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THEORY

1.1 Quality Management

Total Quality Management (TQM) is a strategic, integrated management system for achieving customer satisfaction.[1] It involves all managers and employees and uses quantitative methods to improve continuously an organization's processes. It is not an efficiency (cost-cutting) program, a morale-boosting scheme, or a project that can be delegated to operational managers or staff specialists. Paying lip service to quality improvement by merely using quality slogans to exhort workers is equally disastrous.

KEY CONCEPTS TO REMEMBER: LESSONS LEARNED FROM TQM

- Learn quality concepts first and tailor them to fit your organization.
- The commitment to change must come from the top management.
- Begin TQM with managers and supervisors who are models and trend setters.
- Data is crucial. You should not guess at what the symptoms or problems are, but go out and look at the facts and let that guide the improvement process.
- Recognition of the team members creates enthusiasm.
- TQM is a management system, hence, cannot be delegated to a quality control department.
- Quality is profit, not cost.
- TQM will reduce costs and risks, increase productivity, and enhance customer satisfaction.

In TQM context, the standard for determining quality is meeting customer requirements and expectations the first time and every time. There are many potential requirements and expectations that customers have, depending upon the particular product or service and needs of the customer. Rather than the organization attempting to specify what it views as quality, a TQM approach to quality systematically inquiries of its customers what they want, and strives to meet, and even exceed, those requirements. Such an approach helps to identify the elements of quality that are of paramount importance to customers. It also recognizes that customers' expectations may change over time. TQM can be applied equally to manufacturing and service organizations.

(a) **Elements of TQM.** The three essential requirements or principles of TQM are: (1) the pursuit of complete customer satisfaction by (2) continuously improving products and services, through (3) the full and active involvement of the entire workforce.

These three principles are met by integrating seven key operating practices.

1. Demonstrating personal leadership of TQM by senior management
2. Strategically planning the short- and long-term implementation of TQM throughout the organization
3. Assuring that everyone focuses on customers' needs and expectations
4. Developing clearly defined measures for tracking progress and identifying improvement opportunities
5. Providing adequate resources for training and recognition to enable workers to carry the mission forward and reinforce positive behavior
6. Empowering workers to make decisions and fostering teamwork
7. Developing systems to assure that quality is built in at the beginning and throughout operations.

(b) **What Is Different about TQM?** Although the adoption and integration of the seven operating practices are essential, leaders beginning a TQM effort should bear in mind that to realize the full potential of

[1] ***Introduction to Total Quality Management,*** *U.S. Office of Personnel Management, Washington, D.C. 1991.*

TQM requires a fundamental cultural change. When this transformation has occurred, everyone in the organization is continuously and systematically working to improve the quality of goods and services, and the processes for delivering them, in order to maximize customer satisfaction. TQM has become a way of managing that is embedded in the culture and environment of the organization, not simply a set of specific management techniques and tools. TQM emphasizes doing each job right the first time.

Components of TQM

- Process management
- Quality teams
- Quality councils
- Ongoing training

It follows that a successful approach to quality improvement requires a long-term commitment and recognition that the effort is an unending journey. Although some early successes can be achieved, a cultural transformation to full use of the TQM approach will occur only gradually.

(c) **Common Areas of Agreement on Quality.** Although each of the quality experts (i.e., Deming, Juran, and Crosby) has developed his individual approach to quality improvement, the following are some significant common areas of agreement:

- Producing a quality product costs less because there is less waste.
- Preventing quality problems is better than detecting and correcting them.
- Statistical data should be used to measure quality.
- Managers need to take a leadership role in improving quality.
- Managers and employees need training in quality improvement.
- Companies need to develop a Quality Management System.

A TQM approach to management represents a unique blending of: the objective, practical, and quantitative aspects of management, for example, focus on processes and reliance on quantitative data and statistical analysis for decision making; and the "soft" aspects of management, for example, providing a visionary leadership role, promoting a spirit of cooperation and teamwork, and practicing participative management. Many organizations, when deciding to undertake a TQM effort, focus on one or the other of these general approaches. A fully successful effort requires balanced attention to both.

The following areas need to be improved:

- Many managers encourage employee involvement and empowerment, but few organizations adopt the specific practices that bring them about, such as reliance on teams of employees to identify and resolve specific operating problems. Where teams are used, few have been delegated sufficient authority to make changes or have been trained to use the full array of TQM tools.

KEY CONCEPTS TO REMEMBER: PITFALLS TO AVOID WHEN IMPLEMENTING TQM

- Overemphasizing the technical tools at the expense of leadership and management issues
- Applying the tools before the needs are determined
- Tendency to rush the quality improvement process
- Viewing TQM as a budget-cutting tool or employee productivity program
- Conducting mass training before support systems for TQM have been set up

- Although many organizations recognize the importance of measurement and analysis to decision making, many measure the wrong things. Also, few organizations focus on internal processes across functions in order to assure that quality is built into the production and service system on a continuing basis.
- Many organizations have in place a system they call "Quality Assurance," but these systems are often designed to check for adherence to quality standards at the end of the production process. TQM creates procedures for assuring quality throughout the production and service process.

- Many organizations claim to serve the customer first, but few systematically and rigorously identify the needs of customers, both internal and external, and monitor the extent to which those needs are being met.

(d) **Characteristics of a Quality Organization.** When organizations adopt TQM principles and practices, the results have been startling. Workers at all levels focus on their customers' needs and become committed and involved in the quest for quality. Management and workers form a team in seeking continuous improvement. The cumulative result of these changes frequently is a profound change in the overall culture and atmosphere of the organization. Organizations become more streamlined, a larger percentage of workers are involved in line operations, and there is a greater spirit of cooperation and working toward common goals. Perhaps most significantly, a spirit of energy and excitement, even fun, permeates the organization.

Some specific contrasting characteristics that frequently result between the traditional approach and the TQM approach to managing are summarized in Exhibit 1.1.

Traditional approach to managing	*TQM approach to managing*
• The organization structure is hierarchical and has rigid lines of authority and responsibility.	• The organization structure becomes flatter, more flexible, and less hierarchical.
• Focus is on maintaining the status quo (don't fix it if it ain't broke).	• Focus shifts to continuous improvement in systems and processes (continue to improve it even if it ain't broke).
• Workers perceive supervisors as bosses or cops.	• Workers perceive supervisors as coaches and facilitators. The manager is seen as a leader.
• Supervisor/subordinate relationships are characterized by dependency, fear, and control.	• Supervisor/subordinate relationships shift to interdependency, trust, and mutual commitment.
• The focus of employee efforts is on individual effort; workers view themselves as competitors.	• The focus of employee effort shifts to team effort; workers see themselves as teammates.
• Management perceives labor and training as costs.	• Management perceives labor as an asset and training as an investment.
• Management determines what quality is and whether it is being provided.	• The organization asks customers to define quality, and develops measures to determine if customers' requirements are met.
• Primary basis for decisions is on "gut feeling" or instinct.	• The primary basis for decisions shifts to facts and systems.

Exhibit 1.1: Comparison of traditional approach to managing with TQM approach to managing

(e) **Quality Assurance, Quality Control, Quality Audit, Quality Circles, and Quality Councils.** In order to meet customer quality requirements, the work processes used to produce their products and services must be designed to prevent problems and errors from occurring in the first place.

Quality assurance focuses on the front end of processes, beginning with inputs, rather than the traditional controlling mode of inspecting and checking products at the end of operations, after errors are made. Processes are designed both to prevent errors and to detect and correct them as they occur throughout the process. As part of the emphasis on prevention and early detection, employees are trained to analyze incoming supplies. Suppliers are asked to assure, assess, and improve their processes and products or services. The organization establishes a partnership with suppliers and customers to assure continuous improvement in the quality of the end products and services.

Quality control is an evaluation to indicate needed corrective action, the act of guiding, or the state of a process in which the variability is attributable to a constant system of chance causes. Quality control includes the operational techniques and activities used to fulfill requirements for quality. Often, quality assurance and quality control are used interchangeably, referring to the actions performed to ensure the quality of a product, service, or process.

QUALITY ASSURANCE VS. QUALITY CONTROL

- Quality assurance focuses on front end of processes
- Quality control focuses on middle and back end of processes
- Quality assurance is a management issue
- Quality control is a technical issue

Quality audit is a systematic, independent examination and review to determine whether quality activities and related results comply with planned arrangements, and whether these arrangements are implemented effectively and are suitable to achieve the objectives.

Quality circles refer to a team of employees (6 to 12) voluntarily getting together periodically to discuss quality-related problems and issues and to devise strategies and plans to take corrective actions. Participative management places a premium on teamwork as the way to solve problems and initiate process improvements, especially issues with cross-functional implications. The focus is on teamwork and processes rather than on individual efforts and tasks. Quality circles should be introduced in an evolutionary manner so that employees feel that they can tap their creative potential.

Establishment of a **quality council** is a prerequisite of implementing a total quality management program in the organization. The quality council is similar to an executive steering committee. By establishing a quality council, senior management provides an identity, structure, and legitimacy to the quality improvement effort. It is the first concrete indication that senior management has recognized the need to improve and has begun to change the way the organization conducts its business. The direction that this change will take becomes clear when the Quality Council publishes its vision, guiding principles, and mission statement. Management needs to support and promote the total quality management program, not just sponsor it.

(f) **Concurrent Engineering.** Long lead times for introducing new products have been a major problem for many manufacturers. This slowness in introducing new products is clearing the way for competitive products entering the market.

The focus of concurrent engineering is to reduce the overall product cycle time, which is measured as the elapsed time between research, development, and marketing of a new product. This is called time to market a new product, which is aimed at increasing performance and productivity.

Concurrent engineering is defined as a systematic approach to the integrated and overlapping design of products and their related processes, including design, manufacturing, and support. It requires that, from the beginning, all elements of product life cycle be evaluated across all design factors to include user requirements, quality cost, and schedule.

The foundation of concurrent engineering is that some 80 to 85% of a product's cost is determined at concept development. Additionally, the integration of support processes early on cuts manufacturing costs while raising quality and reducing development time.

The significant benefits to be obtained from concurrent engineering include

- Improved quality of design, leading to a reduction in change orders
- Reduction in product cycle time as a result of using concurrent design, rather than sequential design
- Reduction in manufacturing costs as a result of using multifunction teams to integrate product and process
- Reduction in scrap and rework as a result of product and process design optimization

Involving suppliers in product design is also a strategic move for a successful concurrent engineering practice. Concurrent design, a part of concurrent engineering, makes the design relatively fixed, requiring limited engineering change orders, so that little line disruption results. This enables new versions of popular products to be introduced with great speed and ease.

(g) **Cost of Quality.** The Cost of Quality (COQ) measurement identifies areas for process improvement. The focus of this measurement is to express quality in terms of quantitative and financial language, that is, costs, return on investment, cost of poor quality, cost of rework, and so on.

The COQ definition includes the following three items:

1. COQ is the cost of making a product conform to quality standards (i.e., quality goods).
2. COQ is the cost of not conforming to quality standards (i.e., waste, loss).
3. COQ is a combination of item 1 and 2.

$$\text{COQ} = \text{The cost of conformance (A)} + \text{The cost of nonconformance (B)}$$

where (A) includes cost to prevent and detect a failure and (B) includes cost to correct a failure.

Costs related to quality are usually separated into at least three areas: prevention costs, appraisal costs, and failure costs (see Exhibit 1.2).

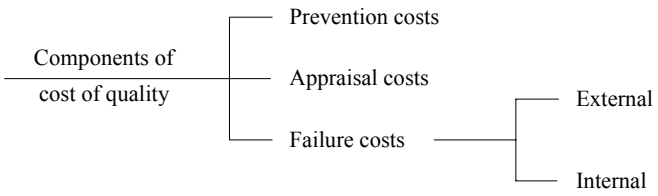


Exhibit 1.2: Components of cost of quality

(i) **Prevention costs.** These costs are associated with all the activities that focus on preventing defects. It is the cost of conformance to quality standards. Some major cost categories included in this cost classification are: operator inspection costs, supplier ratings, supplier reviews, purchase-order technical data reviews, training, supplier certification, design reviews, pilot projects, prototype test, vendor surveys, quality design, and quality department review costs.

KEY CONCEPTS TO REMEMBER: BASIC INTERRELATIONSHIPS AMONG QUALITY COSTS

The basic relationships among the three types of quality costs are that money invested in prevention and appraisal can substantially reduce failure costs. In addition to reducing expenses, the reduction in external failure costs results in fewer customer complaints. A dollar invested in a prevention program saves money many times in failure costs.

(ii) **Appraisal costs.** These costs are associated with measuring, evaluating, or auditing products to assure conformance with quality standards and performance requirements. Some major cost categories included in this cost classification are purchasing appraisal costs, qualifications of supplier product, equipment calibration, receiving and shipping inspection costs, tests, and product quality audits.

(iii) **Failure costs.** These costs are associated with evaluating and either correcting or replacing defective products, components, or materials that do not meet quality standards. Failure costs can be either internal failure costs that occur prior to the completion or shipment of a product or the rendering of a service, or external failure costs that occur after a product is shipped or a service is rendered. Examples of internal failure costs include repair, redesign, reinspection, rework, retesting, sorting, and scrap. Examples of external failure costs include product warranty charges, returns, and recalls; liability suits; and field service staff training costs.

Quality metrics can be developed for the cost of quality measurement to help managers monitor quality. These metrics include

- The total cost of quality as percentage of revenue by year
- The cost of conformance as percentage of total cost of quality
- The cost of nonconformance as percentage of total cost of quality

(h) **Quality Tools.** Either an auditor or an auditee can use quality tools. These tools can be used to analyze processes, prioritize problems, report the results, and to evaluate the results of a corrective action plan. The seven quality control tools include check sheets, histograms, scatter diagrams, Pareto diagrams, flowcharts, cause-and-effect diagrams, and control charts. Later, seven other tools came into effect, called the seven quality management tools. These management tools include affinity diagram (also called KJ method), tree diagram, process decision program chart, matrix diagram, interrelationship digraph, prioritization matrices, and activity network diagram. The seven quality management tools are modern while the seven quality control tools are traditional.

QUALITY CONTROL TOOLS VS. QUALITY MANAGEMENT TOOLS

- The old seven quality control tools are used for quantitative data analysis.
- The new seven quality management tools are used for qualitative data analysis.

(i) **Old seven quality control tools.**

(A) ***Check sheets.*** Check sheets are used for collecting data in a logical and systematic manner. The data collected can be used in constructing a quality control chart, Pareto diagram, or histogram. The most important use of the check sheet is that it enables the user to gather and organize data in a format that permits efficient and easy analysis of data.

Process improvement is facilitated by the determination of what data or information is needed to reduce the difference between customer needs and process performance. Some examples of data that can be collected include: process variables including size, length, weight, and diameter; number of defects generated by each cause; product characteristics; costs; vendors; inspection procedures; customer profiles; employees attitudes; and defect location. The idea is that once this data is collected and analyzed, the cause can be found and a plan to eliminate the problem can be implemented.

