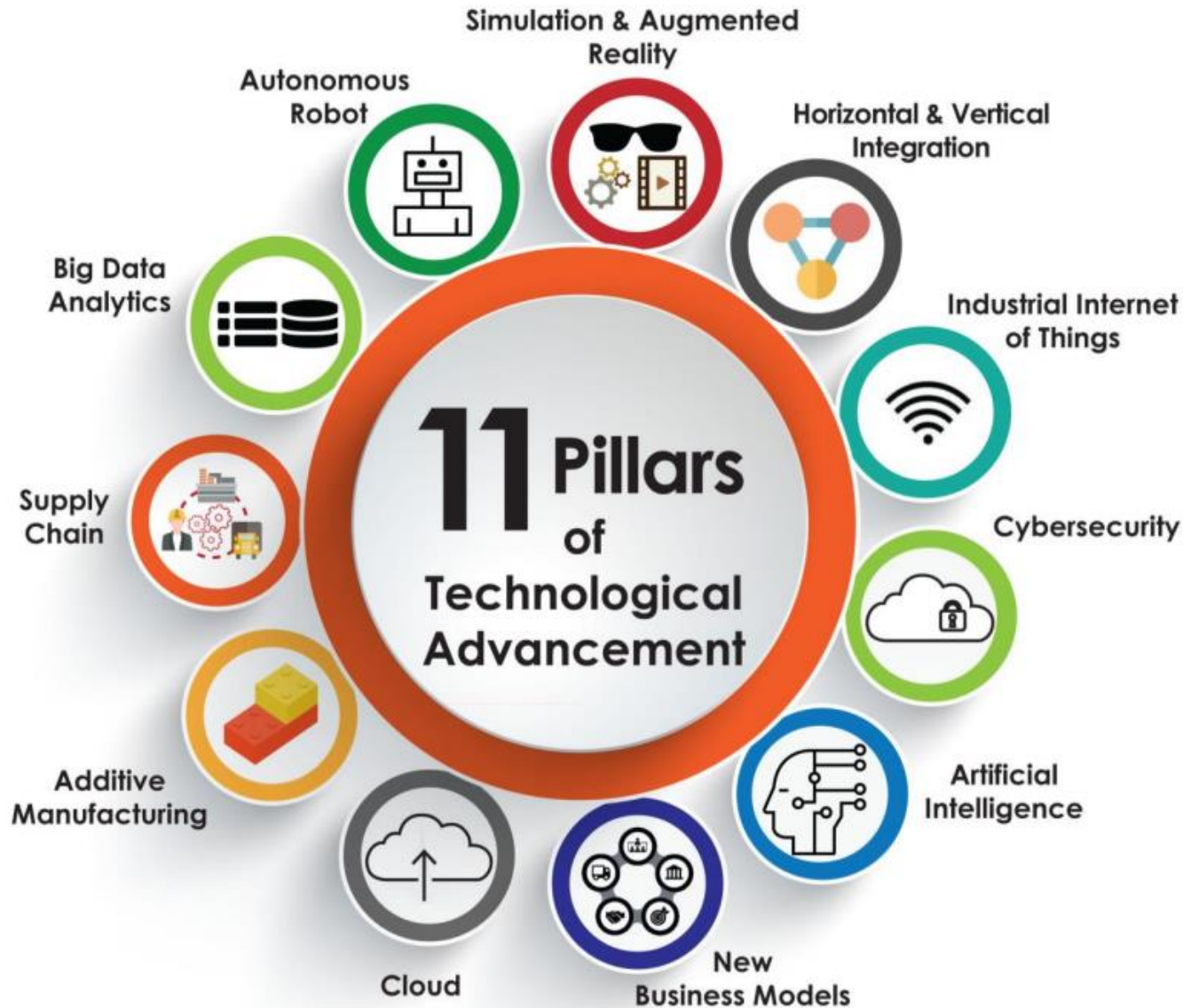
- **Recycling**

- Recovering materials for future use
  - Applies to manufactured parts
  - Also applies to materials used during production
- Why recycle?
  - Cost savings
  - Environmental concerns
  - Environmental regulations
- Companies doing business in the EU must show that a specified proportion of their products are recyclable
- **Design for recycling (DFR)**
  - Product design that takes into account the ability to disassemble a used product to recover the recyclable parts

# Strategic Product and Service Design

- Video 3: Product Design (2.5-min)
  - <https://www.youtube.com/watch?v=j64RhSpPJEI>
  - Q1) Is product design only about creating something new? Why?
  - Q2) What is it about?
  - Q3) List the steps in Product Design?
  
- Video 4 (5-min)
  - [https://www.youtube.com/watch?v=8P8gspd\\_Bx8](https://www.youtube.com/watch?v=8P8gspd_Bx8)
  - Q1) What is Netflix (as explained by the presenter)?
  - Q2) How did Netflix implement Design Thinking?
  - Q3) What was the major change in their business model?
  - Q4) List the steps?
  
- **Group Discussion 2: [20-points]**

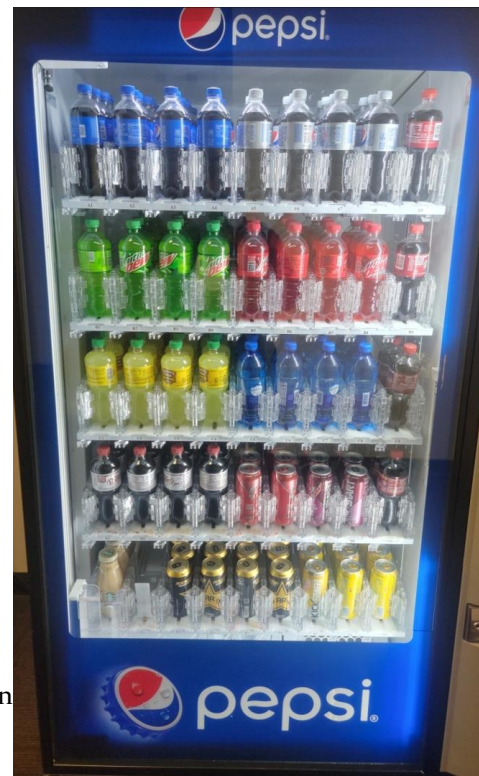
# 11 Pillars of Industry 4.0



# Standardization

- **Standardization**

- Extent to which there is an absence of variety in a product, service, or process
  - Products are made in large quantities of identical items
  - Every customer or item processed receives essentially the same service



# Standardization – Advantages and Disadvantages

## Advantages

- Fewer parts to deal with
- Reduced training costs and time
- More routine purchasing, handling, and inspection
- Orders fillable from inventory
- Opportunities for long production runs and automation

## Disadvantages

- Designs may be frozen too early
- High cost of design changes
- Decreased product variety

# Designing for Mass Customization

- **Mass customization**

- A strategy of producing basically standardized goods or services, but incorporating some degree of customization in the final product or service
- Facilitating techniques
  - Delayed differentiation
  - Modular design

# Delayed Differentiation

- **Delayed differentiation**
  - The process of producing a product or service but not quite completing production until customer preferences are known
  - It is a postponement tactic
    - Produce a piece of furniture, but do not stain it; the customer chooses the stain

# Modular Design

- **Modular design**

- A form of standardization in which component parts are grouped into modules that are easily replaced or interchanged

- Advantages

- Easier diagnosis and remedy of failures
- Easier repair and replacement
- Simplification of manufacturing and assembly
- Training costs are relatively low

- Disadvantages

- Limited number of possible product configurations
- Limited ability to repair a faulty module; if it cannot be disassembled, the entire module must often be scrapped

# Reliability

- **Reliability**

- The ability of a product, part, or system to perform its intended function under a prescribed set of conditions

- **Failure**

- Situation in which a product, part, or system does not perform as intended

- **Reliabilities are always specified with respect to certain conditions**

- **Normal operating conditions**

- The set of conditions under which an item's reliability is specified

# Potential ways to improve reliability

- Improve component design
- Improve production and/or assembly techniques
- Improve testing
- Use backups
- Improve preventive maintenance procedures
- Improve user education
- Improve system design

# Robust Design

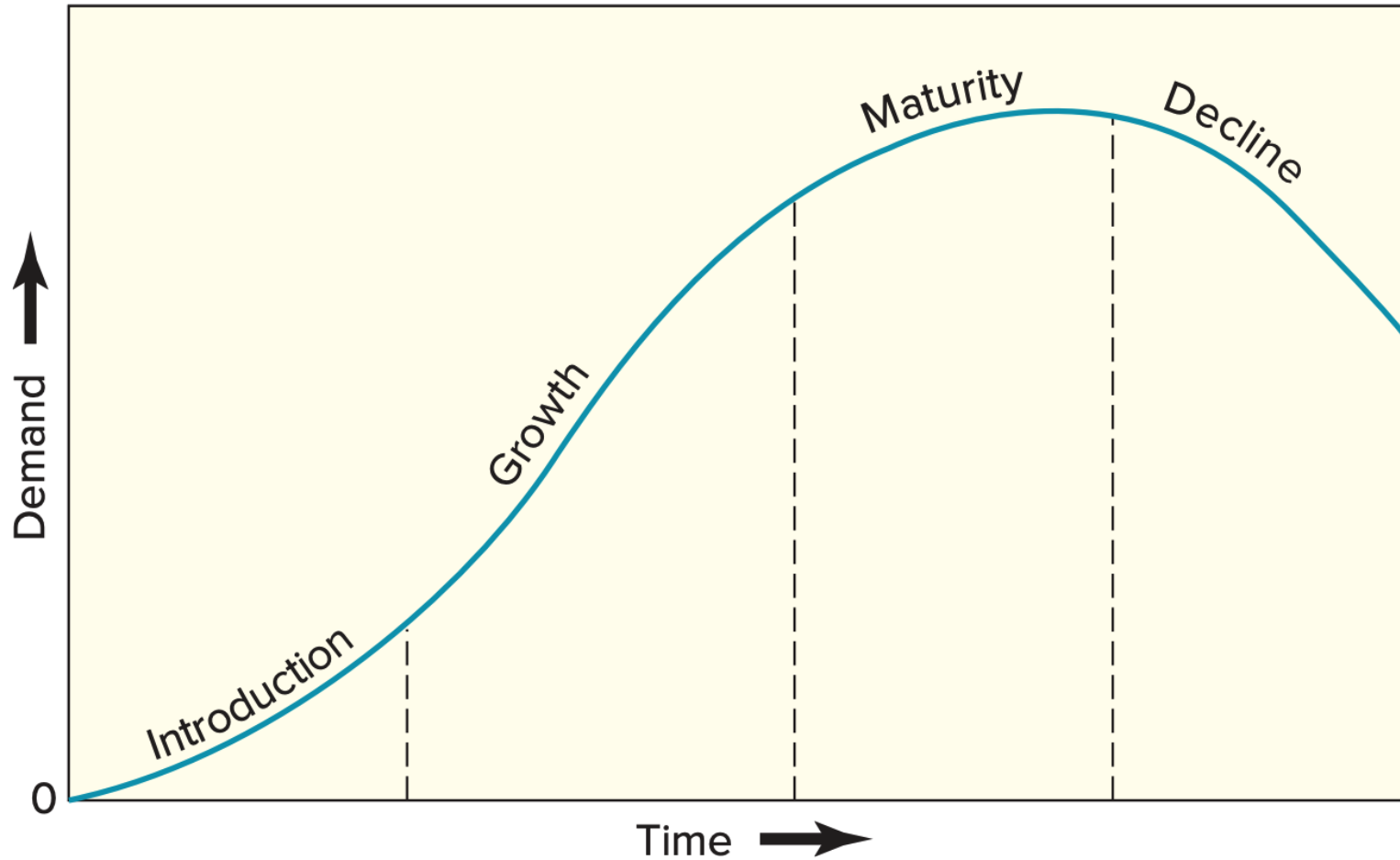
- **Robust design**

- A design that results in products or services that can function over a broad range of conditions
  - The more robust a product or service, the less likely it will fail due to a change in the environment in which it is used or in which it is performed
- Pertains to product as well as process design
  - Consider the following automobiles:
    - Ferrari Enzo
    - Toyota Avalon
      - Which is design is more robust?

# Degree of Newness

- **Product or service design changes:**
  1. Modification of an existing product or service
  2. Expansion of an existing product line or service offering
  3. Clone of a competitor's product or service
  4. New product or service
- The degree of change affects the newness of the product or service to the market and to the organization
  - Risks and benefits?

# Product or Service Life Stages

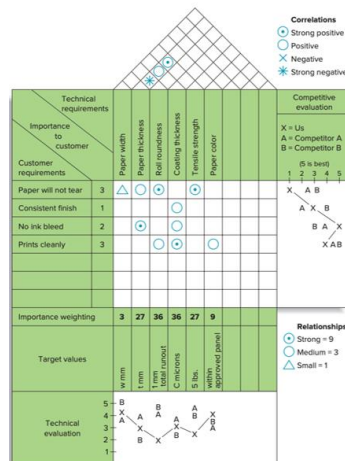


# Strategic Product and Service Design

- Video 5: Product Life Cycle: Coca Cola & iPhone (9-min)
  - <https://www.youtube.com/watch?v=ob5KWs3I3aY>
  - Q1) What is product life cycle? What does it describe?
  - Q2) Explain R&D stage? How are the sales? Cost of production? Profits? Cashflow?
  - Q3) Explain Introduction stage?
  - Q4) Explain Growth stage?
  - Q5) Explain Maturity stage?
  - Q6) Explain Decline/End of Life Cycle stag?
  - Q7) Explain Product Extension Strategies?
- 
- **Group Discussion 3: [10-points]**

# Quality Function Deployment

- **Quality Function Deployment (QFD)**
  - An approach that integrates the “voice of the customer” into both product and service development
    - The purpose is to ensure that customer requirements are factored into every aspect of the process
    - Listening to and understanding the customer is the central feature of QFD
- **House of Quality**

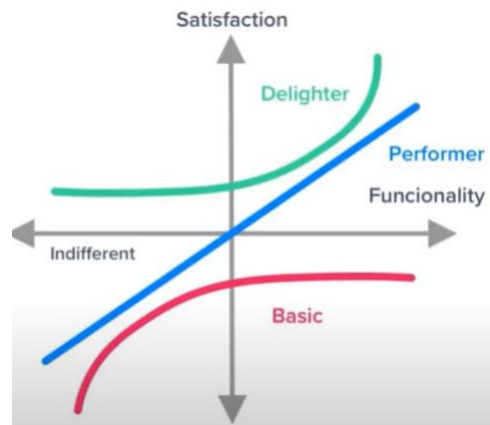


In 1980s  
↓  
UNITED STATES



# Kano Model

- **Basic quality**
  - Refers to customer requirements that have only limited effect on customer satisfaction if present, but lead to dissatisfaction if absent
- **Performance quality**
  - Refers to customer requirements that generate satisfaction or dissatisfaction in proportion to their level of functionality and appeal
- **Excitement quality**
  - Refers to a feature or attribute that was unexpected by the customer and causes excitement



# Phases in Product Design and Development

1. Feasibility analysis
2. Product specifications
3. Process specifications
4. Prototype development
5. Design review
6. Market test
7. Product introduction
8. Follow-up evaluation

# Concurrent Engineering

- **Concurrent engineering**
  - Bringing engineering design and manufacturing personnel together early in the design phase
    - Also may involve manufacturing, marketing and purchasing personnel in loosely integrated cross-functional teams
    - Views of suppliers and customers may also be sought
  - The purpose is to achieve product designs that reflect customer wants as well as manufacturing capabilities

# Computer-Aided Design (CAD)

- CAD
  - Product design using computer graphics
  - Advantages
    - Increases productivity of designers, 3 to 10 times
    - Creates a database for manufacturing information and product specifications
    - Provides possibility of engineering and cost analysis on proposed designs
  - CAD that includes finite element analysis (FEA) can significantly reduce time to market
    - Enables developers to perform simulations that aid in the design, analysis, and commercialization of new products

# Production Requirements

- Designers must take into account production capabilities (right? and enough?)
  - Equipment
  - Skills
  - Types of materials
  - Schedules
  - Technologies
  - Special abilities

# Manufacturability

- Manufacturability
  - Ease of fabrication and/or assembly
  - It has important implications for
    - Cost
    - Productivity
    - Quality
  - Design for manufacturing
  - Design for assembly

# Component Commonality

- When products have a high degree of similarity in features and components, a part can be used in multiple products
- Benefits:
  - Savings in design time
  - Standard training for assembly and installation
  - Opportunities to buy in bulk from suppliers
  - Commonality of parts for repair
  - Fewer inventory items must be handled

# Service Design

- Begins with a choice of service strategy, which determines the nature and focus of the service, and the target market
  - Key issues in service design
    - Degree of variation in service requirements
    - Degree of customer contact and involvement

<https://www.youtube.com/watch?v=330YCLMDaRg>

# Differences between Service and Product Design

1. Products are generally tangible; services are intangible
2. Services are created and delivered at the same time
3. Services cannot be inventoried
4. Services are highly visible to consumers
5. Some services have low barriers to entry and exit
6. Location is often important to service design, with convenience as a major factor
7. Service systems range from those with little or no customer contact to those that have a very high degree of customer contact
8. Demand variability alternately creates waiting lines or idle service resources

# Phases in service design process

1. Conceptualize
  - Idea generation
  - Assessment of customer wants/needs
  - Assessment of demand potential
2. Identify service package components needed
3. Determine performance specifications
4. Translate performance specifications into design specifications
5. Translate design specifications into delivery specifications

# The Well-Designed Service System

- **Characteristics**

- Consistent with the organization mission
- User-friendly
- Robust if variability is a factor
- Easy to sustain
- Cost-effective
- Has value that is obvious to the customer
- Has effective linkages between back- and front-of-the-house operations
- Has a single, unifying theme
- Has design features and checks that will ensure service that is reliable and of high quality

# Successful Service Design

1. Define the service package in detail
2. Focus on the operation from the customer's perspective
3. Consider the image that the service package will present both to customers and to prospective customers
4. Recognize that designers' familiarity with the system may give them a quite different perspective than that of the customer, and take steps to overcome this
5. Make sure that managers are involved and will support the design once it is implemented
6. Define quality for both tangibles and intangibles
7. Make sure that recruitment, training, and reward policies are consistent with service expectations
8. Establish procedures to handle both predictable and unpredictable events
9. Establish system to monitor, maintain, and improve service

# Operations Strategy

- **Effective product and service design can help the organization achieve competitive advantage:**
  - Packaging products and ancillary services to increase sales
  - Using multiple-use platforms
  - Implementing tactics that will achieve the benefits of high volume while satisfying customer needs for variety
  - Continually monitoring products and services for small improvement opportunities
  - Reducing the time it takes to get a new or redesigned product or service to the market

# Extra

# Extra

- [Documentary: Nordic Service Design – YouTube](#)
- [Process Mapping – YouTube](#)
- [What is Service Design – YouTube](#)
- [How design thinking helped improve the patient experience in the emergency room? | Case Studio - 02 – YouTube](#)
- [Philips Healthcare Consulting and Design Thinking in Emergency Department – YouTube](#)
- [What is Service Design A tale of two coffee shops – YouTube](#)
- [Mass Customization in marketing – YouTube](#)
- [Product Life Cycle \(With Real World Examples\) | Strategic Management | From A Business Professor – YouTube](#)
- [Product Life Cycle Explained | Apple iPhone & Coca Cola Examples – YouTube](#)
- [QFD \(Quality Function Deployment\): With Practical Example \(PART-1\) – YouTube](#)
- [Kano Model Explained - Increase customer satisfaction and develop products and services - YouTube](#)
- [Transport Services Design – YouTube](#)

# Chapter 5

## Strategic Capacity Planning for Products and Services

# Chapter 5: Key Activities Today

- 1) **Video: 1 Capacity Planning, Slide #3**
  - **Discussion** (Group 4-5 Students) [10-points]
- 2) **Video: 2 Capacity Planning Tips, Slide #24**
  - **Discussion** (Group 4-5 Students)
- 3) **Video: 3 Bottleneck Analysis, Slide #27**
  - **Discussion** (Group 4-5 Students) [15-points]
  
- 4) **Theory**

# Capacity Planning

- **Video 1:** <https://www.youtube.com/watch?v=5-hhfBXykec>
  - Q1) What is capacity?
  - Q2) Give more examples of capacity in your daily life?
  - Q3) Explain Design Capacity? Give more examples?
  - Q4) Explain Effective Capacity? Give more examples?
  - Q5) What factors affect “Capacity Available”?
  - Q6) Explain “#3 Capacity and Strategy”?
  - Q7) Explain “Short term/Medium/Long Term Capacity”?
- **Video 2:** <https://www.youtube.com/watch?v=uoSVfyIETaA>
  - Q1) How to plan better for variation in demand?
  - Q2) Explain the demand and capacity models?
  - Q3) How can the demand and capacity planning help the organizations??
- **Group Discussion 1: [10-points]**

# Capacity Planning

- **Capacity**
  - The upper limit or ceiling on the load that an operating unit can handle
  - Capacity needs include
    - Equipment
    - Space
    - Employee skills

# Strategic Capacity Planning

- **Goal**
  - To achieve a match between the long-term supply capabilities of an organization and the predicted level of long-term demand
    - Overcapacity → operating costs that are too high
    - Undercapacity → strained resources and possible loss of customers

# Capacity Planning Questions

- **Key questions:**

- What kind of capacity is needed?
- How much is needed to match demand?
- When is it needed?

- **Related questions:**

- How much will it cost?
- What are the potential benefits and risks?
- Are there sustainability issues?
- Should capacity be changed all at once, or through several smaller changes?
- Can the supply chain handle the necessary changes?

# Capacity Decisions Are Strategic

- **Capacity decisions**

1. Impact the ability of the organization to meet future demands
2. Affect operating costs
3. Are a major determinant of initial cost
4. Often involve long-term commitment of resources
5. Can affect competitiveness
6. Affect the ease of management
7. Have become more important and complex due to globalization
8. Need to be planned for in advance due to their consumption of financial and other resources

# Defining and Measuring Capacity

- **Measure capacity in units that do not require updating**
  - Why is measuring capacity in dollars problematic?
- **Two useful definitions of capacity**
  - **Design capacity**
    - The maximum output rate or service capacity an operation, process, or facility is designed for
  - **Effective capacity**
    - Design capacity minus allowances such as personal time and maintenance

# Measures of capacity

Business	Inputs	Outputs
Auto manufacturing	Labor hours, machine hours	Number of cars per shift
Steel mill	Furnace size	Tons of steel per day
Oil refinery	Refinery size	Gallons of fuel per day
Farming	Number of acres, number of cows	Bushels of grain per acre per year, gallons of milk per day
Restaurant	Number of tables, seating capacity	Number of meals served per day
Theater	Number of seats	Number of tickets sold per performance
Retail sales	Square feet of floor space	Revenue generated per day

**TABLE 5.1** Measures of capacity

# Measuring System Effectiveness

- **Actual output**
  - The rate of output actually achieved
  - It cannot exceed effective capacity
- **Efficiency**

$$\text{Efficiency} = \frac{\text{actual output}}{\text{effective capacity}}$$

- **Utilization**

$$\text{Utilization } n = \frac{\text{actual output}}{\text{design capacity}}$$

Measured as percentages

# Example – Efficiency and Utilization

- Design Capacity = 50 trucks per day
- Effective Capacity = 40 trucks per day
- Actual Output = 36 trucks per day

$$\text{Efficiency} = \frac{\text{actual output}}{\text{effective capacity}} = \frac{36}{40} = 90\%$$

$$\text{Utilization} = \frac{\text{actual output}}{\text{design capacity}} = \frac{36}{50} = 72\%$$

# Determinants of Effective Capacity

- Facilities
- Product and service factors
- Process factors
- Human factors
- Policy factors
- Operational factors
- Supply chain factors
- External factors

# Factors that determine effective capacity

- A. Facilities
  - 1. Design
  - 2. Location
  - 3. Layout
  - 4. Environment
- B. Product/service
  - 1. Design
  - 2. Product or service mix
- C. Process
  - 1. Quantity capabilities
  - 2. Quality capabilities
- D. Human factors
  - 1. Job content
  - 2. Job design
  - 3. Training and experience
  - 4. Motivation
- 5. Compensation
- 6. Learning rates
- 7. Absenteeism and labor turnover
- E. Policy
- F. Operational
  - 1. Scheduling
  - 2. Materials management
  - 3. Quality assurance
  - 4. Maintenance policies
  - 5. Equipment breakdowns
- G. Supply chain
- H. External factors
  - 1. Product standards
  - 2. Safety regulations
  - 3. Unions
  - 4. Pollution control standards

**TABLE 5.2** Factors that determine effective capacity

# Strategy Formulation

- **Strategies are typically based on assumptions and predictions about:**
  - Long-term demand patterns
  - Technological change
  - Competitor behavior

# Capacity Strategies

- **Leading**
  - Build capacity in anticipation of future demand increases
- **Following**
  - Build capacity when demand exceeds current capacity
- **Tracking**
  - Similar to the following strategy, but adds capacity in relatively small increments to keep pace with increasing demand

# Capacity Cushion

- **Capacity cushion**
  - Extra capacity used to offset demand uncertainty
  - Capacity cushion =  $100\% - \text{utilization}$
  - Capacity cushion strategy
    - Organizations that have greater demand uncertainty typically have greater capacity cushions
    - Organizations that have standard products and services generally have smaller capacity cushions

# Steps in Capacity Planning

1. Estimate future capacity requirements
2. Evaluate existing capacity and facilities; identify gaps
3. Identify alternatives for meeting requirements
4. Conduct financial analyses
5. Assess key qualitative issues
6. Select the best alternative for the long term
7. Implement alternative chosen
8. Monitor results

# Forecasting Capacity Requirements

- Long-term considerations relate to overall *level* of capacity requirements
  - Require forecasting demand over a time horizon and converting those needs into capacity requirements
- Short-term considerations relate to probable *variations* in capacity requirements
  - Less concerned with cycles and trends than with seasonal variations and other variations from average

# Service Capacity Planning

- Service capacity planning can present a number of challenges related to:
  - **The need to be near customers**
    - Convenience
  - **The inability to store services**
    - Cannot store services for consumption later
  - **The degree of demand volatility**
    - Volume and timing of demand
    - Time required to service individual customers

# Demand Management Strategies

- Strategies used to **offset capacity limitations** and that are intended to achieve a closer match between supply and demand
  - Pricing
  - Promotions
  - Discounts
  - Other tactics to shift demand from peak periods into slow periods

# In-House or Outsource?

- Once capacity requirements are determined, the organization must decide whether to produce a good or service itself or outsource
- Factors to consider:
  - Available capacity
  - Expertise
  - Quality considerations
  - The nature of demand
  - Cost
  - Risks

# Capacity Planning Tips (for IT Teams)

- **Video 3:** <https://www.youtube.com/watch?v=fi6M6YV2q3w>
- Q1) What is a GAP in capacity planning? Name some scenarios mentioned?
- Q2) What is the difference between capacity planning and resource planning?
- Q3) What are the 5-steps in the Checklist?
- Q4) Reasons for establishing a cross functional team?
- Q5) What are the 3-Tips stated?

- **Bottleneck Analysis:**

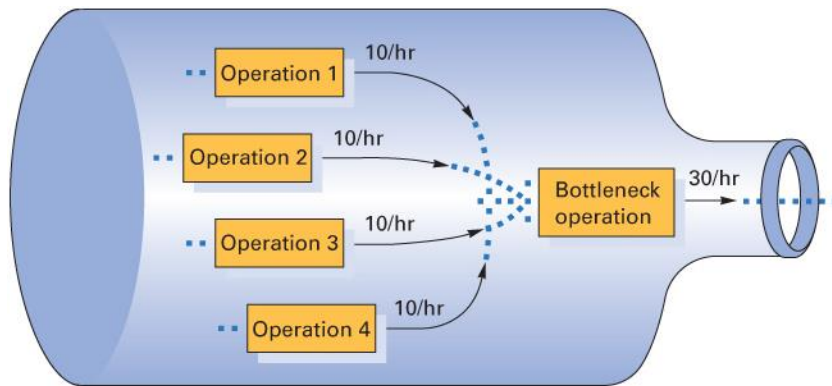
- **Video 4:** <https://www.youtube.com/watch?v=lekRCY1LkLo>
- Q1) What is bottleneck analysis?
- Q2) What are some of the examples of bottlenecks shown in the video?
- Q3) Explain the example of “car parts” producing factory?
- Q4) Why Bottleneck Analysis is a crucial tool for companies?
- Q5) What are the benefits of eliminating the bottlenecks?

- **Group Discussion 2: [15-points]**

# Developing Capacity Alternatives

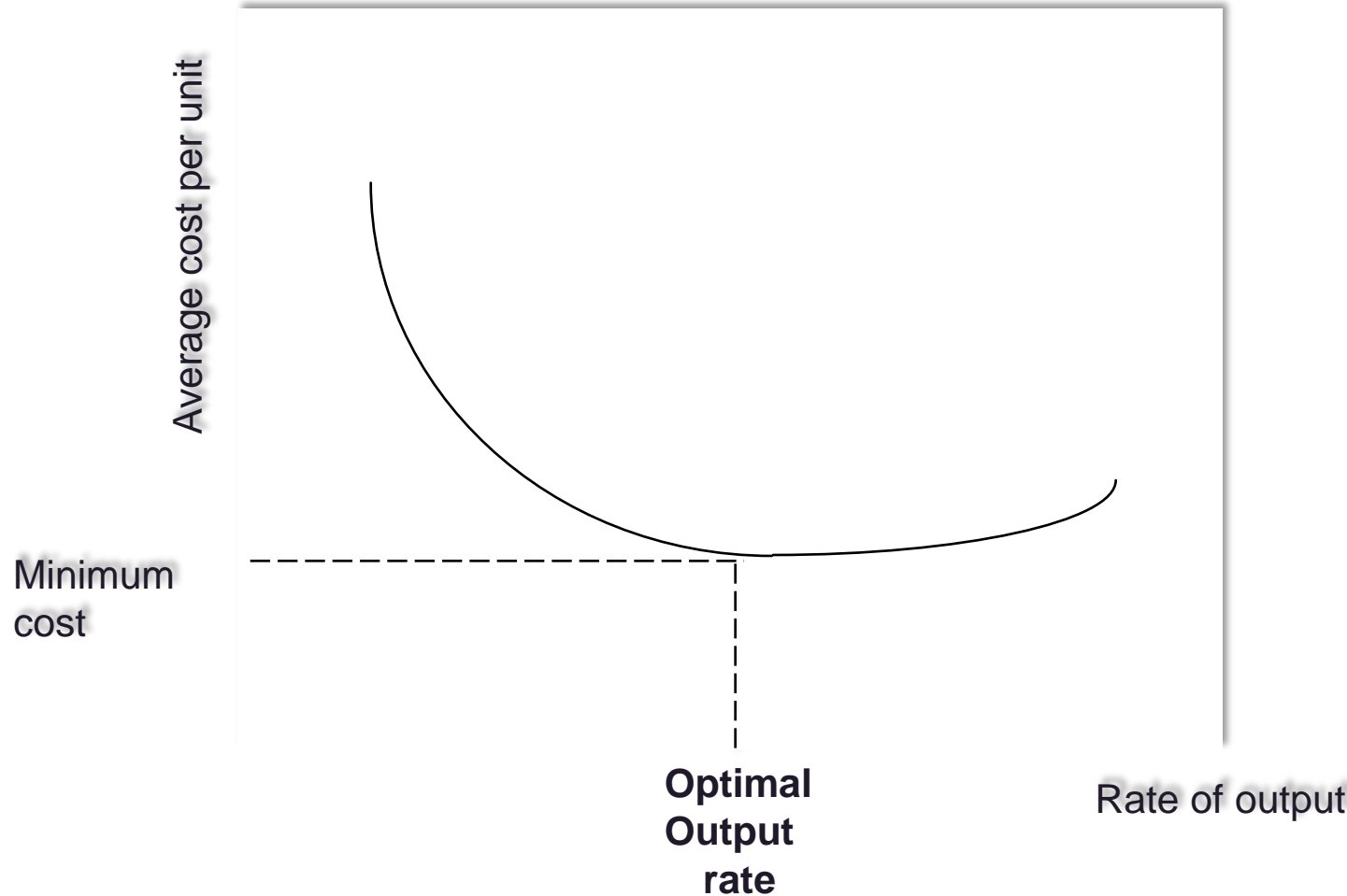
- Things that can be done to enhance capacity management:
  - Design flexibility into systems
  - Take stage of life cycle into account
  - Take a “big-picture” approach to capacity changes
  - Prepare to deal with capacity “chunks”
  - Attempt to smooth capacity requirements
  - Identify the optimal operating level
  - Choose a strategy if expansion is involved

# Bottleneck Operation



- An operation in a sequence of operations whose capacity is lower than that of the other operations

# Optimal Operating Level



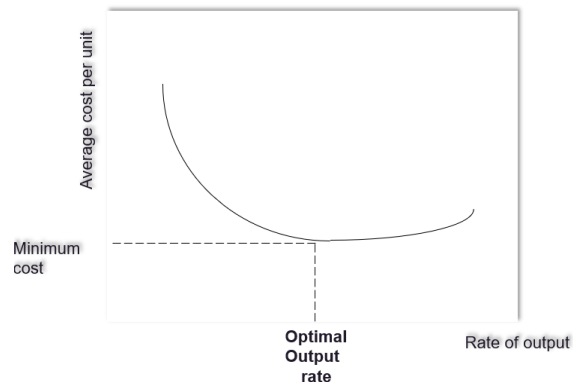
# Economies and Diseconomies of Scale

- **Economies of scale**

- If output rate is less than the optimal level, increasing the output rate results in decreasing average per unit costs

- **Diseconomies of scale**

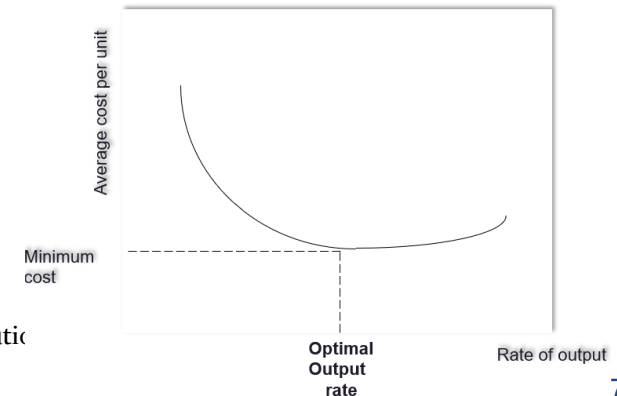
- If the output rate is more than the optimal level, increasing the output rate results in increasing average costs per unit



# Economies of Scale

- **Economies of scale**

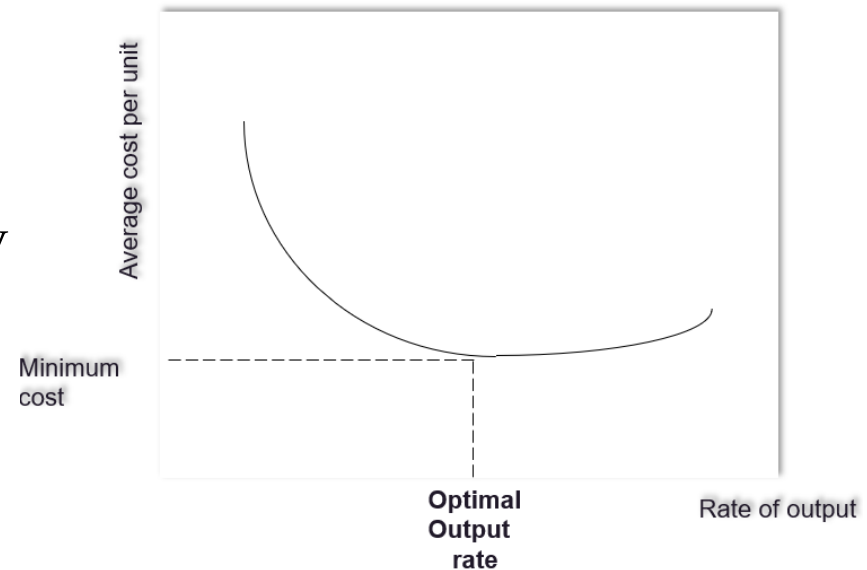
- If output rate is less than the optimal level, increasing the output rate results in decreasing average per unit costs
- Reasons for economies of scale:
  - Fixed costs are spread over a larger number of units
  - Construction costs increase at a decreasing rate as facility size increases
  - Processing costs decrease due to standardization



# Diseconomies of Scale

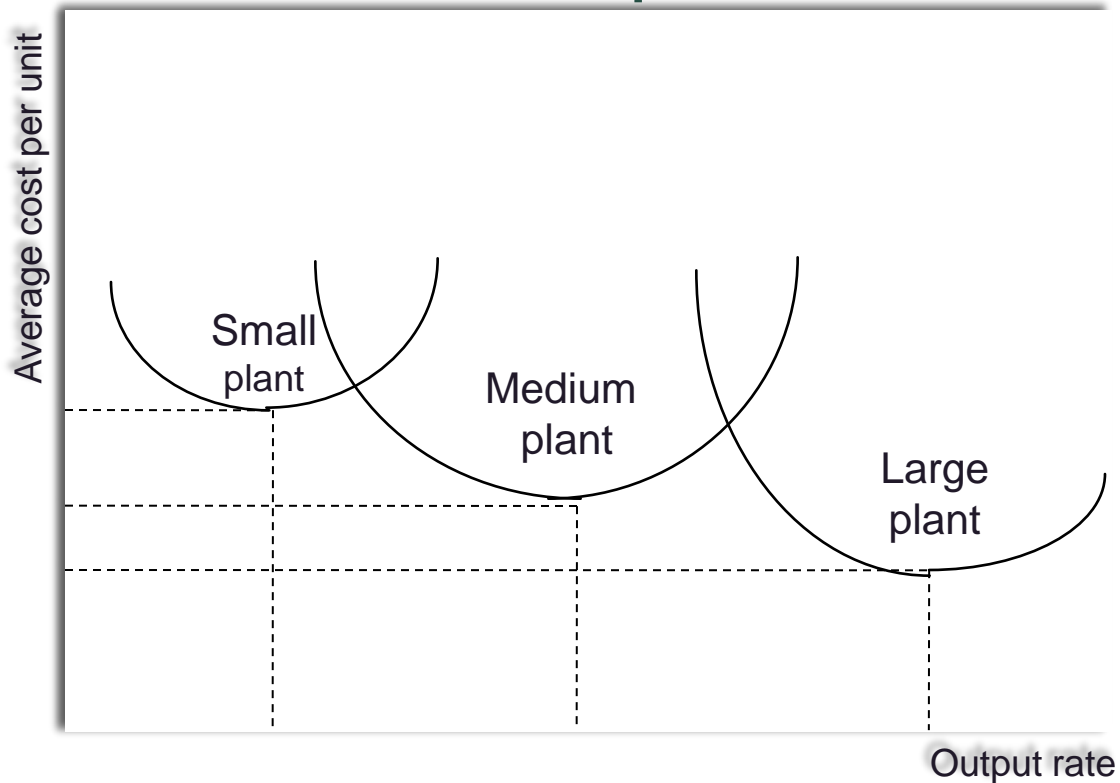
- **Diseconomies of scale**

- If the output rate is more than the optimal level, increasing the output rate results in increasing average per unit costs
- Reasons for diseconomies of scale
  - Distribution costs increase due to traffic congestion and shipping from a centralized facility rather than multiple smaller facilities
  - Complexity increases costs
  - Inflexibility can be an issue
  - Additional levels of bureaucracy



# Facility Size and Optimal Operating Level

Minimum cost & optimal operating rate are functions of size of production unit.