(B) ***Histograms.*** A histogram is a frequency distribution diagram in which the frequencies of occurrences of the different variables being plotted are represented by bars. The purpose is to determine the shape of the graph relative to the normal distribution (or other distributions). It is often confused with a bar graph, in which the frequency of a variable is indicated by the height of the bars. In a histogram, the frequency is indicated by the area of the bar. Histograms can only be used with variable data, which require measurements on a continuous scale. Only 1 characteristic can be shown per histogram, and at least 30 observations representing homogeneous conditions are needed.

Old Quality Control Tools

The old seven quality control tools include check sheets, histograms, scatter diagrams, Pareto diagrams, flowcharts, cause and effect diagrams, and control charts.

A histogram is a frequency distribution, in which the area of each bar is always proportional to the actual percentage of the total falling in a given range. If the bars are of equal length, then the histogram is equivalent to a bar graph, in which the relative size of the bars depends only on their heights. A histogram can be compared to the normal distribution (or other distribution). For example, if the graph is off-center or skewed, this may indicate that a process requires adjustment. Histograms are essentially used for the same applications as bar graphs, except that the horizontal scale in a histogram must be numerical, usually representing a continuous random variable.

A bar graph is a frequency distribution diagram in which each bar represents a characteristic or attribute, and the height of the bar represents the frequency of that characteristic. The horizontal axis may represent a continuous numerical scale (e.g., hours), or a discrete nonnumerical scale (e.g., phases of a project). Generally, numerical-scale bar graphs in which the bars have equal widths are more useful for comparison purposes; numerical-scale bar charts with unequal intervals can be misleading because the characteristics with the largest bars (in terms of area) do not necessarily have the highest frequency. Bar graphs are used to compare the frequencies of different attributes (e.g., number or percentage of problem reports by phase).

(C) ***Scatter diagrams.*** A scatter diagram is a plot of the values of one variable against those of another variable to determine the relationship between them. These diagrams are used during analysis to understand the cause and effect relationship between two variables. Scatter diagrams are also called correlation diagrams.

If the data points fall approximately in a straight line, this indicates that there is a linear relationship, which is positive or negative, depending on whether the slope of the line is positive or negative. Further analysis using the method of least squares can be performed. If the data points form a curve, then there is a nonlinear relationship. If there is no apparent pattern, this may indicate no relationship. However, another sample should be taken before making such a conclusion.

Method of least squares can be used in conjunction with scatter diagrams to obtain a more precise relationship between variables. It is used to determine the equation of the regression line (i.e., the line that “best fits” the data point). With this equation, one can approximate values of one variable when given values of the other.

(D) ***Pareto diagram.*** A Pareto diagram is a special use of the bar graph in which the bars are arranged in descending order of magnitude. The purpose of Pareto analysis, using Pareto diagrams, is to identify the major problems in a product or process, or more generally, to identify the most significant causes for a given effect. This allows a developer to prioritize problems and decide which problem area to work on first.

Pareto analysis is based on the 20/80 rule, which states that approximately 20% of the causes (the "vital few") account for 80% of the effects (problems). The "vital few" can be determined by drawing a cumulative percent line and noting which bars are to the left of the point marking 80% of the total count. The vital few are usually indicated by significantly higher bars and/or a relatively steep slope of the cumulative percent line.

Pareto diagrams (charts) can be helpful in determining whether efforts towards process improvement are producing results. These diagrams are useful when the process is stable; it will not be effective if used on a chaotic process because the process is not ready for improvement. The process must first be stabilized through the use of control charts. *Root cause analysis is performed using the Pareto diagrams.*

Pareto diagrams can be drawn showing before and after improvements, demonstrating the effect of the improvements through the use of Pareto diagrams. This is a powerful tool when used in this way because it can mobilize support for further process improvement and reinforce the continuation of current efforts. Pareto diagrams are based on 80/20 rule indicating that 20% of things account for 80% of problems, and are usually drawn as pie charts, histograms, or vertical bar charts. Pareto diagrams focus on "vital few" instead of "trivial many." When arranged from greatest to least, the Pareto chart graphically indicates which problems should be handled first.

(E) ***Flowcharts.*** A flowcharting tool can be used to document every phase of a company's operation, for example, from order taking to shipping in a manufacturing company. It will become an effective way to break down a process or pinpoint a problem. Flowcharting can be done at both the summary level and the detailed level serving different user needs.

Flowcharting is a first step towards the documentation of a process required for ISO 9000 and other quality awards. In this way, problems can be traced quickly to the right source and corrected properly. Also, the flowcharts can be used as a training tool or a reference document on the job.

A process map is similar to a flowchart. Mapping is the activity of developing a detailed flowchart of a work process showing its inputs, tasks, and activities in sequence. A process map provides a broader perspective than typical flowcharts.

(F) ***Cause-and-effect diagrams.*** One form of a cause-and-effect (C&E) diagram is used for process analysis. It is used when a series of events or steps in a process creates a problem and it is not clear which event or step is the major cause of the problems. Each process or subprocess is examined for possible causes; after the causes from each step in the process are discovered, significant root causes of the problem are selected, verified, and corrected. The C&E diagrams are also called fishbone or Ishikawa (the inventor) diagrams.

The C&E diagrams should be used as a framework for collecting efforts. If a process is stable, it will help organize efforts to improve the process. If a process is chaotic, the C&E diagram will help uncover areas that can help stabilize the process.

(G) ***Control chart.*** A control chart assesses a process variation. The control chart displays sequential process measurements relative to the overall process average and control limits. The upper and lower control limits establish the boundaries of normal variation for the process being measured. Variation within control limits is attributable to random or chance causes, while variation beyond control limits indicates a process change due to causes other than chance—a condition that may require investigation. The upper control limit and lower control limit give the boundaries within which observed fluctuations are typical and acceptable. They are usually set, respectively, at three standard deviations above and below the mean of all observations.

There are many different types of control charts (e.g., np, p, c, u, X, XB, R, XM, and MR). "np" is number of nonconforming units, "p" is fraction of nonconforming units, "c" is number of nonconformities, "u" is number of nonconformities per unit, "X" is a single observed value, "XB" is X-Bar, "R" is a range, "XM" is a median, and "MR" is a moving range.

A run chart is a simplified control chart, in which the upper and lower control limits are omitted. The purpose of the run chart is more to determine trends in a process, rather than its variation. Run charts can be used effectively to monitor a process, for example, to detect sudden changes and to assess the effects of corrective actions. Run charts provide the input for establishing control charts after a process has matured or stabilized in time. Limitations of this technique are that it analyzes only one characteristic over time, and it does not indicate if a single data point is an outlier.

Dr. Genichi Taguchi, a Japanese statistician and Deming Prize winner, developed what is called Taguchi method, the off-line quality control method, which includes product and process design. This is contrasted to on-line quality control in which quality control activities are focused on control charts and process control methods. Taguchi's methods provide a system to develop specifications, design those specifications into a product and/or process, and produce products that continuously surpass said specifications. *There are seven aspects to off-line quality control.*

1. The quality of a manufactured product is measured by the total loss to society created by that product.
2. Continuous quality improvement and cost reduction are necessary for an organization's health in a competitive economy.
3. Quality improvement requires the never-ending reduction of variation in product and/or process performance around nominal values.
4. Society's loss due to performance variation is frequently proportional to the square of the deviation of the performance characteristic from its nominal value.
5. Product and process design can have a significant impact on a product's quality and cost.
6. Performance variation can be reduced by exploiting the nonlinear effects between a product's and-or process's parameters and the product's desired performance characteristics.
7. Product and/or process parameter settings that reduce performance variation can be identified with statistically designed experiments.

(ii) **New seven quality management tools.** The original quality tools were adequate for data collection and analysis, but the seven new tools allow better identification, planning, and coordination in quality problem solving. These new tools include affinity diagram (also called KJ method), tree diagram, process decision program chart, matrix diagram, interrelationship digraph, prioritization matrices, and activity network diagram. Each tool is discussed briefly.

(A) ***Affinity diagram.*** The affinity diagram is a data reduction tool in that it organizes a large number of qualitative inputs into a smaller number of major categories. These diagrams are useful in analyzing defect data and other quality problems, and used in conjunction with cause-and-effect diagrams or interrelationship digraphs.

(B) ***Tree diagram.*** A tree diagram can be used to show the relationships of a production process by breaking it down from few larger steps into many smaller steps. The greater the detail of steps, the better simplified they are. Quality improvement actions can start from the right-most of the tree to the left-most.

(C) ***Process decision program chart.*** The process decision program chart (PDPC) is a preventive control tool in that it prevents problems from occurring in the first place and mitigates the impact of the problems if they do occur. From this aspect, it is a contingency planning tool. The objective of the tool is to determine the impact of the "failures" or problems on project schedule.

(D) ***Matrix diagram.*** A matrix diagram is developed to analyze the correlations between two groups of ideas with the use of a decision table. This diagram allows one to systematically analyze correlations. Quality Function Deployment (QFD) is an extension of the matrix diagram. The American Supplier Institute defines QFD as: "A system for translating consumer/customer requirements into appropriate company requirements at each stage, from research and product development, to engineering and manufacturing, to marketing/sales and distribution."

The QFD is a structured method and uses a series of charts called "quality tables" to provide the discipline and communication required to focus on answering three action-oriented questions: what? how? and how much? QFD can be used both for products and services.

(E) ***Interrelationship digraph.*** The interrelationship digraph is used to organize disparate ideas. Arrows are drawn between related ideas. An idea that has arrows leaving it but none entering is a "root idea." More attention is then given to the root ideas for system improvement. The digraph is often used in conjunction with affinity diagrams.

(F) ***Prioritization matrices.*** Prioritization matrices are used to help decision makers determine the order of importance of the activities being considered in a decision. Key issues and choices are identified for further improvement. These matrices combine the use of a tree diagram and a matrix diagram.

New Quality Management Tools

The new seven quality management tools include affinity diagram (also called KJ method), tree diagram, process decision program chart, matrix diagram, interrelationship digraph, prioritization matrices, and activity network diagram.

(G) ***Activity network diagram.*** Activity network diagrams are project management tools to determine which activities must be performed, when they must be performed, and in what sequence. These diagrams are similar to PERT and CPM, the popular tools in project management. Unlike PERT and CPM, activity network diagrams are simple to construct and require less training to use.

(iii) **Plan-do-check-act (PDCA) cycle.** The PDCA cycle was first known as the Shewhart cycle and later known as the Deming cycle. It is a core management tool for problem solving and quality improvement. The PDCA cycle can be used for planning and implementing quality improvements. The "plan" calls for developing an implementation plan for initial effort followed by organization-wide effort.

The "do" part carries out the plan on a small scale using a pilot organization, and later on a large scale. The "check" phase evaluates lessons learned by pilot organization. The "act" phase uses lessons learned to improve the implementation. It supports both old and new quality tools.

(iv) **Stratification.** Stratification is a procedure used to describe the systematic subdivision of population or process data to obtain a detailed understanding of the structure of the population or process. It is not to be confused with a stratified sampling method. Stratification can be used to break down a problem to discover its root causes and can establish appropriate corrective actions, called countermeasures.

Stratification is important to the proper functioning of the Deming PDCA cycle. *Failure to perform meaningful stratification can result in the establishment of inappropriate countermeasures, which can then result in process or product deterioration in quality.*

STRATIFICATION VS. PARETO DIAGRAM VS. C & E DIAGRAM

- Stratification can be used when performing root cause analysis with Pareto diagrams. A problem can be broken down into subcomponents, and each subcomponent can be further broken down into its subcomponents, and so on. Then, attention should be paid to one or more of the root causes of a process or product problem, from which countermeasures can be established to resolve the problem.
- Stratification can also be used when performing root cause analysis with C&E diagrams. A C&E diagram can be used to stratify one bar from a Pareto diagram at a time to get an in-depth understanding of the corresponding cause (bar) before any other cause (bar) is studied.

(i) **Quality Models and Awards.** A system should be put in place to allow the organization to determine systematically the degree to which product and services please customers, and focus on internal process

improvement. Data should be collected on features of customer satisfaction such as responsiveness, reliability, accuracy, and ease of access. The measurement systems should also focus on internal processes, especially on processes that generate variation in quality and cycle time. *Cycle time is the time required from conception to completion of an idea or a process.* When customer data indicates a problem, or when the organization wants to raise the level of customer satisfaction, the organization should focus on improving the processes that deliver the product or service.

In order to assure that processes are continuously improved, data should be collected and analyzed on a continuing basis, with particular attention to variation in processes. The causes of variation are examined to determine whether they result from special circumstances (special causes) or from recurring ("common") causes. Different strategies should be adopted to correct each occurrence. The immediate objectives of the analysis and measurement effort are to reduce rework, waste, and cycle-time and to improve cost-effectiveness and accuracy. The ultimate objectives are to assure that the organization understands the extent to which customer satisfaction is being realized, where there are deficiencies, and why, and to isolate causes that can be attacked systematically.

(i) **Three quality preachers.** We will discuss quality models from three quality preachers' viewpoints: (1) Deming, (2) Juran, and (3) Crosby.

(A) ***Deming quality model.*** According to Deming, good quality does not necessarily mean high quality. It is, rather, "a predictable degree of uniformity and dependability, at low cost, and suited to the market." He recognizes that the quality of any product or service has many scales, and may get a high mark on one scale and a low mark on another. In other words, quality is whatever the customer needs and wants. And since the customer's requirements and tastes are always changing, the solution to defining quality in terms of the customer is to constantly conduct customer research.

Deming said people are eager to do a good job and are disturbed when they are unable to because of limitations imposed by management. Deming's basic philosophy on quality is that productivity improves as variability decreases. Since all things vary, he says, that is why the statistical method of quality control is needed. "Statistical control does not imply absence of defective items. It is a state of random variation, in which the limits of variation are predictable," he explains.

There are two types of variation: chance and assignable, and says Deming, "The difference between these is one of most difficult things to comprehend." It is a waste of time and money to look for the cause of the chance variation, yet, he says, this is exactly what many companies do when they attempt to solve quality problems without using statistical methods. He advocates the use of statistics to measure performance in all areas, not just conformance to product specifications. Furthermore, he says it is not enough to meet specifications; one has to keep working to reduce the variation as well.

Inspection, whether of incoming or outgoing goods, is, according to Deming, too late, ineffective, and costly. "Inspection does not improve quality, nor guarantee it," he says. Moreover, inspection is usually designed to allow a certain number of defects to enter the system. For example, a company that buys items with an acceptable quality level of three percent is, in effect, telling the vendor that it can send three bad items out of every 100. "The vendor will be pleased to meet these requirements," says Deming.

Deming says that judging quality requires knowledge of the "statistical evidence of quality," and that companies dealing with vendors under statistical control can eliminate inspection. "You will note from the control charts that came along with the product, far better than any inspection can tell you, what the distribution of quality is, and what it will be tomorrow." In this way, quality is predictable, and one can also safely predict that the vendor's quality will improve over time. "One of the first steps for managers of purchasing to take is to learn enough about the statistical control of quality to be able to assess the qualifications of a supplier, to be able to talk to him in statistical language," says Deming.

Deming also points out that simply checking the specifications of incoming materials may not be enough if the material encounters problems in production. "Specifications cannot tell you the whole story. The supplier must know what the material is to be used for," he says. He is critical of most producers for qualifying vendors on quality because once qualified, the vendor, "has discharged his responsibility, and the purchaser accepts whatever he gets." The only effec-

tive way to qualify vendors is to see if their management abides by his 14 points, uses statistical process control, and is willing to cooperate on the tests and use of instruments and gauges.

The best recognition one can give a quality vendor, according to Deming, is to give that vendor more business. He points out that requiring statistical evidence of process control in selecting vendors would mean, in most companies, a drastic reduction in the number of vendors they deal with simply because not that many vendors would qualify. Nevertheless, he says, this is the only way to choose vendors, even if that means relying on a single source for critical items.

In fact, Deming advocates single sourcing. "A second source, for protection, for every item purchased is a costly practice," he says. The advantages of single sourcing include better vendor commitment, eliminating small differences between products from two suppliers, and simplifying accounting and paperwork. A disadvantage is the risk of depending on one supplier without any backup alternatives.

As to the fact that relying on a single source can often mean paying a higher price, Deming says, "The policy of forever trying to drive down the price of anything purchased, with no regard to quality and service, can drive good vendors and good service out of business. The ways of doing business with vendors and customers that were good enough in the past must now be revised to meet new requirements of quality and productivity."

DEMING'S FOURTEEN POINTS FOR MANAGEMENT

1. Create constancy of purpose toward improvement of products and services.
2. Adopt the new philosophy. We can no longer live with commonly accepted levels of delays, mistakes, defective materials, and defective workmanship.
3. Cease dependence on mass inspection. Require, instead, statistical evidence that quality is built in.
4. End the practice of awarding business on the basis of price tag.
5. Find problems. It is management's job to work continually on the system.
6. Institute modern methods of training on the job.
7. Institute modern methods of supervision of production workers. The responsibility of foremen must be changed from quantity to quality.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments.
10. Eliminate numerical goals, posters, and slogans for the work force, asking for new levels of productivity without providing methods.
11. Eliminate work standards that prescribe numerical quotas.
12. Remove barriers that stand between the hourly worker and his right to pride of workmanship.
13. Institute a vigorous program of education and retraining.
14. Create a structure in top management that will push every day on the above thirteen points.

(B) ***Juran quality model.*** According to Jospeh M. Juran, there are two kinds of quality: "fitness for use" and "conformance to specifications." To illustrate the difference, he says a dangerous product could meet all specifications, but not be fit for use. He pointed out that the technical aspects of quality control had been well covered, but that firms did not know how to manage for quality. He identified some of the problems as organizational, communication, and coordination of functions—in other words, the human element.

Juran talks about three basic steps to progress: (1) structured annual improvements combined with devotion and a sense of urgency, (2) massive training programs, and (3) upper management leadership. In his view, less than 20% of quality problems are due to workers; the remainder is caused by management.

JURAN'S TEN STEPS TO QUALITY IMPROVEMENT

1. Build awareness of the need and opportunity for improvement.
2. Set goals for improvement.
3. Organize to reach the goals (establish a quality council, identify problems, select projects, appoint teams, designate facilitator).
4. Provide training.
5. Carry out projects to solve problems.
6. Report progress.
7. Give recognition.
8. Communicate results.
9. Keep score.
10. Maintain momentum by making annual improvement part of the regular systems and processes of the company.

(C) ***Crosby quality model.*** According to Philip B. Crosby's definition, quality is conformance to requirements, and it can only be measured by the cost of nonconformance. "Don't talk about poor quality or high quality. Talk about conformance and nonconformance," he says. This approach means that the only standard of performance is zero defects. Crosby encourages "prevention (perfection)" as opposed to "inspection," "testing," and "checking."

CROSBY'S FOURTEEN STEPS TO QUALITY IMPROVEMENT

1. Make it clear that management is committed to quality.
2. Form quality improvement teams with representatives from each department.
3. Determine where current and potential quality problems lie.
4. Evaluate the cost of quality and explain its use as a management tool.
5. Raise the quality awareness and personal concern of all employees.
6. Take actions to correct problems identified through previous steps.
7. Establish a committee for the zero defects program.
8. Train supervisors to actively carry out their part of the quality improvement program.
9. Hold a "zero defects day" to let all employees realize that there has been a change.
10. Encourage individuals to establish improvement goals for themselves and their groups.
11. Encourage employees to communicate to management the obstacles they face in attaining their improvement goals.
12. Recognize and appreciate those who participate.
13. Establish quality councils to communicate on a regular basis.
14. Do it all over again to emphasize that the quality improvement program never ends.

(ii) **Malcolm Baldrige National Quality Award.** The Malcolm Baldrige National Quality Award (NQA) is an annual award to recognize US companies that excel in quality management and quality achievement. The award promotes

- Awareness of quality as an increasingly important element of competitiveness
- Understanding of the requirements for quality excellence
- Sharing of information on successful quality strategies and the benefits derived from implementation of these strategies

Award criteria goals include delivery of ever-improving value to customers and improvement of overall company operational performance. The Award criteria are built on a set of core values and concepts. Together, these values and concepts represent the underlying basis for integrating the overall customer and company operational performance requirements. These core values and concepts include customer-driven quality, leadership, continuous improvement, employee participation

and development, fast response, design quality and prevention, long-range outlook, management by fact, partnership development, and corporate responsibility and citizenship.

The core values and concepts are embodied in seven categories, including leadership, information and analysis, strategic quality planning, human resource development and management, management of process quality, quality and operational results, and customer focus and satisfaction.

(iii) **European Quality Award.** The European Quality Management Association has set up a European equivalent to the US Baldrige program, the European Quality Award (EQA). **Quality measures** for EQA include: leadership, information and analysis, strategic quality planning, human resource development and management, management of process quality, quality and operational results, customer focus and satisfaction, financial results, and environmental concerns.

(j) **Six-Sigma.** Six-sigma is an approach to measuring and improving product and service quality. In six-sigma terminology, a defect (nonconformance) is any mistake or error that is passed on to the customer. It redefines quality performance as defects per million opportunities (dpmo), as follows:

$$\text{dpmo} = (\text{Defects per unit}) \times 1{,}000{,}000/\text{opportunities for error where defects per unit} = \text{Number of defects discovered/Number of units produced}$$

Six-sigma represents a quality level of at most 3.4 defects per million opportunities. Its goal is to find and eliminate causes of errors or defects in processes by focusing on characteristics that are critical to customers.

(i) **Six-sigma metrics.** The recognized benchmark for six-sigma implementation is General Electric (GE). GE's six-sigma problem solving approach (DMAIC) employs five phases: (1) define, (2) measure, (3) analyze, (4) improve, and (5) control.

The define (D) phase focuses on identifying customers and their priorities, identifying a project suitable for six-sigma efforts based on business objectives as well as customer needs and feedback, and identifying critical-to-quality characteristics (CTQs) that the customer considers to have the most impact on quality. Specific tools useful in the define phase include cause-and-effect diagram, brainstorming, and process mapping ("as is").

The measure (M) phase focuses on determining how to measure the process and how it is performing and identifying the key internal processes that influence CTQs and measure the defects currently generated relative to those processes. Specific tools useful in the measure phase include systems analysis, cause-and-effect diagram, process mapping, and common cause and special cause identification.

The analyze (A) phase focuses on determining the most likely causes of defects and understanding why defects are generated by identifying the key variables that are most likely to create process variation. Specific tools useful in the analyze phase include statistical process control (SPC) and process mapping.

The improve (I) phase focuses on identifying means to remove the causes of the defects, confirming the key variables and quantifying their effects on the CTQs, identifying the maximum acceptable ranges of the key variables and a system for measuring deviations of the variables, and modifying the process to stay within the acceptable range. Specific tools useful in the improve phase include brainstorming (idea gathering), process mapping ("should be"), and quality function deployment (house of quality and voice of the customer).

The control (C) phase focuses on determining how to maintain the improvements and putting the tools in place to ensure that the key variables remain within the maximum acceptable ranges under the modified process. Specific tools useful in the control phase include mistake proofing and institutionalization.

The concept behind the six-sigma is similar to TQM, which is the integration of human and process elements of improvement. Human elements include management leadership, a sense of urgency, focus on results and customers, team processes, and culture change. Process elements include the use of process management techniques, analysis of variation and statistical methods, a disciplined problem-solving approach, and management by fact.

According to American Society for Quality (ASQ), several key principles are necessary for effective implementation of six-sigma.

- Committed leadership from top management
- Integration with existing initiatives, business strategy, and performance measurement

- Process thinking
- Disciplined customer and market intelligence gathering
- A bottom-line orientation
- Leadership in the trenches. It includes technical and nontechnical employees and managers. It also includes: champions, who are fully trained business leaders who promote and lead the deployment of six-sigma in a significant area of the business; master black belts, who are fully trained quality leaders responsible for six-sigma strategy, training, mentoring, deployment, and results; black belts, who are fully trained six-sigma experts who lead improvement teams, work projects across the business, and mentor green belts; green belts, who are full-time teachers with quantitative skills as well as teaching and leadership ability; they are fully trained quality leaders responsible for six-sigma strategy, training, mentoring, deployment, and results; and team members, who are individuals who support specific projects in their area.
- Training
- Continuous reinforcement and rewards

(ii) **Six-sigma tools.** Six-sigma tools can be categorized into eight general groups, which will integrate the tools and the methodology into management systems across the organization.

1. Elementary statistical tools include basic statistics, statistical thinking, hypothesis testing, correlation, and simple regression.
2. Advanced statistical tools include design of experiments, analysis of variance, and multiple regression.
3. Product design and reliability tools include quality function deployment (QFD) and failure mode and effects analysis (FMEA).
4. Measurement tools include process capability and measurement systems analysis.
5. Process improvement tools include process improvement planning, process mapping, and mistake-proofing (Poka-Yoke).
6. Implementation tools focus on organizational effectiveness and facilitation of meetings and communication.
7. Teamwork tools focus on team development and team assessment.
8. Process control tools include quality control plans and statistical process control (SPC).

1.2 International Organization for Standardization Framework

ISO 9000 consists of a series of generic standards with appropriate guidelines published by the International Organization for Standardization (called ISO) for vendor certification programs. ISO 9000 addresses quality system processes not product performance specifications. In other words, the ISO 9000 covers how products are made, but not necessarily how they work. ISO 9000 focuses on processes, not on products or people. It is based on the concept that one will fix the product by fixing the process. The ISO 9000 is a standard to judge the quality of suppliers. It assumes that suppliers have a sound quality system in place and it is being followed. ISO 9000 can be used as a baseline quality system to achieve Total Quality Management objectives.

The standards are becoming an acceptable worldwide approach to vendor certification and international trade. The real push is from companies throughout the world who are requesting that their suppliers become certified. The ISO 9000 standards are equally applicable to manufacturing and service industries, and remove the nontariff barriers that arise from differences and inadequacies among national, local, or company standards. Major categories of nontariff barriers include quantitative import restrictions such as quotas, voluntary export restraints, and price controls.

There are two kinds of standards: (1) product standards dealing with technical specifications and (2) quality standards dealing with management systems. Quality measures for ISO 9000 include: leadership, human resource development and management, management of process quality, and customer focus and satisfaction.

(a) **ISO Certification Process.** To earn ISO 9000 certification, a company must set up and document all procedures that relate to the process to be certified. These procedures can include everything from procuring and storing raw materials, to designing products, to issuing change orders on designs, to controlling inventory, to answering customer phone calls. Flowcharts can be used to document the procedures in place.

Documentation of these procedures ensures that they are followed throughout the organization. The idea is that by rethinking and documenting every step of the corporate process, companies can identify and eliminate trouble spots—and thus improve overall quality. *The probability of producing a high-quality product increases because the risk that leads to poor quality decline as the processes are documented and followed. ISO 9000 forces discipline into the system.*

After an application for certification is filed, registrars or auditors accredited by a national quality board will conduct on-site audits. During the audit, registrars ask questions about company procedures and policies.

(b) **Benefits of ISO 9000.** The painstaking certification process yields several benefits for customers of certified manufacturers and service providers. These benefits include

- Products from ISO 9000-certified suppliers are likely to be more reliable.
- When every step of a manufacturing process is documented, it is easier to spot problems and trace them back to an exact point in the manufacturing line. Problem tracking is facilitated.
- Its document-it-all approach makes it easier for users to evaluate products and services and to anticipate potential problems.
- Costs will be lower for both the manufacturer and the customer due to efficient operations. Lower design costs translate to lower product costs, which should mean lower prices for users.
- Buying products from ISO-certified suppliers can save customers the time and expense of conducting on-site visits of manufacturing facilities.
- It saves time and money by not having to test incoming parts from ISO-certified suppliers because its suppliers' procedures include testing.

(c) **Types of ISO 9000 Standards.** There are several types of ISO 9000 family of standards, including the 9000 and 10000 series.

- **ISO 8402.** It presents vocabulary for quality management and quality assurance.
- **ISO 9000.** It presents quality management and quality assurance standards. It serves as an introduction to the other standards in the series. Part 1 provides guidelines for selection and use. Part 2 provides generic guidelines for the application of ISO 9001, 9002, 9003. Part 3 provides guidelines for the application of ISO 9001 to the development, supply, and maintenance of software. The key process is the design phase. Part 4 deals with application for dependability management. It focuses on the reliability, maintainability, and availability characteristics of products such as transportation, electricity, telecommunications, and information services.
- **ISO 9001.** It addresses quality systems. It is the most comprehensive model for quality assurance in design, development, production, installation, and servicing.
- **ISO 9002.** It addresses quality systems and it is a model for quality assurance in production, installation, and servicing.
- **ISO 9003.** It addresses quality systems and it is a model for quality assurance in final test and inspection.
- **ISO 9004.** It deals with quality management and quality system elements. There are four parts in this standard.
  - **Part 1** provides general guidelines for most of the quality system elements contained in ISO 9001, 9002, and 9003 in greater detail. It addresses various areas such as organizational goals (consider costs, benefits, and risks); management responsibility (establish quality policy); quality system elements (configuration management, quality plans, quality records, audits and reviews, quality improvement); financial considerations of quality systems (quality-costing approach, process-cost approach, quality-loss approach); quality in marketing (defining product requirements, obtaining customer feedback); quality in specification and design (translating customer needs into technical specifications); quality in purchasing (agreement on quality assurance, selection of contractors and suppliers); quality of processes (process capability, product handling); control of processes (material control, traceability, process control and change control); product verification (verifying incoming materials, in-process, and finished product); control of inspection, measuring and test equipment (corrective action, outside testing); control of nonconforming product (segregation, disposition, action and avoidance); corrective action (analyzing the problem, investigation and elimination of causes); post production activities (storage and service, postmarketing surveillance); quality records (inspection

reports, test data, drawings, specifications, procedures); personnel (qualifications, motivation); product safety (standards, tests, product recall methods, emergency plan for contingencies); and use of statistical methods (graphical methods, regression analysis, control charts, analysis of variance methods, design of experiments, statistical sampling).