# Constraint Management

- **Constraint**

- Something that limits the performance of a process or system in achieving its goals
- Categories
  - Market
  - Resource
  - Material
  - Financial
  - Knowledge or competency
  - Policy

# Resolving Constraint Issues

1. Identify the most pressing constraint
2. Change the operation to achieve maximum benefit, given the constraint
3. Make sure other portions of the process are supportive of the constraint
4. Explore and evaluate ways to overcome the constraint
5. Repeat the process until the constraint levels are at acceptable levels

# Evaluating Alternatives

- **Alternatives should be evaluated from varying perspectives**
  - **Economic**
    - Is it economically feasible?
    - How much will it cost?
    - How soon can we have it?
    - What will operating and maintenance costs be?
    - What will its useful life be?
    - Will it be compatible with present personnel and present operations?
  - **Non-economic**
    - Public opinion

# Evaluating Alternatives (cont.)

- **Techniques for Evaluating Alternatives**
  - Cost-volume analysis
  - Financial analysis
  - Decision theory
  - Waiting-line analysis
  - Simulation

# Operations Strategy

- **Capacity planning impacts all areas of the organization**
  - It determines the conditions under which operations will have to function
  - Flexibility allows an organization to be agile
    - It reduces the organization's dependence on forecast accuracy and reliability
    - Many organizations utilize capacity cushions to achieve flexibility
  - Bottleneck management is one way by which organizations can enhance their effective capacities
  - Capacity expansion strategies are important organizational considerations
    - Expand-early strategy
    - Wait-and-see strategy
  - Capacity contraction is sometimes necessary
    - Capacity disposal strategies become important under these conditions

# Chapter 9

## Management of Quality

# Quality and Quality Management

## Video 1: Quality

[\(3\) Steve Jobs on Quality - YouTube](#)

[What is Quality - YouTube](#)

[What is Quality | Quality Definition - YouTube](#)

[\(3\) What is Quality? - YouTube](#)

- Q1) How do Customers form opinions about “Quality” of products & Services?
- Q2) Does “Quality” rules apply to manufacturing/production only? Why?
- Q3) What is “Quality Thinking”? Examples from your work experiences?
- Q4) What is “Quality”? Examples?
- Q5) What is the difference between Quality & Quantity?

- **Group Discussion 1: [30-points]**

[Five Dimensions of Service Quality - YouTube](#)

[Example of Quality Management - YouTube](#)

[How to Create a Project Quality Management Plan - YouTube](#)

# Quality Management

- **Quality**

- The ability of a product or service to consistently meet or exceed customer expectations
  - For a decade or so, quality was an important focal point in business. After a while, this emphasis began to fade as other concerns took precedence
  - There has been a recent resurgence in attention to quality given recent experiences with the costs and adverse attention associated with highly visible quality failures:
    - Auto recalls
    - Toys
    - Produce
    - Dog food
    - Pharmaceuticals

# Quality Contributors

- **Walter Shewart**

- “Father of statistical quality control”
- Control charts
- Variance reduction

- **W. Edwards Deming**

- Special vs. common cause variation
- The 14 points

- **Joseph Juran**

- *Quality Control Handbook*, 1951
- Viewed quality as fitness-for-use
- Quality trilogy – quality planning, quality control, quality improvement

[History of Continuous Improvements & Quality Gurus: PART-1 - YouTube](#)

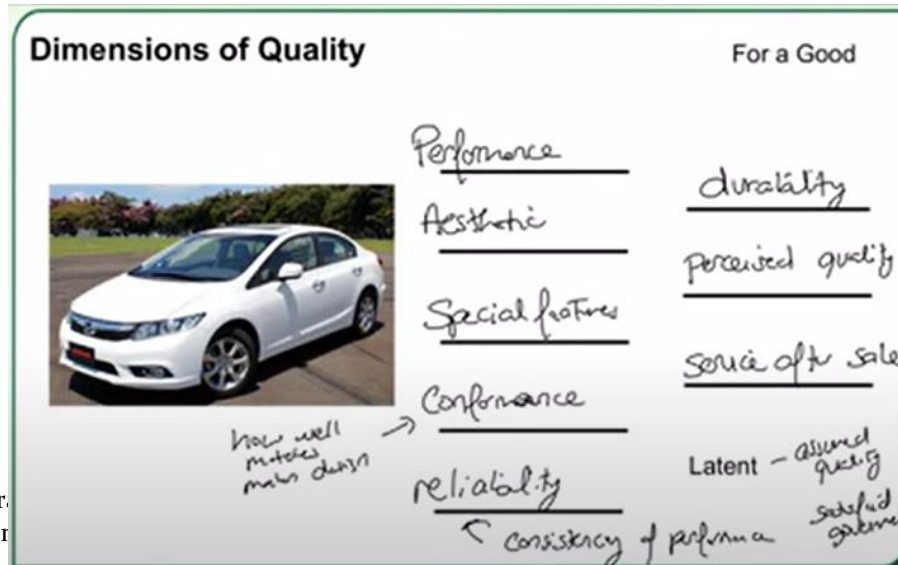
[History of Continuous Improvements & Quality Gurus: PART-2 - YouTube](#)

# Quality Contributors (2 of 3)

- **Armand Feigenbaum**
  - Quality is a “total field”
  - The customer defines quality
- **Philip B. Crosby**
  - Zero defects
  - *Quality is Free*, 1979
- **Kaoru Ishikawa**
  - Cause-and-effect diagram
  - Quality circles
  - Recognized the internal customer
- **Genichi Taguchi**
  - Taguchi loss function
- **Taiichi Ohno and Shigeo Shingo**
  - Developed philosophy and methods of *kaizen*

# Dimensions of Product Quality

- **Performance** – main characteristics of the product
- **Aesthetics** – appearance, feel, smell, taste
- **Special features** – extra characteristics
- **Conformance** – how well the product conforms to design specifications
- **Reliability** – consistency of performance
- **Durability** – the useful life of the product
- **Perceived quality** – indirect evaluation of quality
- **Serviceability** – handling of complaints or repairs
- **Consistency** – quality doesn't vary




# Dimensions of Service Quality

- **Convenience** – the availability and accessibility of the service
- **Reliability** – ability to perform a service dependably, consistently, and accurately
- **Responsiveness** – willingness to help customers in unusual situations and to deal with problems
- **Time** – the speed with which the service is delivered
- **Assurance** – knowledge exhibited by personnel and their ability to convey trust and confidence
- **Courtesy** – the way customers are treated by employees
- **Tangibles** – the physical appearance of facilities, equipment, personnel, and communication materials
- **Consistency** – the ability to provide the same level of good quality repeatedly
- **Expectancy** – meet (or exceed) customer expectations

**Dimensions of Quality** For a Service

<u>Tangibles</u>	<u>Courtesy</u>	<u>Consistency</u>
Convenience - availability - accessibility		
Reliability - dependability - consistency - accuracy		
Responsiveness		
Timeliness		
Assurance - knowledge		



[Presentation What is service quality - YouTube](#)

# Quality Management

**Video 2: Quality Management System QMS** (3) [What is Quality Management? - YouTube](#)

(3) [What is a Quality Management System \(QMS\)? - YouTube](#)

Q6) Explain Quality Management QM?

Q7) What are the 4 main components of QM?

Q8) Explain using the fictitious example or your own work example?

Q9) What is QMS? What are its benefits?

Q10) Explain CAPA? Benefits of Improved Design Process

- **Group Discussion 1: [20-points]**

# Assessing Service Quality

- **Audit service to identify strengths and weaknesses**
- **In particular, look for discrepancies between:**
  1. Customer expectations and management perceptions of those expectations
  2. Management perceptions, customer expectations, and service-quality specifications
  3. Service quality and service actually delivered
  4. Service actually delivered and what is communicated about the service to customers
  5. Customers' expectations of the service provider and their perceptions of provider delivery

# Determinants of Quality

- **Quality of design**
  - Intention of designers to include or exclude features in a product or service
- **Quality of conformance**
  - The degree to which goods or services conform to the intent of the designers
- **Ease-of-use and user instructions**
  - Increase the likelihood that a product will be used for its intended purpose and in such a way that it will continue to function properly and safely
- **After-the-sale service**
  - Taking care of issues and problems that arise after the sale

[Determinants of Quality - YouTube](#)

# Responsibility for Quality

- Top management
  - Design
  - Procurement
  - Production/operations
  - Quality assurance
  - Packaging and shipping
  - Marketing and sales
  - Customer service
- Everyone in the organization has some responsibility for quality, but certain areas of the organization are involved in activities that make them key areas of responsibility

# Benefits of Good Quality

- Enhanced reputation for quality
- Ability to command premium prices
- Increased market share
- Greater customer loyalty
- Lower liability costs
- Fewer production or service problems
- Lower production costs
- Higher profits

# The Consequences of Poor Quality

- Loss of business
- Liability
- Productivity
- Costs

# Costs of Quality

- **Appraisal costs**
  - Costs of activities designed to ensure quality or uncover defects
- **Prevention costs**
  - All TQ training, TQ planning, customer assessment, process control, and quality improvement costs to prevent defects from occurring

# Costs of Quality (cont.)

- **Failure costs - costs incurred by defective parts/products or faulty services**
  - **Internal failure costs**
    - Costs incurred to fix problems that are detected before the product/service is delivered to the customer
  - **External failure costs**
    - All costs incurred to fix problems that are detected after the product/service is delivered to the customer

# Ethics and Quality

# QualityFIRST

- **Substandard work**
  - Defective products
  - Substandard service
  - Poor designs
  - Shoddy workmanship
  - Substandard parts and materials



**Having knowledge of this and failing to correct and report it in a timely manner is unethical.**

# The Baldrige Competition

- **Award categories**

[Introduction to Baldrige - YouTube](#)

[Baldrige Award Explained | Management & Business Concepts - YouTube](#)

1. Education
2. Healthcare
3. Manufacturing
4. Nonprofit/government
5. Service
6. Small Business

- **Purpose of the award**

1. Stimulate efforts to improve quality
2. Recognize quality achievements
3. Publicize successful programs

# Baldrige Criteria

- I. Leadership**
- II. Strategic planning**
- III. Customer focus**
- IV. Measurement, analysis, and knowledge management**
- V. Workforce focus**
- VI. Operations focus**
- VII. Results**

# Quality Certification

- **International Organization for Standardization**
- **ISO 9000**
  - Set of international standards on quality management and quality assurance, critical to international business
- **ISO 14000**
  - A set of international standards for assessing a company's environmental performance
- **ISO 24700**
  - Pertains to the quality and performance of office equipment that contains reused components

# Quality Certification (cont.)

- **ISO 9000**

- **Quality principles**

- Principle 1 Customer focus
    - Principle 2 Leadership
    - Principle 3 Involvement of people
    - Principle 4 Process approach
    - Principle 5 System approach to management
    - Principle 6 Continual improvement
    - Principle 7 Factual approach to decision making
    - Principle 8 Mutually beneficial supplier relationships

# Quality and the Supply Chain

- Business leaders are increasingly recognizing the importance of their supply chains in achieving their quality goals
  - Requires:
    - Measuring customer perceptions of quality
    - Identifying problem areas
    - Correcting these problems
  - Supply chain quality management can benefit from a collaborative relationship with suppliers
    - Helping suppliers with quality assurance efforts
    - Information sharing on quality-related matters

# Total Quality Management

- A philosophy that involves everyone in an organization in a continual effort to improve quality and achieve customer satisfaction



[Deming, Juran & Crosby: Contributors to TQM \(Total Quality Management\) - YouTube](#)

# TQM Approach

1. Find out what the customer wants
2. Design a product or service that meets or exceeds customer wants
3. Design processes that facilitate doing the job right the first time
4. Keep track of results
5. Extend these concepts throughout the supply chain
6. Top management must be involved and committed

# TQM Elements

1. Continuous improvement
2. Competitive benchmarking
3. Employee empowerment
4. Team approach
5. Decision based on fact, not opinion
6. Knowledge of tools
7. Supplier quality
8. Champion
9. Quality at the source
10. Suppliers are partners in the process

# Continuous Improvement

- **Continuous improvement**
  - Philosophy that seeks to make never-ending improvements to the process of converting inputs into outputs
  - **Kaizen**
    - Japanese word for continuous improvement

## Quality at the Source

- **The philosophy of making each worker responsible for the quality of his or her work**
  - “Do it right” and “If it isn’t right, fix it”

# Obstacles to Implementing TQM

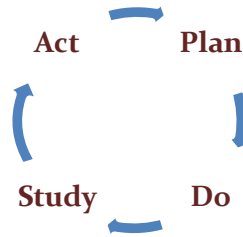
- **Obstacles include:**

- Lack of company-wide definition of quality
- Lack of strategic plan for change
- Lack of customer focus
- Poor intra-organizational communication
- Lack of employee empowerment
- View of quality as a “quick fix”
- Emphasis on short-term financial results
- Inordinate presence of internal politics and “turf” issues
- Lack of strong motivation
- Lack of time to devote to quality initiatives
- Lack of leadership

# Criticisms of TQM

- Overzealous advocates may pursue TQM programs blindly, focusing attention on quality
- Programs may not be linked to the strategies of the organization in a meaningful way
- Quality-related decisions may not be tied to market performance
- Failure to carefully plan a program before embarking on it can lead to false starts, employee confusion, and meaningless results
- Organizations sometimes pursue continuous improvement
- Quality efforts may not be tied to results

# PDSA Cycle



- **Plan-Do-Study-Act (PDSA) cycle**

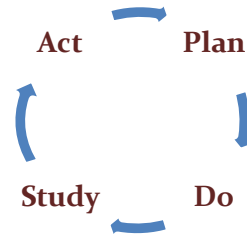
- **Plan**

- Begin by studying and documenting the current process.
- Collect data on the process or problem
- Analyze the data and develop a plan for improvement
- Specify measures for evaluating the plan

- **Do**

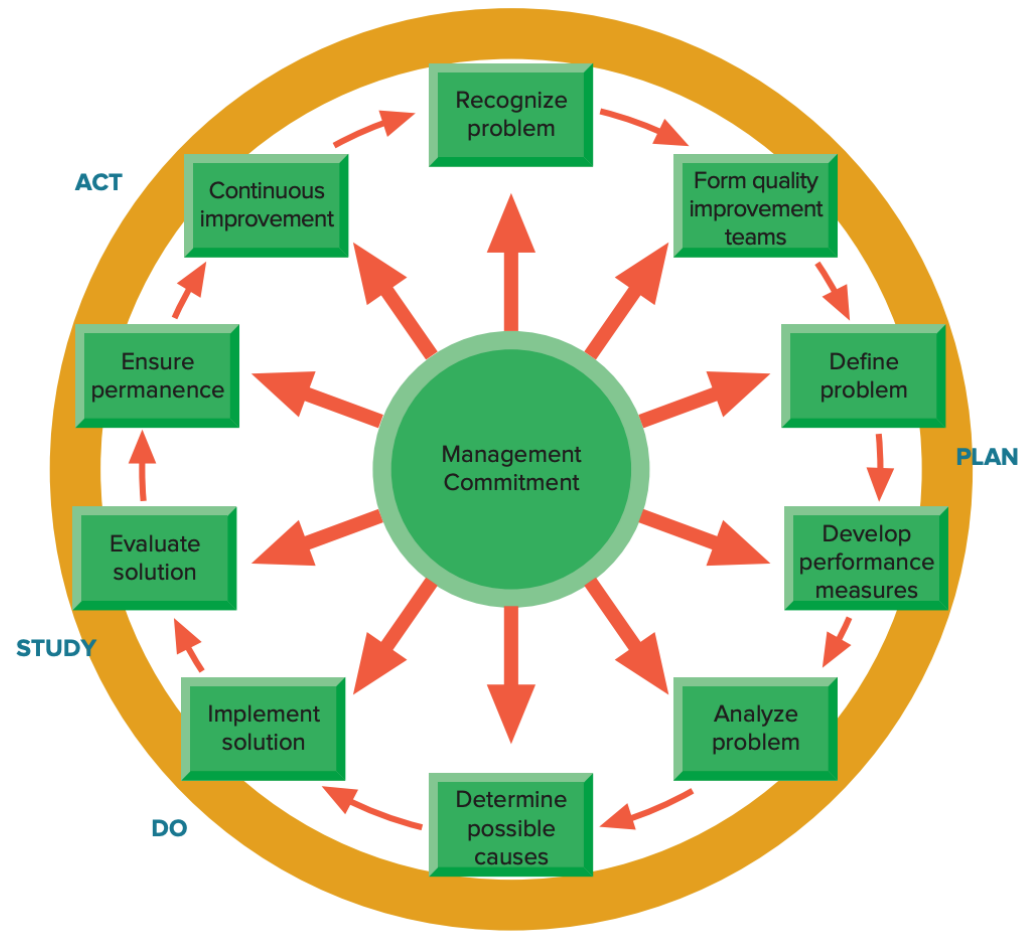
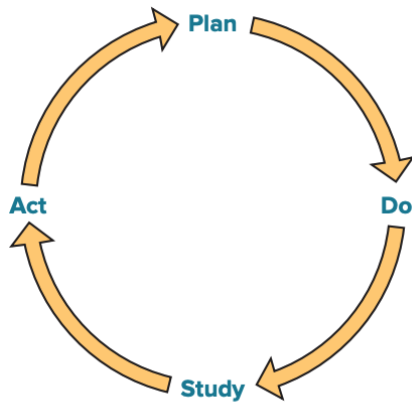
- Implement the plan, document any changes made, collect data for analysis

# PDSA Cycle (cont.)



- **Plan-Do-Study-Act (PDSA) cycle**
  - **Study**
    - Evaluate the data collection during the do phase
    - Check results against goals formulated during the plan phase
  - **Act**
    - If the results are successful, standardize the new method and communicate it to the relevant personnel
    - Implement training for the new method
    - If unsuccessful, revise the plan and repeat the process

# Problem Solving



LO 9.10

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# Process Improvement

- **Process improvement**
  - A systematic approach to improving a process
    - Map the process
      - Collect information about the process and identify each step in the process
      - Prepare a flowchart that accurately depicts the process
    - Analyze the process
      - Ask critical questions about the process
      - Ask specific questions about each step in the process
    - Redesign the process

# Six Sigma

- **Six Sigma**
  - A business process for improving quality, reducing costs, and increasing customer satisfaction
  - **Statistically**
    - Having no more than 3.4 defects per million
  - **Conceptually**
    - Program designed to reduce defects
    - Requires the use of certain tools and techniques

# Six Sigma (cont.)

- **Principles**

- Reduction in variation is an important goal
- The methodology is data driven; it requires data validation
- Outputs are determined by inputs
- Only a critical few inputs have a significant impact on outputs

- **DMAIC**

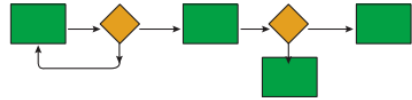
- **Define:** Set the context and objectives for improvement
- **Measure:** Determine the baseline performance and capability of the process
- **Analyze:** Use data and tools to understand the cause-and-effect relationships of the process
- **Improve:** Develop the modifications that lead to a validated improvement of the process
- **Control:** Establish plans and procedures to ensure that improvements are sustained

# Basic Quality Tools

- Flowchart
- Check sheet
- Histogram
- Pareto chart
- Scatter diagram
- Control chart
- Cause-and-effect diagram

# Basic Quality Tools (cont.)

**Flowchart**



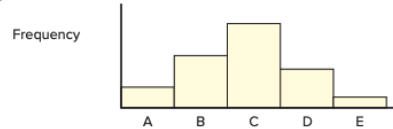
A diagram of the steps in a process

**Check sheet**

Defect	Day			
	1	2	3	4
A	///		///	/
B	//	/	//	///
C	/	///	//	///

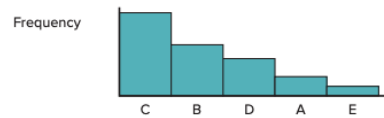
A tool for organizing and collecting data; a tally of problems or other events by category

**Histogram**



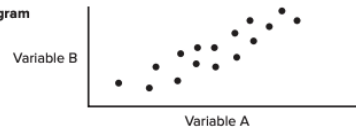
A chart that shows an empirical frequency distribution

**Pareto chart**



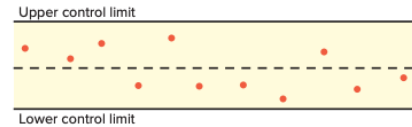
A diagram that arranges categories from highest to lowest frequency of occurrence

**Scatter diagram**



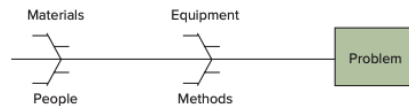
A graph that shows the degree and direction of relationship between two variables

**Control chart**



A statistical chart of time-ordered values of a sample statistic (e.g., sample means)

**Cause-and-effect diagram**



A diagram used to organize a search for the cause(s) of a problem; also known as a *fishbone* diagram

# Methods for Generating Ideas

- Brainstorming
- Quality circles
- Benchmarking

## Quality Circles

- **Quality circle**
  - Groups of workers who meet to discuss ways of improving products or processes
    - Less structured and more informal than teams involved in continuous improvement
    - Quality circle teams have historically had relatively little authority to make any but the most minor changes

# Benchmarking Process

1. Identify a critical process that needs improvement
2. Identify an organization that excels in this process
3. Contact that organization
4. Analyze the data
5. Improve the critical process

# Operations Strategy

- **Quality is a strategic imperative for organizations**
  - Customers are very concerned with the quality of goods and services they receive
- **Quality is a never-ending journey**
  - It is important that most organizational members understand and buy into this idea
- **Customer satisfaction = customer loyalty**
- **Quality needs to be incorporated throughout the entire supply chain, not just the organization itself**

# Extra

[\(3\) Seven Quality Management principles - YouTube](#)

[\(2\) Example of Quality Management - YouTube](#)

[\(3\) What is QMS | Quality Management System Explained - YouTube](#)

[\(3\) management of quality - YouTube](#)

[\(2\) What is a Quality Management System \(QMS\)? - YouTube](#)

[\(2\) What is a quality management system \(QMS\)? - YouTube](#)

[\(2\) Quality Management - The Basics - YouTube](#)

[\(2\) What is Quality in Project Management? - YouTube](#)

[\(2\) What is Quality Management? | Quality Management Tutorial | Invensis Learning - YouTube](#)

[\(2\) Quality, Grade, Accuracy and Precision - YouTube](#)

[\(2\) Quality Management Plan \(QMP\) Tutorial - YouTube](#)

[\(2\) Quality Management Plan, Process Improvement Plan, Quality Checklists and Quality Metrics - YouTube](#)

# Chapter 10

## Quality Control

# Chapter 10: Learning Objectives

## You should be able to:

- LO 10.1 Explain the need for quality control
- LO 10.2 Discuss the basic issues of inspection
- LO 10.3 List and briefly explain the elements of the control process
- LO 10.4 Explain how control charts are used to monitor a process, and the concepts that underlie their use
- LO 10.5 Use and interpret control charts
- LO 10.6 Perform run tests to check for nonrandomness in process output
- LO 10.7 Assess process capability

# Quality Control

## Video:

- 1) What is Inspection? [Inspection and Quality control in Manufacturing. What is quality inspection? - YouTube](#)
- 2) Objectives of Inspection?
- 3) Name 4 types of Inspection Methods?
- 4) What is Quality Control? [The 7 Quality Control \(QC\) Tools Explained with an Example! - YouTube](#)
- 5) Role of Testing? Importance of Quality Control? Basic Functions - SQC?

- 6) Name the 7 QC Tools?
- 7) Explain any 3 QC Tools?

[Amazon's Bezos says you can't invent without experimenting - YouTube](#)

- 8) Jeff Bezos: Explain significance of Experiments?
- 9) What is the benefits of Experiments?
- 10) Explain Business Experimentation? [Jeff Bezos - Do Experiments - YouTube](#)

[Netflix Research: Experimentation - YouTube](#)

[Business Experimentation \(in 2 Minutes\) - YouTube](#)

- **Group Discussion 1: [15-points]**

# Extra

[BMW 3 Series. BMW Quality Management. - YouTube](#)

[How Toyota Maintains 99.9999% Quality | Toyota Quality Management System | Invensis Learning - YouTube](#)

[Mulsanne Quality Control - /INSIDE BENTLEY - YouTube](#)

[Quality Control & Quality Assurance for Service Based Businesses - YouTube](#)

[\(3\) 3 Steps To Implementing Quality Control In Your Business - YouTube](#)

[\(3\) Learn What the 7 Quality Control Tools Are in 8 Minutes - YouTube](#)

[\(3\) 7 Basic Quality Control Tools for Efficient Project Management - YouTube](#)

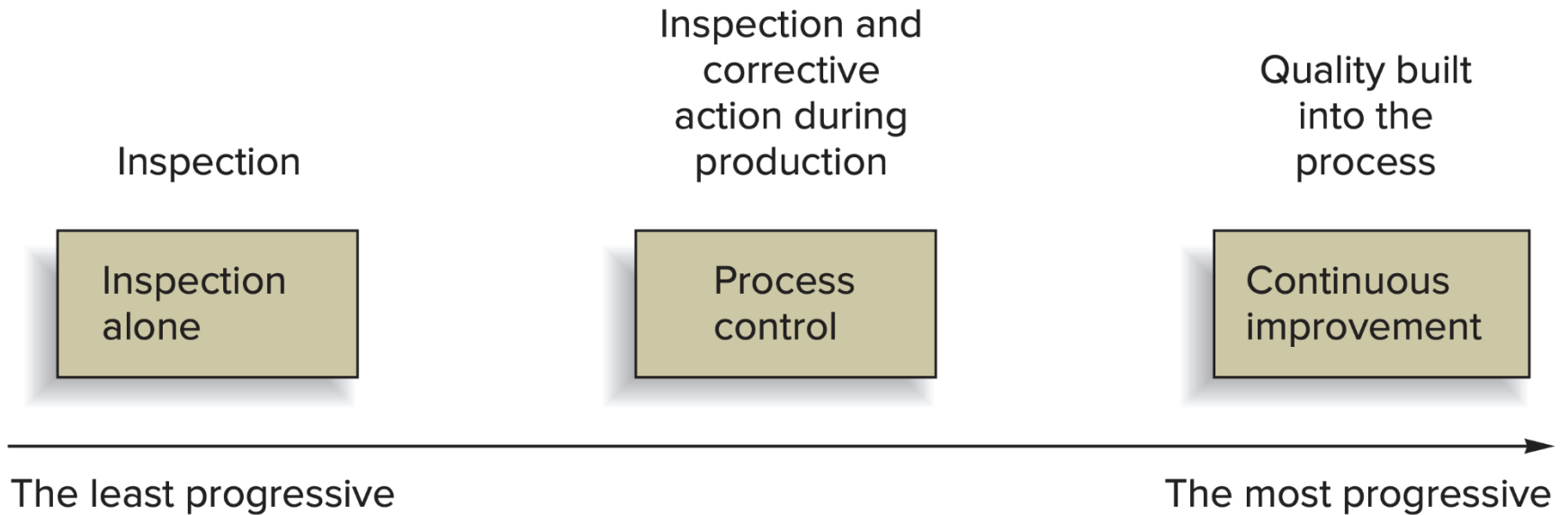
[\(3\) Statistical Process Control in Quality Management - 7 Tools - YouTube](#)

[Quality Management in Construction - Case Study 1 - YouTube](#)

# What is Quality Control?

- **Quality control**
  - A process that evaluates output relative to a standard and takes corrective action when output doesn't meet standards
    - If results are acceptable no further action is required
    - Unacceptable results call for correction action
  - **Inspection alone is not sufficient to achieve a reasonable level of quality**
    - Most organizations rely upon some inspection and a great deal of process control to achieve an acceptable level of quality

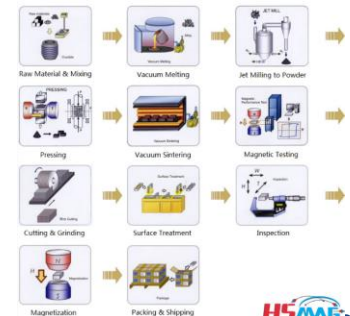
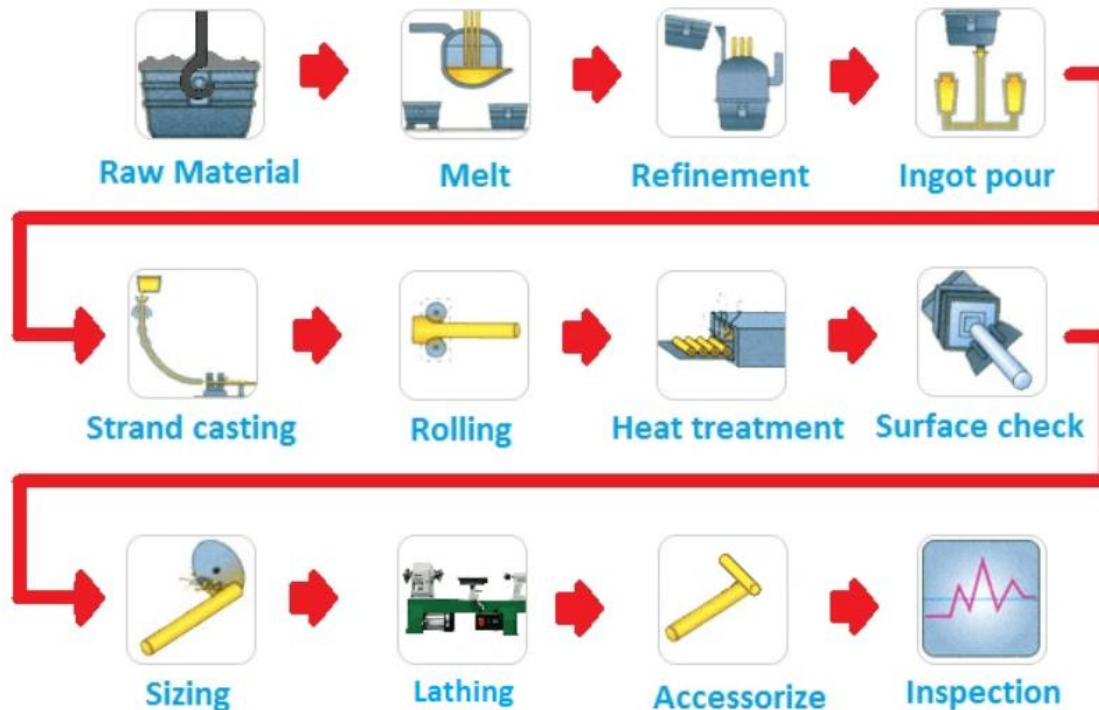
# Phases of Quality Assurance