- **Part 2** provides guidelines for services. It applies to organizations that provide services or whose products include a service component.
- **Part 3** provides guidelines for processed materials. It applies to organizations whose products consists of processed materials such as solids, liquids, or gases that are delivered in pipelines, drums, tanks, or cans. It includes guidelines on process control, process capability, equipment control, maintenance, and documentation. It points out the importance of statistical sampling.
- **Part 4** provides guidelines for quality improvement. This standard states "the motivation for quality improvement comes from the need to provide increased value and satisfaction to customers." An important concept is that companies should "seek opportunities for improvement, rather than waiting for a problem to reveal opportunities. It also talks about performing processes more efficiently and effectively with less waste and resource consumption.

- **ISO 10005.** It deals with quality management providing guidelines for quality plans.
- **ISO 10007.** It provides guidelines for configuration management. It describes the technical organizational activities of configuration identification, control, status accounting, and audit. It is applied over the life cycle of a product to provide visibility and control of functional and physical characteristics.
- **ISO 10011.** It provides guidelines for auditing quality systems. Part 1 deals with auditing and includes first-, second-, and third-party audits. Part 2 covers qualification criteria (education, training, and experience) for quality systems auditors. Part 3 addresses management of an audit from initial planning to the closing meeting.
- **ISO 10012.** It deals with quality assurance requirements for measuring equipment. It assumes that quality depends upon accurate measurements.
- **ISO 10013.** It deals with guidelines for developing quality manuals. It describes the development and control of quality manuals, tailored to the specific user needs.
- **QS-9000.** This guideline makes it easier for suppliers to do business with auto manufacturers and other original equipment manufacturers. This guideline applies to all internal and external suppliers that provide production materials, production or service parts, or heat treating and other finishing services. QS-9000 was developed because ISO 9001 was not current for the automotive industry; the QS-9000 interpretations updated the ISO 9001 requirements.

WHICH ISO STANDARD IS WHICH?

- ISO 9001, 9002, and 9003 are called conformance standards and quality assurance models. They are used for external quality assurance to provide confidence to the customer that the company's quality system is capable of providing a satisfactory product or service. They are not levels of quality and are used in contractual situations. They are prescriptive documents.
- ISO 9000-1 and 9004-1 are guidance standards. They are used for internal quality assurance activities aimed at providing confidence to the management of an organization that the intended quality is being achieved. They are used in noncontractual situations. They are descriptive documents.
- ISO 10005, 10011, and 10013 deal with quality plans, auditing, and quality manuals respectively.
- QS-9000 is not a standard, but it contains the ISO 9001 standard; its reqirements are much broader than ISO 9001.
- The ISO 9000 standards provide a baseline or foundation for a Total Quality Management (TQM) program

BALDRIGE VS. ISO 9000 VS. EQA

- Compared with Baldrige and EQA, ISO 9000 offers somewhat thin coverage of specific quality categories.
- ISO 9000 only covers four categories, compared with the seven covered by Baldrige and nine by EQA. For example, ISO 9000 does not address the "information and analysis" category, which defines how to collect corporate data, internally and externally, to measure management quality.
- ISO 9000 does not cover "strategic quality planning," a category used to judge the importance of improving quality as part of the corporate planning process, or "quality and operational results," which deals with the financial soundness of a company.
- EQA actually goes beyond Baldrige to encompass nine specific quality categories, in which categories 8 and 9 are additional items in the EQA.

1.3 Forecasting

The simplest form of forecasting is the projection of past trends called extrapolation. Model building activities are examples of analytical techniques. A model breaks down a major problem into parts or subproblems and solves it sequentially. Some examples of applications of forecasting models in managerial accounting are pricing, costs, revenue, and inventory decisions.

For example, when forecasting purchases of inventory for a firm, factors such as knowledge of the behavior of business cycles, econometrics, and information on the seasonal variations in demand are important.

Models require a set of predetermined procedures. If there are no well-ordered and fully-developed procedures there is no need to model. That is, *no procedure, no model.* For example, a onetime crisis situation cannot be modeled due to lack of a preset procedure.

A key concept in all forecasting models dealing with probabilities is the expected value. The expected value equals the sum of the products of the possible payoffs and their probabilities.

(a) **Time Series Analysis.** Time series analysis is the process by which a set of data measured over time is analyzed. Decision makers need to understand how to analyze the past data if they expect to incorporate past information into future decisions. Although the factors that affect the future are uncertain, often the past offers a good indication of what the future will hold. *The key is to know how to extract the meaningful information from all the available past data.*

All time series contain at least one of four time series components: long-term trend, seasonal, cyclical, and random or irregular components. Time series analysis involves breaking down data measured over time into one or more of these components. Time series analysis is similar to regression analysis in that both techniques help to explain the variability in data as much as possible. The four types of components of time series analysis help explain that variability (see Exhibit 1.3). The purpose of time series analysis is to use these components to explain the total variability in past data. The problem is how to best separate each component from the others so that each can be analyzed clearly.

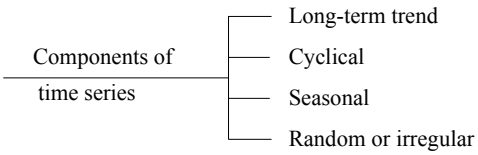


Exhibit 1.3: Components of time series

(i) **Long-term trend.** The trend component is the long-term increase (growth) or decrease (decline) in a variable being measured over time. An example is annual sales over the past 10 to 15 years. Because long-term forecasting is becoming increasingly important due to severe global competition, the trend component in time series analysis is important to all organizations.

Long-term growth patterns have a wide variety of shapes such as the first-degree, exponential, and Gompertz curves. The easiest method to fit trend lines to a series of data is to graph the data and draw the trend line freehand. Another way of fitting a trend line to a set of data is to use the least square regression method. *Two methods are available to fit a trend line to a series of data: (1) draw the trend line freehand, and (2) use the least square regression method.*

(ii) **Seasonal component.** The seasonal component represents those changes in a time series that occur at the same time every year. An example is peak sales occurring once in the spring and once in the fall season.

Some organizations (e.g., toy stores, food processors, lumber mills) are affected not only by long-term trends but also by seasonal variations. The demand for products or services is highly dependent on the time of year. Those organizations facing seasonal variations are interested in knowing how well or poorly they are doing relative to the normal seasonal variation. The question is whether the increase or decrease is more or less than expected, or whether it occurs at more or less than the average rate.

A seasonal index known as the ratio to moving average can be calculated to measure seasonal variation in a time series. A 12-month moving average is used here. *Seasonal variation affects the overall planning process, especially in labor requests, inventory levels, training needs, and periodic maintenance work.*

Some prefer to eliminate irregular components in the data by taking the normalized average of the ratio to moving averages. A requirement prior to separating the irregular components from the data is to make sure that the ratio to moving averages is stable from year to year. Another assumption to be made prior to eliminating irregular components is that the irregular fluctuations are caused by purely random circumstances.

(iii) **Cyclical component.** In addition to the seasonal component, data can contain certain cyclical effects. Cyclical effects in a time series are represented by war-like fluctuations around a long-term trend. These fluctuations are thought to be caused by pulsations in factors such as interest rates, money supply, consumer demand, market conditions, and government policies. Cyclical fluctuations repeat themselves in a general pattern in the long term, but occur with differing frequencies and intensities. Thus, they can be isolated, but not totally predicted. *Firms affected by cyclical fluctuations are those vulnerable to unexpected changes in the economy. The effect is different each time it occurs.*

Cyclical variations in time series data do not repeat themselves in a regular pattern as do seasonal factors, but they cannot be considered random variations in the data either.

The organizations hardest hit by the cyclical component are those connected with items purchased with discretionary income (e.g., big-ticket items such as home appliances and automobiles). Consumers can postpone purchasing these items and consequently these producing organizations are the most affected by a downturn in the economy.

The cyclical component is isolated by first removing the long-term trend and seasonal factors from the time series data. Then statistical normal values are calculated by multiplying the trend value by the seasonal index values. Finally, the cyclical component, which also contains the irregular component, is determined for each time period.

(iv) **Random or irregular component.** The random or irregular component is the one that cannot be attributed to any of the three components already discussed, namely long-term trend, seasonal, and cyclical components (see Exhibit 1.4). Random fluctuations can be caused by many factors, such as economic failures, weather, political events.

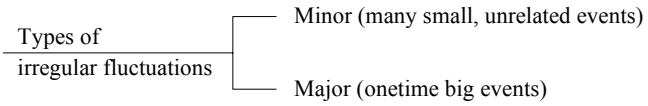


Exhibit 1.4: Types of irregular fluctuations

Minor irregularities show up as sawtooth-like patterns around the long-term trend. Individually, they are not significant, but collectively they can be significant and could cause problems to many organizations.

LARGE VS. SMALL IRREGULAR VARIATIONS

- Large irregular variations cause greater problems.
- Small irregular variations cause lesser problems.

Major irregularities are significant onetime, unpredictable changes in the time series due to such extended and uncontrolled factors as a war, an oil embargo, a summer drought, or a severe winter storm.

Almost all industries and organizations are affected by irregular components. Agriculture, insurance, and mining companies will be more interested in this component. Minor irregularities can be smoothed out by using a moving average method. The goal is to eliminate as much as possible the irregular influences so that the true, seasonal, and cyclical components can be recognized and used. *A random component is unwanted. Buying insurance coverage is one way to mitigate the risks resulting from major irregular fluctuations.*

(b) **Regression Analysis.** Regression analysis is a statistical technique used to measure the extent to which a change in the value of one variable, the independent variable, tends to be accompanied by a change in the value of another variable, the dependent variable.

Most measures of associations are nondirectional, that is, when calculated, it is not necessary to indicate which variable is hypothesized to influence the other. Measures of association show to what degree, on a zero-to-one scale, two variables are linked.

DEFINITION OF KEY TERMS: REGRESSION ANALYSIS

- *Analysis of covariance*. A method of analyzing the differences in the means of two or more groups of cases while taking account of variation in one or more interval-ratio variables.
- *Analysis of variance.* A method for analyzing the differences in the means of two or more groups of cases.
- *Asymmetric measure of association.* A measure of association that makes a distinction between independent and dependent variables.
- *Auxiliary variable.* Another name for independent variable.
- *Correlation.* Correlation is a synonym for association and it is one of several measures of association. Correlation means the interdependence between two sets of numbers or a relation between two quantities, such that when one changes, the other changes. Simultaneous increasing or decreasing of quantities is called "positive correlation"; when one quantity increases while the other decreases, it is called "negative correlation."
- *Dependent variable.* A variable that may, it is believed, be predicted by or caused by one or more other variables called independent variables. It will show the "effect."
- *Discriminant analysis.* A tool for discriminating between effective and ineffective policies or procedures. It is based on subjective assessment (not based on statistics), and discrete values.
- *Explanatory variable.* Another name for independent variable.
- *Independent variable.* A variable that may, it is believed, predict or cause fluctuation in a dependent variable.
- *Primary variable.* Another name for dependent variable.
- *Regression.* The line of average relationship between the dependent (or primary) variable and the independent (or auxiliary) variable.
- *Regression analysis.* A method for determining the association between a dependent variable and one or more independent variables.
- *Regression coefficient.* A measure of change in a primary variable associated with a unit change in the auxiliary variable. An asymmetric measure of association; a statistic computed as part of a regression analysis.
- *Regression estimate.* An estimate of a population parameter for one variable that is obtained by substituting the known total for another variable into a regression equation calculated on the basis of the sample values of the two variables. Note that ratio estimates are special kinds of regression estimates.
- *Symmetric measure of association.* A measure of association that does not make a distinction between independent and dependent variables.

Managers often need to determine the relationships between two or more variables prior to making a decision or for predicting and planning purposes or when analyzing a problem. When two variables are involved, simple linear regression and correlation analysis are the most often applied statistical tools for decision making. They provide a basis for analyzing two variables and their relationship to each other.

When more than two variables are involved, multiple regression analysis will be useful. Where only one independent variable is involved in the analysis, the technique is known as simple regression analysis; where two or more independent variables are involved, the technique is called multiple regression analysis (see Exhibit 1.5).

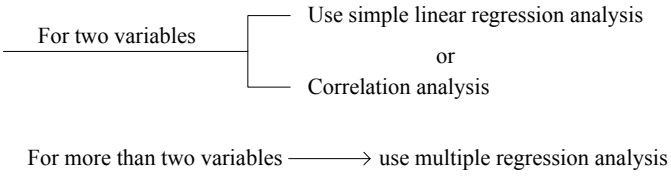


Exhibit 1.5: Simple regression and multiple regression

The basic diagram, or scatter plots, can be used to depict potential relationships between a dependent variable Y (e.g., sales) and an independent variable X (e.g., advertising). The scatter plot provides a visual feel for the relationship between variables (qualitative measurement). A dependent variable is the variable whose variation is of interest. An independent variable is a variable used to explain variation in the dependent variable. The independent variable is also called an explanatory variable. Three possible relationships can emerge from the scatter plots: (1) linear, (2) curvilinear, and (3) no relationship (see Exhibit 1.6).

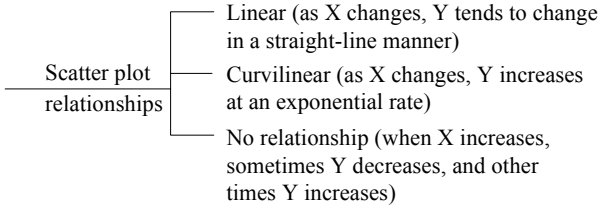


Exhibit 1.6: Scatter plot relationships

- **Linear.** As X changes, Y tends to change in a straight line or near straight-line manner. It can be positive change (Y increases as X increases) or negative change (Y decreases as X increases).
- **Curvilinear.** As X increases, Y increases at an exponential rate (example, as production increases, overtime is increasing at an exponential rate). As X increases, Y increases at a diminishing rate (example, as advertising is allowed to grow too large, diminishing returns will occur for sales).
- **No relationship.** When X increases, sometimes Y decreases, and other times Y increases.

In addition to qualitative measure (i.e., visual feel), quantitative measurement using *correlation coefficient* is needed to measure the strength between two variables. The correlation coefficient can range from a perfect positive correlation (+1.0) to a perfect negative correlation (-1.0). If two variables have no linear relationship, the correlation between them is zero. Consequently, the more the correlation differs from zero, the stronger the linear relationship between the two variables. The sign of the correlation coefficient indicates the direction of the relationship, but does not aid in determining the strength.

Example

Given four values of correlation coefficient, -0.15, -0.75, 0.19, and 0.35, which value indicates the weakest linear association between two variables. The value -0.15 has the weakest linear association because it is farther from -1.0.

USES OF REGRESSION ANALYSIS

Two basic uses of regression analysis are as a descriptive tool and as a predictive tool. The following are some examples for using the **descriptive tool:**

- To describe the relationship between a loan's term (number of months) and its dollar value by a loan officer in a bank. A positive linear relationship might exist between time and amount in which smaller loans would tend to be associated with shorter lending periods whereas larger loans would be for longer periods.
- To explain the meaning of economy as viewed by economists.
- To describe the factors that influence the demand for products as presented by market researchers.

The following are some examples for using the **predictive tool:**

- To predict manufacturing production levels
- To forecast annual tax revenues
- To predict inventory levels

To determine whether the linear relationship between sales and advertising is significant requires us to test whether the sample data support or refute the hypothesis that the population correlation coefficient is zero. A 't' statistic is used to test the hypothesis that the population coefficient is zero.

The correlation does not imply cause and effect, since two seemingly unconnected variables could often be highly correlated. When a correlation exists between two seemingly unrelated variables, the correlation is spurious at best. Even in the case of sales and advertising one might be tempted to say that a cause and effect exist, but in reality there is no guarantee of a cause-and-effect situation.

(i) **Simple linear regression analysis.** When the relationship between the dependent variable and the independent variable is a straight line, linear, the technique used for prediction and estimation is called the simple linear regression model. Exhibit 1.7 shows simple linear regression where the plotted data represents the heights of boys of various ages. The straight line represents the relationship between height (the dependent variable) and age (the independent variable) as disclosed by regression analysis. If the change in the dependent variable associated with a change in the independent variable does not occur at a constant rate, the relationship can be represented by a curved line and is referred to as curvilinear.

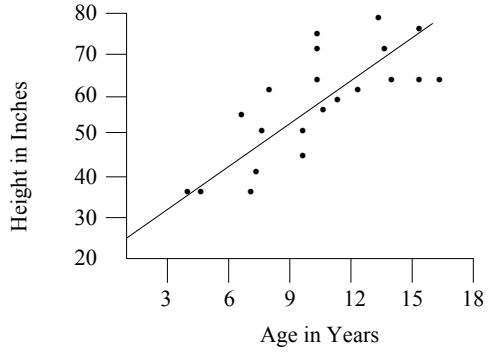


Exhibit 1.7: Simple linear regression

The simple linear regression model is represented by the following equation:

$$Yi = ß0 + ß1\ Xi + ei$$

Where *Yi* is the value of the dependent variable, *Xi* is the value of the independent variable, ß0 is the *Y*-intercept (a regression coefficient defining the true population model), ß1 is the slope of the regression line (a regression coefficient defining the true population model), and *ei* is the error term or residual and is a random component.

The random component is the difference between the actual *Y* value and the value of *Y* predicted by the model, and *i* could be positive or negative, depending on whether a single value of *Y* for a given *X* falls above or below the regression line. These *ei* values will have a mean of zero and a

standard deviation called the standard error of the estimate. If this standard error is too large, the regression model may not be very useful for prediction.

Here, the regression model connects the averages of dependent variable *Y* for each level of the independent variable, *X*. The regression line, a straight line, is determined by two values, ß0 and ß1.

Simple Regression Analysis

In simple regression analysis, the correlation coefficient measures the strength of the linear relationship between any two variables (X and Y); the analysis of variance "F" test indicates whether the regression model explains a significant proportion of variation in the dependent variable.

Managers would like to estimate the true linear relationship between dependent and independent variables by determining the regression model using sample data. A scatter plot can be drawn with the sample data to estimate the population regression line. The least squares criterion is used to select the best line since many possible regression lines exist for a sample of data. According to the least squares criterion, the best regression line is the one that minimizes the sum of squared distances between the observed (X,Y) points and the regression line. *Residual is the difference between the true regression line and the actual* Y *value.*

(ii) **Assumptions of the simple linear regression model.** The following list provides assumptions of the simple linear regression model:

- Individual values of the dependent variable, *Y*, are statistically independent of one another.
- For a given *X* value, there can exist many values of *Y*. Further, the distribution of possible *Y* values for any *X* value is normal.
- The distribution of possible *Y* values have equal variances for all values of *X*.
- The means of the dependent variable, *Y*, for all specified values of the independent variable can be connected by a straight line called the population regression model.

The following are some major considerations in using regression analysis as a predictive tool:

- Note that conclusions and inferences made from a regression line apply only over the range of data contained in the sample used to develop the regression line. The applicable range of data is called the" relevant range of data." Any predictions beyond the relevant range of data would lead to "overpredictions." Thus, the range of data in the sample should cover the range of data in the population. Then only a true relationship between the dependent variable and the independent variable will emerge.
- Be aware of the fact that a significant linear relationship existing between two variables does not imply that one variable causes the other. Although there may be a cause-and-effect relationship, managers should not infer the presence of such a relationship based only on regression and/or correlation analysis. Other factors such as judgment, experience, and knowledge of the specific area of interest should also be considered.
- A cause-and-effect relationship between two variables is not necessary for regression analysis to be used for prediction. It is important to make sure that the regression model accurately reflects the relationship between the two variables and that the relationship remains stable.
- A high *coefficient of determination* (R^2) does not guarantee that the regression model will be a good predictor. The R^2 applies only to the sample data—measuring the fit of the regression line to the sample data—not to any other data.

The least squares regression line minimizes the sum of squared residuals. This value is called the sum of squares error (SSE). It represents the amount of variation in the dependent variable that is not explained by the least squares regression line, the amount of variation in the dependent variable that is explained by the regression line is called the sum of squares regression (SSR).

$$SSR = TSS - SSE$$

where TSS is the total sum of squares explaining the amount of total variation in the dependent variable.

The percentage of the total variable in the dependent variable which is explained by the independent variable is called the coefficient of determination (R^2). R^2 can be a value between zero and 1.0. R^2 indicates how well the linear regression line fits the data points (X,Y). *The better the fit, the closer R^2 will be to 1.0.*

INTERPRETATION OF R^2

- R^2 is 1.0 when there is a perfect linear relationship between two variables.
- R^2 will be close to zero when there is a weak linear relationship or no linear relationship at all.

When R^2 is 1.0, it corresponds to a situation in which the least squares regression line would pass through each of the points in the scatter plot. Least square criterion ensures that R^2 will be maximized. R^2 applies only to the sample data used to develop the model.

APPLICATION OF REGRESSION ANALYSIS

Example 1

XYZ Company derived the following cost relationship from a regression analysis of its monthly manufacturing overhead cost.

$$C = \$80{,}000 + \$12\ M$$

where C is monthly manufacturing overhead cost and M is machine hours. The standard error of estimate of the regression is $6,000. The standard time required to manufacture a case of the company's single product is four machine hours. XYZ applies manufacturing overhead to production on the basis of machine hours, and its normal annual production is 50,000 cases.

Question: What is the estimated variable manufacturing overhead cost for a month in which scheduled production is 5,000 cases?

Answer: In the cost equation C = $80,000 + $12 M, $80,000 is the fixed cost component and $12M is the variable cost component. That is, $12 x 5,000 cases x 4 machine hours per case = $240,000.

Question: What is the predetermined fixed manufacturing overhead rate?

Answer: Since $80,000 is the fixed component per month, we need to multiply this by 12 to obtain one year fixed cost. The predetermined overhead rate per machine hour is ($80,000 x 12)/(50,000 x 4) = $4.80.

Example 2

The linear regression equation, Y=15.8 + 1.1(x), was used to prepare the data table below.

Actual X	*Predicted Y*	*Actual Y*	*Residual*
0	15.8	10	-5.8
1	16.9	18	1.1
2	18.0	27	9.0
3	19.1	21	1.9
4	20.2	14	-6.2

Question: What do you conclude from the above data table?

Answer: The best description of the data is that the relationship is not linear. A linear equation was used with nonlinear relationship. If the relationship was linear, the results of actual Y would have been higher than or equal to 15.8; it is not. Two values (10 and 14) are less than 15.8, indicating a nonlinear relationship.

(iii) **Multiple regression analysis.** Regression analysis is used for prediction and description to determine the relationship between two or more variables. The multiple regression analysis technique analyzes the relationship between three or more variables, and is an extension of the simple regression analysis. *In simple regression analysis, there is only one independent variable. In multiple regression analysis, there is more than one independent variable.* Exhibit 1.8 presents a comparison between simple regression and multiple regression analysis.

Characteristics of simple regression	*Characteristics of multiple regression*
• Sales is a dependent variable and advertising expenditures is an independent variable. • The model is an equation for a straight line in a two-dimensional space. • Each regression coefficient represents a slope and involves a matrix algebra. • Can use graph or calculator to solve the problem. Use of computer is optional. • The correlation coefficient is calculated.	• House price is a dependent variable and square feet of house, age of house, number of bedrooms, and number of bathrooms are examples of independent variables. • The model forms a hyperplane through multidimensional space. • Each regression coefficient represents a slope and involves a matrix algebra. • Must use computer to solve the problem. • The correlation matrix is calculated.

Exhibit 1.8: A comparison between simple regression and multiple regression

From a theoretical viewpoint, the sample size required to compute a regression model must be at least one greater than the number of independent variables, that is, for a model with four independent variables, the absolute minimum number of case samples required is five. Otherwise, the model will produce meaningless values. From a practical standpoint, the sample size should be at least four times the number of independent variables.

SIMPLE REGRESSION VS. MULTIPLE REGRESSION

- When there are two variables (one dependent and one independent), we call it a bivariate or simple regression.
- When thee are more than two variables (one dependent and more than one independent), we call it a multivariate or multiple regression.
- The multivariate model offers a better fit than the bivariate model.

(iv) **Assumptions of the multiple regression model.** The following list provides assumptions about the multiple regression model:

- The errors are normally distributed.
- The mean of the error terms is zero.
- The error terms have a constant variance for all combined values of the independent variables.

In multiple regression analysis, additional independent variables are added to the regression model to explain some of the yet-unexplained variation in the dependent variable. Adding appropriate additional variables would reduce the standard error of the estimate where the value of the latter is too large for the regression model to be useful for prediction.

The *correlation matrix* is useful for determining which independent variables are likely to help explain variation in the dependent variable. A value of ± 1.0 indicates that changes in the independent variable are linearly related to changes in the dependent variable.

Similar to simple regression, multiple regression uses R^2, the multiple coefficient determination, and is determined as follows:

$$R^2 = \frac{\text{Sum of squares regression}}{\text{Total sum of square}} = \frac{SSR}{TSS}$$

Example

If R^2 is 0.75, then 75% of the variation in the dependent variable can be explained by all independent variables in the multiple regression model.

When highly correlated independent variables are included in the regression model, a condition of overlapping called **multicollinearity** can exist. Specifically, when two independent variables are correlated with each other, adding redundant information to the model, multicollinearity does exist in practice. The best practical advise is to drop the independent variable(s) that is the main cause of the multicollinearity problems from the model.

Multicollinearity influences the regression model negatively—the regression coefficient sign is the opposite of the expected sign. The independent variable causing multicollinearity is not necessary to the functioning of the model and hence can be removed without any loss. It is highly correlated with other independent variables and has low correlation with the dependent variable.

(v) **Symptoms of multicollinearity in regression.** The following list provides symptoms of multicollinearity in regression analysis:

- Incorrect signs on the coefficients
- A change in the values of the previous coefficients when a new variable is added to the model
- The change to insignificant of a previously significant variable when a new variable is added to the model
- An increase in the standard error of the estimate when a variable is added to the model

Not all independent variables contribute to the explanation of the variation in a dependent variable. Some variables are significant, but not all. *The significance of each independent variable can be tested using a "t" test. It is calculated by dividing the regression coefficient by the standard deviation of the regression coefficients.*

"F" TEST VS. "t" TEST

- The "F" test is used to explain the significance of just one independent variable.
- The "t" test is used to explain the significance of each independent variable. Multicollinearity affects the "t" test.

The regression model used for prediction should contain significant independent variables only. If insignificant variables exist, they should be removed and the regression model rerun before it is used for prediction purposes. *Any coefficient with an unexpected sign indicates a problem condition. Unexpected sign implies unreasonable relationships between variables.*

Developing a multiple regression model is an art and requires judgment when selecting the best set of independent variables for the model that are less in conflict and contributing to best predictor.

(vi) **Dummy variables in regression models.** When an independent variable in a regression model is a nominal or ordinal variable, it is called a qualitative variable. For example, in a model for predicting individual income, each manager may assign different values for a potential qualitative variable, for example, sex (male or female), affecting the regression analysis.

In order to assign unique numerical values for these qualitative variables, dummy variables are added to the regression model. Rules for dummy variables include: if the qualitative variable has two possible categories (e.g., male or female), one dummy variable is added, and for more than two possible categories, one less than the number of possible categories is added (i.e., for five categories, only four dummy variables). Not following these rules would introduce the unwanted multicollinearity and the fact that least squares regression estimates cannot be obtained if the number of dummy variables equals the number of possible categories. Dummy variables take on values of zero and one, and they represent the qualitative variables in the regression analysis.

(vii) **Regression methods.** Basically, there are two methods for developing a regression model: (1) ordinary regression and (2) stepwise regression (see Exhibit 1.9).

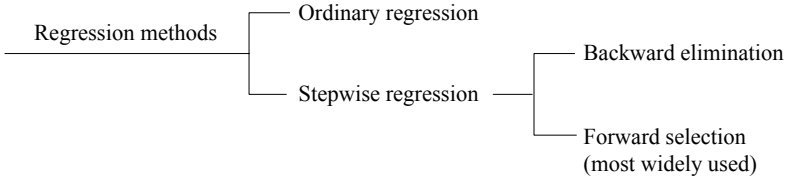


Exhibit 1.9: Regression methods

In the **ordinary regression method,** all independent variables are brought into the model at one step. The **stepwise regression method** develops the least squares regression equation in steps, either through backward elimination or through forward selection.

(A) ***Backward elimination.*** The backward elimination stepwise method begins by developing an ordinary regression model using all independent variables. All insignificant independent variables are eliminated in a stepwise fashion. The only independent variables left are the ones that have coefficients that are significantly different from zero. The advantage is that the manager

has the opportunity to look at all the independent variables in the model before removing the variables that are not significant.

(B) ***Forward selection.*** The forward selection procedure works in the opposite direction of the backward elimination procedure. It begins by selecting a single independent variable that is highly significant—the one highly correlated with the dependent variable. In the next step, a second independent variable is selected based on its ability to explain the remaining unexplained variation in the dependent variable.

The forward selection procedure prevents multicollinearity from occurring. It does this by dropping an insignificant variable that is causing the overlap from the model. The forward selection procedure is widely used in decision-making applications and is generally recognized as a useful regression method. Because the selection process is automatic by the computer, the manager needs to use his judgment to make sure the regression model is usable and meaningful.

(viii) **Econometrics.** The application of statistical methods to economic data is called econometrics. It analyzes the relationships between economic variables. Econometrics uses multiple regression analysis.