# Inspection

- **Inspection**

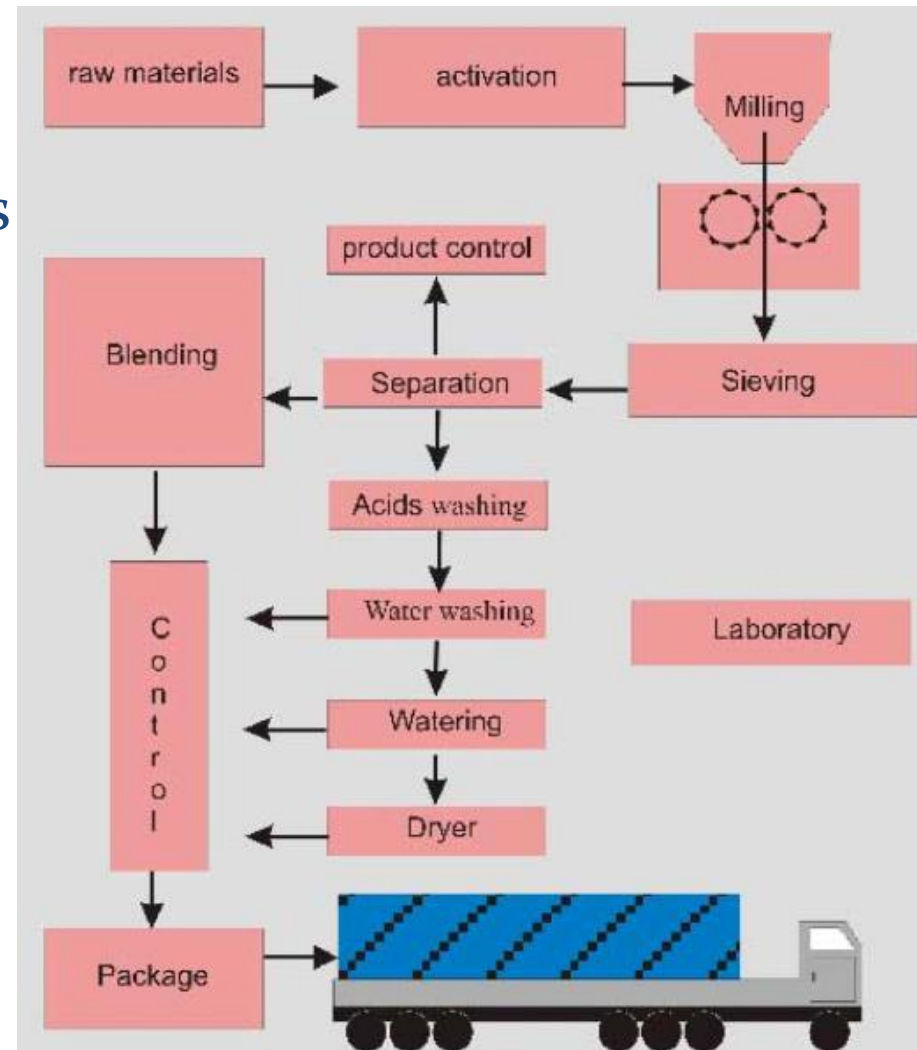
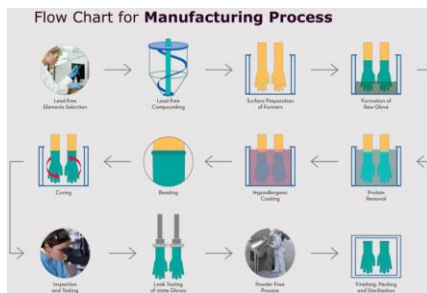
- An appraisal activity that compares goods or services to a standard
- Inspection issues:
  - How much to inspect and how often
  - At what points in the process to inspect
  - Whether to inspect in a centralized or on-site location
  - Whether to inspect attributes or variables



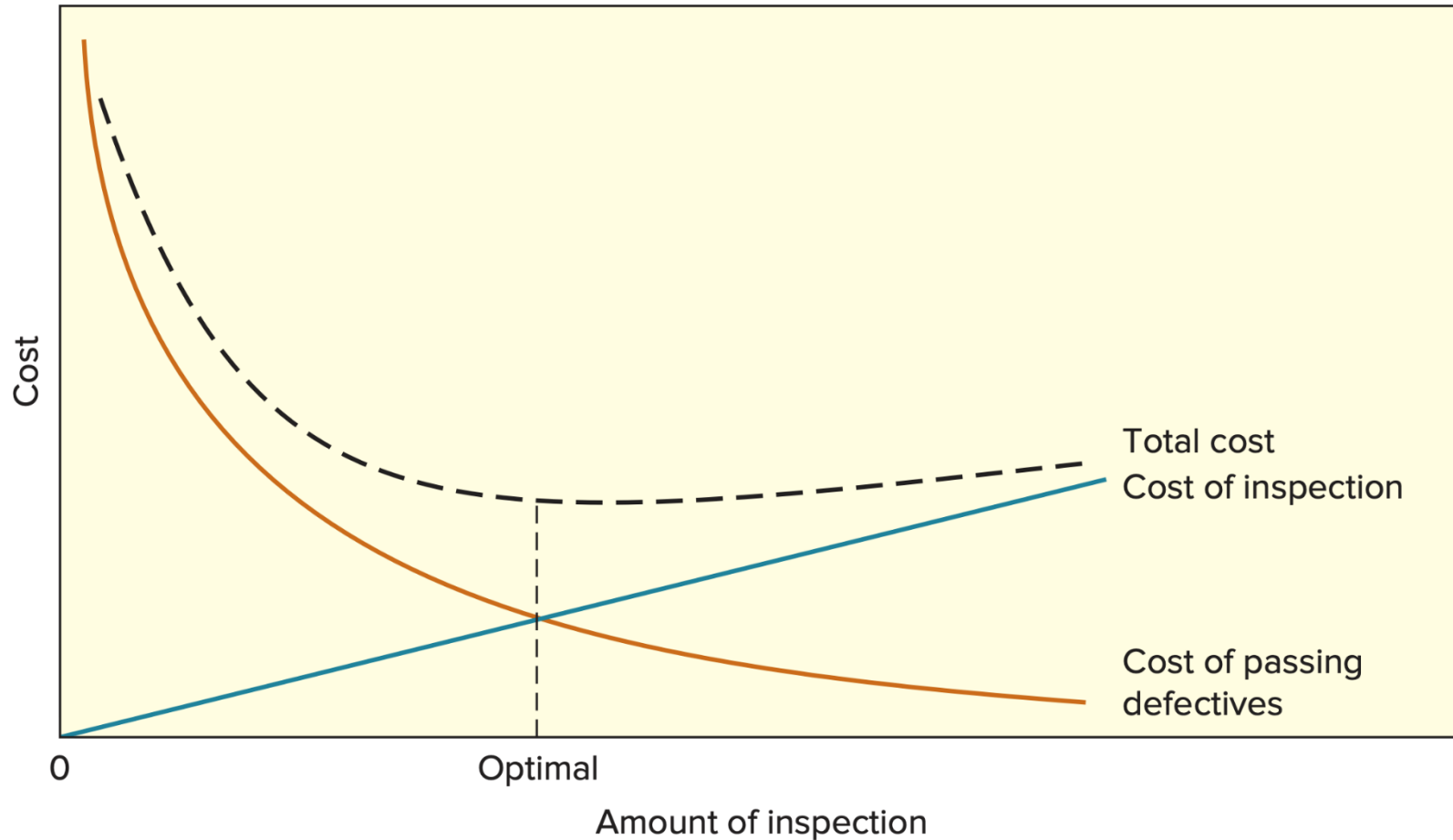
LO 10.2

# Where to Inspect in the Process

- Typical inspection points:
  - Raw materials and purchased parts
  - Finished products
  - Before a costly operation
  - Before an irreversible process
  - Before a covering process

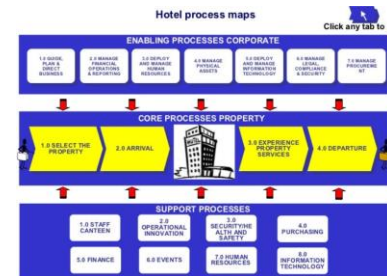
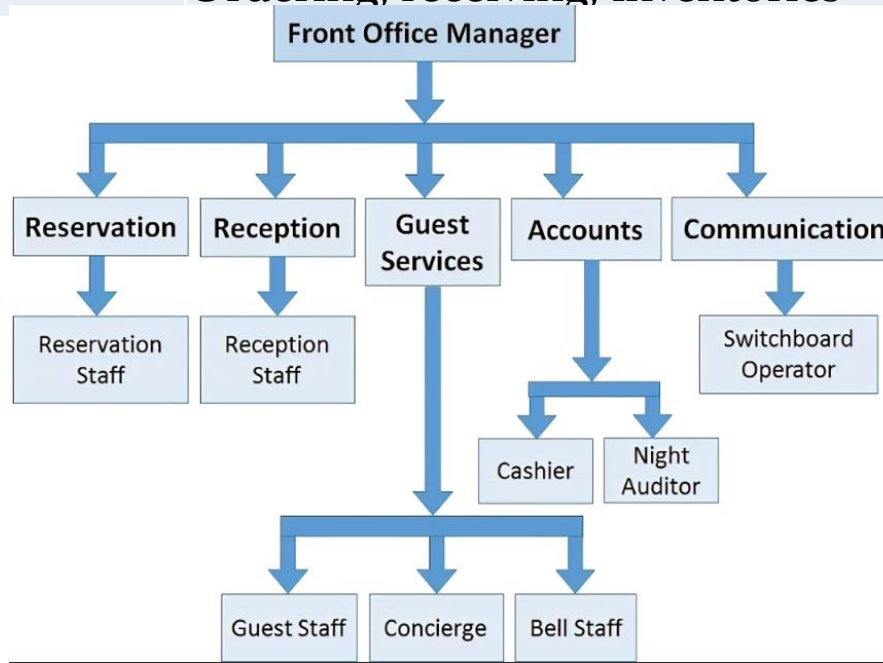


# How Much to Inspect

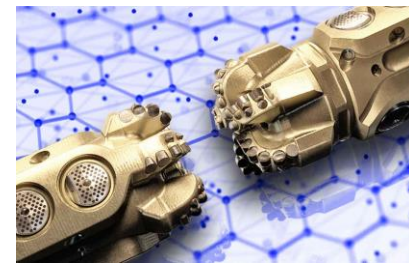


# Example of inspection at a Hotel/Motel

Inspection Point	Characteristics
Accounting/billing	Accuracy, timeliness
Building and grounds	Appearance and safety
Main desk	Appearance, waiting times, accuracy of bills
Maid service	Completeness, productivity
Personnel	Appearance, manners, productivity
Reservations/occupancy	Over/underbooking, percent occupancy
Restaurants	Kitchen, menus, meals, bills
Room service	Waiting time, quality of food
Supplies	Ordering, receiving, inventories



# Off-Site vs. On-Site Inspection



- **Effects on cost and level of disruption are a major issue in selecting centralized vs. on-site inspection**

- **Off-Site**

- Specialized tests that may best be completed in a lab
  - More specialized testing equipment
  - More favorable testing environment



- **On-Site**

- Quicker decisions are rendered
- Avoid introduction of extraneous factors
- Quality at the source



# Statistical Process Control (SPC)

- **Quality control seeks quality of conformance**
  - A product or service conforms to specifications
- **A tool used to help in this process:**
  - **SPC**
    - Statistical evaluation of the output of a process
    - Helps us to decide if a process is “in control” or if corrective action is needed

[\(3\) Quality \(Part 1: Statistical Process Control\) - YouTube](#)

[\(3\) SPC Vs SQC | Statistical Process Control #SPC Vs Statistical Quality Control #SQC \] - YouTube](#)

# Process Variability

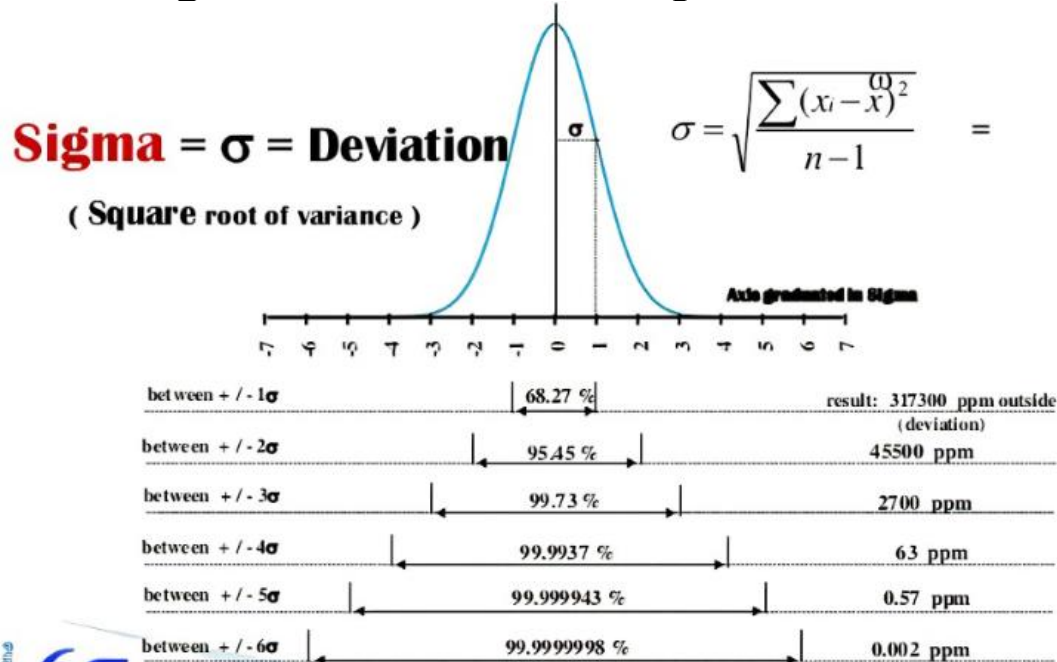
- Two basic questions concerning variability:

1. Issue of process control

- Are the variations random? If nonrandom variation is present, the process is said to be unstable.

2. Issue of process capability

- Given a stable process, is the inherent variability of the process within a range that conforms to performance criteria?



# Variation

- **Variation**

- Random (common cause) variation:

- Natural variation in the output of a process, created by countless minor factors

- Assignable (special cause) variation:

- A variation whose cause can be identified
- A nonrandom variation

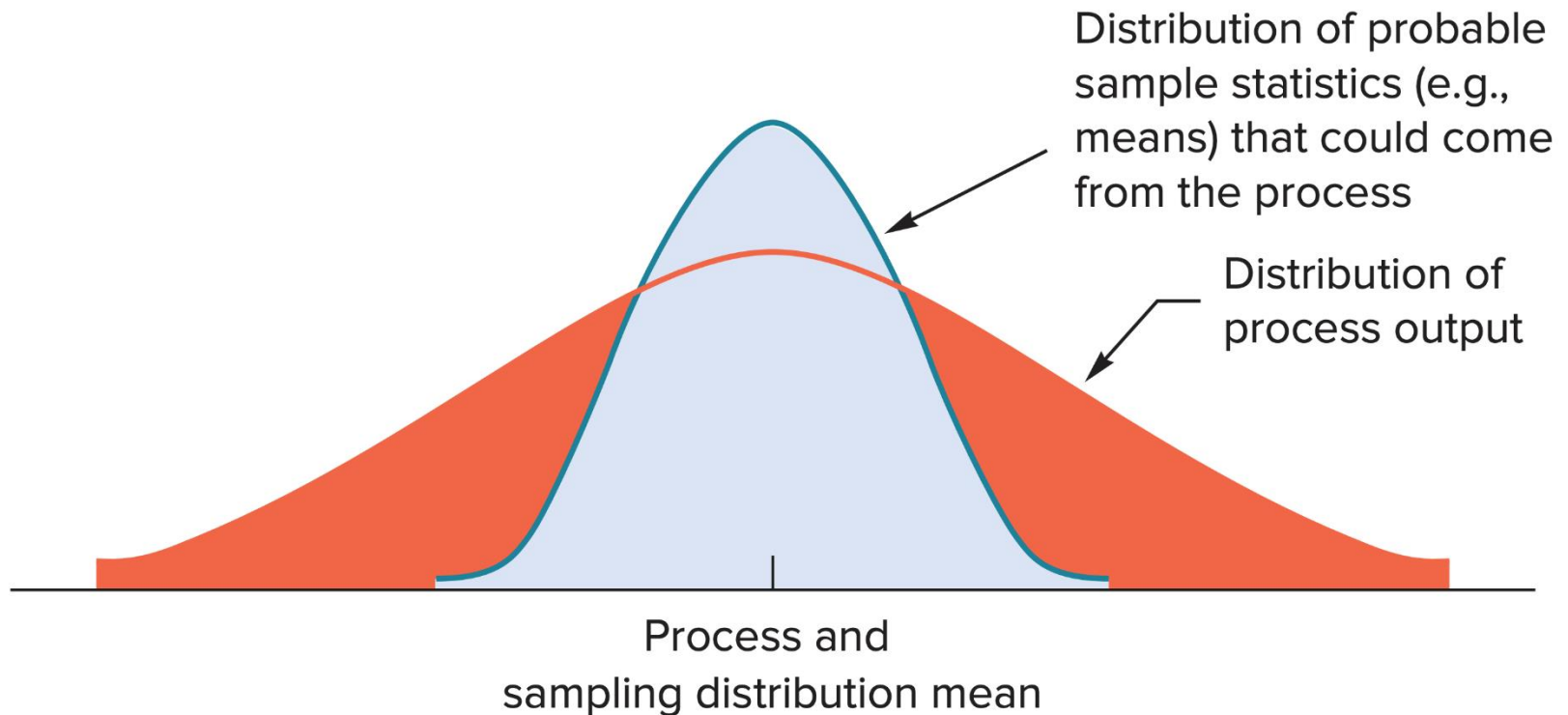
[\(3\) Two Types of Variations // Common cause \(random\) & Special cause \(signal\) - YouTube](#)

[\(3\) What is Six Sigma Process Variation | Common Cause Vs Special Cause of Variation - YouTube](#)

# Sampling and Sampling Distribution

- SPC involves periodically taking samples of process output and computing sample statistics:
  - Sample means
  - The number of occurrences of some outcome
- Sample statistics are used to judge the randomness of process variation

# Sampling and Sampling Distribution (cont.)



**FIGURE 10.4A** The sampling distribution of means is normal, and it has less variability than the process distribution, which might not be normal

# Control Process

- Sampling and corrective action are only a part of the control process
- Steps required for effective control:
  - **Define:** What is to be controlled?
  - **Measure:** How will measurement be accomplished?
  - **Compare:** There must be a standard of comparison
  - **Evaluate:** Establish a definition of *out of control*
  - **Correct:** Uncover the cause of nonrandom variability and fix it
  - **Monitor:** Verify that the problem has been eliminated

# Control Charts: The Voice of the Process

- **Control chart**

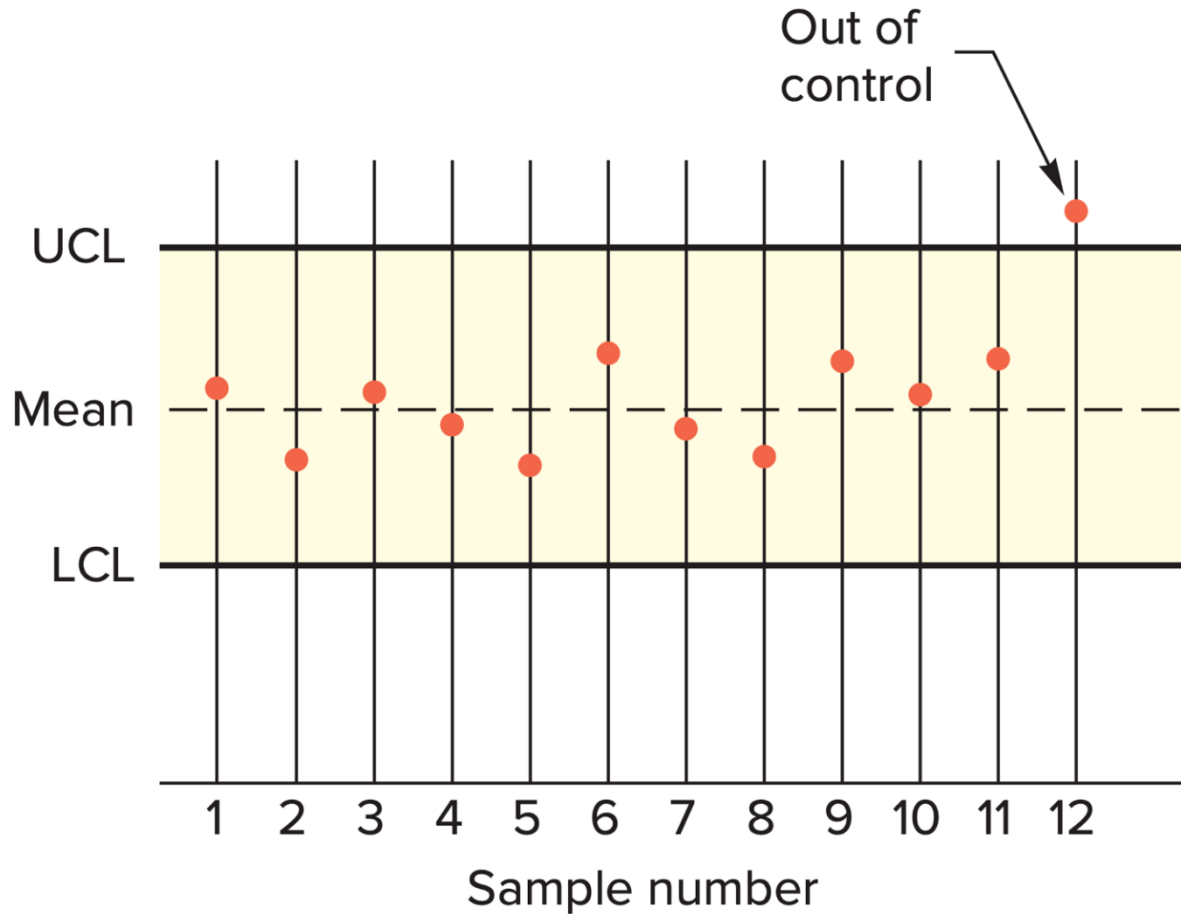
- A time-ordered plot of representative sample statistics obtained from an ongoing process (e.g. sample means), used to distinguish between random and nonrandom variability

- **Control limits**

- The dividing lines between random and nonrandom deviations from the mean of the distribution
- Upper and lower control limits define the range of acceptable variation

[\(3\) Control Charting Explained \(SPC\) - YouTube](#)

# Control Chart



Abnormal variation due to assignable sources



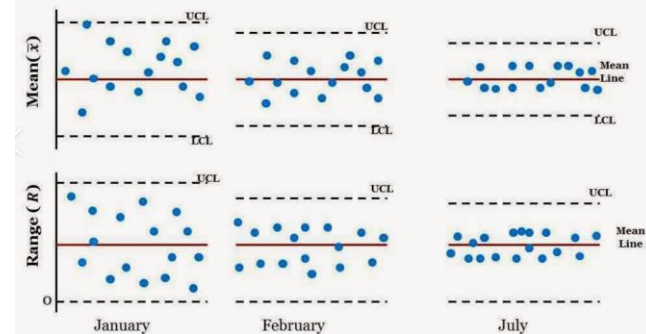
Normal variation due to chance



Abnormal variation due to assignable sources

Each point on the control chart represents a sample of  $n$  observations

Continuing Use of Control Charts, Showing Improved Quality



LO 10.4

# Errors

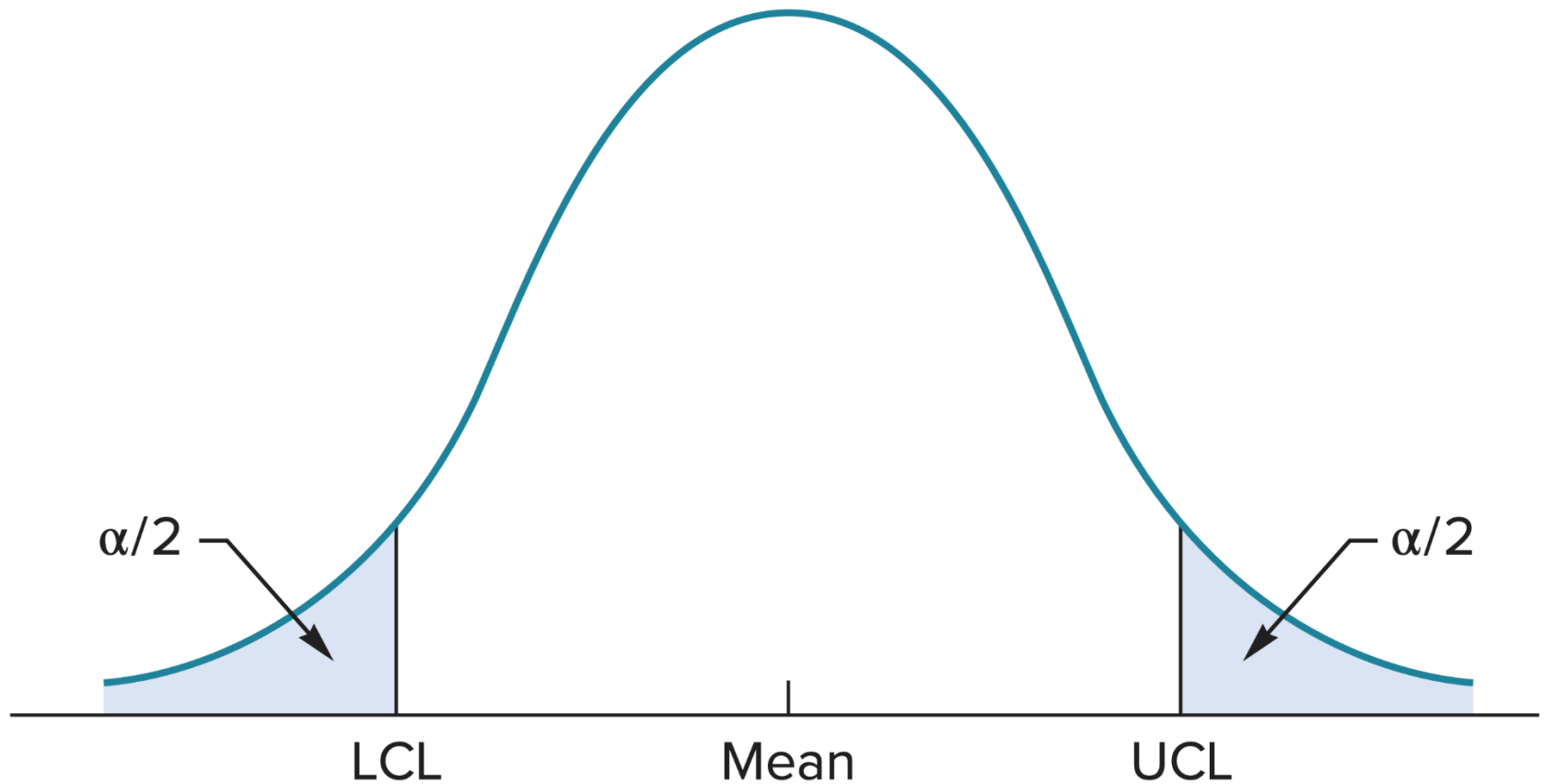
- **Type I error**

- Concluding a process is not in control when it actually is.
  - The probability of rejecting the null hypothesis when the null hypothesis is true
  - Manufacturer's risk

- **Type II error**

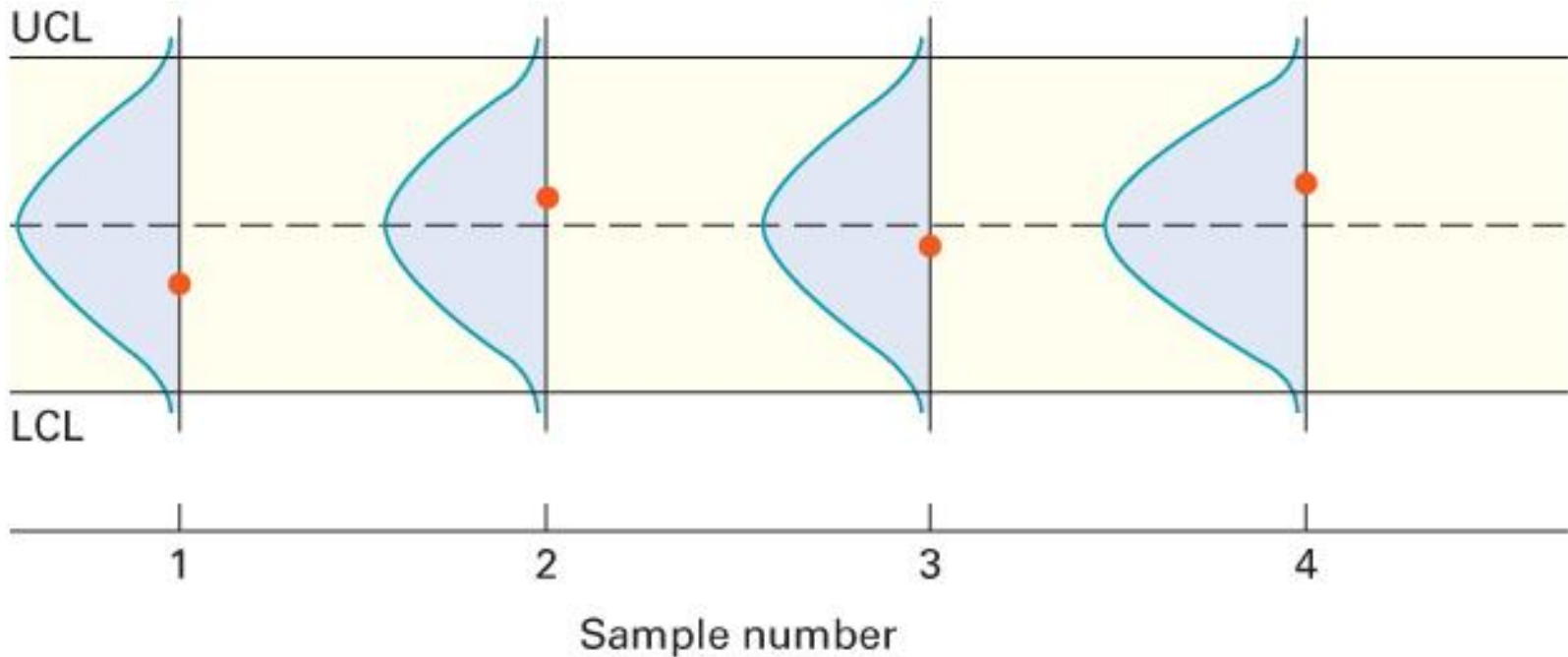
- Concluding a process is in control when it is not.
  - The probability of failing to reject the null hypothesis when the null hypothesis is false
  - Consumer's risk

# Type I Error



$\alpha$  = Probability of a Type I error

# Observations from Sample Distribution



**LO 10.4**

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# Control Charts for Variables

- **Variables generate data that are measured**
  - Mean control charts
    - Used to monitor the central tendency of a process
      - “x-bar” charts
  - Range control charts
    - Used to monitor the process dispersion
      - R charts

# Establishing Control Limits

$$\bar{x} = \frac{\sum_{i=1}^k \bar{x}_i}{k}$$

where

$\bar{x}$  = Average of sample means

$\bar{x}_i$  = mean of sample  $i$

$k$  = number of samples

$$\bar{R} = \frac{\sum_{i=1}^k R_i}{k}$$

where

$\bar{R}$  = Average of sample ranges

$R_i$  = Range of sample  $i$

# X-Bar Chart: Control Limits

- Used to monitor the central tendency of a process

$\bar{x}$  – chart Control Limits

$$UCL_{\bar{x}} = \bar{x} + A_2 \bar{R}$$

$$LCL_{\bar{x}} = \bar{x} - A_2 \bar{R}$$

where

$A_2$  = a control chart factor based on sample size,  $n$

# Range Chart: Control Limits

- Used to monitor process dispersion

## R Chart Control Limits

$$UCL_R = D_4 \bar{R}$$

$$LCL_R = D_3 \bar{R}$$

where

$D_3$  = a control chart factor based on sample size,  $n$

$D_4$  = a control chart factor based on sample size,  $n$

# Factors for Three Sigma Control Charts

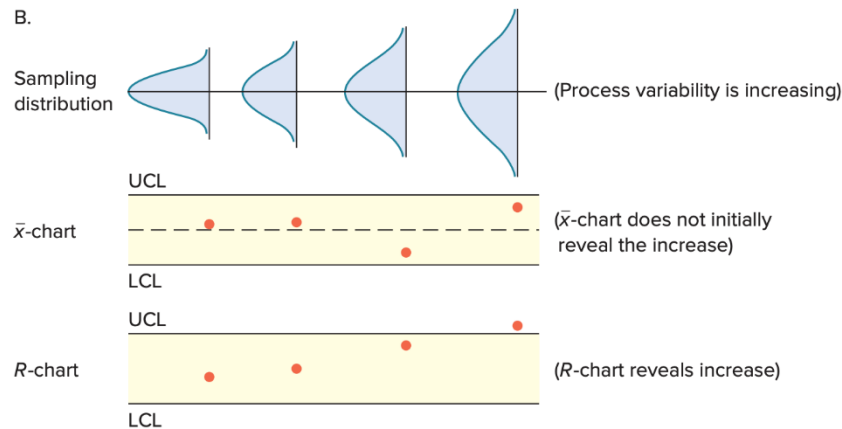
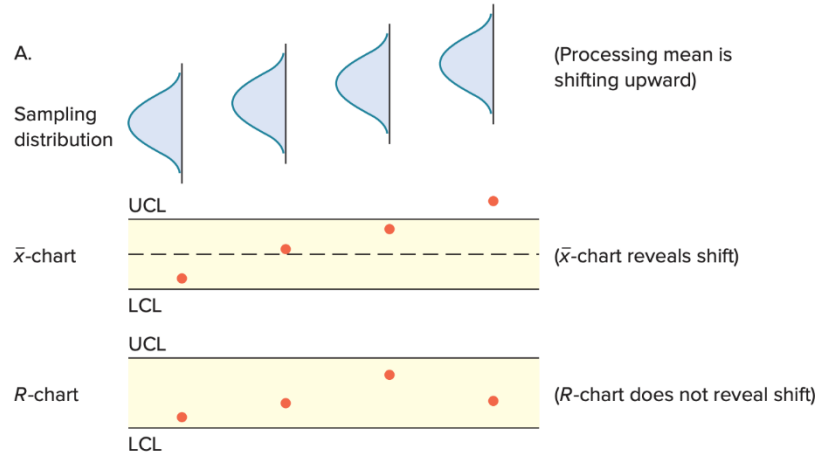
Number of Observations in Sample, $n$	Factor for Chart, $A_2$	FACTORS FOR R CHARTS	
		Lower Control Limit, $D_3$	Upper Control Limit, $D_4$
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.82
10	0.31	0.22	1.78
11	0.29	0.26	1.74
12	0.27	0.28	1.72
13	0.25	0.31	1.69
14	0.24	0.33	1.67
15	0.22	0.35	1.65
16	0.21	0.36	1.64
17	0.20	0.38	1.62
18	0.19	0.39	1.61
19	0.19	0.40	1.60
20	0.18	0.41	1.59