Example

Recent events caused the time-series used by an electric utility company to become too unpredictable for practical use. An econometric model is developed to predict the demand for electricity based on factors such as (1) class of service, (2) population growth, and (3) unemployment in the area of service. Since there are three independent variables, multiple regression is used.

(c) **Sensitivity Analysis.** Sensitivity analysis is an evaluation of how certain changes in inputs results in what changes in outputs of a model or system (see Exhibit 1.10).

Changes in inputs $\xrightarrow{\text{Lead to}}$ Changes in outputs

Exhibit 1.10: Scope of sensitivity analysis

The primary reason that sensitivity analysis is important to managers is that real-world problems exist in a dynamic environment. Change is inevitable. Prices of raw materials change as demand fluctuates, changes in the labor market cause changes in production costs. Sensitivity analysis provides the manager the information needed to respond to such changes without rebuilding the model. For example, bank management can use sensitivity analysis technique to determine the effects of policy changes on the optimal mix for its portfolio of earning assets.

Computer simulation techniques can be used to perform sensitivity analysis. The capability to ask "what if" questions is one of the biggest advantages of computer simulation. Next, sensitivity analysis is presented for manufacturing applications, linear programming applications, financial applications, network applications, and inventory applications.

(i) **Manufacturing applications.** The linking of production process improvement to financial results is critical to a successful computer-integrated manufacturing implementation. Management has established priorities: to decrease process variability, to shorten feedback time, and to reduce support functions. A process model was developed with the following parameters: facilities and equipment cost, theoretical materials consumption, actual materials consumption, and supplies cost. Sensitivity analysis was used to study the behavior of those parameters.

Sensitivity analysis was applied to the process model to compare the cash flows associated with various plan alternatives. Testing the model for changes in several parameters indicated that the model is sensitive to process inefficiency, product yields, volume variation, and price variations. Conversely, the model is relatively insensitive to change in labor costs.

The relationships between increased labor efficiency and gross profit can be studied using sensitivity analysis in a manufacturing plant environment.

(ii) **Linear programming applications.** Sensitivity analysis is the study of how changes in the coefficient of a linear program affect the optimal solution. The optimal solution is a feasible solution that maximizes or minimizes the value of the objective function. The objective function is used to measure the profit or cost of a particular solution.

Sensitivity analysis associated with the optimal solution provides valuable supplementary information for the decision maker. In the linear programming case, sensitivity analysis can be used to answer questions such as

- How will a change in a coefficient of the objective function affect the optimal solution?
- How will a change in the right-hand side value for a constraint affect the optimal solution?

However, there is one prerequisite prior to making the above changes, that is, optimal solution to the original linear programming problem needs to be in place. The changes are applied to the optimal solution. For this reason sensitivity analysis is often called postoptimality analysis. For example, in a production environment, sensitivity analysis can help determine how much each additional labor hour is worth and how many hours can be added before diminishing returns set in.

(iii) **Financial applications.** Integer linear programming techniques have been successfully used to solve capital budgeting problems. Only the integer variables are permitted to assure the values of zero or one. They could be of either the all-integer or the mixed-integer type. Fractional values of the decision variable are not allowed. The firm's goal is to select the most profitable projects and budgets for the capital expenditures. The outcome is usually whether the project is accepted (a value of 1) or rejected (a value of zero).

Another advantage of using an integer linear programming technique in a capital budgeting is its ability to handle multiple-choice constraints such as multiple projects under consideration and only one project can be selected in the end.

Sensitivity analysis is more critical for integer linear programming problems than that for linear-programming problems because a small change in one of the coefficients in the constraints can cause a large change in the value of the optimal solution. An example would be that one additional dollar in the budget can lead to a $20 increase in the return.

(iv) **Network applications.** Sensitivity analysis can be performed on the network. It provides the ability for checking the feasibility of current schedules and for permitting management to "experiment" with or evaluate the effects of proposed changes.

(v) **Inventory applications.** It is good to know how much the recommended order quantity would change if the estimated ordering and holding costs had been different. Depending on whether the total annual cost increased, decreased, or remained the same, we can tell whether the economic order quantity (EOQ) model is sensitive or insensitive to variations in the cost estimates.

(d) **Simulation Models.** The primary objective of simulation models is to describe the behavior of a real system. A model is designed and developed and a study is conducted to understand the behavior of the simulation model. The characteristics that are learned from the model are then used to make inferences about the real system. Later, the model is modified (asking "what if" questions) to improve the system's performance. The behavior of the model in response to the "what if" questions is studied to determine how well the real system will respond to the proposed modifications. Thus, the simulation model will help the decision maker by predicting what can be expected in practice. A key requisite is that the logic of the model should be as close to the actual operations as possible. In most cases, a computer is used for simulation models.

Computer simulation should not be viewed as an optimization technique, but as a way to improve the behavior or performance of the system. Model parameters are adjusted to improve the performance of the system. When good parameter settings have been found for the model, these settings can be used to improve the performance of the real system.

The steps involved in a computer simulation model include

- A computer simulation model that "behaves like" or simulates the real world system is developed.
- A series of computer runs or experiments is performed to learn about the behavior of the simulation model.
- The design of the model is changed to determine if the modifications improve the system performance. "What if" questions are asked of the model in this step. Thus, the simulation model helps the manager in predicting the future.

Usually, a computer simulator is used to conduct a simulation exercise on a computer. The simulator run by computer programs would perform mathematical calculations and keep track of the simulation results. Examples of calculations in a retail store environment include

- Number of customers serviced at a retail store during the twenty hours of simulated operations
- The average profit per hour per store
- Number of lost customers at a store per hour
- Average dollar loss per hour per store due to lost customers

Generic computer programming languages such as BASIC, FORTRAN, and PASCAL can be used to develop computer simulators. More specific simulation languages such as SIMSCRIPT, GPSS are favored due to their powerful and few programming statements required compared to many statements needed for generic languages.

(i) **Simulation applications in forecasting.** The following list describes simulation applications in forecasting:

- To perform a role play in order to reflect reality in a person being trained
- To study the performance of a waiting line system
- To simulate traffic flow through a busy street intersection to determine the number of traffic signals required for improving the traffic
- To simulate airplane flight conditions for training pilots
- To simulate the behavior of an inventory system in order to determine the best order quantity and reorder point
- To undergo a "dry run" evacuation in an office due to fire in a high-risk building
- To create mock disasters to provide experience in dealing with crisis situations such as product tampering, power outages, and flood
- To train auditors by providing financial statements and operating data to conduct a financial audit or an operational audit, respectively

(ii) **Simulation procedures and approaches.** Computer simulation is performed using the two basic procedures: (1) heuristic and (2) probabilistic, as shown in Exhibit 1.11.

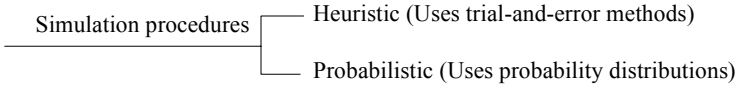


Exhibit 1.11: Simulation procedures

Heuristic procedures do not require probabilistic components. A variety of deterministic values are generated for the decision variables, and the best of the feasible solutions is selected.

When **probabilistic distributions** are involved, it is called the Monte Carlo simulation. Model inputs such as the number of customer arrivals in a service center are generated from probability distributions. These models are based on probabilities and time intervals of outcomes. When probabilities are involved, it is called a stochastic model.

Two approaches exist to the logic and recordkeeping of a simulation model: fixed time period and next event. In the fixed time period approach, each time period is of equal length, and the state of the system is updated at either the beginning or the end of each time period. The time between system updates is fixed.

In the next event approach, the time between arrivals and the time to complete service is randomly generated for a customer. The state of the system would be updated each time there was either a customer arriving or a customer completing service. The time between system updates is variable. Exhibit 1.12 presents advantages and disadvantages of simulation models.

ANALYTICAL PROCEDURES VS. COMPUTER SIMULATION

- Analytical procedures are best used to solve simple problems.
- Computer simulation is best used to solve complex problems.

Advantages of simulation models	*Disadvantages of simulation models*
• Solves complex problems where analytical procedures cannot be used. • Provides a convenient experimental laboratory. "What if" questions can be asked of the model. • Then danger of obtaining bad solutions to a problem is slight and the consequences have no effect on the organization. • The model can be run long enough to reach a steady state that will enable the manager to identify the apparent best decisions. • Learning is active for participants. • Mistakes are made in a risk-free environment. • Time spans can be compressed for key problems • Provides immediate feedback concerning proper and improper actions or decisions. Corrective action is timely	• There is a high cost of model development for design and programming. • The model does not guarantee an optimal solution to a problem. Decision variables are selected that have a good chance of being near the optimal solution. Also, not all values of the decision variables are tried in the model because it is costly to do so. • Simulation may not be able to replicate all situations or complexities that may arise in a real-world case. • Participants may tend to generalize from the model. It can create a "false sense of confidence" concerning their ability to cope with reality.

Exhibit 1.12: Advantages and disadvantages of simulation models

The sequence of model activities is

Model validation → Model implementation

Model validation is a step in the simulation procedure.

(iii) **Simulation model validation.** Validation involves verifying that the simulation model accurately describes the real-world system it is designed to simulate. The purpose of model validation is to make sure that it is a reasonable reflection of the real world. *The following methods will help to validate the model:*

- The simulation results can be compared with the current and past behavior of the real system. The model is run with an actual set of past observations and the output is compared directly with the behavior of the actual system.
- The model is reviewed by experts evaluating the reasonableness of the simulation model and the simulation results.
- The assumptions made during model construction need to be revisited, clarified, expanded, and adjusted as needed.
- The model is peer reviewed or desk-checked by programming staff to detect errors. *Improper programming of the model can lead to inaccurate results.*
- The simulated distributions for the probabilistic components can be compared with the corresponding probability distributions in the real system.
- It is good to collect the data on the system after it has reached a stable, or steady-state condition. Management is interested in what happens during "normal" business hours of operation. The steady-state condition of the model is synonymous with the "normal" hours of operation.

(iv) **Simulation model implementation.** Model implementation includes steps such as searching for errors, searching for exceptions, searching for gaps between actual and expected, searching for overlaps or duplications between procedures, and searching for root causes of poor implementation.

1.4 Project Management Techniques

In order for projects to be successfully implemented, they must be well managed. Many organizations apply a variety of project management techniques to optimize project success and enhance the likelihood of meeting project-specific as well as organization-wide goals. These techniques include monitoring project performance, establishing incentives to meet project goals, and developing a project management team with the right people and the right skills. This can help avert cost overruns, schedule delays, and performance problems common to many organizations.

It is important to develop **performance measures** and link project outcomes to business unit and strategic goals and objectives. The key is monitoring project performance and establishing incentives for accountability, and using cross-functional teams to involve those with the technical and operational expertise necessary to plan and manage the project.

Typically, a **project plan** is used to manage and control project implementation and includes performance measurement baselines for schedule and cost, major milestones, and target dates and risks associated with the project. By tracking cost, schedule, and technical performance, a project team is aware of potential

problem areas and is able to determine any impact of the deviation and decide if corrective action is needed. Regular review of the status of cost, schedule, and technical performance goals by individuals outside the project team allows for an independent assessment of the project and verification that the project is meeting stated goals.

Major projects should include **multidisciplinary teams,** consisting of individuals from different functional areas and led by a project manager, to plan and manage projects. Typically, a core project team is established early in the life cycle of a project and additional individuals with particular technical or operational expertise are added during appropriate phases of the project. The team must not only possess technical and operational expertise, but it must also be composed of the "right" people. The selection of the team members is critical—they must be knowledgeable, willing to trade off leadership roles, and able to plan work and set goals in a team setting. The successful team will have a high spirit, trust, and enthusiasm. A sense of ownership and the drive of the team committed to a project are key factors in the successful completion of a project. This integrated and comprehensive approach improves communication between upper management and project managers and among the various stakeholders in the project. It also increases the likelihood that potential problems will be identified and resolved quickly, thus increasing the chances that the project will remain on schedule and within budget.

(a) **Why Project Management?** Management needs to know what parts of the project or program are most likely to cause serious delays. This knowledge will lead to management actions that will achieve the project or program objectives and deadlines.

When is project management preferred? The project management approach is the preferred method for dealing with projects defined onetime. The task is very complex and involves interdependence between a number of departments. The task has great significance to the organization. Onetime tasks can be accomplished with a minimum interruption of routine business. Exhibit 1.13 shows factors responsible for a successful performance of a project as well as symptoms of project management failures.

Managers need to coordinate diverse activities toward a common goal. Management must devise plans, which will tell with reasonable accuracy how the efforts of the people representing these functions should be directed toward the project's completion. In order to devise such plans and implement them, management must be able to collect pertinent information to accomplish the following tasks:

- To form a basis for prediction and planning
- To evaluate alternative plans for accomplishing the objective
- To check progress against current plans and objectives
- To form a basis for obtaining the facts so that decisions can be made and the job can be done

A single master plan for a project should include planning, scheduling, and controlling functions. The plan should point directly to the difficult and significant activities—the problem of achieving the objective. For example, the plan should form the basis of a system for management by exception. It should indicate the exceptions (red flags). Under such a system, management need act only when deviations from the plan occur.

A reporting system should be designed for middle to senior management to use. The monthly progress report calls for specific reestimate only for those events on critical paths and subcritical events. It should accomplish the following tasks:

- Preparing a master schedule for a project
- Revising schedules to meet changing conditions in the most economical way
- Keeping senior management and the operating department management advised of project progress and changes

Plans should be separated from scheduling. Planning is the act of stating what activities must occur in a project and in what order these activities must take place. Scheduling follows planning and is defined as the act of producing project timetables in consideration of the plan and costs. Controlling is ensuring that plans are accomplished. The correct sequence is

Planning → Scheduling → Controlling

Project structure is a characteristic of all projects that provides for all work being performed in some well-defined order. For example: In research and development and product planning, specifications must be determined before drawings can be made. In advertising, artwork must be made before layouts can be done.

Factors responsible for successful performance of a project	*Symptoms of project management failures*
• The organization of the project • The authority of the project manager • Scheduling and planning techniques used • The project manager's good relationship with senior management • The use of resources, including slack time	• High costs • Schedule overruns • Poor-quality product • Failure to meet project objectives • Customer or user dissatisfaction with the end result

Exhibit 1.13: Successful factors and symptoms of project management

(b) **Project Management's Basic Guidelines.** The following list provides basic guidelines for project management:

1. **Define the objective(s) of the project.** This includes defining management's intent in undertaking the project, outlining the scope of the project, and describing the end results of the project including its effects on the organization.
2. **Establish a project organization.** This includes appointment of one experienced manager to run the project full-time, organization of the project management function in terms of responsibilities, assignment of manpower to the project team, and maintenance of a balance of power between the functional department managers and the project manager.
3. **Install project controls.** This includes controls over time, cost, and quality.

(c) **Project Controls.** In any project, there will be at least three types of controls applied: (1) time control, (2) cost control, and (3) quality control.

(i) **Time control.** Project network scheduling begins with the construction of a diagram that reflects the interdependencies and time requirements of the individual tasks that make up a project. It calls for work plans prepared in advance of the project. Once the overall schedule is established, weekly or biweekly review meetings should be held to check progress against schedule. Control must be rigorous, especially at the start, so that missed commitments call for immediate corrective action.

(ii) **Cost control.** Periodic reports showing the budget, the actual cost, and variances is a good start for cost controls. It is necessary to break the comprehensive cost summary reports into work packages or major tasks and focus on major problems and opportunities. The cost reports should be distributed to technical as well as functional managers alike.

(iii) **Quality control.** Quality control comprises three elements: defining performance criteria, expressing the project objective in terms of quality standards, and monitoring progress toward these standards. Examples of performance criteria include market penetration of a product line, processing time for customer inquiries, and the like. Both quantitative and qualitative measures need to be defined.

(d) **Project Organization.** Project organization is where the reporting relationships and the work location rest predominantly with the project manager. Three common types of project organization include traditional structure, matrix organization, and hybrid form (see Exhibit 1.14).

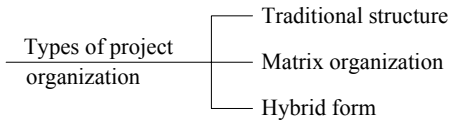


Exhibit 1.14: Types of project organization

In **traditional structure,** the basic interrelationship was with the functional manager. A hierarchy of reporting relationships is followed. In **matrix organization,** most of the personnel were directly responsible to the project manager for work assignments but remained physically located with their functional manager. Other forms include combining a large project team with several small functional teams or basic functional teams with a small project task force.

The matrix team members must learn new ways of relating and working together to solve cross-functional problems and to attain synergy. According to Dr. Jack Baugh[2] of Hughes Aircraft Company, the matrix management structure must be used when there is (1) a rapid technological advancement, a need for timely decisions, (2) a vast quantity of data to be analyzed, (3) an increased volume of new

[2] ***WINGS: Project Leaders Guide,*** *Volumes 1 and 2, AGS Management Systems, King of Prussia, PA, 1986. Original citation by Dr. Jack Baugh of Hughes Aircraft Company.*

products and services to be introduced, (4) a need for simultaneous dual decision making, and (5) a strong constraint on financial and/or human resources.

He also cited reasons for using a matrix management structure as (1) providing a flexible adaptive system, (2) providing timely, balanced decision making, (3) permitting rapid management response to a changing market and technology, (4) training managers for ambiguity, complexity, and executive positions, and (5) helping in synergizing and motivating human resources.

Hybrid form is the best possible option since it can achieve technical excellence, and, at the same time, meet cost and schedule deadlines.

Project authority is a measure of the degree of control the project manager has over all the activities necessary to complete the project successfully. Delays can be reduced if the project manager can make decisions without having to wait for the approval of someone "higher up." This type of delay is often the cause of schedule and cost overruns.

The authority of the project manager is seldom spelled out in formal directives or policies. The traditional forms of management—one man, one boss—is simply not adequate for completing projects.

The conflict is between the project manager and the functional manager. It is the influence rather than authority that matters. What counts is the priority assigned to the project, and the experience and personal characteristics of the project manager. *There may not be any relation between the formal authority of the project manager and the actual success of the project.*

KEY CONCEPTS TO REMEMBER: MOST COMMON REASONS FOR PROJECT MANAGEMENT FAILURES

- The basis for a project is not sound.
- The wrong person is appointed as the project manager.
- Company management fails to provide enough support.
- Task definitions are inadequate.
- Management monitoring techniques are not appropriate.
- Project termination is not planned properly (that is, to reduce adverse effect on the employee's progress in the company after the project is completed).
- Redefinitions of the project's scope are unclear.
- Large-scale design changes are occurring.
- The need for additional funding is not approved.

(e) **Problems in Project Management.** Project managers face unusual problems in trying to direct and harmonize the diverse forces at work in the project situation. Their main difficulties arise from three sources: (1) organizational uncertainties, (2) unusual decision pressure, and (3) inadequate senior management support (see Exhibit 1.15).

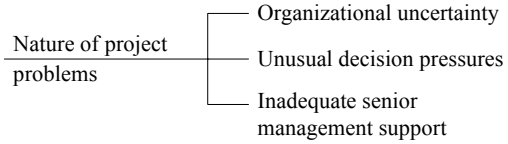


Exhibit 1.15: Nature of project problems

(i) **Organizational uncertainty.** The working relationships between the project manager and the functional department managers have not been clearly defined by senior management. Uncertainties arise with respect to handling delays, cost overruns, work assignments, and design changes. Unless the project manager is skillful in handling these situations, senior management may resolve them in the interest of functional departments, at the expense of the project as a whole.

(ii) **Unusual decision pressures.** When uncertainties are added to the situation, the project manager has to make his decisions based on limited data and with little or no analysis. He must move fast, even if it means an intuitive decision that might expose him to senior managements' criticism. *Decisions to sacrifice time for cost, cost for quality, or quality for time, are common in most projects.* There is a clear indication that the project manager needs support from senior management due to these trade-offs.

(iii) **Inadequate senior management support.** Senior management can seldom give the project manager as much guidance and support as his line counterpart gets. Delays in initial approval of the project by senior management, inability to resolve conflicts between the project manager and the functional department managers, and delays in allocating resources are the most common issues on which the project manager needs more attention from senior management. Otherwise, project performance can be hampered.

(f) **Project Scheduling Techniques.** Six project scheduling techniques are discussed in this section, including program evaluation and review techniques, critical path methods, line-of-balance method, graphical evaluation and review techniques, work breakdown structure, and Gantt chart (see Exhibit 1.16).

- Program evaluation and review technique (uses probabilities and three-time estimates, focus is on time)
- Critical path method (uses probabilities and a single-time estimate, focus is on cost)
- Line-of-balance technique (does not use probabilities, shows out-of-balance operating conditions)
- Graphical evaluation and review technique (uses probabilities, handles mutually-exclusive activities)
- Work breakdown structure (does not use probabilities, provides a conceptual organization of a project)
- Gantt chart (does not use probabilities, focus is on presentation status)

Exhibit 1.16: Project scheduling techniques

(i) **Program evaluation and review techniques.** Project management frequently uses network diagrams to plan the project, evaluate alternatives, and control large and complex projects toward completion. Program evaluation and review techniques (PERT) requires extremely careful plans from the very outset of the project. This allows management to allocate resources to critical areas before they become critical. This will alert a manager to trouble areas or bottlenecks before they become a major problem and the source of a project overrun. PERT also helps to allocate resources, but has no influence on the excellence of the end product.

PERT improves communication upward to the manager and the customer (client). PERT lets the supervisor believe that the project manager is doing a superior job, regardless of how well the project manager is actually performing.

(A) ***PERT features.*** The following list provides features of PERT:

- Manages "one-of-a-kind programs, as opposed to repetitive tasks. It develops a network diagram that identifies the sequence of events and their relationships to one another along with estimated start and completion times.

Sensitivity Analysis and PERT

Sensitivity analysis can be performed on the network. It provides the ability for checking the feasibility of current schedules and for permitting management to "experiment" with or evaluate the effects of proposed changes.

- Uncertainties involved in programs can be handled where no standard cost and time data are available.
- It includes a network comprised of events and activities. An event represents a specified program accomplishment at a particular instant in time. An activity represents the time and resources, which are necessary to progress from one event to the next.
- Events and activities must be sequenced on the network under a highly logical set of ground rules, which allow the determination of critical and subcritical paths. These ground rules include: the fact that no successor event can be considered completed until all of its

predecessor events have been completed, and no looping is allowed, that is, no successor event can have an activity dependency which leads back to a predecessor event.

- Time estimates are made for each activity of the network on a three-way basis: optimistic, most likely, and pessimistic. The three time estimates are required as a gauge of the "measure of uncertainty" of the activity, and represent the probabilistic nature of many tasks. The three estimates are reduced to a single expected time and a statistical variance.

(B) ***PERT assumptions.*** Interrelationships of activities are depicted in a network of directed arcs (arcs with arrows, which denote the sequence of the activities they represent). The **nodes,** called events, represent instants in time when certain activities have been completed and others can then be started. All inwardly-directed activities at a node must be completed before any outwardly-directed activity of that node can be started. A **path** is defined as an unbroken chain of activities from the origin node to some other node. The origin node is the beginning of the project. An **event** is said to have occurred when all activities on all paths directed into the node representing that event have been completed.

Another assumption of PERT is that all activities are started as soon as possible. This assumption may not hold true when scarce resources must be allocated to individual activities.

(C) ***PERT applications.*** The development of a critical path network is accomplished by establishing the major milestones that must be reached. Construction of the network diagram requires identification and recording of the project's internal time dependencies—dependencies that might otherwise go unnoticed until a deadline slips by or impacts other activities. A new activity can be added by identifying its successor and predecessor.

An ordered sequence of events to be achieved would constitute a valid model of the program. The network provides a detailed, systematized plan and time schedule before the project begins. As the project progresses, the time estimates can be refined. A top-down approach is taken when developing the network. The total project is fully planned and all components of the plan are included.

Applications of PERT and CPM

- Construction and maintenance of chemical plant facilities, highways, dams, buildings, railroads, and irrigation systems
- Planning of retooling programs for high-volume products in plants such as automotive and appliance plants
- Introduction of a new product
- Installation of a computer system
- Acquisition of a company

Critical path scheduling helps coordinate the timing of activities on paper and helps avert costly emergencies. The network diagram must be developed in detail as much as possible so that discrepancies, omissions, and work coordination problems can be resolved inexpensively, at least to the extent that they can be foreseen.

Project diagrams of large projects can be constructed by sections. Within each section the task is accomplished one arrow at a time by asking and answering the following questions for each job:

- What immediately preceded this job?
- What immediately succeeds (follows) this job?
- What can be concurrent with this job?

If the maximum time available for a job equals its duration, the job is called critical. A delay in a critical job will cause a comparable delay in the project completion time. A project contains at least one contiguous path of critical jobs through the project diagram from beginning to end. Such a path is called a critical path.

Meaning of the Critical Path

Typically only about ten to fifteen percent of the jobs in a large project are critical. The primary purpose of determining the "critical path" is to identify those activities that must be finished as scheduled if the new program or project is to be completed on time. The "critical path" of those activities cannot be delayed without jeopardizing the entire program or project.

If the maximum time available for a job exceeds its duration, the job is called a **floater**. Some floaters can be displaced in time or delayed to a certain extent without interfering with other jobs or the completion of the project. Others, if displaced, will start a chain reaction of displacements downstream in the project.

The technological ordering is impossible if a cycle error exists in the job data (i.e., job "a" preceded "b," "b" precedes "c," and "c" precedes "a"). The time required to traverse each arrow path is the sum of the times associated with all jobs on the path. The critical path (or paths) is the longest path in time from start to finish; it indicates the minimum time necessary to complete the entire project.

In order to accurately portray all predecessor relationships, "dummy jobs" must often be added to the project graph. The critical path is the bottleneck route; only by finding ways to shorten jobs along the critical path can the overall project time be reduced; the time required to perform noncritical jobs is irrelevant from the viewpoint of total project time.

(D) ***PERT approach.*** The status of a project at any time is a function of several variables such as resources, performance, and time. Resources are in the form of dollars, or what "dollars" represent—manpower, materials, energy, and methods of production; and technical performance of systems, subsystems, and components. An optimum schedule is the one that would properly balance resources, performance, and time.

Information concerning the inherent difficulties and variability in the activity being estimated are reflected in the three numbers: the optimistic, pessimistic, and most likely elapsed time estimates should be obtained for each activity. The purpose of the analysis is to estimate, for each network event, the expected times (mean or average) and calendar time of occurrence (TE).

When PERT is used on a project, the three time estimates (optimistic, most likely, and pessimistic) are combined to determine the expected duration and the variance for each activity.

- **Optimistic.** An estimate of the minimum time an activity will take. This is based on everything "going right the first time." It can be obtained under unusual, good luck situations.
- **Most likely.** An estimate of the normal time an activity will take, a result which would occur most often if the activity could be repeated a number of times under similar circumstances.
- **Pessimistic.** An estimate of the maximum time an activity will take, a result that can occur only if unusually bad luck is experienced.

The expected times determine the critical path, and the variances for the activities on this path are summed to obtain the duration variance for the project. A probability distribution for the project completion time can be constructed from this information. However, the variances of activities, which do not lie on the critical path are not considered when developing the project variance, and this fact can lead to serious errors in the estimate of project duration.

An estimate of the length of an activity is an uncertain one. A stochastic model can be used to reflect this uncertainty. This model measures the possible variation in activity duration. This may take the form of a distribution showing the various probabilities that an activity will be completed in its various possible completion times. Alternatively, this may be nondistribution such as range or standard deviation.

$$\text{The expected time} = 1/6\,(a + 4m + b)$$

Where a is optimistic time, m is most likely time, and b is pessimistic time. The expected activity times derived from a three-estimate, PERT-type calculation provides a more accurate

estimate and allows the activity time variance to be calculated and included in the estimates of project duration.

APPLICATION OF PERT

Example

A company is planning a multiphase construction project. The time estimates for a particular phase of the project are

Optimistic	2 months
Most likely	4 months
Pessimistic	9 months

Question: Using PERT, what is the expected completion time for this particular phase?

Answer: The expected completion time would be 4.5 months, as shown below.

The expected time = 1/6 (a + 4m + b) = 1/6 (2 + 4x4 + 9) = 27/6 = 4.5.

The latest calendar time at which an event must be accomplished so as not to cause a slippage in meeting a calendar time for accomplishing the objective event is referred to as the "latest time," and denoted as *TL*. The difference between the latest and expected times, *TL–TE*, is defined as **slack**. Slack can be taken as a measure of scheduling flexibility that is present in a workflow plan, and the slack for an event also represents the time interval in which it might reasonably be scheduled. Slack exists in a system as a consequence of multiple path junctures that arise when two or more activities contribute to a third.

What is Slack Time?

Slack time is a free time associated with each activity as it represents unused resources that can be diverted to the critical path. Noncritical paths have slack time while critical paths have no slack time.

A slack is extra time available for all events and activities not on the critical path. A negative slack condition can prevail when a calculated end date does not achieve a program date objective established earlier.

The manager must determine valid means of shortening lead times along the critical path by applying new resources or additional funds, which are obtained from those activities that can "afford" it because of their slack condition. "Safety factor" is another name for "slack." Alternatively, the manager can reevaluate the sequencing of activities along the critical path. If necessary, those activities, which were formerly connected in a series can be organized on a parallel or concurrent basis, with the associated trade-off risks involved. Alternatively, the manager may choose to change the scope of work of a critical path alternative in order to achieve a given schedule objective.

When some events have **zero slack,** it is an indication that the expected and latest times for these events are identical. If the zero-slack events are joined together, they will form a path that will extend from the present to the final event. This path can be looked upon as "the critical path." Should any event on the critical path slip beyond its expected date of accomplishment, then the final event can be expected to slip a similar amount. The paths having the greatest slack can be examined for possible performance or resource trade-offs.