**TABLE 10.3**

Factors for three-sigma control limits for  $\bar{X}$  and  $R$  charts

Source: Adapted from Eugene Grant and Richard Leavenworth, *Statistical Quality Control*, 5th ed. Copyright ©1980 McGraw-Hill Companies, Inc. Used with permission

# Mean and Range Charts

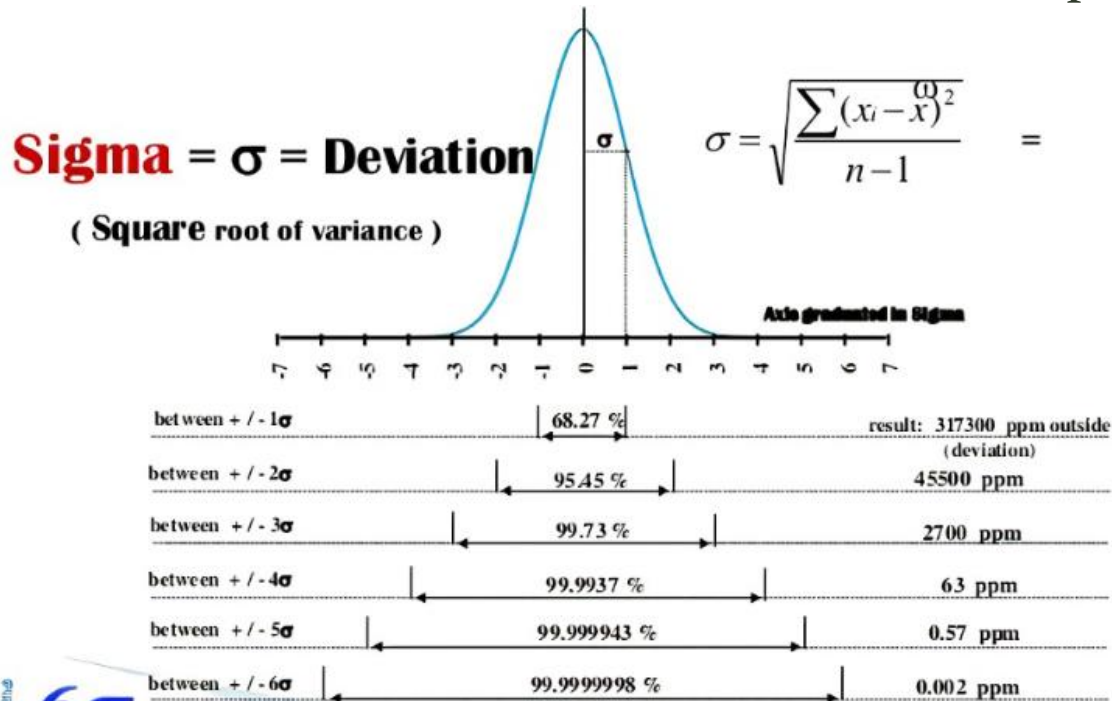


# Using Mean and Range Charts

- **To determine initial control limits:**
  - Obtain 20 to 25 samples
  - Compute appropriate sample statistics
  - Establish preliminary control limits
  - Determine if any points fall outside of the control limits
    - If you find no out-of-control signals, assume the process is in control
    - If you find an out-of-control signal, search for and correct the assignable cause of variation
  - Resume the process and collect another set of observations on which to base control limits
  - Plot the data on the control chart and check for out-of-control signals

# Control Charts for Attributes

- Attributes generate data that are counted.
- p-chart
  - Control chart used to monitor the proportion of defectives in a process
- c-chart
  - Control chart used to monitor the number of defects per unit



# Use a $p$ -chart:

- **When observations can be placed into two categories**
  - Good or bad
  - Pass or fail
  - Operate or don't operate
- **When the data consists of multiple samples of several observations each**

# *p*-chart Control Limits

$$\bar{p} = \frac{\text{Total number of defectives}}{\text{Total number of observations}}$$

$$\hat{\sigma}_p = \sqrt{\frac{\bar{p}(1 - \bar{p})}{n}}$$

$$\text{UCL}_p = \bar{p} + z(\hat{\sigma}_p)$$

$$\text{LCL}_p = \bar{p} - z(\hat{\sigma}_p)$$

# Use a *c*-chart:

- Use only when the number of occurrences per unit of measure can be counted; non-occurrences cannot be counted.
  - Scratches, chips, dents, or errors per item
  - Cracks or faults per unit of distance
  - Breaks or tears per unit of area
  - Bacteria or pollutants per unit of volume
  - Calls, complaints, failures per unit of time

$$UCL_c = c + z\sqrt{c}$$

$$LCL_c = c - z\sqrt{c}$$

# Managerial Considerations

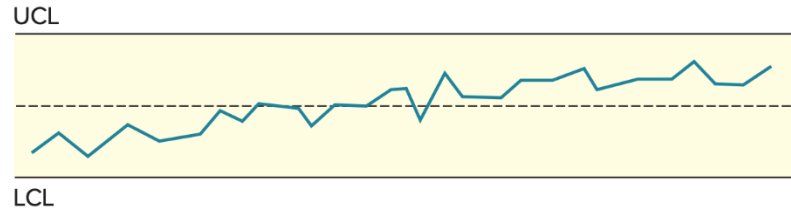
- At what points in the process to use control charts
- What size samples to take
- Sample frequency
- What type of control chart to use
  - Variables
  - Attributes

# Run Tests

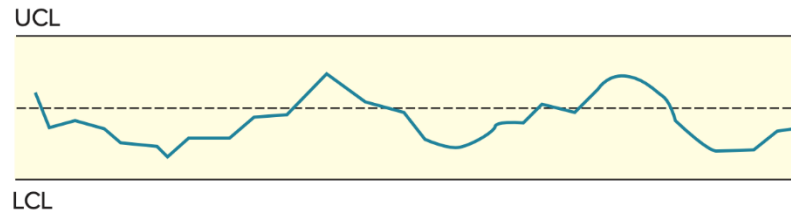
- **Even if a process appears to be in control, the data may still not reflect a random process**
- **Analysts often supplement control charts with a run test**
  - **Run test**
    - A test for patterns in a sequence
  - **Run**
    - Sequence of observations with a certain characteristic

# Nonrandom Patterns

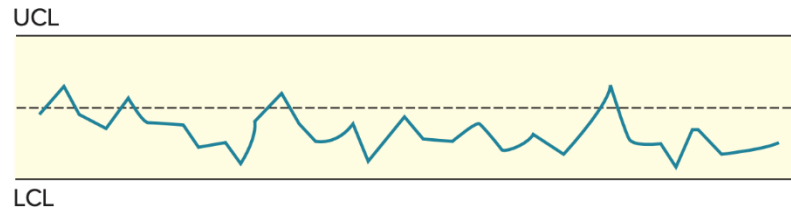
**Trend**  
Sustained  
upward or  
downward  
movement



**Cycles**  
A wave  
pattern



**Bias**  
Too many  
observations  
on one side  
of the center  
line



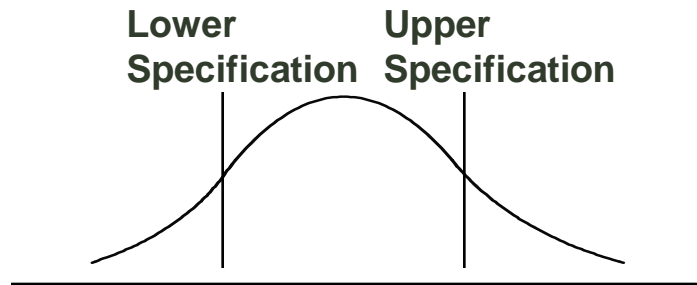
**Too much  
dispersion**  
The values  
are too  
spread out



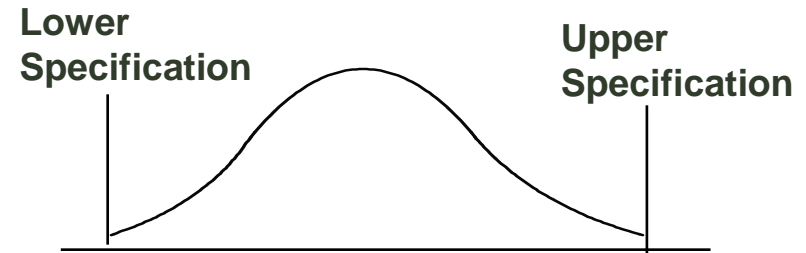
# Process Capability

- **Once a process has been determined to be stable, it is necessary to determine if the process is capable of producing output that is within an acceptable range**
  - **Tolerances or specifications**
    - Range of acceptable values established by engineering design or customer requirements
  - **Process variability**
    - Natural or inherent variability in a process
  - **Process capability**
    - The inherent variability of process output (process width) relative to the variation allowed by the design specification (specification width)

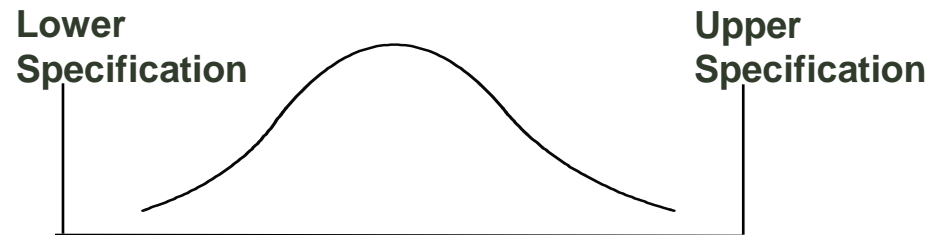
# Process Capability (cont.)



**Process variability (width)  
exceeds specifications**



**Process variability (width)  
matches specifications width**



**Process variability (width) is less  
than the specification width**

$C_p$ 

$$C_p = \frac{UTL - LTL}{6\sigma}$$

where

UTL = upper tolerance (specification) limit

LTL = lower tolerance (specification) limit

# $C_{pk}$

- Used when a process is not centered at its target, or nominal, value

$$C_{pk} = \min \{C_{pu}, C_{pl}\}$$
$$= \min \left\{ \frac{UTL - \bar{x}}{3\sigma}, \frac{\bar{x} - LTL}{3\sigma} \right\}$$

# Improving Process Capability

- Simplify
- Standardize
- Mistake-proof
- Upgrade equipment
- Automate

# Limitations of Capability Measures

- There are several risks of using capability measures:
  - The process may not be stable
  - The process output may not be normally distributed
  - The process is not centered but  $C_p$  is used

# Operations Strategy

- **Quality is a primary consideration for nearly all customers**
  - Achieving and maintaining quality standards is of strategic importance to all business organizations
    - Product and service design
    - Increase capability in order to move from extensive use of control charts and inspection to achieve desired quality outcomes

# Chapter 12

## Inventory Management

# Inventory Management

## Video & Discussion:

- 1) What is Inventory? Why is it needed – 6 Reasons?
- 2) Examples of Inventory: manufacturing & Service?
- 3) What is Inventory Management?
- 4) Comment about various business departments being “interlinked”?
- 5) Efficient “Inventory Management” affects the health of \_\_\_\_\_? Why?

[\(4\) What is inventory? | Types of inventory - YouTube](#)

[\(4\) Why Companies hold Inventories? Need for Inventory Management. - YouTube](#)

[\(4\) Inventory Management in Operations Management - YouTube](#)

## • Group Discussion 1: [20-points]

[\(4\) Introduction to Inventory Management. - YouTube](#)

# Inventory

- **Inventory**
  - A stock or store of goods
  - Raw materials used in production as well as the goods produced that are available for sale.
- **Independent-demand items**
  - Items that are ready to be sold or used
  - Inventory is a very important asset for any company.
- **Examples**
  - Aluminum and steel for the manufacture of cars
  - Flour for bakeries that produce bread
  - Crude oil held by refineries

Inventories are a vital part of business: (1) necessary for operations and (2) contribute to customer satisfaction

A “typical” firm has roughly 30% of its current assets and as much as 90% of its working capital invested in inventory

# Inventory – Basic Types

**Raw materials** - basic materials, ingredients, parts and components used in products and services

**Work-in-progress (WIP)** - partially completed products

**Finished goods** - products that are ready to be sold

**Maintenance, repair and operations (MRO)** - supplies necessary for the maintenance, repair, and support of production processes and facilities

# Inventory - Examples

Wood on a construction site	Packaging materials	Cotton fabric in a textile factory	Glass bottles in a recycling facility
Parts	Components	Soybeans harvested from a farm	Wood logs at a sawmill
Food ingredients	Product samples	A partially completed painting in an artist's studio	A partially constructed house owned by a house builder
Cleaning supplies in a factory	Cakes in a cake shop	Lubricants in a repair shop	Fasteners such as screws in a craft shop
Partially completed products on an assembly line	Small tools used in production	Air conditioning parts owned by a HVAC repair person	Safety equipment in a factory such as a fire extinguisher
Computer parts in a data center	Stock such as boxes of shoes in an ecommerce fulfillment center	Receipt paper in a retail shop	Antiques in an antique shop
Soap used to stock rooms in a hotel	Kimono in a kimono rental shop	Fuel in a airline's airplane	
Clothes in a clothing retail shop	Cake decorations in a cake shop		
Goods in transit until they are owned by the customer	Excess inventory such as unpopular colors of a product that won't sell		

# Inventory – Business Concepts

Service inventory	A unit of a service that can be sold that expires. For example, a seat on a flight. Not a true type of inventory but an important business concept.
Perishable inventory	Inventory that expires at a point in time such as food.
Obsolete inventory	Inventory that is outdated or obsolete such as a case for an electronic device that is no longer on the market.
Consignment inventory	A retailer that sells inventory that is still owned by the producer.
Safety stock	Inventory held to guard against supply shortfalls or sudden demand surges.
Service parts	Parts and components used to provide repair or maintenance services.

Backordered inventory	Inventory that hasn't arrived yet that has already been sold.
Seasonal inventory	Stock used to meet seasonal demand.
Excess inventory	Inventory that hasn't been sold in the expected period of time. For example, unpopular colors that remain on the shelf as other colors sell out.
Cycle inventory	Inventory that a business replaces regularly such as shampoo in a drug store that sells many units a day.
Transit inventory	Inventory that is in the supply chain or that is being delivered to customers.

# Types of Inventory

- Raw materials and purchased parts
- Work-in-process (WIP)
- Finished goods inventories or merchandise
- Tools and supplies
- Maintenance and repairs (MRO) inventory
- Goods-in-transit to warehouses or customers (pipeline inventory)

“Inventory is the stock of goods held for doing business.”

**Inventory**  
*consists of...*

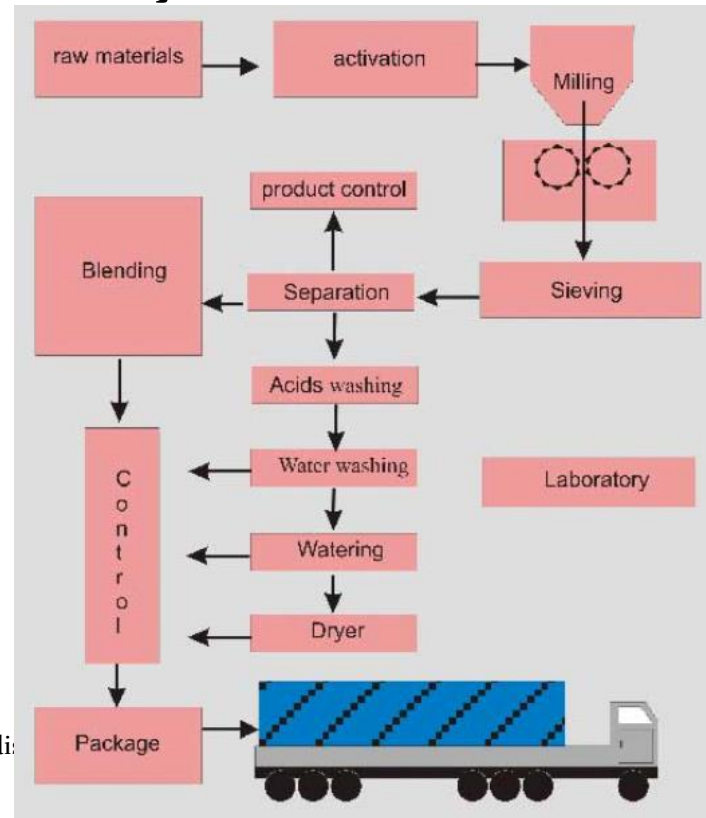
Raw-materials  
required for  
production process

Work in progress  
(WIP). For example,  
semi-finished goods

Captive consumable  
goods, goods used  
by manufacturer

Finished goods  
which are  
available for sale

McGraw-Hill Education.



ion or di

# Inventory Functions

- **Inventories serve a number of functions such as:**
  1. To meet anticipated customer demand
  2. To smooth production requirements
  3. To decouple operations
  4. To protect against stockouts
  5. To take advantage of order cycles
  6. To hedge against price increases
  7. To permit operations
  8. To take advantage of quantity discounts

# Objectives of Inventory Control

- **Inventory management has two main concerns:**
  1. **Level of customer service**
    - Having the right goods available in the right quantity in the right place at the right time
  2. **Costs of ordering and carrying inventories**
    - The overall objective of inventory management is to achieve satisfactory levels of customer service while keeping inventory costs within reasonable bounds
      1. **Measures of performance**
      2. **Customer satisfaction**
        - Number and quantity of backorders
        - Customer complaints
      3. **Inventory turnover**

# Inventory Turnover Ratio

- **Ratio of annual cost of goods sold to average inventory investment**
  - How many times a year the inventory is sold
  - Higher the better as it implies more efficient use of the inventory

# Effective Inventory Management

- **Requires:**

1. A system keep track of inventory
2. A reliable forecast of demand
3. Knowledge of lead time and lead time variability
4. Reasonable estimates of
  - Holding costs
  - Ordering costs
  - Shortage costs
5. A classification system for inventory items

# Inventory Decisions and Planning

**Video:** [\(4\) Inventory Decisions in Efficient Production Planning and Control - YouTube](#)

- 1) 5 important factors while making Inventory Decisions?
- 2) What is Cycle Inventory, Safety Inventory & Seasonal?
- 3) Explain Sourcing & Overall Trade-Off?

[\(4\) Basic Concepts of Inventory Planning \(EOQ calculation, Continuous, & Periodic Ordering Model\) - YouTube](#)

- 4) What is Inventory Planning? What are the 3 Inventory Management Models?
- 5) Explain each model in Q2?

- **Group Discussion 2: [20-points]**

# Inventory Counting Systems

- **Periodic system**
  - Physical count of items in inventory made at periodic intervals
- **Perpetual inventory system**
  - System that keeps track of removals from inventory continuously, thus monitoring current levels of each item
    - An order is placed when inventory drops to a predetermined minimum level
      - **Two-bin system**
        - Two containers of inventory; reorder when the first is empty

# Inventory Counting Technologies

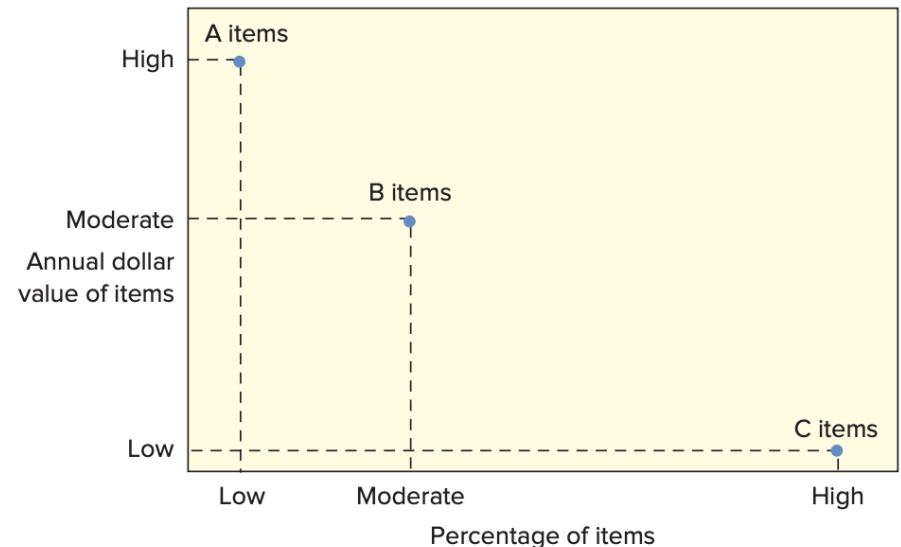
- **Universal product code (UPC)**
  - Bar code printed on a label that has information about the item to which it is attached
- **Radio frequency identification (RFID) tags**
  - A technology that uses radio waves to identify objects, such as goods, in supply chains

# Inventory Costs

- **Purchase cost**
  - The amount paid to buy the inventory
- **Holding (carrying) costs**
  - Cost to carry an item in inventory for a length of time, usually a year
- **Ordering costs**
  - Costs of ordering and receiving inventory
- **Setup costs**
  - The costs involved in preparing equipment for a job
  - Analogous to ordering costs
- **Shortage costs**
  - Costs resulting when demand exceeds the supply of inventory; often unrealized profit per unit

# ABC Classification System

- **A-B-C approach** [\(4\) ABC Analysis - Easily Explained - YouTube](#)
  - Classifying inventory according to some measure of importance, and allocating control efforts accordingly
  - **A items** (very important)
    - 10 to 20 percent of the number of items in inventory and about 60 to 70 percent of the annual dollar value
  - **B items** (moderately important)
  - **C items** (least important)
    - 50 to 60 percent of the number of items in inventory but only about 10 to 15 percent of the annual dollar value



# Cycle Counting

- **Cycle counting**
  - A physical count of items in inventory
- **Cycle counting management**
  - How much accuracy is needed?
    - A items:  $\pm 0.2$  percent
    - B items:  $\pm 1$  percent
    - C items:  $\pm 5$  percent
  - When should cycle counting be performed?
  - Who should do it?

# Inv Control Strategies: EOQ, EPQ & ABC Analysis

**Video:** [\(4\) What is EOQ vs EPQ + ABC Analysis, Vendor Managed Inventory, and JIT - YouTube](#)

- 1) What is EOQ?
- 2) What is EPQ?
- 3) WHAT is ABC Analysis?

[\(4\) Inventory Control - Cycle Counts and Inventory Audits. - YouTube](#)

- 4) What is Cycle Counts?
- 5) What is Inventory Audits?

- **Group Discussion 1: [10-points]**

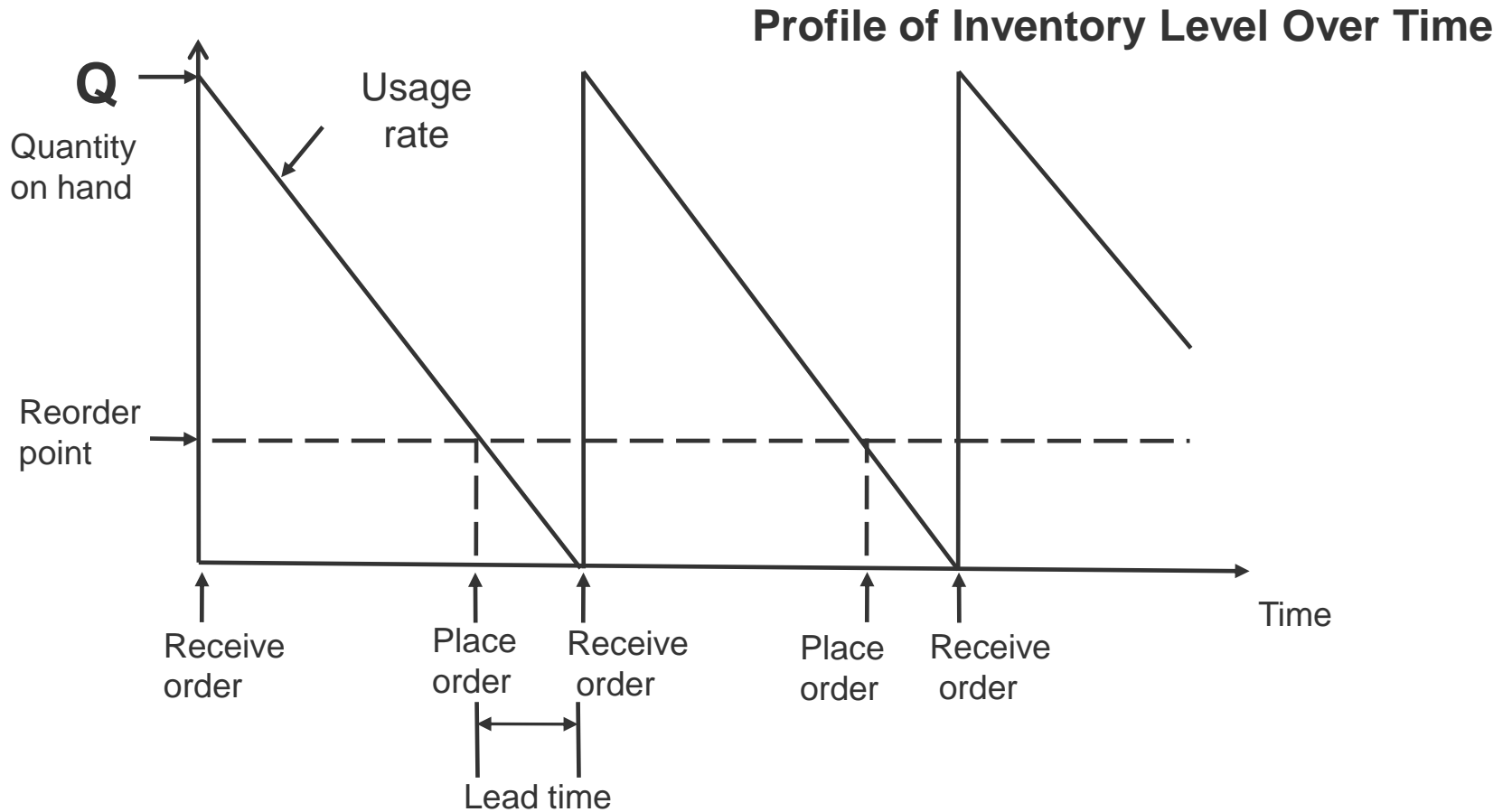
# How Much to Order: EOQ Models

- Economic Order Quantity models identify the optimal order quantity by minimizing the sum of annual costs that vary with order size and frequency
  1. The basic Economic Order Quantity model
  2. The Economic Production Quantity model
  3. The Quantity Discount model

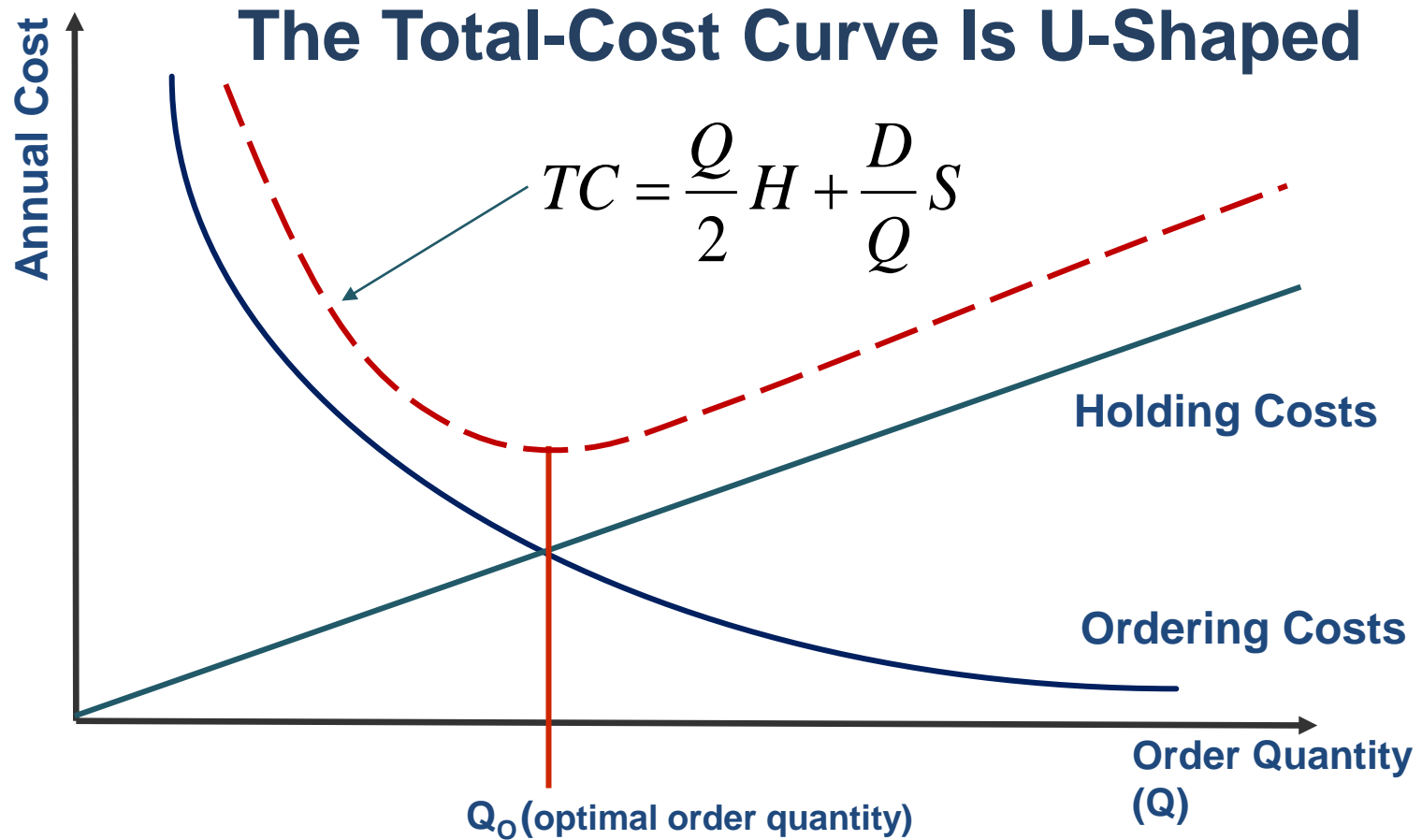
# Basic EOQ Model

- **The basic EOQ model is used to find a fixed order quantity that will minimize total annual inventory costs**
- **Assumptions:**
  1. Only one product is involved
  2. Annual demand requirements are known
  3. Demand is even throughout the year
  4. Lead time does not vary
  5. Each order is received in a single delivery
  6. There are no quantity discounts

# The Inventory Cycle



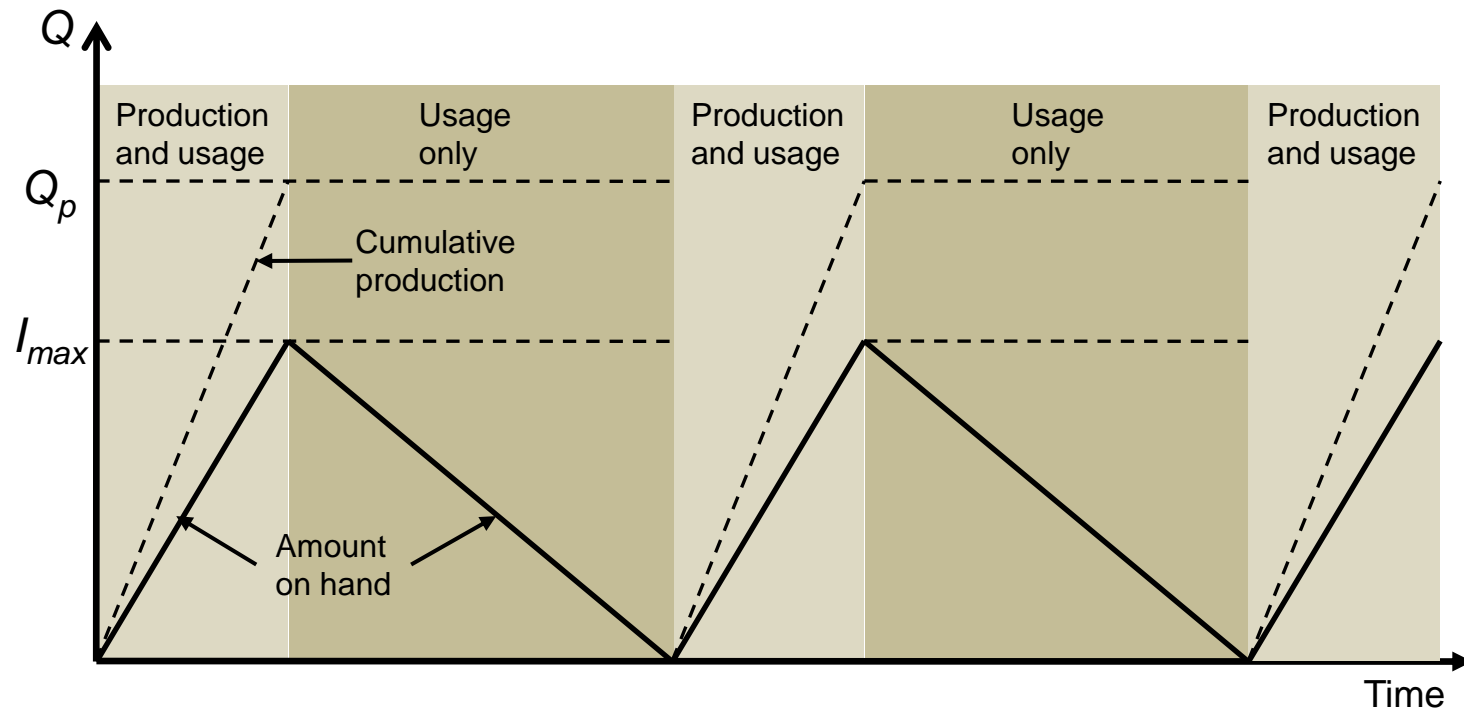
# Goal: Total Cost Minimization



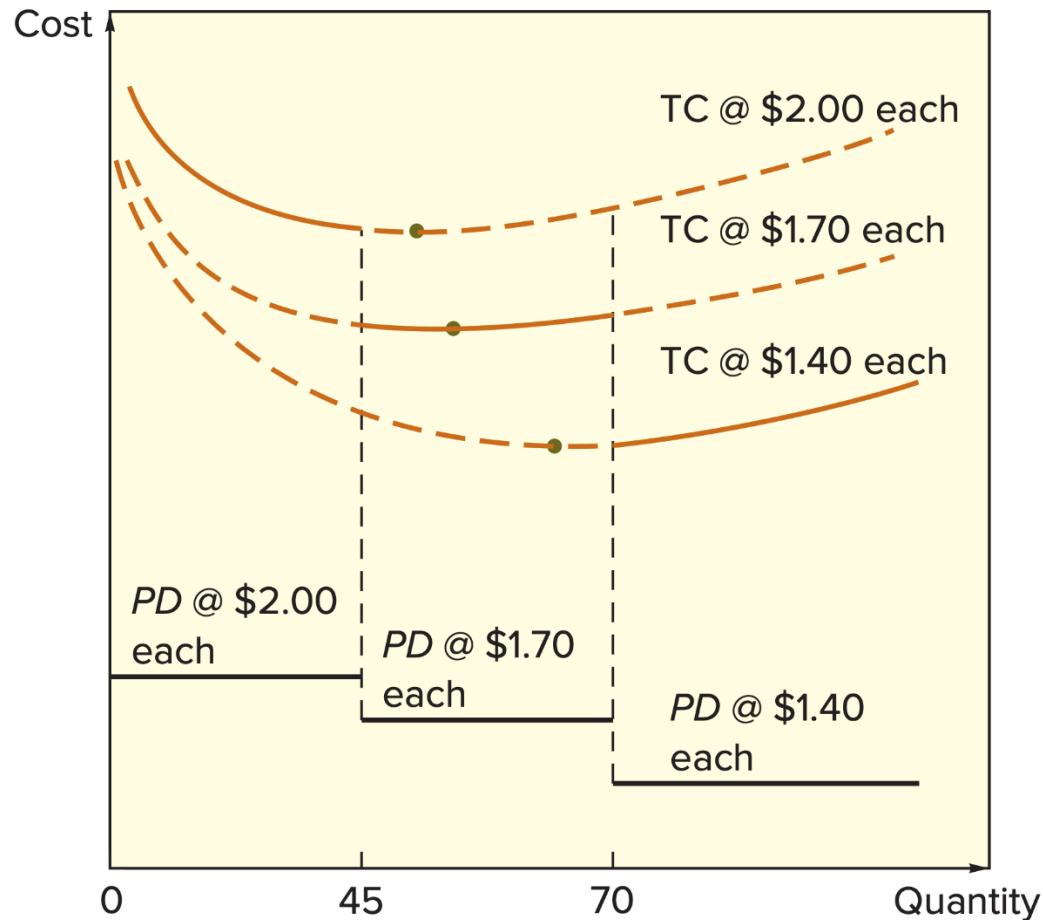
# Economic Production Quantity (EPQ)

- The batch mode is widely used in production. In certain instances, the capacity to produce a part exceeds its usage (demand rate).
  - **Assumptions**
    - Only one item is involved
    - Annual demand requirements are known
    - Usage rate is constant
    - Usage occurs continually, but production occurs periodically
    - The production rate is constant
    - Lead time is known and constant
    - There are no quantity discounts

# EPQ: Inventory Profile



# Quantity Discounts (cont.)



The total-cost curve with quantity discounts is composed of a portion of the total-cost curve for each price

# When to Reorder

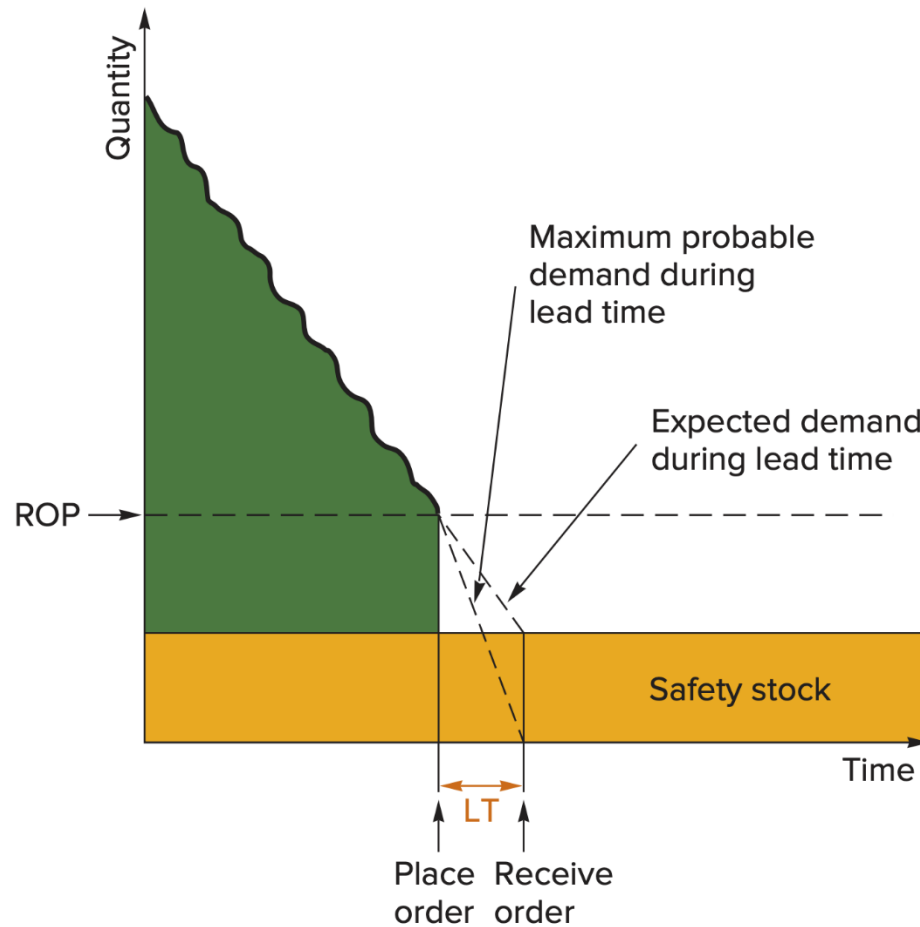
- **Reorder point**
  - When the quantity on hand of an item drops to this amount, the item is reordered.
  - Determinants of the reorder point
    1. The rate of demand
    2. The lead time
    3. The extent of demand and/or lead time variability
    4. The degree of stockout risk acceptable to management

# Reorder Point: Under Uncertainty

- Demand or lead time uncertainty creates the possibility that demand will be greater than available supply
- To reduce the likelihood of a stockout, it becomes necessary to carry safety stock
  - **Safety stock**
    - Stock that is held in excess of expected demand due to variable demand and/or lead time

$$\text{ROP} = \text{Expected demand during lead time} + \text{Safety Stock}$$

# Safety Stock



# Safety Stock?

- **As the amount of safety stock carried increases, the risk of stockout decreases.**
  - This improves customer service level
- **Service level**
  - The probability that demand will not exceed supply during lead time
  - Service level =  $100\% - \text{stockout risk}$

# How Much Safety Stock?

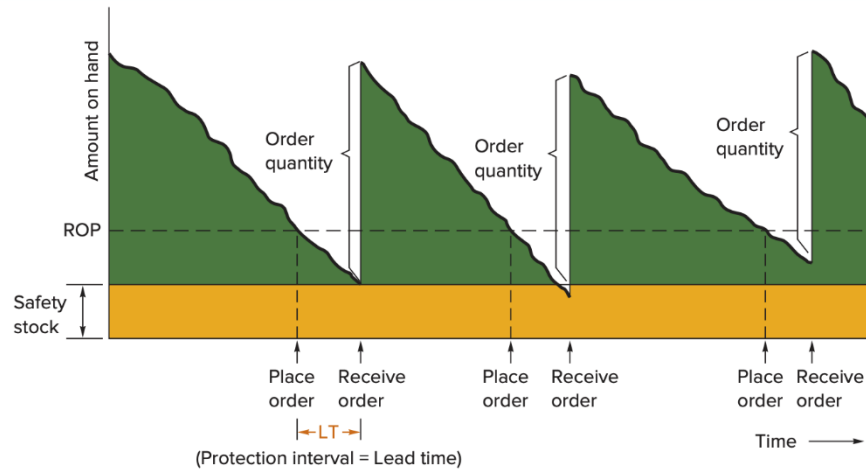
- The amount of safety stock that is appropriate for a given situation depends upon:
  1. The average demand rate and average lead time
  2. Demand and lead time variability
  3. The desired service level

# How Much to Order: FOI

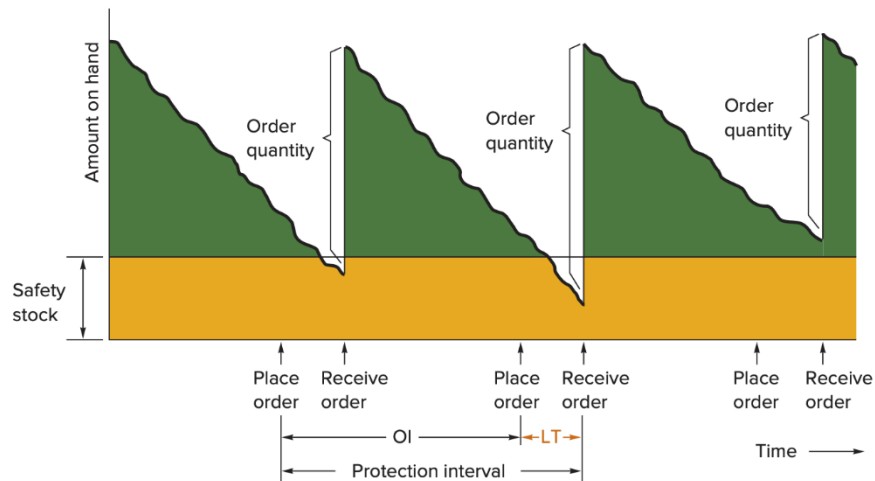
- **Fixed-Order-Interval (FOI) model**
  - Orders are placed at fixed time intervals
- **Reasons for using the FOI model**
  - Supplier's policy may encourage its use
  - Grouping orders from the same supplier can produce savings in shipping costs
  - Some circumstances do not lend themselves to continuously monitoring inventory position

# Fixed-Quantity vs. Fixed-Interval Ordering

**Fixed Quantity**



**Fixed Interval**



# Single-Period Model

- **Single-period model**

- Model for ordering of perishables and other items with limited useful lives
- **Shortage cost**
  - Generally, the unrealized profit per unit
  - $C_{shortage} = C_s = \text{Revenue per unit} - \text{Cost per unit}$
- **Excess cost**
  - Different between purchase cost and salvage value of items left over at the end of the period
  - $C_{excess} = C_e = \text{Cost per unit} - \text{Salvage value per unit}$

# Single-Period Model (cont.)

- The goal of the single-period model is to identify the order quantity that will minimize the long-run excess and shortage costs
- Two categories of problem:
  - Demand can be characterized by a continuous distribution
  - Demand can be characterized by a discrete distribution

# Extra

- [\(4\) Types of Inventory in Operations and Supply Chain Management | #StayHome and Study #WithMe - YouTube](#)
- [\(4\) Why Companies hold Inventories? Need for Inventory Management. - YouTube](#)
- [\(4\) Dependent and Independent Demand Inventories \(Types of Inventories\) - YouTube](#)
- [\(4\) Types of Inventory \(Movement, Buffer, Anticipation, Decoupling, and Cycle Inventories\) - YouTube](#)
- [\(4\) The Painful Small-Business Inventory Lessons I've Learned - YouTube](#)
- [\(4\) Components of Inventory Costs \(Ordering Cost, Carrying Cost, Stock Out Cost & Cost of Replenishment\) - YouTube](#)
- [\(4\) Inventory Costs \(Purchase Cost, Ordering Cost, Set-up Cost, Carrying Cost, Stockout Cost\) - YouTube](#)
- [\(4\) Economic Order Quantity - YouTube](#)
- [\(4\) What is EOQ? - YouTube](#)
- [\(4\) Ford Video Network Training - Inventory Management - Profit Strategy 1975, From U-Matic Tape, 720p - YouTube](#)



**HOW TO DO AND USE**  
**ABC-XYZ Inventory**  
**Segmentation**



**STEP BY STEP**



**SWIPE**

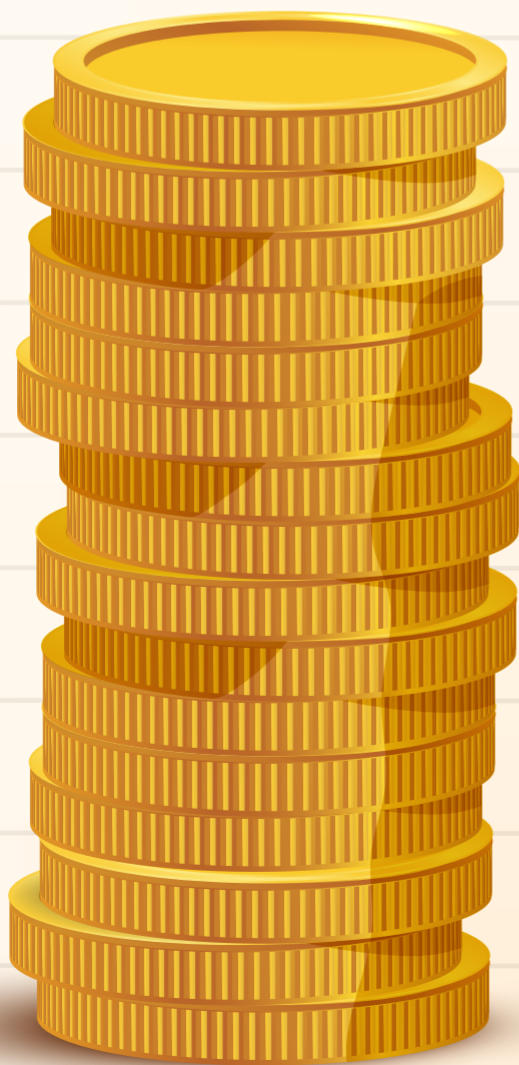
## Step 1

# RUN ABC ANALYSIS — BASED ON VALUE CONTRIBUTION

Use annual consumption  $\times$  unit cost to rank SKUs

## A ITEMS

Top 70-80% of value  
(usually 10-20% of



## B ITEMS

Next 15-25% of  
value



## C ITEMS

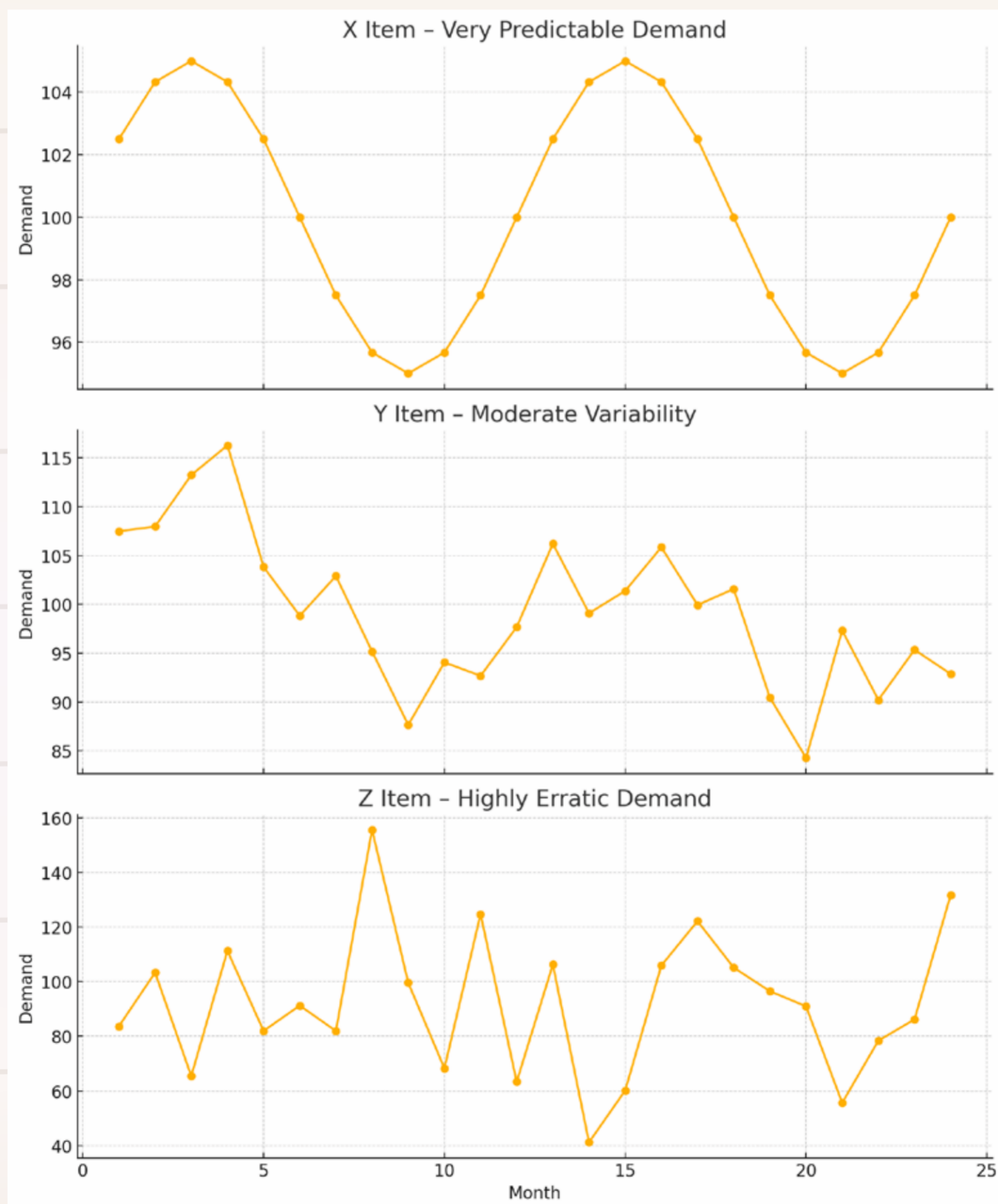
Bottom 5-10% of  
value



## Step 2

# RUN XYZ ANALYSIS – BASED ON DEMAND PREDICTABILITY

Use demand data over 12–18 months



**Coefficient of Variation = (Standard Deviation ( $\sigma$ ) / Mean ( $\mu$ )) X 100**

## Step 3

# COMBINE ABC WITH XYZ TO FORM 9 INVENTORY BUCKETS

X (Predictable)   Y (Variable)   Z (Erratic)

A

AX

AY

AZ

B

BX

BY

BZ

C

CX

CY

CZ

## Step 4

# USE THE OUTPUT TO MAKE SMARTER INVENTORY DECISIONS

**AX / BX**

Frequent review, tight controls, lean inventory

**AZ / CZ**

Keep minimal stock or make-to-order

**AY / BY**

Forecast cautiously, build buffers

**CY / CZ**

Consider phasing out, review periodically

## Step 5

# SEGMENT CUSTOMERS BASED ON STRATEGIC IMPORTANCE AND PROFITABILITY

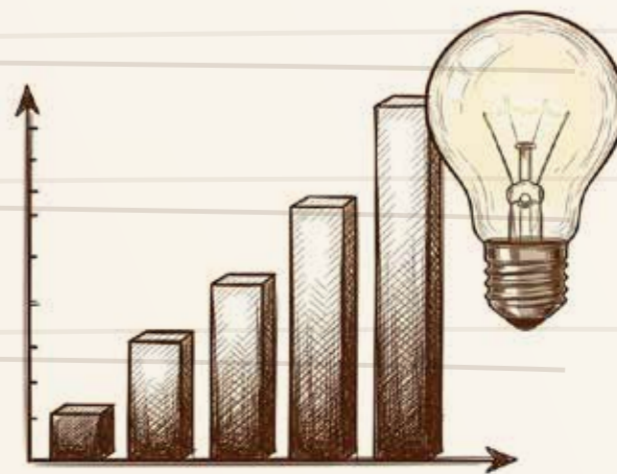
Use metrics like:

**REVENUE  
CONTRIBUTION**



**GROSS MARGIN**

**STRATEGIC VALUE**



## Step 6

# CROSS-REFERENCE INVENTORY BUCKETS WITH CUSTOMER SEGMENTS

✓ Avoid blunt phase-out decisions

✓ Consider strategic priorities,  
service levels



## Step 7

# REFRESH THE SEGMENTATION ON A REGULAR CADENCE



Run ABC-XYZ analysis twice a year or quarterly



Use it for better decision making



# Chapter 13

## MRP, MRP II and ERP

# Material Requirements Planning (MRP)

## Video & Discussion:

- 1) What is MRP System? What are its functions?
- 2) Process of MRP?
- 3) MRP output reports? Advantages of MRP?
- 4) Key Inputs & Outputs of MRP system?
- 5) Key differences between MRP, MRP II & ERP systems?

[What is the Material Requirement planning \(MRP\)? | MRP Process - YouTube](#)

[Materials Requirement Planning | MRP | Inputs & Outputs of MRP | Manufacturing resource planning - YouTube](#)

[MRP vs MRP II vs ERP - A Comparison of Planning Systems - YouTube](#)

## • Group Discussion 1: [30-points]

[Why Food Manufacturing is Hard and How MRP System Helps? - YouTube](#)

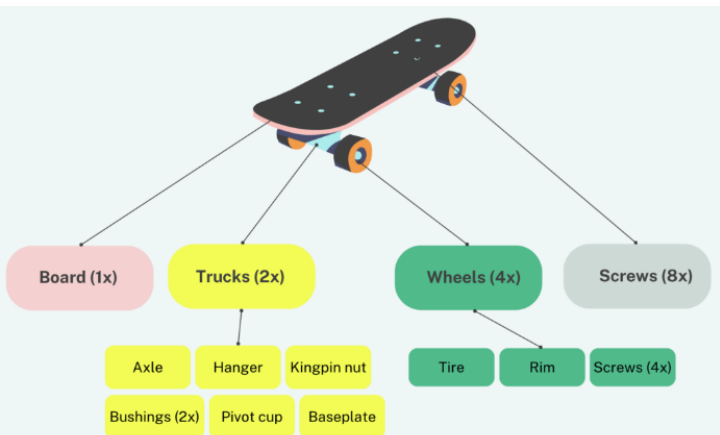
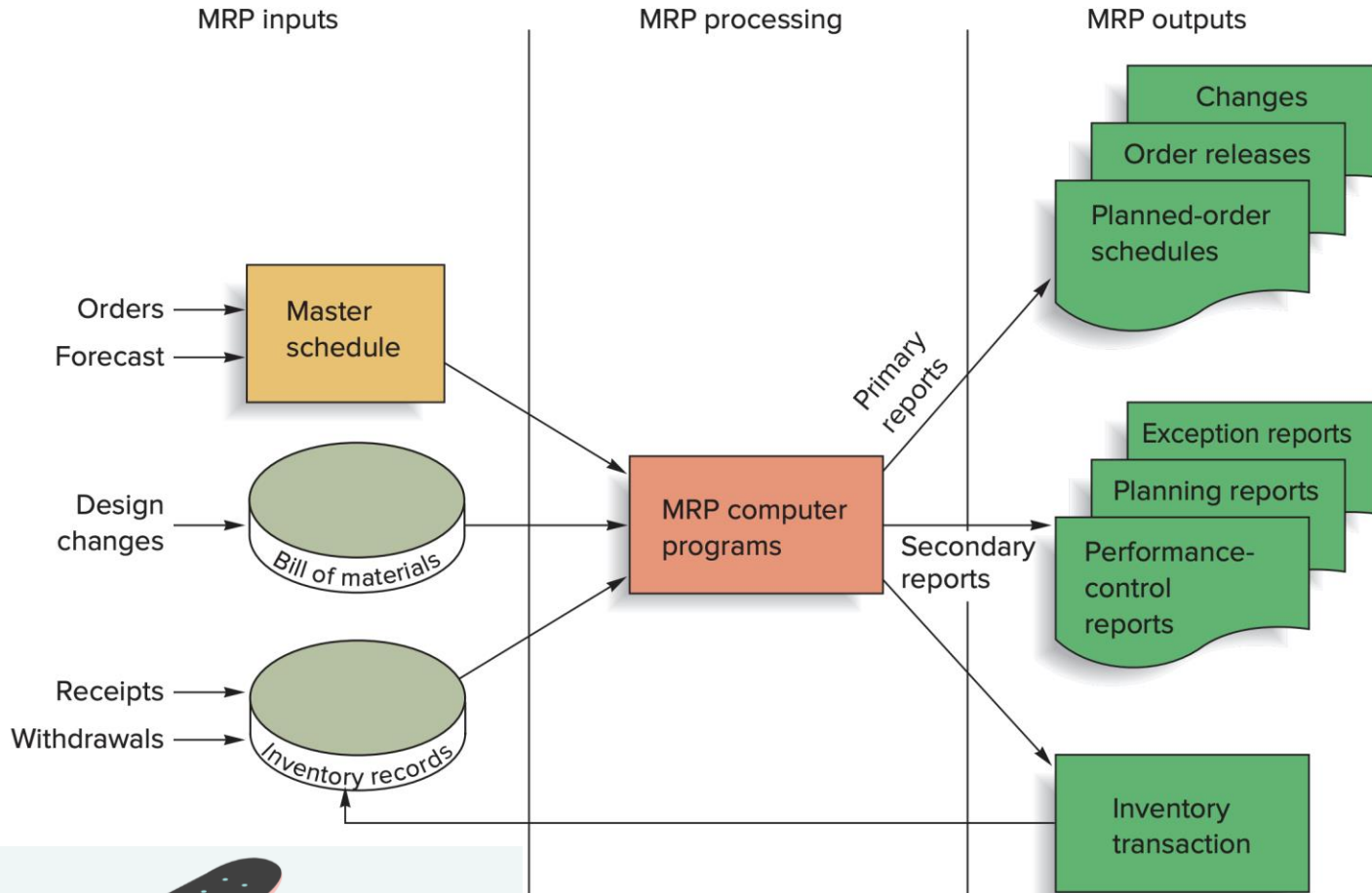
[Inputs and Outputs in MRP System. - YouTube](#)

[Case Study: Skin Actives Scientific and MRPeasy - YouTube](#)

# MRP

- **Material Requirements Planning (MRP):**
  - A computer-based information system that translates master schedule requirements for end items into time-phased requirements for subassemblies, components, and raw materials
  - The MRP is designed to answer three questions:
    1. What is needed?
    2. How much is needed?
    3. When is it needed?

# Overview of MRP



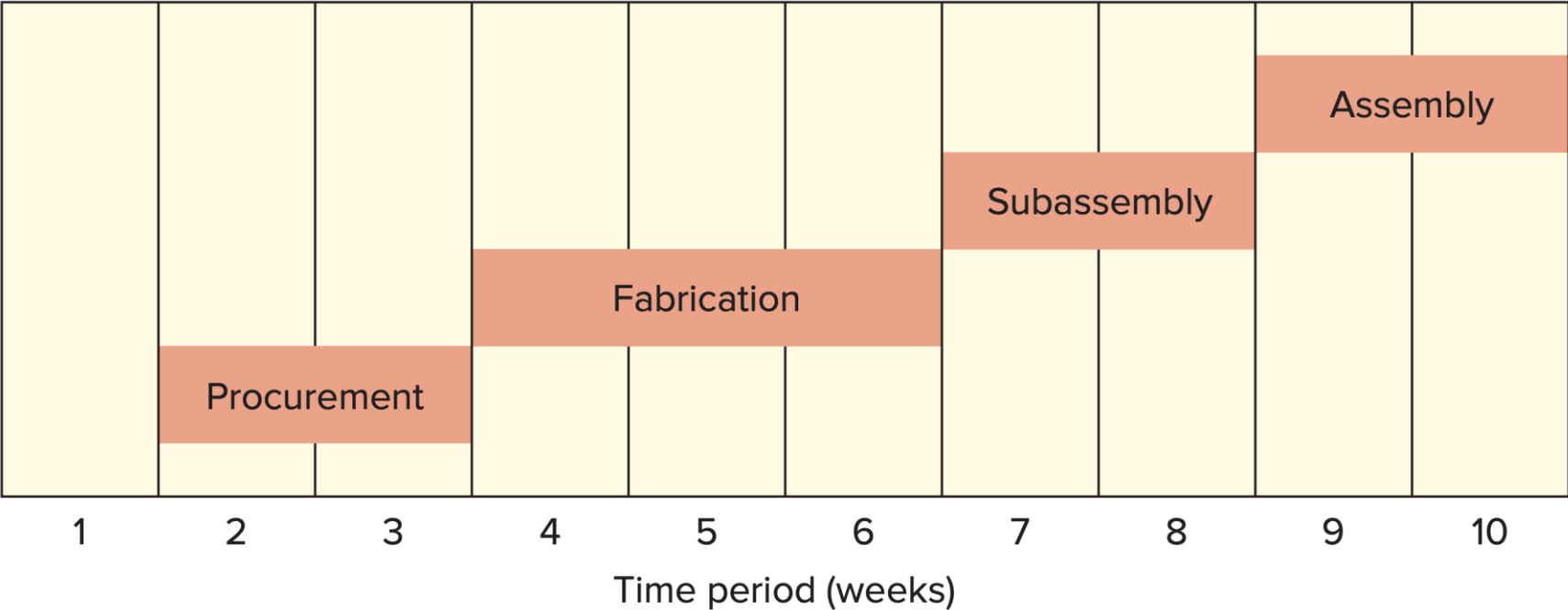
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# MRP Inputs: Master Schedule

[\(2\) Master Production Schedule Operations Management - A Review of the Production Planning Process - YouTube](#)

- **Master schedule:**
  - One of three primary inputs in MRP; states which end items are to be produced, when these are needed, and in what quantities
  - Managers like to plan far enough into the future so they have reasonable estimates of upcoming demands
  - The master schedule should cover a period that is at least equivalent to the cumulative lead time
    - **Cumulative lead time**
      - The sum of the lead times that sequential phases of a process require, from ordering of parts or raw materials to completion of the final assembly

# Cumulative Lead Time

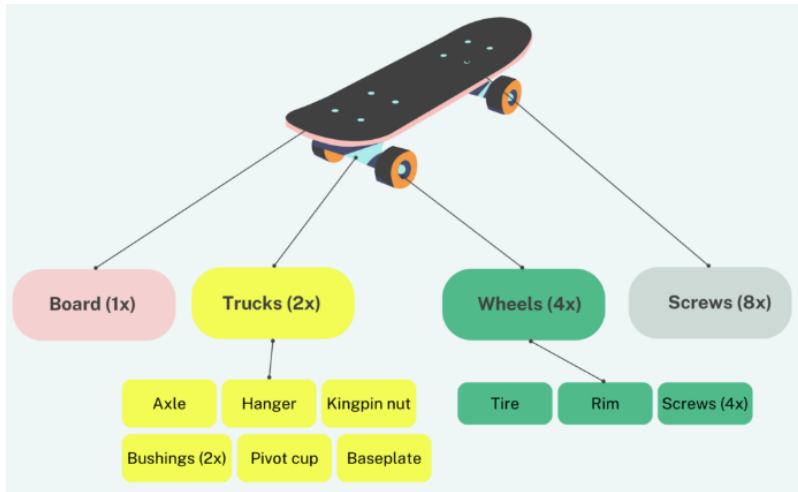


# MRP Inputs: Bill of Materials

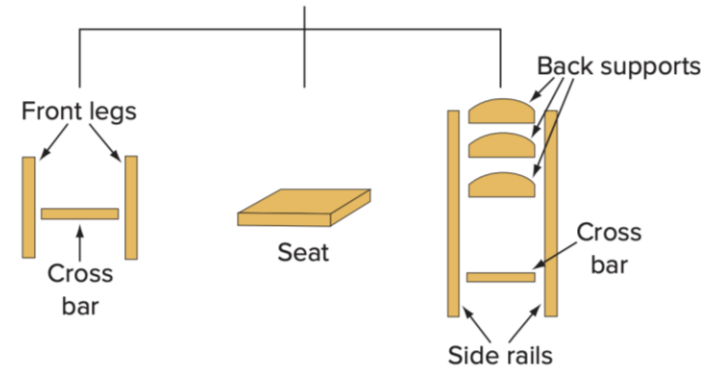
[What is a Bill of Materials \(BOM\)? Why is it Important? - YouTube](#)

- **Bill of Materials (BOM)**
  - A listing of all of the assemblies, subassemblies, parts, and raw materials needed to produce one unit of a product
  - **Product structure tree**
    - A visual depiction of the requirements in a bill of materials, where all components are listed by levels

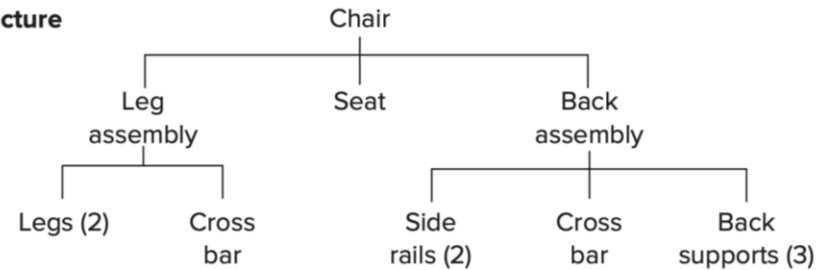
# Assembly Diagram and Product Structure Tree



**Assembly diagram**

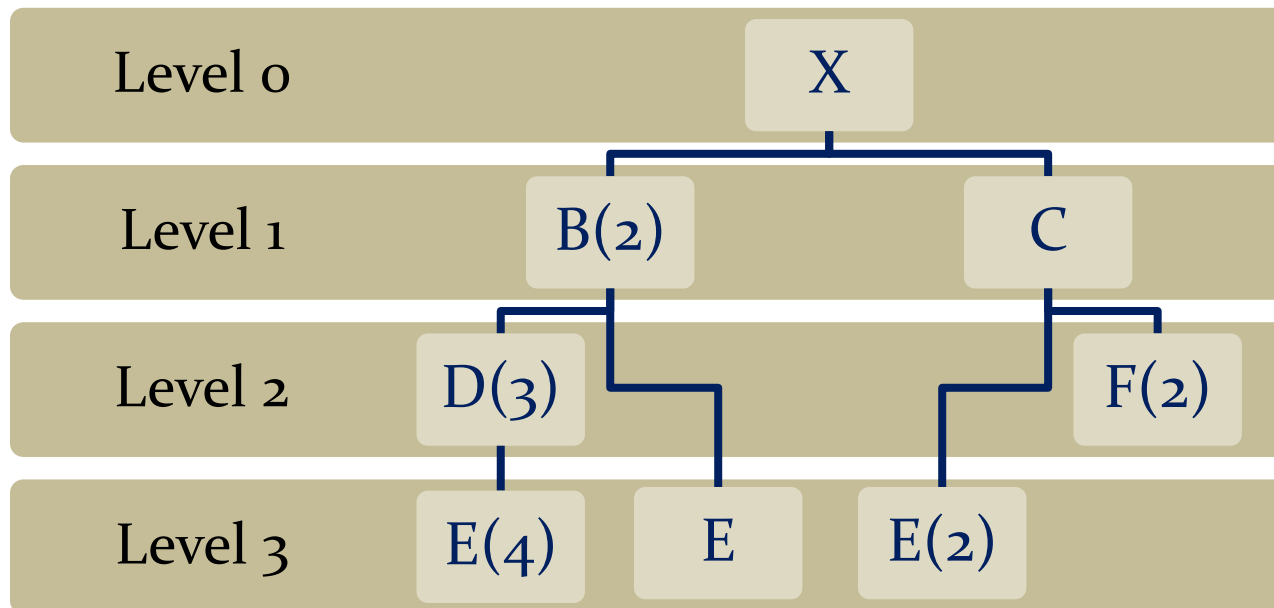


**Product structure tree**



# Low-Level Coding

- **Low-level coding**
  - Restructuring the bill of materials so that multiple occurrences of a component all coincide with the lowest level at which the component occurs

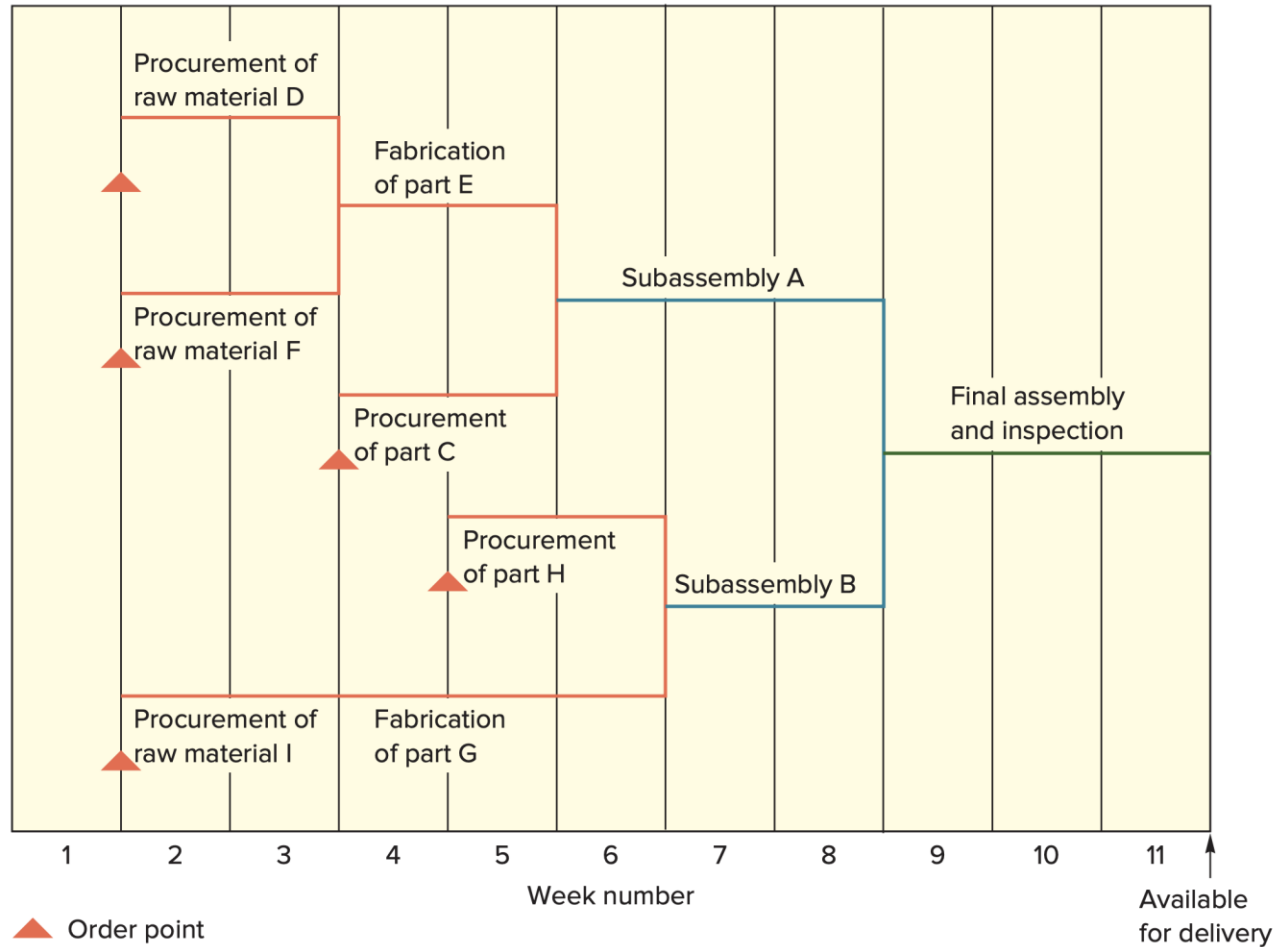


# MRP Inputs: Inventory Records

- **Inventory records**

- Includes information on the status of each item by time period, called *time buckets*
  - Information about
    - Gross requirements
    - Scheduled receipts
    - Expected amount on hand
  - Other details for each item such as
    - Supplier
    - Lead time
    - Lot size policy
    - Changes due to stock receipts and withdrawals
    - Canceled orders and similar events

# Assembly Time Chart



# MRP Outputs: Primary

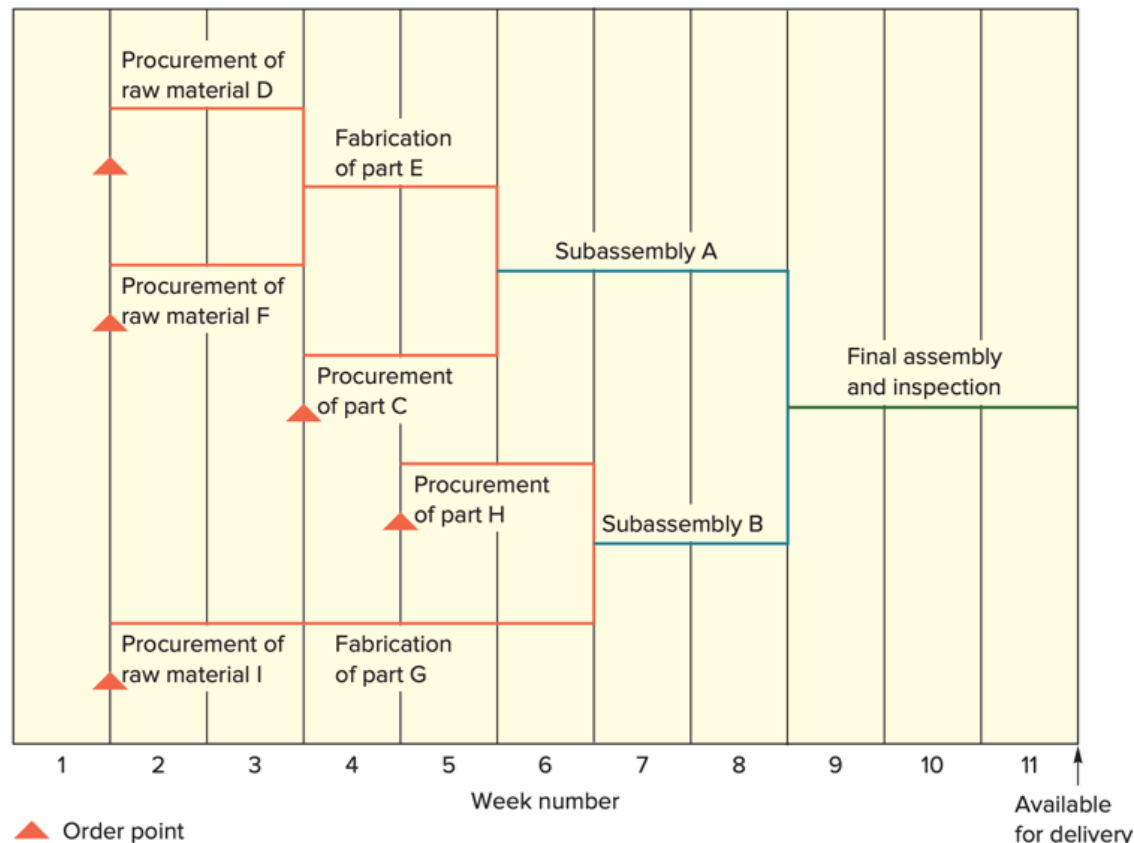
- **Primary Outputs**
  - **Planned orders**
    - A schedule indicating the amount and timing of future orders
  - **Order releases**
    - Authorizing the execution of planned orders
  - **Changes**
    - Revisions of the dates or quantities, or the cancellation of orders

# MRP Outputs: Secondary

- **Secondary Outputs**
  - **Performance-control reports**
    - Evaluation of system operation, including deviations from plans and cost information
      - e.g., missed deliveries and stockouts
  - **Planning reports**
    - Data useful for assessing future material requirements
      - e.g., purchase commitments
  - **Exception reports**
    - Data on any major discrepancies encountered
      - e.g., late and overdue orders, excessive scrap rates, requirements for nonexistent parts

# MRP Processing

- MRP processing takes the end item requirements specified by the master schedule and “explodes” them into *time-phased* requirements for assemblies, parts, and raw materials offset by lead times



# MRP Record

Week Number	1	2	3	4	5	6
Gross Requirements						
Scheduled Receipts						
Projected on hand						
Net requirements						
Planned-order-receipt						
Planned-order release						

## Gross requirements

- Total expected demand

## Scheduled receipts

- Open orders scheduled to arrive

## Projected Available

- Expected inventory on hand at the beginning of each time period

# MRP Record (cont.)

Week Number	1	2	3	4	5	6
Gross Requirements						
Scheduled Receipts						
Projected on hand						
Net requirements						
Planned-order-receipt						
Planned-order release						

## Net requirements

- Actual amount needed in each time period

## Planned-order receipts

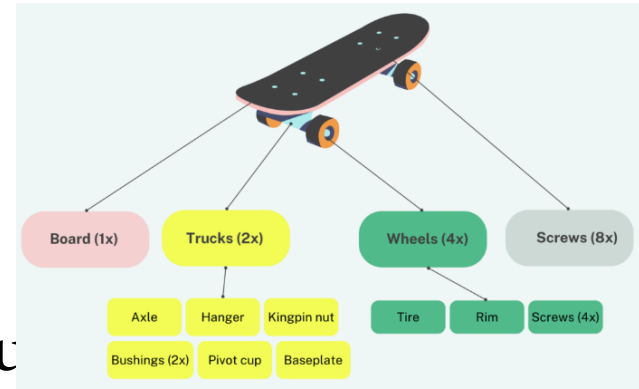
- Quantity expected to received at the beginning of the period offset by lead time

## Planned-order releases

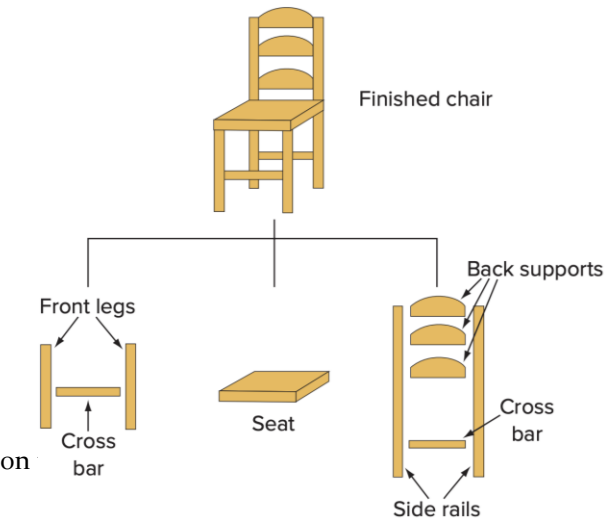
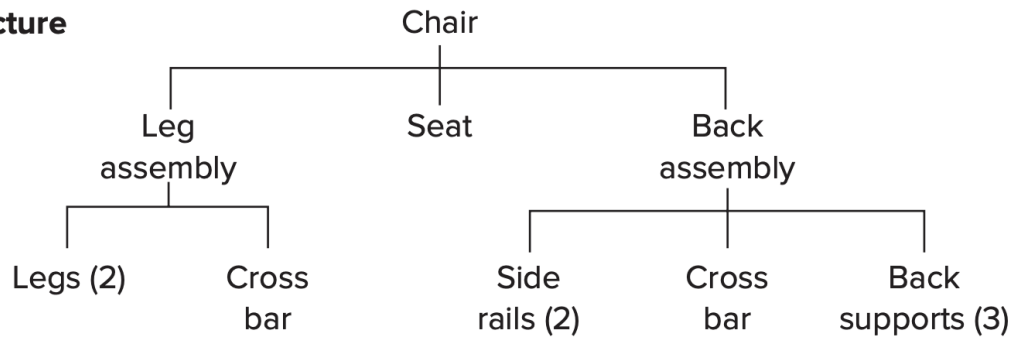
- Planned amount to order in each time period

# MRP: Development

- The MRP is based on the product structure (from BOM)
- Requirements are determined level by level, beginning with the end item and working down the tree
  - The timing and quantity of each “parent” becomes the basis for determining the timing and quantity of the “children” items directly below it
  - The “children” items then become the “parent” items for the next level, and so on



Product structure tree



# Example MRP

Master schedule  
for shutters:

Week number	Beg. Inv.	1	2	3	4	5	6	7	8
Quantity					100				150

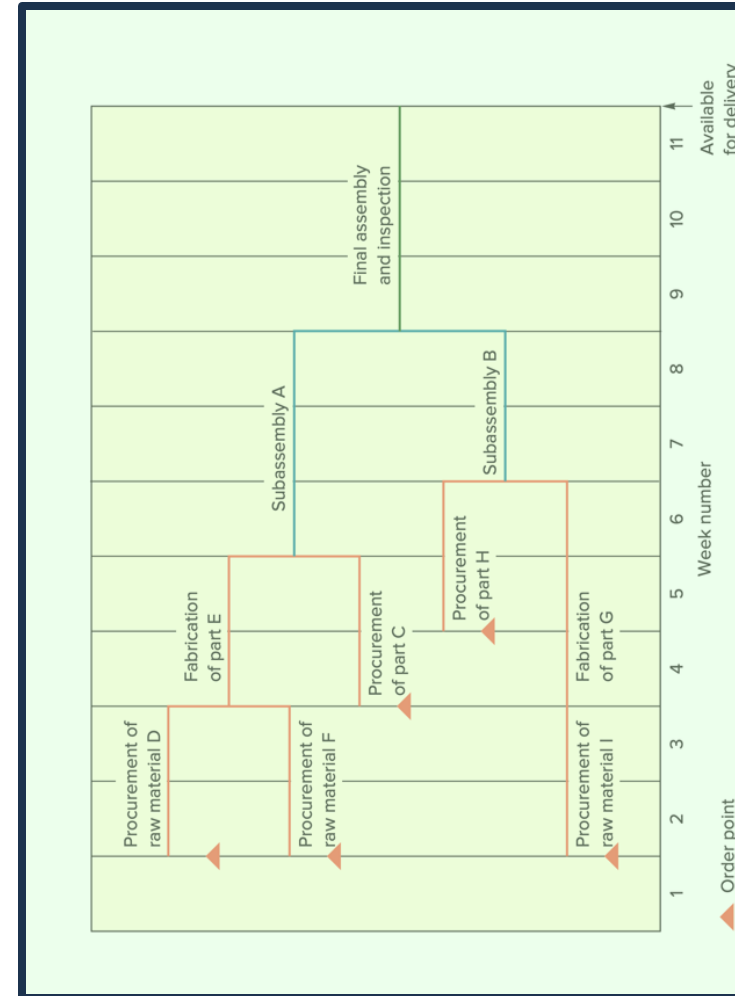
Shutters: LT = 1 week	Gross requirements				100				150
	Scheduled receipts								
	Projected on hand								
	Net requirements				100				150
	Planned-order receipts				100				150
	Planned-order releases			100				150	

times 2                      times 2

Frames: LT = 2 weeks	Gross requirements			200				300
	Scheduled receipts							
	Projected on hand							
	Net requirements			200				300
	Planned-order receipts			200				300
	Planned-order releases		200				300	

times 4                      times 4

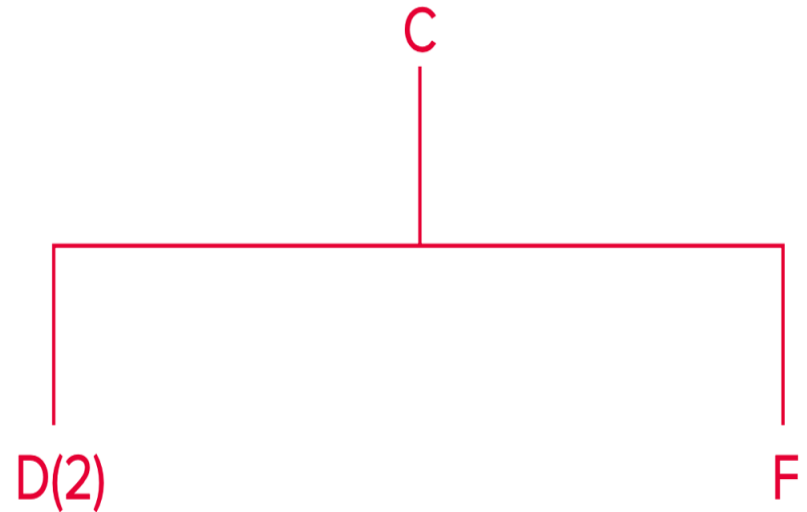
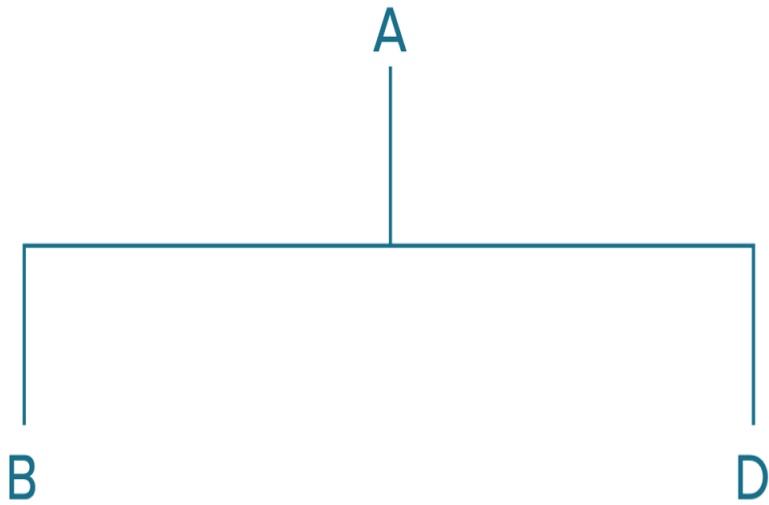
Wood sections: LT = 1 week	Gross requirements			400				600	
	Scheduled receipts		70						
	Projected on hand		70	70	70				
	Net requirements				330				600
	Planned-order receipts				330				600
	Planned-order releases			330				600	



# Using the MRP

- **Pegging**

- The process of identifying the parent items that have generated a given set of material requirements for an item.
- Dependent Demand in SCM



# Updating the System

- **An MRP is not a static document**
  - As time passes
    - Some orders get completed
    - Other orders are nearing completion
    - New orders will have been entered
    - Existing orders will have been altered
      - Quantity changes
      - Delays
      - Missed deliveries

# Updating the System (cont.)

- **Two basic systems**

- **Regenerative system**

- Approach that updates MRP records **periodically**

- Essentially a batch system that compiles all changes that occur within the time interval and periodically updates the system
      - A revised production plan is developed in the same way the original plan was developed

- **Net-change system**

- Approach that updates MRP records **continuously**

- The production plan is modified to reflect changes as they occur
      - Only the changes are exploded through the system

# Other MRP Considerations: Safety Stock

- **Safety Stock**

- Theoretically, MRP systems should not require safety stock
- Variability may necessitate the strategic use of safety stock
  - A bottleneck process or one with varying scrap rates may cause shortages in downstream operations
  - Shortages may occur if orders are late or fabrication or assembly times are longer than expected
  - When lead times are variable, the concept of *safety time* is often used
    - **Safety time**
      - Scheduling orders for arrival or completion sufficiently ahead of their need so that the probability of shortage is eliminated or significantly reduced

# Other MRP Considerations: Lot Sizing Rules

- **Lot-for-Lot (L4L) ordering**
  - The order or run size is set equal to the demand for that period
  - Minimizes investment in inventory
  - Results in variable order quantities
  - A new setup is required for each run
- **Economic Order Quantity (EOQ)**
  - Can lead to minimum costs if usage of item is fairly uniform
    - This may be the case for some lower-level items that are common to different 'parents'
    - Less appropriate for 'lumpy demand' items because inventory remnants often result
- **Fixed Period Ordering**
  - Provides coverage for some predetermined number of periods

# MRP in Service

- **Material goods that form a part of product - service**
  - Food catering service
    - Estimating quantities of ingredients
    - Estimating delivery times

# MRP Benefits

- **Enables managers to easily**
  - Determine the quantities of each component for a given order size
  - Know when to release orders for each component
  - Be alerted when items need attention
- **Additional benefits**
  - Low levels of in-process inventories
  - The ability to track material requirements
  - The ability to evaluate capacity requirements
  - A means of allocating production time
  - The ability to easily determine inventory usage via *backflushing*
    - Exploding an end item's BOM to determine the quantities of the components that were used to make the item

# MRP Requirements

- **To implement an effective MRP system requires:**
  - A computer and the necessary software to handle computations and maintain records
  - Accurate and up-to-date
    - Master schedules
    - Bills of materials
    - Inventory records
  - Integrity of data files

# MRP Difficulties

- **Consequence of inaccurate data**
  - Missing parts
  - Ordering incorrect numbers of items
  - Inability to stay on schedule
- **Other problems**
  - Assumptions of constant lead times
  - Products being produced differently from the BOM
  - Failure to alter a BOM when customizing a product
  - Inaccurate forecasts

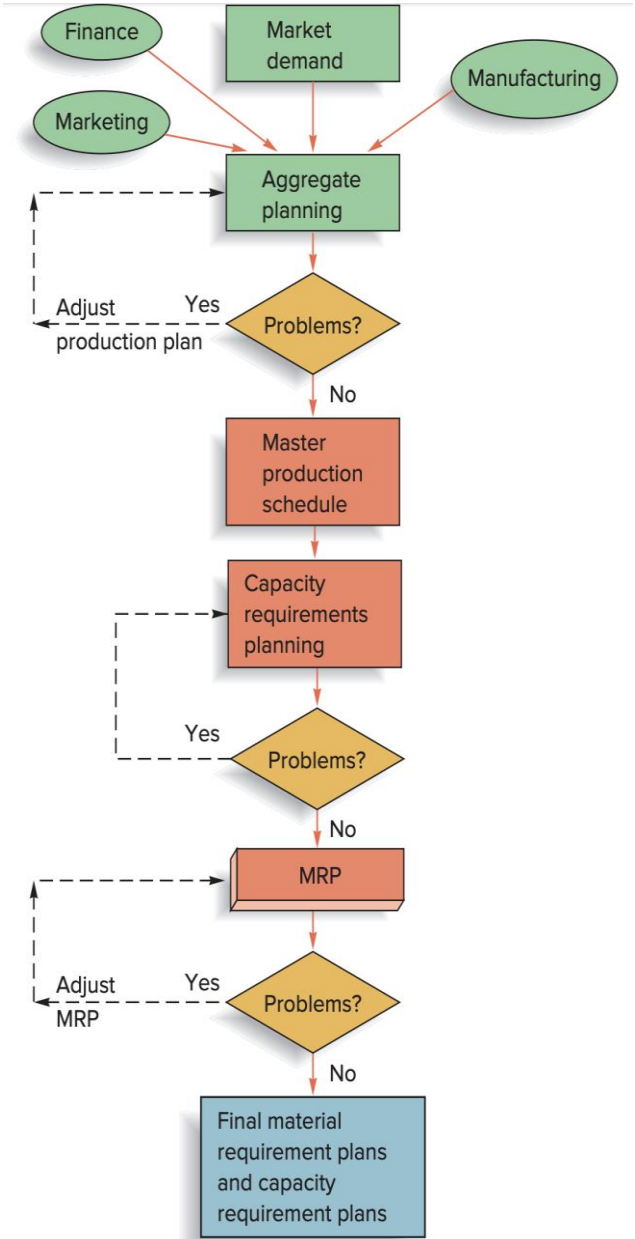
# MRP II

[Manufacturing Resource Planning | MRP II - YouTube](#)

[MRP I vs MRP II: What's the Difference? - YouTube](#)

- **Manufacturing Resources Planning (MRP II)**
  - Expanded approach to production resource planning, involving other areas of the firm in the planning process and enabling capacity requirements planning
    - Most MRP II systems have the capability of performing simulations to answer a variety of “what if” questions so they can gain a better appreciation of available options and their consequences

# MRP II: Overview



# Closed Loop MRP

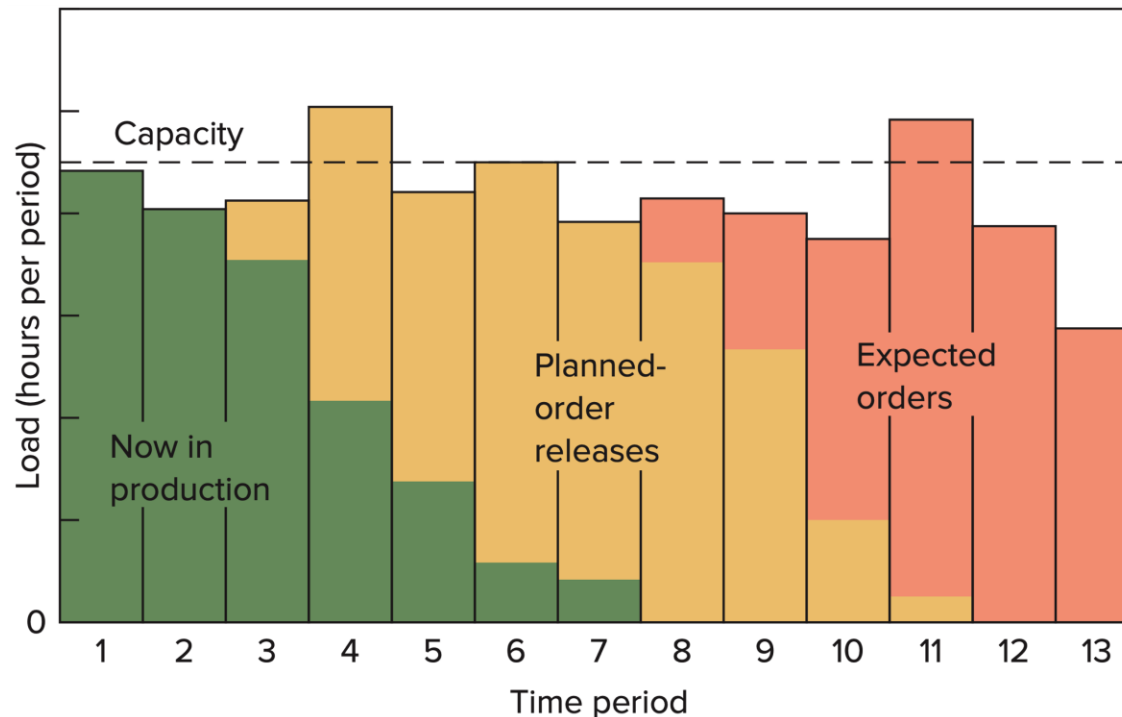
- When MRP II systems began to include feedback loops, they were referred to as Closed Loop MRP
- Closed Loop MRP
  - Systems evaluate a proposed material plan relative to available capacity
  - If a proposed plan is not feasible, it must be revised
    - This evaluation is referred to as capacity requirements planning

# Capacity Requirements Planning

- **Capacity requirements planning (CRP)**
  - The process of determining short-range capacity requirements.
  - Inputs to capacity requirement planning
    - Planned-order releases for the MRP
    - Current shop loading
    - Routing information
    - Job time
  - Key outputs
    - Load reports for each work center

# Load Reports

- Load reports
  - Department or work center reports that compare known and expected future capacity requirements with projected capacity availability



# Enterprise Resource Planning (ERP)

## Video & Discussion:

- 1) What is ERP System?
- 2) Name the 6 functional modules of ERP system (from video)?
- 3) How does ERP system works?
- 4) Advantages & disadvantages?
- 5) Benefits of ERP to Accounting, Finance & Planning/Scheduling Dept.?

[What is ERP? | System ERP | SAP for beginners - YouTube](#)

[What is Enterprise Resource Planning \(ERP\)? - YouTube](#)

[Integrating ERP with Accounting and Financial Management Software - YouTube](#)

## • Group Discussion 1: [10-points]

[What is Financial reporting? | Definition, Types, Benefits of Financial reporting - YouTube](#)

[Integrated Planning - Optimization for the entire internal supply chain - YouTube](#)

[\(2\) Conversational ERP – Lesson 1 – What is ERP \(15m\) - YouTube](#)

# Enterprise Resource Planning

- **Enterprise Resource Planning (ERP)**
  - ERP was the next step in an evolution that began with MRP and evolved into MRPII
  - ERP, like MRP II, typically has an MRP core
  - ERP provides a system to capture and make data available in real time to decision makers and other users throughout an organization
  - ERP systems are composed of a collection of integrated modules

# Overview of ERP Software Modules

Module	Brief Description
Accounting/Finance	A central component of most ERP systems. It provides a range of financial reports, including general ledger, accounts payable, accounts receivable, payroll, income statements, and balance sheets
Marketing	Supports lead generation, target marketing, direct mail, and sales
Human Resources	Maintains a complete data base of employee information such as date of hire, salary, contact information, performance evaluations, and other pertinent information
Purchasing	Facilitates vendor selection, price negotiation, making purchasing decisions, and bill payment
Production Planning	Integrates information on forecasts, orders, production capacity, on-hand inventory quantities, bills of material, work in process, schedules, and production lead times
Inventory Management	Identifies inventory requirements, inventory availability, replenishment rules, and inventory tracking
Distribution	Contains information on third-party shippers, shipping and delivery schedules, delivery tracking
Sales	Information on orders, invoices, order tracking, and shipping
Supply Chain Management	Facilitates supplier and customer management, supply chain visibility, and event management

# ERP Project Organization (Implementation)

- ***The 'big bang'***
  - Companies cast off all of their legacy systems at once and implement a single ERP system across the entire company
  - The most ambitious and difficult implementation approach
- ***Franchising strategy***
  - Independent ERP systems are installed in each business unit of the enterprise while linking common processes across the enterprise
  - Suits large or diverse companies that do not share many common processes across business units
- ***Slam dunk***
  - ERP dictates the process design where the focus is on a few key processes
  - More appropriate for smaller companies expecting to grow into ERP

# ERP Considerations

- How can ERP improve a company's business performance?
- How long will an ERP implementation project take?
- How will ERP affect current business processes?
- What is the ERP total cost of ownership?
- What are the hidden costs of ERP ownership?

# Chapter 14

## JIT, Lean Operations & Six Sigma

# Lean Management / Operations

**Video & Discussion:** [\(4\) Taiichi Ohno on the Toyota Production System - YouTube](#)

- 1) What is TPS & Lean Manufacturing System?
- 2) Explain 3-simple ideas & 5-basic Lean Principles?
- 3) Video 2: Name and explain the 6-Basic LM Tools?
- 4) What are the 5-main steps of the Lean Manager? Explain 2?
- 5) Explain next 3?

[Introduction to Lean Management \(Definition, Lean Principles & Benefits\) - YouTube](#)

[\(4\) ♻️ Lean Manufacturing | A pursuit of perfection - YouTube](#)

[The 5 Main Steps Of The Lean Manager - YouTube](#)

## • **Group Discussion 1: [15-points]**

[TEDxKnoxville - Bill Peterson - Lean Applied to Us - YouTube](#)

[An Introduction to Lean Thinking - YouTube](#)

[Introduction to Lean Manufacturing - YouTube](#)

[Steve Jobs on Continuous Process Improvement - YouTube](#)

[Jeff Bezos on fixing the root cause than symptom LEAN SIX SIGMA - YouTube](#)

# Lean Operations

- **Lean operation**

- A flexible system of operation that uses considerably less resources than a traditional system
  - Tend to achieve
    - Greater productivity
    - Lower costs
    - Shorter cycle times
    - Higher quality

- **Just-in-Time**

- A highly coordinated processing system in which goods move through the system, and services are performed, just as they are needed

# Lean System Characteristics

- **A number of characteristics are commonly found in lean systems:**
  - Waste reduction
  - Continuous improvement
  - Use of teams
  - Work cells
  - Visual controls
  - High quality
  - Minimal inventory
  - Output only to match demand
  - Quick changeovers
  - Small lot sizes
  - Lean culture

# Lean System Principles

- **Five principles embody the way lean systems function:**
  1. Identify customer values
  2. Focus on processes that create value
  3. Eliminate waste to create “flow”
  4. Produce only according to customer demand
  5. Strive for perfection

# Benefits & Risks of Lean Systems

- **Key benefits**

- Reduced waste
- Lower costs
- Increased quality
- Reduced cycle time
- Increased flexibility
- Increased productivity

- **Critical risks**

- Increased stress on workers
- Fewer resources available if problems occur
- Supply chain disruptions can halt operations

# Lean Operations: The Beginning

- Lean operations began as lean manufacturing, also known as JIT, in the mid-1900s
- Developed by Taiichi Ohno and Shigeo Ohno of Toyota
  - Focus was on eliminating all waste from every aspect of the process
    - Waste is viewed as anything that interferes with, or does not add value to, the process of producing automobiles
  - Many terms used by Toyota, such as Kanban, Kaizen, and Muda, are commonly used industry wide.

[The History of Lean & the TPS \(Toyota Production System\) \(youtube.com\)](#)

[Lean Manufacturing : History of Manufacturing - YouTube](#)

# Lean: Ultimate Goal

- **The ultimate goal:**
  - Achieve a balanced system–
    - One that achieves a smooth, rapid flow of materials and/or work through the system

## Lean: Supporting Goals

- The degree to which lean's ultimate goal is achieved depends upon how well its supporting goals are achieved:
  1. Eliminate disruptions
  2. Make the system flexible
  3. Eliminate waste, especially excess inventory

# Waste

[The 8 Wastes of Lean : TIMWOODS | Rowtons Training by Laurence Gartside - YouTube](#)

- **Waste**

- Represents unproductive resources
- *Eight sources of waste in lean systems:*
  1. Excess inventory
  2. Overproduction
  3. Waiting time
  4. Unnecessary transporting
  5. Processing waste
  6. Inefficient work methods
  7. Product defects
  8. Underused people

# *Kaizen*

[KAIZEN | A Japanese Philosophy for Continuous Improvement \(PDCA Cycle\) - YouTube](#)

[Kaizen The Secret behind Japanese Productivity - YouTube](#)

- **The kaizen philosophy for attacking waste is based upon these ideas:**
  1. Waste is the enemy, and to eliminate waste it is necessary to get the hands dirty
  2. Improvement should be done gradually and continuously; the goal is not big improvements done intermittently
  3. Everyone should be involved
  4. *Kaizen* is built on a cheap strategy, and it does not require spending great sums on technology or consultants
  5. It can be applied everywhere
  6. It is supported by a visual system
  7. It focuses attention where value is created
  8. It is process oriented
  9. It stresses that the main effort for improvement should come from new thinking and a new work style
  10. The essence of organizational learning is to learn while doing

# Lean: Building Blocks

- Product design
- Process design
- Personnel/organizational elements
- Manufacturing planning and control

## Building Blocks: Product Design

- Four elements of product design important for lean systems:
  1. Standard parts
  2. Modular design
  3. Highly capable systems with quality built in
  4. Concurrent engineering

# Building Blocks: Process Design

- **Eight aspects of process design that are important for lean systems:**
  1. Small lot sizes
  2. Setup time reduction
  3. Manufacturing cells
  4. Quality improvement
  5. Production flexibility
  6. A balanced system
  7. Little inventory storage
  8. Fail-safe methods

# Just in Time (JIT) Operations

## Video & Discussion:

- 1) Explain Just-In-Time System?
- 2) Explain Compare Just-In-Time vs. Just-In-Case System?
- 3) What is Kanban System?
- 4) Principle of Kanban System?
- 5) Benefits of Kanban System?

[\(4\) Just in Time by Toyota: The Smartest Production System in The World - YouTube](#)

[What is Kanban? | Principles & Benefits of Kanban. - YouTube](#)

[Just-in-time and Kanban - YouTube](#)

[Introduction to Kanban in JIT - YouTube](#)

## • **Group Discussion 1: [15-points]**

[Two Bin Supply System at St Clair Hospital - YouTube](#)

[2 Bin Training Video - YouTube](#)

[Just in time or JIT | Advantages & Disadvantages of Just-in-time. - YouTube](#)

[Lean kanban Point of Use Example - YouTube](#)

# Process Design: Small Lot Sizes

- In the lean philosophy, the *ideal* lot size is one
- **Benefits of small lot size**
  - Reduced in-process inventory
    - Lower carrying costs
    - Less storage space is necessary
  - Inspection and rework costs are less when problems with quality do occur
  - Permits greater flexibility in scheduling
  - Less inventory to ‘work off’ before implementing product improvements
  - Increased visibility of problems
  - Increased ease of balancing operations

# Process Design: Setup Time Reduction

- **Small lot sizes and changing product mixes require frequent setups**
- **Unless these are quick and relatively inexpensive, they can be prohibitive**
- **Setup time reduction requires deliberate improvement efforts**
  - **Single-minute exchange of die (SMED)**
    - **A system for reducing changeover time**
  - **Group technology may be used to reduce setup time by capitalizing on similarities in recurring operations**

# Process Design: Manufacturing Cells

- **One characteristic of lean production systems is multiple manufacturing cells**
- **Benefits include**
  - Reduced changeover times
  - High equipment utilization
  - Ease of cross-training workers

# Process Design: Quality Improvement

- **Quality defects during the process can disrupt the orderly flow of work**
- **Autonomation (*jidoka*)**
  - **Automatic detection of defects during production**
    - **Two mechanisms are employed**
      1. One for detecting defects when they occur
      2. Another for stopping production to correct the cause of the defects

# Process Design: Work Flexibility

- **Guidelines for increasing flexibility**

1. Reduce downtime due to changeovers by reducing changeover time
2. Use preventive maintenance on key equipment to reduce breakdowns and downtime
3. Cross-train workers so they can help when bottlenecks occur or other workers are absent
4. Use many small units of capacity; many small cells make it easier to shift capacity temporarily and to add or subtract capacity
5. Use off-line buffers. Store infrequently used safety stock away from the production area
6. Reserve capacity for important customers

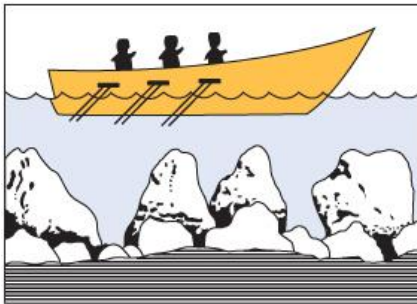
# Process Design: Balanced System

- ***Takt* time**

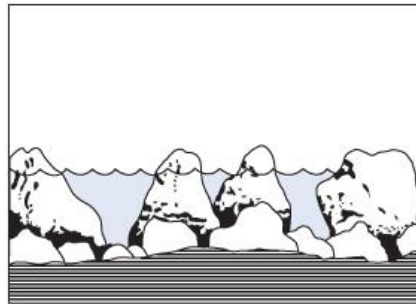
- The cycle time needed to match customer demand for final product
- Sometimes referred to as the heartbeat of a lean system
  - *Takt* time is often set for a work shift
  - Procedure:
    1. Determine the net time available per shift
    2. If there is more than one shift per day, multiply the net time by the number of shifts
    3. Compute the *takt* time by dividing the net available time by demand

# Process Design: Inventory Storage

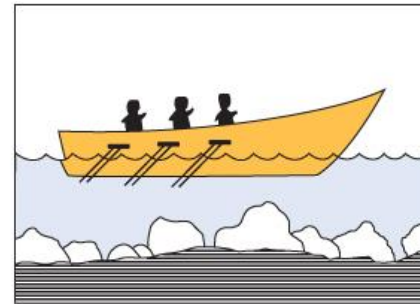
- **Lean systems are designed to minimize inventory storage**
  - Inventories are buffers that tend to cover up recurring problems that are never resolved
    - *Partly because they are not obvious*
    - *Partly because the presence of inventory makes them seem less serious*



A



B



C

# Process Design: Fail-Safe Methods

- ***Poka-yoke* (Fail-safing)**
  - Building safeguards into a process to reduce or eliminate the potential for errors during a process
    - Examples:
      - Electric breakers
      - Seatbelt fastener warnings
      - ATMs that signal if a card is left in a machine
      - Designing parts that can only be assembled in the correct position
      - Electrical fuses and circuit breakers that interrupt electrical supply if a circuit is overloaded
      - Detectors at department stores that signal if a monitoring tag hasn't been removed from an item

# Building Blocks: Personnel/Organizational

- **Five personnel/organizational elements that are important for lean systems:**
  1. Workers as assets
  2. Cross-trained workers
  3. Continuous improvement
  4. Cost accounting
  5. Leadership/project management

# Personnel/Organizational: Workers as Assets

- **Workers as assets**
  - Well-trained and motivated workers are the heart of the lean system
    - They are given greater authority to make decisions, but more is expected of them

# Personnel/Organizational: Cross-Trained Workers

- **Cross-trained workers**
  - Workers are trained to perform several parts of a process and operate a variety of machines
    - Facilitates flexibility
    - Helps in line balancing

# Personnel/Organizational: Continuous Improvement

- **Continuous improvement**
  - Workers in lean systems have greater responsibility for quality, and they are expected to be involved in problem solving and continuous improvement
  - Lean workers receive training in
    - Statistical process control
    - Quality improvement
    - Problem solving

# Personnel/Organizational: Cost Accounting

- **Cost accounting**
  - **Activity-based costing**
    - Allocation of overhead to specific jobs based on their percentage of activities

# Personnel/Organizational: Leadership

- **Leadership/project management**
  - Managers are expected to be leaders and facilitators, not order givers
  - Lean systems encourage two-way communication between workers and managers

# Building Blocks: MPC

- **Seven elements of Manufacturing Planning and Control (MPC) are particularly important for lean system:**
  1. Level loading
  2. Pull systems
  3. Visual systems
  4. Limited work-in-process (WIP)
  5. Close vendor relationships
  6. Reduced transaction processing
  7. Preventive maintenance and housekeeping

# MPC: Pull Systems

- **Push system**
  - Work is pushed to the next station as it is completed
- **Pull system**
  - A workstation pulls output from the preceding workstation as it is needed
  - Output of the final operation is pulled by customer demand or the master schedule
  - Pull systems are not appropriate for all operations
    - Large variations in volume, product mix, or product design will undermine the system

# MPC: Visual Systems

- *Kanban*
  - Card or other device that communicates demand for work or materials from the preceding station
    - Kanban is the Japanese word meaning “signal” or “visible record”
  - Paperless production control system
  - Authority to pull, or produce, comes from a downstream process
  - Two main types of kanbans:
    1. *Production kanban (p-kanban)*: signals the need to produce parts
    2. *Conveyance kanban (c-kanban)*: signals the need to deliver parts to the next work center

# MPC: Limited WIP

- **Benefits of lower WIP**
  - Lower carrying costs
  - Increased flexibility
  - Aids scheduling
  - Saves costs of scrap and rework if there are design changes
  - Lower cycle-time variability

# MPC: Close Vendor Relationships

- **Lean systems typically have close relationships with vendors**
  - They are expected to provide frequent, small deliveries of high-quality goods
- **A key feature of many lean systems is the relatively small number of suppliers used**

# MPC: Reduced Transaction Processing

- **Lean systems seek to reduce costs associated with the ‘hidden factory’:**
  - Logistical transactions
  - Balancing transactions
  - Quality transactions
  - Change transactions

# Preventive Maintenance and Housekeeping

- **Preventive maintenance**
  - Maintaining equipment in good operating condition and replacing parts that have a tendency to fail before they actually do fail
- **Housekeeping**
  - Maintaining a workplace that is clean and free of unnecessary materials. It involves the following 5 behaviors to make the workplace effective
    1. Sort
    2. Straighten
    3. Sweep
    4. Standardize
    5. Self-discipline

# Lean Tools: Value Stream Mapping

- **Value stream mapping**
  - A visual tool to systematically examine the flows of materials and information
    - Its purpose is to help identify waste and opportunities for improvement
    - Data collected:
      - Times
      - Distances traveled
      - Mistakes
      - Inefficient work methods
      - Waiting times
      - Information flows

# Six Sigma

## Video & Discussion:

- 1) Explain Six Sigma?
- 2) Explain Six Sigma Methodology?
- 3) Explain Lean Six Sigma?
- 4) Explain Lean Six Sigma Methodology?
- 5) Examples of each?

[Six Sigma In 9 Minutes | What Is Six Sigma? | Six Sigma Explained | Six Sigma Training | Simplilearn - YouTube](#)

[Lean Six Sigma In 8 Minutes | What Is Lean Six Sigma? | Lean Six Sigma Explained | Simplilearn - YouTube](#)

[What is Six sigma \(6σ\)? Six sigma methodology - YouTube](#)

## • **Group Discussion 1: [15-points]**

[Six Sigma Overview and Sigma Levels using Golfing Analogy - Green Belt and Black Belt Content - YouTube](#)

[Steve Jobs Talks Lean Six Sigma core principles - YouTube](#)

[Six Sigma Interview with Jack Welch - YouTube](#)

# Lean Tools: 5W2H & Six Sigma

- **5W2H**

- A method of asking questions about a process that includes what, why, where, when, who, how, and how much

- **Lean and Six Sigma**

- Lean and Six Sigma can be viewed as two complementary approaches to process improvement
  - Lean focuses on eliminating non-value-added activity to maximize process velocity
  - Six Sigma seeks to eliminate process variation
  - Together the two approaches can achieve process flow and quality

# Transitioning to Lean Systems

1. Make sure top management is committed and that they know what will be required
2. Decide which parts will need the most effort to convert
3. Obtain support and cooperation of workers
4. Begin by trying to reduce setup times while maintaining the current system
5. Gradually convert operations, begin at the end and work backwards
6. Convert suppliers to JIT
7. Prepare for obstacles

# Obstacles to Conversion

1. Management may not be fully committed or willing to devote the necessary resources to conversion
2. Workers/management may not be cooperative
3. It can be difficult to change the organizational culture to one consistent with the lean philosophy
4. Suppliers may resist

# Chapter 15

## Supply Chain Management (SCM): Supply Chain, Procurement & Logistics

# Supply Chain

## Video & Discussion:

[\(1\) Supply Chain Evolution - YouTube](#)

- 1) What are Supply Chains? [Supply Chain Evolution | Evolution of Supply Chain - YouTube](#)
- 2) Explain the start to end process of Supply Chain?
- 3) What is Supply Chain Management?
- 4) What is Logistics Management? Name any 3 Logistics Goals?

[What are Supply Chains? | Back to Basics - YouTube](#)

[\(1\) Explained Supply Chain Management in 10 Minutes - YouTube](#)



[What is Logistics Management? Meaning, Importance, Basic Functions & Strategies | AIMS UK - YouTube](#)

## • Group Discussion 1: [30-points]

[\(1\) What is Supply Chain Analytics? - YouTube](#)

[\(1\) Lean vs Agile - A Comparison of Agile and Lean Supply Chains - YouTube](#)

[What is Supply chain Management \( SCM \)? | What is Supply chain? - YouTube](#)

[Supply Chain Management In 6 Minutes | What Is Supply Chain Management? | Simplilearn - YouTube](#)

[Logistics Industry Explained? - The Insane Story Behind It - YouTube](#)

# Supply Chain

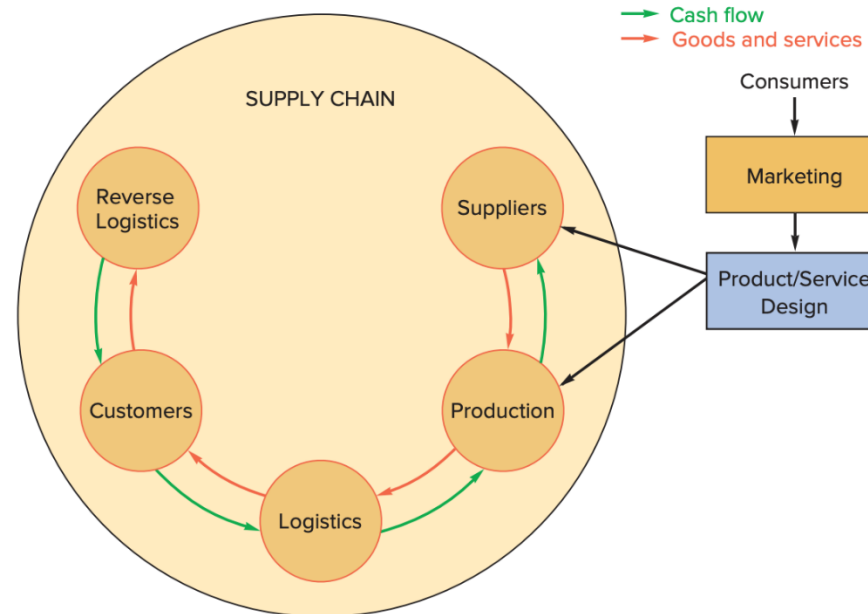
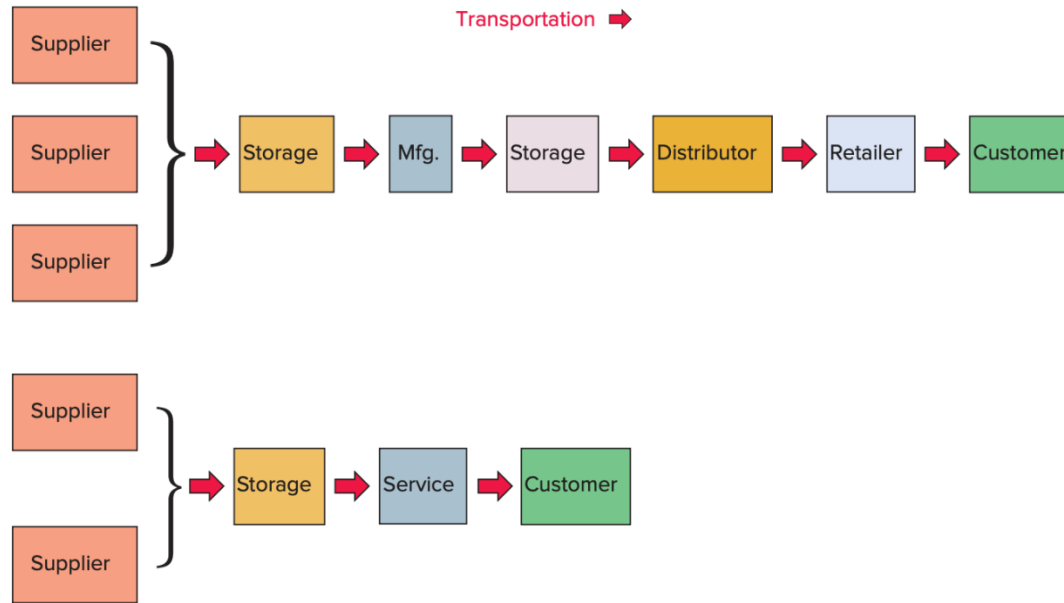
- **Supply chain:**

- The sequence of organizations—their facilities, functions, and activities—that are involved in producing and delivering a product or service. Also referred to as value chains.

- **Logistics:**

- The part of a supply chain involved with the forward and reverse flow of goods, services, cash, and information.

# Typical Supply Chains



# Facilities

- The sequence of the supply chain begins with basic suppliers and extends all the way to the final customer
  - Warehouses
  - Factories
  - Processing centers
  - Distribution centers
  - Retail outlets
  - Offices

# Functions and Activities

- **Supply chain functions and activities**
  - Forecasting
  - Purchasing
  - Inventory management
  - Information management
  - Quality assurance
  - Scheduling
  - Production and delivery
  - Customer service

# Supply Chain Management (SCM)

- The strategic coordination of business functions within a business organization and throughout its supply chain for the purpose of *integrating* supply and demand management

## SCM Managers

[What Makes a Good Supply Chain Manager? - I Think 3 Things - YouTube](#)

- People at various levels of the organization who are responsible for managing supply and demand both within and across business organizations
- Involved with planning and coordinating activities
  - Sourcing and procurement of materials and services
  - Transformation activities
  - Logistics

# Key Aspects of SCM

- The goal of SCM is to match supply to demand as effectively and efficiently as possible
- Key issues:
  1. Determining appropriate levels of outsourcing
  2. Managing procurement
  3. Managing suppliers
  4. Managing customer relationships
  5. Being able to quickly identify problems and respond to them

# Flow Management

- **Three types of flow management**
  - **Product and service flow**
    - Involves movement of goods and services from suppliers to customers as well as handling customer service needs and product returns
  - **Information flow**
    - Involves sharing forecasts and sales data, transmitting orders, tracking shipments, and updating order status
  - **Financial flow**
    - Involves credit terms, payments, and consignment and title ownership arrangements

# Trends in SCM

- **Trends affecting supply chain design and management:**

- Measuring supply chain ROI

- “Greening” the supply chain

- Re-evaluating outsourcing

- Integrating IT

- Adopting lean principles

- Managing risks

[Ambrosus - Protecting Baby Food with Blockchain - YouTube](#)

- Adopting blockchain technology

[Journey of Coffee - Blockchain Supply Chain - Provenance to](#)

- Establishing transparency [Consumption - YouTube](#)

- Adopting new delivery method

# Benefits & Risks of Outsourcing

- **Benefits:**

- Lower prices may result from lower labor costs
- The ability of the organization to focus on its core strengths
- Permits the conversion of some fixed costs to variable costs
- It can free up capital to address other needs
- Some risks can be shifted to the supplier
- The ability to take advantage of a supplier's expertise
- Makes it easier to expand outside of the home country

- **Risks**

- Inflexibility due to longer lead times
- Increased transportation costs
- Language and cultural differences
- Loss of jobs
- Loss of control
- Lower productivity
- Loss of business knowledge
- Knowledge transfer and intellectual property concerns
- Increased effort required to manage the supply chain

# Supply Chain Risks

- **Supply chain risks**

- **Supply chain disruption** [Supply Chain Disruptions: Problems and Solutions - YouTube](#)
  - Natural disasters
  - Supplier problems
- **Quality issues**
  - Another form of disruption that may disrupt supplies and lead to product recalls, liability claims, and negative publicity
- **Loss of control of sensitive information**
  - If suppliers divulge sensitive information to competitors, it can weaken a firm's competitive position

# Risk Management

- **Risk management**

- Involves identifying risks, assessing their likelihood of occurring and their potential impact and then developing strategies for addressing those risks
  - Strategies for addressing risk include:
    - Risk avoidance
    - Risk reduction
    - Risk sharing
- Key elements of successful risk management include:
  - Know your suppliers
  - Provide supply chain visibility
  - Develop event-response capability

# Global Supply Chains

- **Global supply chains**
  - Product design often uses inputs from around the world
  - Some manufacturing and service activities are outsourced to countries where labor and/or materials costs are lower
  - Products are sold globally
- **Complexities**
  - Language and cultural differences
  - Currency fluctuations
  - Political instability
  - Increasing transportation costs and lead times

# Global Supply Chains

## Video & Discussion:

- 1) What is “Globalization”?
- 2) Benefits of Global Supply Chain?
- 3) Name the “Emerging Technologies” in GSCM? Explain any 2?
- 4) Explain the next 2 “Emerging technologies”?

[Global Supply Chain Management | International Business | From A Business Professor - YouTube](#)

[\(1\) The Truth About Tesla's Global Supply Chain! - YouTube](#)

- **Group Discussion 1: [20-points]**

[\(1\) Global Supply Chain Management & Global Logistics Management - Participants & Mechanism | AIMS UK - YouTube](#)

# ERP and Supply Chain Management

[SYSPRO | ERP for Supply Chain Management - YouTube](#)

Supply Chain Management that integrates ERP is a formal approach to effectively plan and manage all the resources of a business enterprise. It provides systemwide visibility of key areas such as

- **Supplier Relationship Management**
- **Performance Management**
- **Sales and Order Fulfillment**

# SCM Ethical Issues

- **Examples:**

- Bribing government or company officials to secure permits or favorable status
- “Exporting smokestacks” to developing countries
- Claiming a “green” supply chain when the level of “green” is only minimal
- Ignoring health, safety, and environmental standards
- Violating basic worker rights
- Mislabeling the country of origin
- Selling products abroad that are banned at home

- **Dealing with ethical issues:**

- Develop an ethical supply chain code of behavior
- Monitor supply chain activities
- Choose suppliers that have a reputation for good ethical behavior
- Incorporate compliance with labor standards in supplier contracts
- Address any ethical problems that arise swiftly

# Small Business Concerns

- **Three small business SCM concerns:**

1. **Inventory management**

- Carry extra inventory as a way to avoid shortages due to supply chain interruption
- Have backups for delivery from suppliers and to customers

2. **Reducing risks**

- Use only reliable suppliers
- Determine which suppliers are critical and get to know them and any challenges they have
- Measure supplier performance
- Recognize warning signs of supplier issues
- Have plans in place to manage supply chain problems

3. **International trade**

- Work with someone who has expertise to help oversee foreign suppliers
- Set expectations for demand and timing
- Do not rely on a single supplier
- Build goodwill to help in negotiations and resolving any problem that arise
- Consider using domestic suppliers if the risks of working with foreign suppliers are prohibitive

# Management Responsibilities

- **Aspects of management responsibility:**
  - **Legal**
    - Being knowledgeable about laws and regulations of the countries where supply chains exist
    - Obeying laws and operating to conform to regulations
  - **Economic**
    - Supplying products and services to meet demand as efficiently as possible
  - **Ethical**
    - Conducting business in ways that are consistent with the moral standards of society

# Management Responsibility: Strategic

- Certain strategic responsibilities have a major impact on the success of both supply chain management and the business itself:
  - Supply chain strategy alignment
  - Network configuration
  - Information technology
  - Products and services
  - Capacity planning
  - Strategic partnerships
  - Distribution strategy
  - Uncertainty and risk reduction

# Management Responsibility: Tactical and Operational

## Tactical

- Forecasting
- Sourcing
- Operations planning
- Managing inventory
- Transportation planning
- Collaborating

## Operational

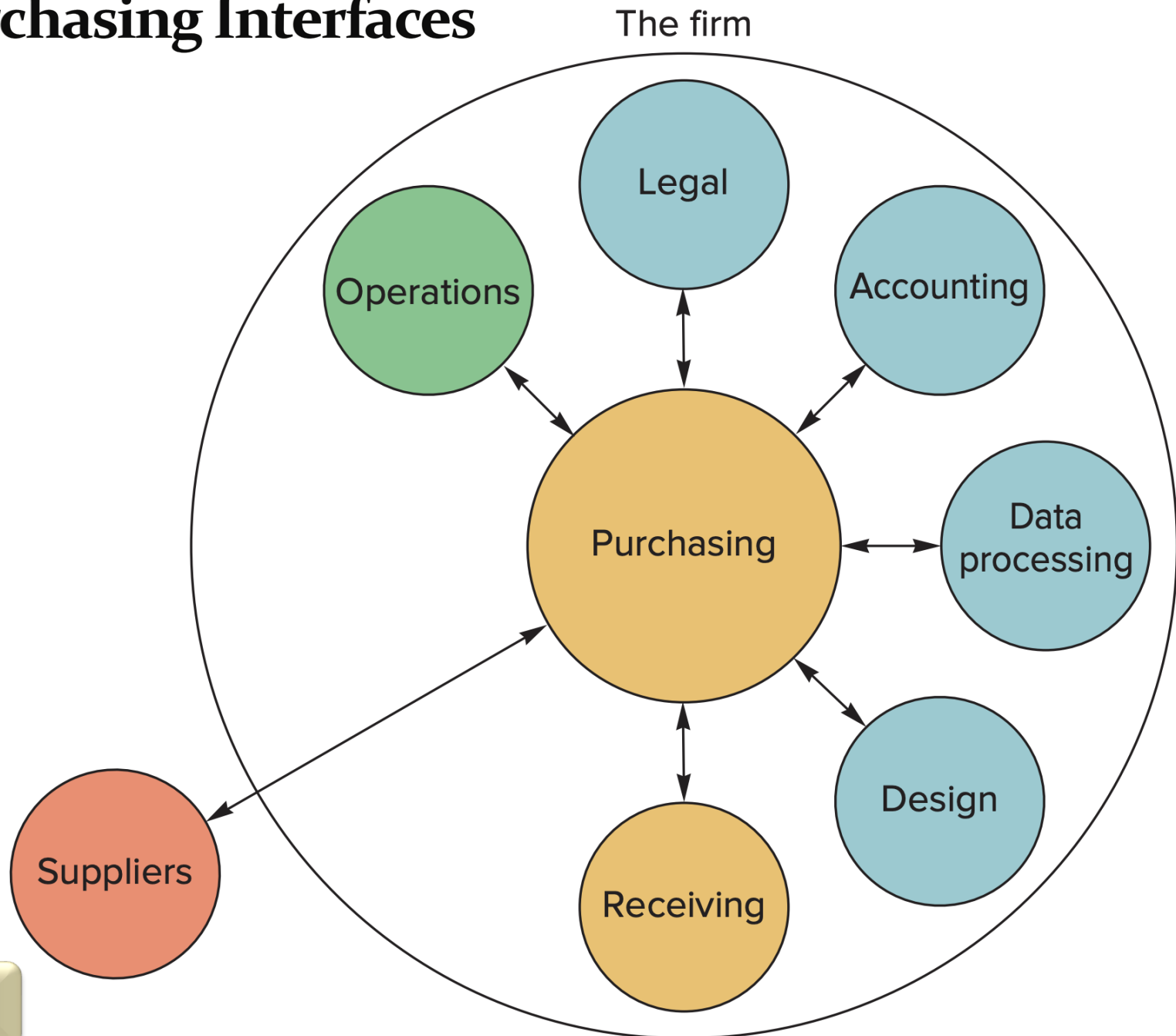
- Scheduling
- Receiving
- Transforming
- Order fulfilling
- Managing inventory
- Shipping
- Information sharing
- Controlling

# Procurement

[What is Procurement? | Procurement Process - YouTube](#)

- The purchasing department is responsible for obtaining the materials, parts, and supplies and services needed to produce a product or provide a service.
- **The goal of procurement**
  - Develop and implement purchasing plans for products and services that support operations strategies

# Purchasing Interfaces



# Duties of Purchasing

- Identifying sources of supply
- Negotiating contracts
- Maintaining a database of suppliers
- Obtaining goods and services
- Managing suppliers

# The Purchasing Cycle

- **The main steps:**

1. Purchasing receives the requisition
2. Purchasing selects a supplier
3. Purchasing places the order with a vendor
4. Monitoring orders
5. Receiving orders

# Centralized vs Decentralized Purchasing

- **Centralized Purchasing**
  - Lower prices by combining orders
  - Better service from suppliers due to larger volumes
  - Better handling of special items
- **Decentralized Purchasing**
  - Departments know their needs better
  - Quicker response time
  - Dealing with local suppliers may save money

# Supplier Management

- Choosing suppliers
- Supplier audits
- Supplier certification
- Supplier relationship management
- Supplier partnerships
  - CPFR (collaborative planning, forecasting, and replenishment)
  - Strategic partnering

# Vendor Analysis, Supplier Audits, and Supplier Certification

- **Vendor analysis**
  - Evaluating the sources of supply in terms of price, quality, reputation, and service
- **Supplier audit**
  - A means of keeping current on suppliers' production (or service) capabilities, quality and delivery problems and resolutions, and performance on other criteria
- **Supplier certification**
  - Involves a detailed examination of a supplier's policies and capabilities
  - The process verifies the supplier meets or exceeds the requirements of a buyer

# Supplier Relationship Management

- **Type of relationship is often governed by the duration of the trading relationship**
  - Short-term
    - Oftentimes involves competitive bidding
    - Minimal interaction
  - Medium-term
    - Often involves an ongoing relationship
  - Long-term
    - Often involves greater cooperation that evolves into a partnership

# Strategic Partnering

- Two or more business organizations that have complementary products or services join so that each may realize a strategic benefit
  - **Example:**
    - When a supplier agrees to hold inventory for a customer in return for a long-term commitment
      - The customer's inventory holding cost is reduced and the supplier is relieved of the costs that would be needed to continually find new customers

# Contrasting Supplier Relationships

Aspect	Adversary	Partner
Number of suppliers	Many; play one off against the others	One or a few
Length of relationship	May be brief	Long-term
Low price	Major consideration	Moderately important
Reliability	May not be high	High
Openness	Low	High
Quality	May be unreliable; buyer inspects	At the source; vendor certified
Volume of business	May be low due to many suppliers	High
Flexibility	Relatively low	Relatively high
Location	Widely dispersed	Nearness is important for short lead times and quick service

# Inventory Management

- **Inventory Velocity**

- Rate at which material moves through a supply chain

- **Bullwhip effect**

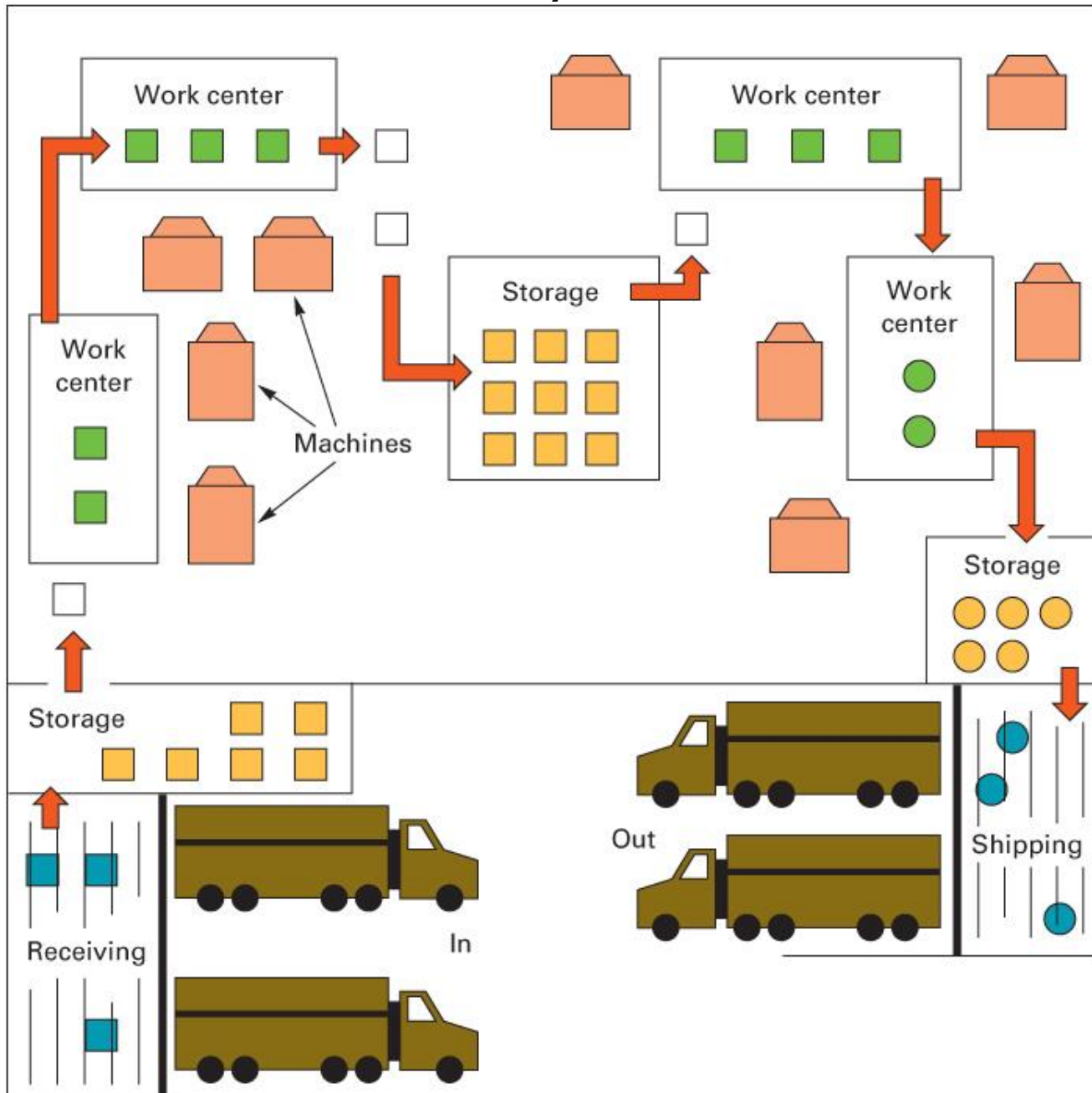
- Variations in demand at the consumer end coupled with periodic ordering and reaction to shortages tend to ripple backward through a supply chain, causing inventories to oscillate in increasingly larger swings

# Logistics

[What is logistics ? Logistics definition and 7 right of logistics explained! - YouTube](#)

- **Logistics** [The Incredible Logistics of Grocery Stores - YouTube](#)
  - Refers to the movement of materials, services, cash, and information in a supply chain
    - Movements within a facility
    - Incoming and outgoing shipments
    - Getting to the right location
    - Tracking foods vis RFID
    - Third-party logistics (3-PL)

# Movement Within a Facility



# Incoming and Outgoing Shipments

- **Traffic management**
  - **Overseeing the shipment of incoming and outgoing goods**
    - Handles schedules and decisions on shipping method and times, taking into account:
      - Costs of shipping alternatives
      - Government regulations
      - Needs of the organization
      - Shipping delays or disruptions

# Tracking Goods: RFID

- **Radio frequency identification (RFID)**
  - A technology that uses radio waves to identify objects, such as goods in supply chains
    - Similar to barcodes but
      - Are able to convey much more information
      - Do not require line-of-sight for reading
      - Do not need to be read one at a time
  - Has the ability to:
    - Increase supply chain visibility
    - Improve inventory management
    - Improve quality control
    - Enhance relationships with suppliers and customers

[\(1\) How Companies Are Overhauling Supply Chains to Ease Bottlenecks | WSJ - YouTube](#)

[\(1\) Nestle Supply chain Management Strategy | Procurement | MBA case study examples with solutions - YouTube](#)

[WALMART's SUPPLY CHAIN CASE STUDY | SCM | SUPPLY CHAIN ANALYTICS | EDI | DRONE | MBA CASE STUDY - YouTube](#)

# 3-PL

- **Third-Party Logistics (3-PL)**
  - The outsourcing of logistics management
  - Includes
    - Warehousing and distribution
  - Potential benefits include taking advantage of:
    - The specialists' knowledge
    - Their well-developed information system
    - Their ability to obtain more favorable shipping rates

[Top Transportation & Logistics Companies in Utah | Glassdoor](#)

[2022 Top 50 Global Freight Companies | Transport Topics \(ttnews.com\)](#)

# Managing Returns

- **Reverse logistics**
  - The process of transporting returned items
- Products are returned to companies or third party handlers for a variety of reasons and in a variety of conditions
  - Elements of return management
    - **Gatekeeping**
      - Screening returned goods to prevent incorrect acceptance of goods
    - **Avoidance**
      - Finding ways to minimize the number of items that are returned

# Creating an Effective Supply Chain

- It begins with strategic sourcing
  - Analyzing the procurement process to lower costs by reducing waste and non-value-added activities, increase profits, reduce risks, and improve supplier performance
  - There must be
    - Trust
    - Effective communication
    - Information velocity
    - Supply chain visibility
    - Event management capability
    - Performance metrics

# Challenges

- Barriers to integration of organizations
- Getting top management on board
- Dealing with trade-offs
- Small businesses
- Variability and uncertainty
- Response time

# Trade-Offs

## 1. Lot-size-inventory trade-off

- Large lot sizes yield benefits in terms of quantity discounts and lower annual setup costs, but they increase the amount of safety stock (and inventory carrying costs) carried by suppliers

## 2. Inventory-transportation cost trade-off

- Suppliers prefer to ship full truckloads instead of partial loads to spread shipping costs over as many units as possible. This leads to greater holding costs for customers
- **Cross-docking**
  - A technique whereby goods arriving at a warehouse from a supplier are unloaded from the suppliers truck and loaded onto outbound truck, thereby avoiding warehouse storage

# Trade-Offs (2 of 3)

## 3. Lead time-transportation costs trade-off

- Suppliers like to ship in full loads, but waiting for sufficient orders and/or production to achieve a full load may increase lead time

## 4. Product variety-inventory trade-off

- Greater product variety usually means smaller lot sizes and higher setup costs, as well as higher transportation and inventory management costs
- **Delayed differentiation**
  - Production of standard components and subassemblies which are held until late in the process to add differentiating features

# Trade-Offs (3 of 3)

## 5. Cost-customer service trade-off

- Producing and shipping in large lots reduces costs, but increases lead time
- **Disintermediation**
  - Reducing one or more steps in a supply chain by cutting out one or more intermediaries

# Chapter 17

## Project Management

# Chapter 17: Learning Objectives

## You should be able to:

- LO 17.1 Describe the project life cycle
- LO 17.2 Discuss the behavioral aspects of projects in terms of project personnel and the project manager
- LO 17.3 Name the six key decisions in project management
- LO 17.4 Explain the nature and importance of a work breakdown structure in project management
- LO 17.5 Give a general description of PERT/CPM techniques
- LO 17.6 Construct simple network diagrams
- LO 17.7 Analyze networks with deterministic times
- LO 17.8 Analyze networks with probabilistic times
- LO 17.9 Describe activity “crashing” and solve typical problems
- LO 17.10 Discuss the advantages of using PERT and potential sources of error
- LO 17.11 Discuss the key steps in risk management

# Project Management

[What is a Project? - YouTube](#)

## Video & Discussion:

[The History of Project Management - YouTube](#)

- 1) What is a Project? Name 5 projects you have worked on?
- 2) What is Project Management? Explain your own experiences while working on major projects?
- 3) Name and explain the 5 KPIs for PMs?
- 4) What is a PMO? Why is it important?

[What is Project Management? | Introduction to Project Management - Zoho Projects - YouTube](#)

[PMO Meaning in Project Management \[+DO YOU NEED ONE\] - YouTube](#)

[Top 5 KPIs for Project Managers \[Pay Attention to These!\] - YouTube](#)

[What is a PMO? - YouTube](#)

## • Group Discussion 1: [10-points]

[Project Planning Process: 5 Steps To Project Management Planning - YouTube](#)

[Project Planning for Beginners - Project Management Training - YouTube](#)

[How to Start a Project - 5 Key Steps - YouTube](#)

[Project Management: Are You Using the Right Stuff? \(Steve Goo\) - YouTube](#)

[NASA Project Management Challenge 2007 - YouTube](#)

[What is Program Management? - YouTube](#)

# Projects

- **Projects**

- Unique, one-time operations designed to accomplish a specific set of objectives in a limited time frame
- Examples:
  - The Olympic Games
  - Producing a movie
  - Software development
  - Product development
  - ERP implementation

# The Nature of Projects

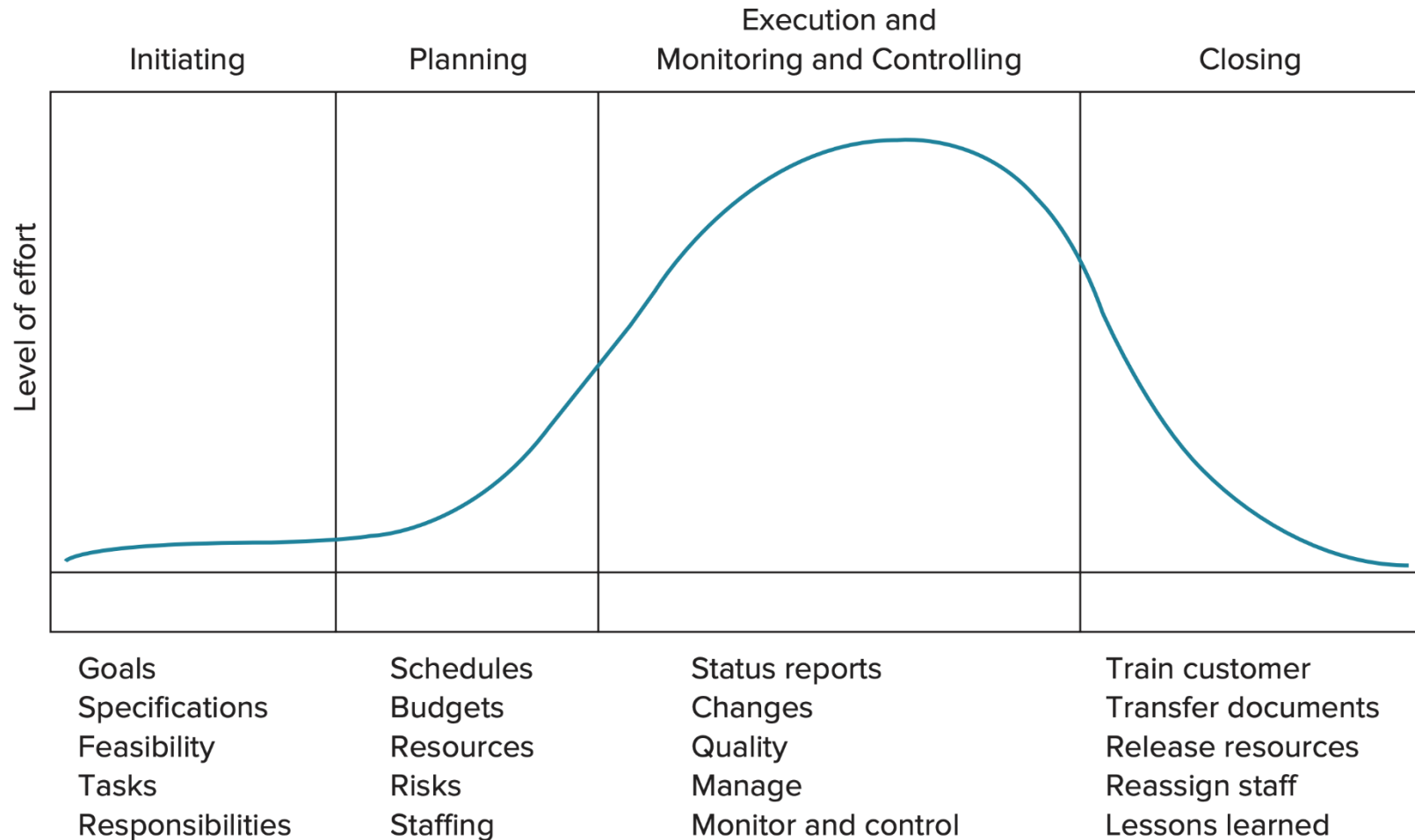
- Projects go through a series of stages – a life cycle
- Projects bring together people with a diversity of knowledge and skills, most of whom remain associated with the project for less than its full life
- Organizational structure affects how projects are managed

# Project Life Cycle

[What Is Project Life Cycle | Phases Of Project Life Cycle | Project Management Tutorial | Simplilearn - YouTube](#)

1. **Initiating**
2. **Planning**
3. **Executing**
4. **Monitoring and Controlling**
5. **Closing**

# Project Life Cycle (cont.)



**FIGURE 17.1**  
Project life cycle

# Project Management Decisions

- **Project success depends upon making key managerial decisions over a sequence of steps:**
  - Deciding which projects to implement
  - Selecting the project manager
  - Selecting the project team
  - Planning and designing the project
  - Managing and controlling project resources
  - Deciding if and when a project should be terminated

# Project Manager

- The project manager is ultimately responsible for the success or failure of the project
- The project manager must effectively manage:
  - The work
  - The human resources
  - Communications
  - Quality
  - Time
  - Costs

[What Does a Project Manager Do \[THE ROLE OF THE PM\] - YouTube](#)

# Project Management Body of Knowledge

The Project Management Institute (PMI) has developed a list of 10 areas of knowledge:

1. Managing integration
2. Managing scope
3. Managing time/schedule
4. Managing costs
5. Managing quality
6. Managing human resources
7. Managing communication
8. Managing risk
9. Managing procurement
10. Managing stakeholders

# The Project Management Triangle



# Behavioral Issues

- Behavioral problems can be created or exacerbated by
  - Decentralized decision making
  - Stress of achieving project milestones on time and within budget
  - Surprises
- The team must be able to function as a unit
  - Interpersonal and coping skills are very important
  - Conflict resolution and negotiation can be an important part of a project manager's job

# Avoiding Problems

- **Many problems can be avoided or mitigated by:**
  - Effective team selection
  - Leadership
  - Motivation
  - Maintaining an environment of
    - Integrity
    - Trust
    - Professionalism
  - Being supportive of team efforts

# Project Champion

- **Project champion**
  - A person who promotes and supports a project
    - Usually resides within the organization
    - Facilitate the work of the project by ‘talking up’ the project to other managers who might be asked to share resources with the project team as well as employees who might be asked to work on parts of the project
    - The project champion can be critical to the success of a project

# Work Breakdown Structure (WBS)

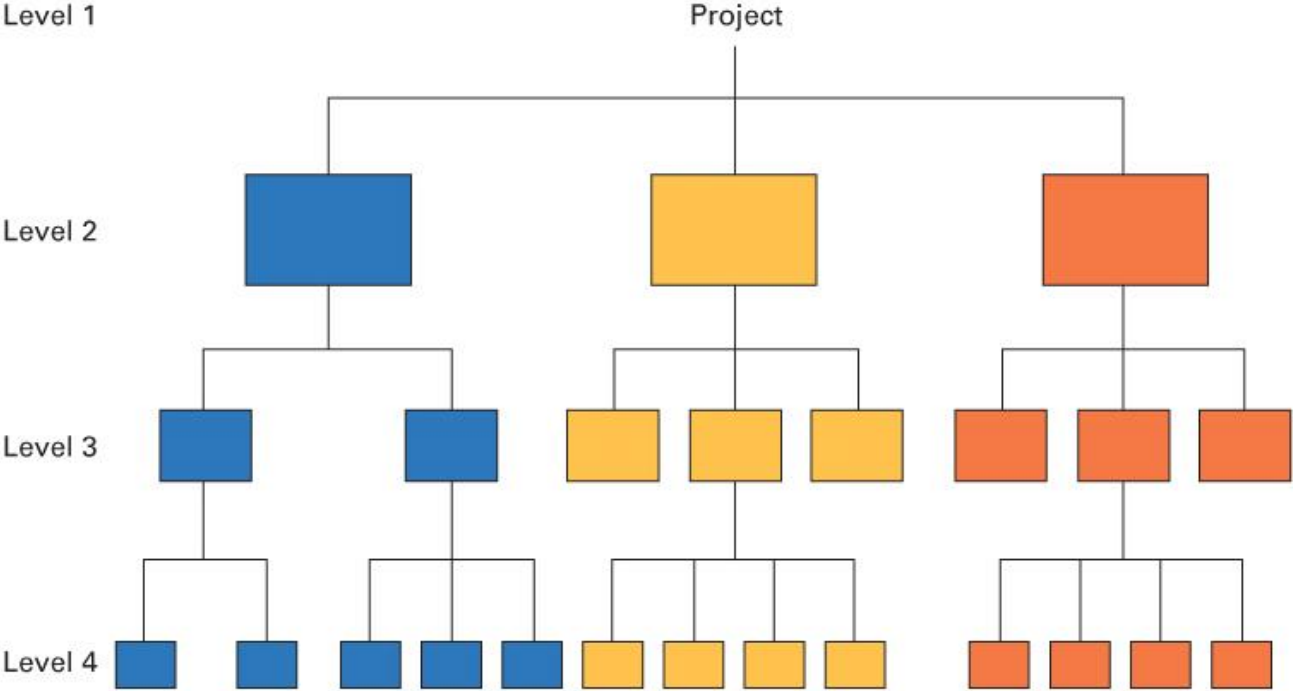
[Work Breakdown Structure \[WBS EXPLAINED\] - YouTube](#)

- **WBS**

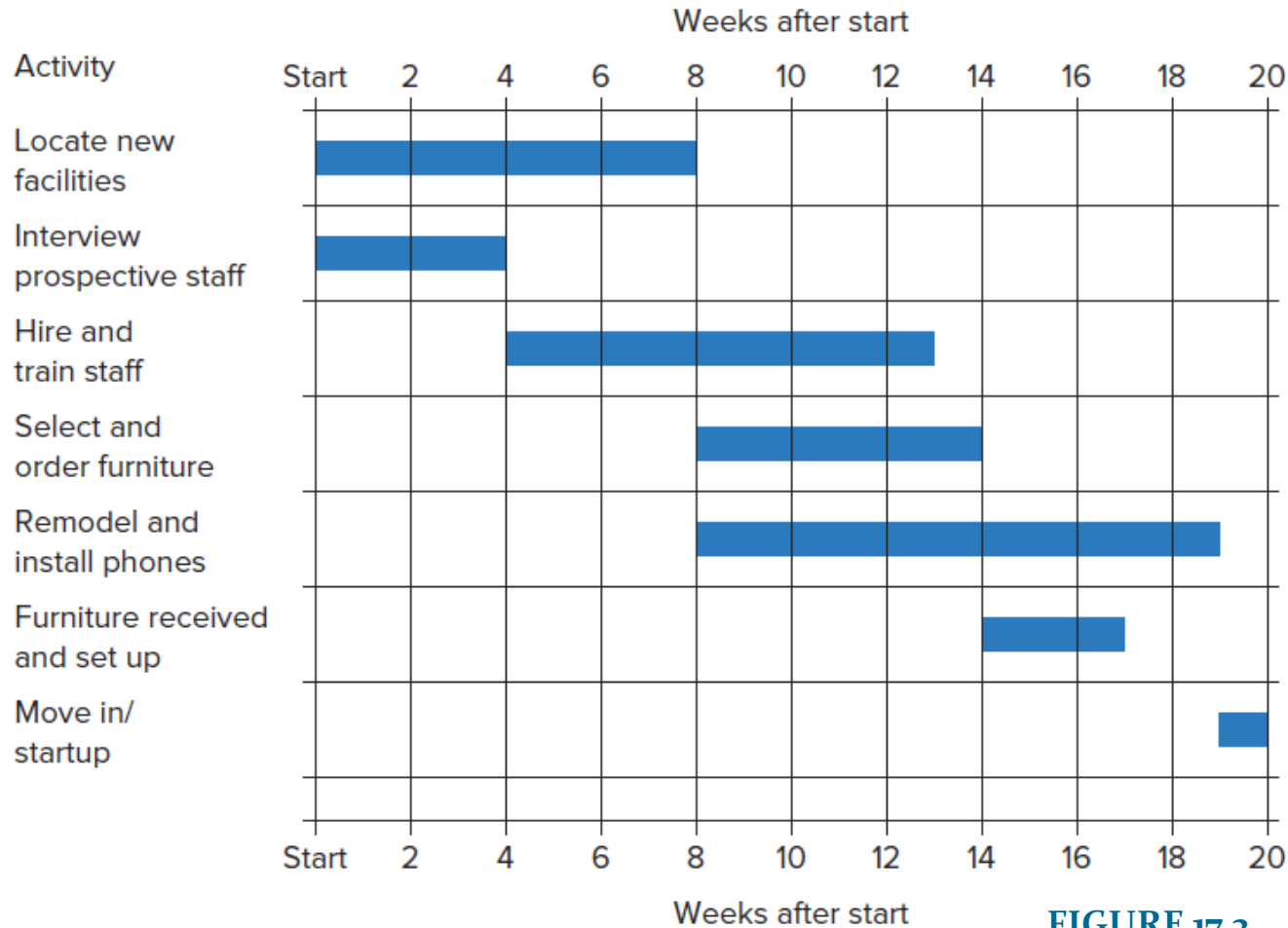
[Work Breakdown Structure | Project Management | Invensis Learning - YouTube](#)

- A hierarchical listing of what must be done during a project
  - Establishes a logical framework for identifying the required activities for the project
    1. Identify the major elements of the project
    2. Identify the major supporting activities for each of the major elements
    3. Break down each major supporting activity into a list of the activities that will be needed to accomplish it

# WBS: Working with Gantt Charts



# WBS: Working with Gantt Charts (cont.)



**FIGURE 17.3**  
Gantt chart for bank example

# PERT and CPM

[Project Scheduling - PERT/CPM | Finding Critical Path - YouTube](#)

- **PERT (program evaluation and review technique) and CPM (critical path method) are two techniques used to manage large-scale projects**
- **By using PERT or CPM managers can obtain:**
  - A graphical display of project activities
  - An estimate of how long the project will take
  - An indication of which activities are most critical to timely project completion
  - An indication of how long any activity can be delayed without delaying the project

# Network Diagram

- **Network diagram**
  - Diagram of project activities that shows sequential relationships by use of arrows and nodes
  - **Activity on arrow (AOA)**
    - Network diagram convention in which arrows designate activities
  - **Activity on node (AON)**
    - Network convention in which nodes designate activities
      - **Activities**
        - Project steps that consume resources and/or time
      - **Events**
        - The starting and finishing of activities

# Network Conventions

**TABLE 17.2** Network conventions

AOA	Interpretation	AON
	<p>Activities must be completed in sequence: first <i>a</i>, then <i>b</i>, and then <i>c</i>.</p>	
	<p>Both <i>a</i> and <i>b</i> must be completed before <i>c</i> can start. Note that activities <i>a</i> and <i>b</i> merge at activity <i>c</i>.</p>	
	<p>Activity <i>a</i> must be completed before <i>b</i> or <i>c</i> can start.</p>	
	<p>Both <i>a</i> and <i>b</i> must be completed before <i>c</i> or <i>d</i> can start.</p>	
	<p>Use a dummy activity to clarify relationships:</p>	<p>(No dummy needed)</p>
	<p>2. When activities share some, but not all, preceding activities. Here, activity <i>c</i> is preceded by activities <i>a</i> and <i>b</i>, while activity <i>d</i> is only preceded by activity <i>b</i>.</p>	<p>(No dummy needed)</p>

# Deterministic Time Estimates

- **Deterministic**
  - Time estimates that are fairly certain
- **Probabilistic**
  - Time estimates that allow for variation

# Early Start, Early Finish

- **Finding ES and EF involves a forward pass through the network diagram**
  - **Early start (ES)**
    - The earliest time an activity can start
    - Assumes all preceding activities start as early as possible
      - For nodes with one entering arrow
        - **ES = EF of the entering arrow**
      - For activities leaving nodes with multiple entering arrows
        - **ES = the largest of the largest entering EF**
  - **Early finish (EF)**
    - The earliest time an activity can finish
      - **EF = ES + t**

# Late Start, Late Finish

- **Finding LS and LF involves a backward pass through the network diagram**
  - **Late Start (LS)**
    - The latest time the activity can start and not delay the project
      - The latest starting time for each activity is equal to its latest finishing time minus its expected duration:
        - $LS = LF - t$
  - **Late Finish (LF)**
    - The latest time the activity can finish and not delay the project
      - For nodes with one leaving arrow, LF for nodes entering that node equals the LS of the leaving arrow
      - For nodes with multiple leaving arrows, LF for arrows entering node equals the smallest of the leaving arrows

# Slack and the Critical Path

- **Slack can be computed one of two ways:**
  - $\text{Slack} = \text{LS} - \text{ES}$
  - $\text{Slack} = \text{LF} - \text{EF}$
- **Critical path**
  - The critical path is indicated by the activities with zero slack

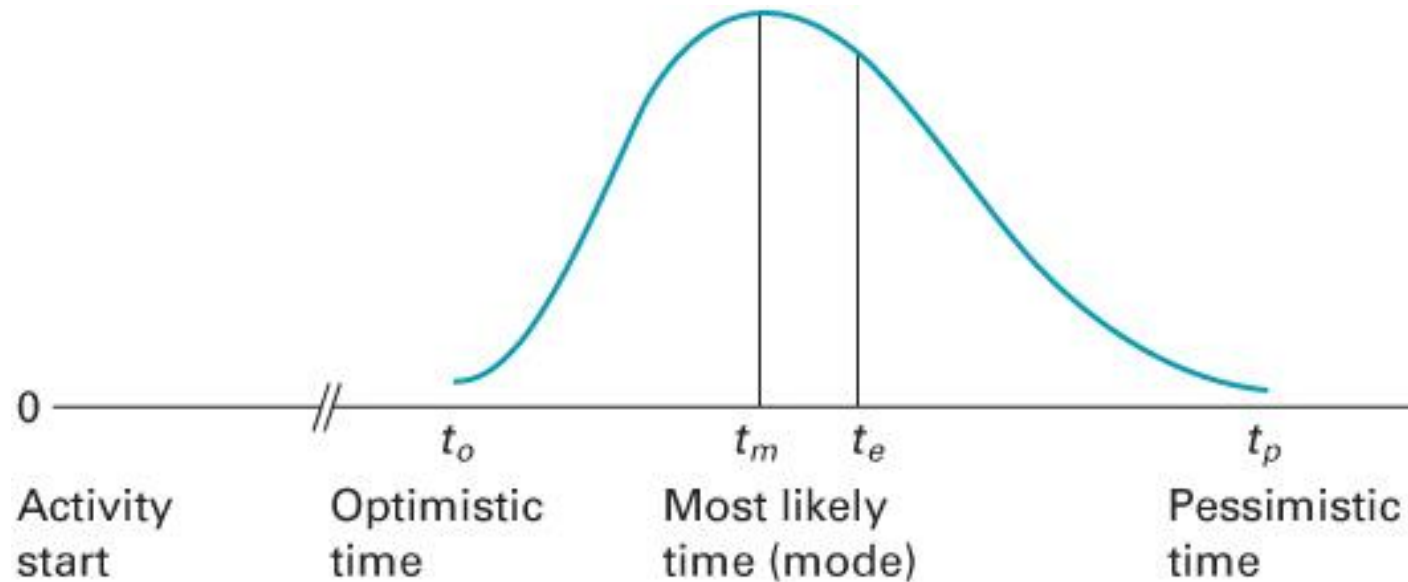
# Using Slack Times

- **Knowledge of slack times provides managers with information for planning allocation of scarce resources**
  - Control efforts will be directed toward those activities that might be most susceptible to delaying the project
  - Activity slack times are based on the assumption that all of the activities on the same path will be started as early as possible and not exceed their expected time
  - If two activities are on the same path and have the same slack, this will be the *total slack* available to both

# Probabilistic Time Estimates

- The beta distribution is generally used to describe the inherent variability in time estimates
- The probabilistic approach involves three time estimates:
  - **Optimistic time, ( $t_o$ )**
    - The length of time required under optimal conditions
  - **Pessimistic time, ( $t_p$ )**
    - The length of time required under the worst conditions
  - **Most likely time, ( $t_m$ )**
    - The most probable length of time required

# The Beta Distribution



# Knowledge of Path Statistics

- Knowledge of expected path times and their standard deviations enables managers to compute probabilistic estimates about project completion such as:
  - The probability that the project will be completed by a certain time
  - The probability that the project will take longer than its expected completion time

# Project Completion Time

- A project is not complete until all project activities are complete
- It is risky to only consider the critical path when assessing the probability of completing a project within a specified time
  - To determine the probability of completing the project within a particular time frame
    - Calculate the probability that *each path* in the project will be completed within the specified time
    - Multiply these probabilities
  - The result is the probability that the *project* will be completed within the specified time

# Assumption: Independence

- **Independence**

- Assumption that path duration times are independent of each other
  - Requires that
    1. Activity times are independent
    2. Each activity is on only one path
  - The assumption of independence is usually considered to be met if only a *few* activities in a large project are on multiple paths

# Simulation

- **When activity times cannot be assumed to be independent, simulation is often used**
  - Repeated sampling is used
    - Many passes are made through the project network
    - In each pass, a random value for each activity time is selected based on the activity time's probability distribution
    - After each pass, the project's duration is determined
    - After a large number of passes, there are enough data points to prepare a frequency distribution of the project duration
    - Probabilistic estimates of completion times are made based on this frequency distribution

# Time-Cost Trade-Offs

- **Activity time estimates are made for some given level of resources**
- **It may be possible to reduce the duration of a project by injecting additional resources**
  - **Motivations:**
    - To avoid late penalties
    - Monetary incentives
    - Free resources for use on other projects

# Time-Cost Trade-Offs: Crashing

- **Crashing**
  - Shortening activity durations
    - Typically, involves the use of additional funds to support additional personnel or more efficient equipment, and the relaxing of some work specifications
  - The project duration may be shortened by increasing direct expenses, thereby realizing savings in indirect project costs

# Crashing Decisions

- **To make decisions concerning crashing requires information about:**
  1. Regular time and crash time estimates for each activity
  2. Regular cost and crash cost estimates for each activity
  3. A list of activities that are on the critical path
    - Critical path activities are potential candidates for crashing
    - Crashing non-critical path activities would not have an impact on overall project duration

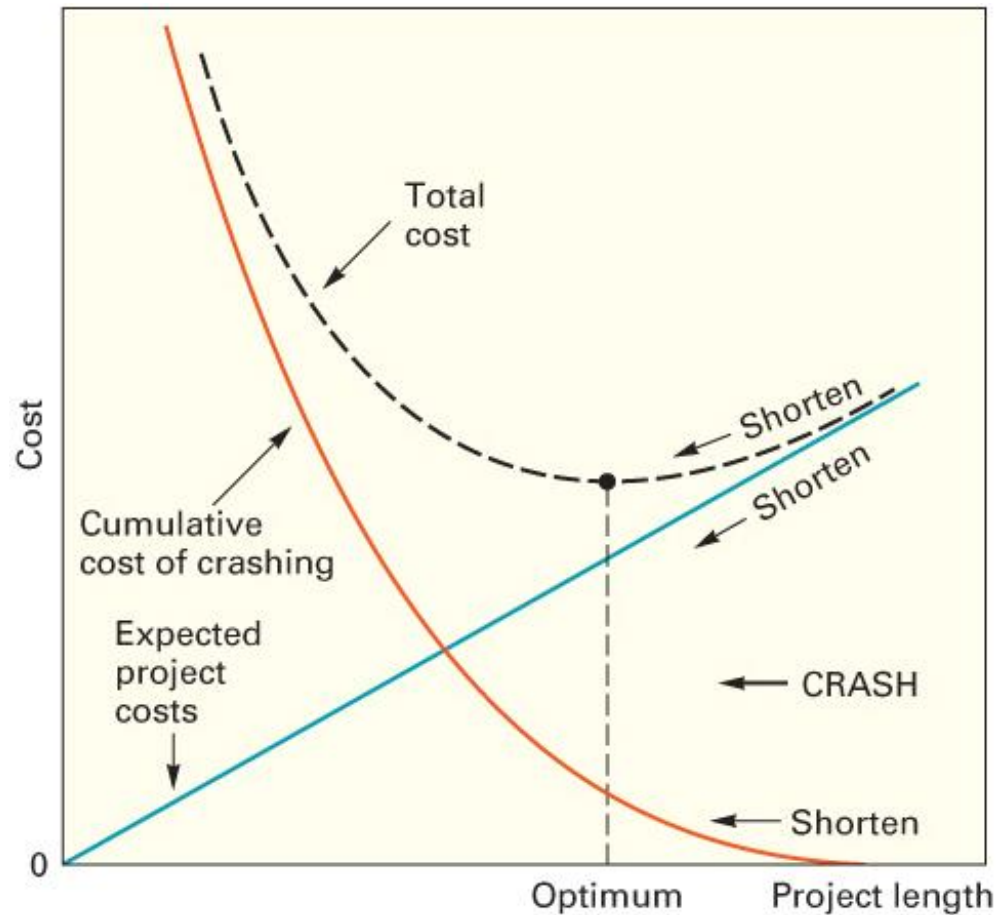
[What is Crashing the Timeline? Project Management in Under 5 - YouTube](#)

# Crashing: Procedure

- **General procedure:**

1. Crash the project one period at a time
  2. Crash the least expensive activity that is on the critical path
  3. When there are multiple critical paths, find the sum of crashing the least expensive activity on each critical path
- If two or more critical paths share common activities, compare the least expensive cost of crashing a common activity shared by critical paths with the sum for the separate critical paths

# Crashing Activities



# PERT: Advantages

- **Among the most useful features of PERT:**
  1. It forces the manager to organize and quantify available information and to identify where additional information is needed
  2. It provides a graphic display of the project and its major activities
  3. It identifies
    - a. Activities that should be closely watched
    - b. Activities that have slack time

# Sources of Error

- **Potential sources of error:**

1. The project network may be incomplete
2. Precedence relationships may not be correctly expressed
3. Time estimates may be inaccurate
4. There may be a tendency to focus on critical path activities to the exclusion of other important project activities
5. Major risk events may not be on the critical path

# Risk Management

[What Is Risk Management In Projects? - YouTube](#)

- **Risks are an inherent part of project management**
  - Risks relate to occurrence of events that have undesirable consequences such as
    - Delays
    - Increased costs
    - Inability to meet technical specifications

# Risk Management (cont.)

- **Good risk management involves**
  - Identifying as many risks as possible
  - Analyzing and assessing those risks
  - Working to minimize the probability of their occurrence
  - Establishing contingency plans and budgets for dealing with any that do occur