When jobs or operations follow one after another, there is no slack. The criteria for defining a subcritical event is related to the amount of slack involved in the event. Those events having as much as five weeks slack have been deemed subcritical.

The PERT analysis permits a quantitative evaluation of conceivable alternatives. Each job in the project is represented by an arrow, which depicts the existence of the job and the direction of time-flows from the tail to the head of the arrow. The arrows are then connected to show graphically the sequence in which the jobs in the project must be performed. The junctions where arrows meet are called events. These are points in time when certain jobs are completed and others must begin.

The difference between a job's early start and its late start (or between early finish and late finish) is called total slack (TS). Total slack represents the maximum amount of time a job may be delayed beyond its early start without necessarily delaying the project's completion time.

KEY CONCEPTS TO REMEMBER: PERT TIME DIMENSIONS

ES = Earliest start time for a particular activity
EF = Earliest finish time for a particular activity
EF = ES + t, where t is expected activity time for the activity
LS = Latest start time for a particular activity
LF = Latest finish time for a particular activity
LS = LF − t, where t is expected activity time for the activity
Slack = LS – ES = LF –EF

The manager examines the work demand and indicates if sufficient resources are available to accomplish all jobs by their early finish. If resources are insufficient, activities are rescheduled within their late finish, using project priority, and available slack. Later, the manager is asked for additional resources or for a decision to delay an activity beyond its late finish.

Critical jobs are those on the longest path throughout the project. That is, critical jobs directly affect the total project time.

If the target date (T) equals the early finish date for the whole project (F), then all critical jobs will have zero total slack. There will be at least one path going from start to finish that includes critical jobs only, that is, the critical path. There could be two or more critical paths in the network, but only one at a time.

If T is greater (later) than F, then the critical jobs will have total slack equal to T minus F. This is a minimum value; since the critical path includes only critical jobs, it included those with the smallest TS. All noncritical jobs will have greater total slack.

Another kind of slack is **free slack** (FS). It is the amount a job can be delayed without delaying the early start of any other job. A job with positive total slack may or may not also have free slack, but the latter never exceeds the former. For purposes of computation, the free slack of a job is defined as the difference between the job's EF time and the earliest of the ES times of all its immediate successors.

When a job has zero total slack, its scheduled start time is automatically fixed (i.e., ES + LS); and to delay the calculated start time is to delay the whole project. Jobs with positive total slack, however, allow the scheduler some discretion in establishing their start times. This flexibility can usefully be applied to smoothing work schedules.

Peak load may be relieved by shifting jobs on the peak days to their late starts. Slack allows this kind of juggling without affecting project time.

Possible data errors in PERT

- The estimated job time may be in error.
- The predecessor relationship may contain cycle errors (job *a* is a predecessor for *b*, *b* is a predecessor for *c*, and *c* is a predecessor for *a*).
- The list of prerequisites for a job may include more than the immediate prerequisites; (e.g., job *a* is a predecessor of *b*, *b* is a predecessor of *c*, and *a* and *b* both are predecessor of *c*).
- Some predecessor relationships may be overlooked.
- Some predecessor relationships may be listed that are spurious.
- The errors in the PERT calculated project's mean and standard deviation will tend to be large if many noncritical paths each have a duration approximately equal to the duration of the critical path. However, the more slack time there is in each of the noncritical paths, the smaller will be the error.

One way to minimize errors and omissions is to continually back-check the data and challenge the assumptions. Exhibit 1.17 presents advantages and limitations of PERT.

Advantages of PERT	*Limitations of PERT*
• Greatly improved control over complex development work and production programs. • Capacity to distill large amounts of data in brief, orderly fashion. • Requires a great deal of planning to create a valid network. • Represents the advent of the management-by-exception principle. • People in different locations can relate their efforts to the total task requirements of a large program. • "Downstream" savings are achieved by earlier and more positive action on the part of management in the early stages of the project.	• There is little interconnection between the different activities pursued. • Requires constant updating and reanalysis of schedules and activities. • Requires greater amount of detail work. • Does not contain the quantity information; only time information is available.

Exhibit 1.17: Advantages and limitations of PERT

(E) ***PERT implementation issues.*** The following list provides issues that should be considered during PERT implementation:

- The people and organization of a project are more important considerations than the use of a particular planning and control technique.
- Consideration should be given to managerial issues such as project organization, personalities of project members, and operating schemes.
- There is a big difference between the criteria of success for the task to be accomplished and the criteria of success for the management system.
- The project manager is a miniature general manager. He usually lacks the commensurate authority and depends on various management techniques to carry out his job.
- The project management approach is the preferred method to deal with onetime defined projects.
- The qualifications of a person making time estimates must include a thorough understanding of the work to be done.
- Precise knowledge of the task sequencing is required or planned in the performance of activities.

APPLICATIONS OF PERT

Example

The network in Exhibit A describes the interrelationships of several activities necessary to complete a project. The arrows represent the activities. The numbers above the arrows indicate the number of weeks required to complete each activity.

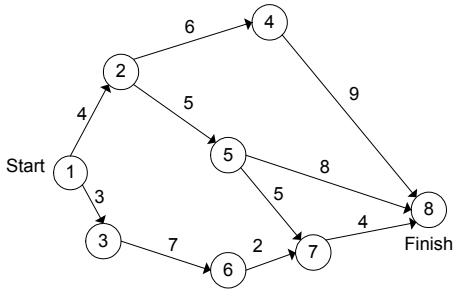


Exhibit A: PERT network

Question: What is the shortest time to complete the project?

Answer: The longest path from node (1) to node (8) is path 1-2-4-8. Since all other paths are shorter in duration than path 1-2-4-8, the activities along those paths can be completed before the activities along path 1-2-4-8. Therefore, the amount of time to complete the activities along path 1-2-4-8, which is 19 weeks (4+6+9), is the shortest time to complete the project.

Question: What is the critical path for the project?

Answer: The critical path is the sequence of activities that constrains the total completion time of the project. The entire project cannot be completed until all the activities on the critical path (the longest path) are completed.

Path 1-2-4-8 which takes 19 weeks is the critical path. Activities along each of the other three paths can be completed (each requires less than 19 weeks) before the activities along 1-2-4-8 can. The other three paths are: 1-2-5-8 (requires 4 + 5 + 8 = 17 weeks), 1-2-5-7-8 (requires 4 + 5 + 5 + 4 = 18 weeks), and 1-3-6-7-8 (requires 3 + 7 + 2 + 4 = 16 weeks).

Example

During an operational audit, an internal auditing team discovers the following document, entitled Project Analysis.

Project Analysis

Activity	*Time in weeks*	*Preceding activity*
A	3	--
B	3	A
C	7	A
D	4	A
E	2	B
F	4	B
G	1	C, E
H	5	D

Using the Project Analysis document, the audit supervisor prepares the PERT diagram shown in Exhibit B.

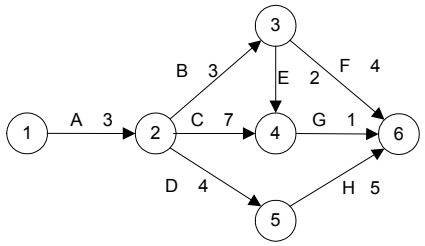


Exhibit B: PERT project analysis

Question: What is the earliest completion time that is indicated by the project analysis?

Answer: There are three paths.

Path 1	A–B–F	=	3 + 3 + 4	=	10 weeks
Path 2	A–C–G	=	3 + 7 + 1	=	11 weeks
Path 3	A–D–H	=	3 + 4 + 5	=	12 weeks

Path 3 has the earliest completion time of 12 weeks since it has the longest time to complete.

Question: What is the earliest time by which Node 4 would be reached?

Answer: There are two paths by which Node 4 can be reached.

Path A	A–C	=	3 + 7	=	10 weeks
Path B	A–B–E	=	3 + 3 + 2	=	8 weeks

Path A has the earliest time of 10 weeks to reach the Node 4 since it has the longest time.

(F) ***PERT cost.*** Once the network has been established, based on the project work breakdown structure, costs can be estimated. If the breakdown has been made satisfactorily, it will serve as both an estimating and actual cost accumulation vehicle. PERT cost adds the consideration of resource costs to the schedule produced by the PERT procedure. *The basic PERT handles the problem of time uncertainty while PERT cost addresses cost uncertainty.* Cost uncertainty as it relates to time can be handled by different cost estimates for three-time differences. The ultimate objective is not only to improve planning and control, but also to assess possibilities for "trading off" time and cost, that is, adding or subtracting from one at the expense of the other.

There is an "optimum" time-cost point for any activity or job as indicated by the "U" shape of the curve drawn between total direct cost (on y-axis) versus time (on x-axis). It is assumed that total costs will increase with any effort to accelerate or delay the job away from this point in

the case where resource application varies. *Crashing the project involves shortening the critical path or paths by operating on those activities that have the lowest time-cost slopes.*

At least three approaches are available to develop the cost estimates.

- A singe cost estimate of expected cost
- Three cost estimates
- Optimum time-cost curves

A **single cost estimate** of expected cost is based upon the summation of the individual cost elements. The three-cost estimate approach determines the "expected cost." The advantage of the **three-cost estimate** over the single-cost estimate is that the result is subject to probability analysis. With this expected cost, the manager cannot assume that he has the optimum time-cost mix.

The third approach to estimate is the **optimum time-cost curve concept**. This is differential costing with time as the variability factor. The intention of this approach is to optimize time and costs by using optimum estimated costs. It assumes there is a direct relationship between time and costs on any activity. This relationship can be expressed by a continuous curve. This method is also based upon the concept that activities are subject to time-cost tradeoffs. The optimum time-cost curve method is difficult to put into practice due to the need to develop continuous time-cost curves.

(ii) **Critical path method.** The critical path method (CPM) is a powerful but basically simple technique for analyzing, planning, and scheduling large, complex projects. In essence, the tool provides a means of determining which jobs or activities, of the many that comprise a project, are "critical" in their effect on total project time, and how best to schedule all jobs in the project in order to meet a target date at minimum cost. CPM is an extension of PERT.

Characteristics of project for analysis by CPM are

- The project consists of a well-defined collection of jobs or activities which, when completed, mark the end of the project.
- The jobs may be started and stopped independently of each other, within a given sequence.
- The jobs are ordered in a technological sequence (for example, the foundation of a house must be constructed before the walls are erected).

CPM focuses attention on those jobs that are critical to the project time, it provides an easy way to determine the effects of shortening various jobs in the project, and it enables the project manager to evaluate the costs of a "crash" program.

Normal Time and Crash Time

Time estimates for both normal and crash options are used in the CPM method. Crash time is the time required by the path if maximum effort and resources are diverted to the task along this path. A balance can be obtained when a project manager knows what the normal time and the crash time would be.

As needed, it is a costly practice to "crash" all jobs in a project in order to reduce total project time. If some way is found to shorten one or more of the critical jobs, then not only will the whole project time be shortened but the critical path itself may shift and some previously noncritical jobs may become critical. It is physically possible to shorten the time required by critical jobs by assigning more people to the jobs; working overtime; and using different equipment, materials, and technology.

When CPM is used in a project to develop a crashing strategy, two or more paths through the network may have nearly the same length. If the activity duration is allowed to vary, a decrease in the length of the critical path may not result in an equivalent decrease in the project duration because of the variance inherent in the parallel or alternate paths. These variations of activity times can even allow the alternate path to become a critical path. Thus, simply allowing the activity times to vary slightly from their estimates in order to make the length of the paths different can cause serious errors in a CPM crashing strategy and lead to wasted resources and cost overruns.

(A) ***Characteristics of CPM networks.*** The following list defines characteristics of CPM networks:

- CPM networks attempt to build the entire project "on paper" at a very early stage of the project—even when the scope is not defined, vaguely defined, or incorrectly defined. In a way, CPM is to project management what modeling or simulation is to economic studies, production problems, plant design, and transportation problems.
- CPM provides a graphic view of the entire project with completion dates, support activities, and costs affixed to every stage of the project.

Value of the Critical Path Techniques

The critical path techniques are as valuable on short- and middle-range planning jobs as they are on major and extremely complex projects.

- CPM's single time estimate fails to consider the effects of variability in path completion times on the crashing strategy.
- The CPM chart is an excellent tool for communicating scope as well as details of the job to other persons directly and indirectly concerned with the development and completion of its various phases.
- The CPM chart serves as a permanent record and reminder of the substance of this communication to all management levels.
- The CPM chart shows the timing of management decisions.
- CPM enables the manager to measure progress (or lack of it) against plans and to take appropriate action quickly when needed. And the underlying simplicity of CPM and its ability to focus attention on crucial problem areas of large projects makes it an ideal tool for the senior manager.

(B) ***CPM vs. PERT.*** CPM and PERT methods are essentially similar in general approach and have much in common. However, important differences in implementation details exist. They were independently derived and based on different concepts. Both techniques define the duration of a project and the relationships among the project's component activities. An important feature of the PERT approach was its statistical treatment of the uncertainty in activity time estimates, which involves the collection of three separate time estimates and the calculation of probability estimates of meeting specified schedule dates.

CPM differs from PERT in two areas.

1. The use of only one time estimate for each activity (and thus no statistical treatment of uncertainty)
2. The inclusion, as an integral part of the overall scheme, of a procedure for time/cost trade-off to minimize the sum of direct and indirect project costs

Common features of PERT and CPM.

- They both use a network diagram for project representation, in which diagram circles represent activities with arrows indicating precedence.
- They both calculate early and late start and finish times and slack time.

Exhibit 1.18 provides a comparison between CPM and PERT.

CPM	*PERT*
• CPM uses a single deterministic time estimate to emphasize minimum project costs while downgrading consideration of time restraints. • It is the choice of cost-conscious managers.	• PERT uses three time estimates to define a probabilistic distribution of activity times which emphasizes minimum project duration while downgrading consideration of cost restraints. • It tends to be used by time-conscious managers.

Exhibit 1.18: A comparison between CPM and PERT

While these two techniques are based on different assumptions, they are related to each other because of the obvious relationship between time and cost. *The "ideal" network technique would combine the concepts of CPM's crashing strategy with PERT's probability distribution of activity times to derive the optimum project duration and cost.*

(iii) **Line-of-balance technique.** Line-of-balance (LOB) is a basic tool of project management and was an early forerunner of PERT and CPM. LOB was not as popular as was PERT and CPM. The most successful applications involve methods such as CPM and PERT, which combine simplicity and clarity. These are managerial tools involving planning, scheduling, and control. *CPM and PERT require complicated mathematical models while LOB does not.*

Scope of LOB Technique

- LOB can be performed manually and can be used on large production jobs, maintenance jobs, research and development jobs, and construction jobs.
- LOB requires little training.
- Complex, large-scale LOB problems may require a computer to solve.

LOB is a managerial tool that can show, at a glance, what is wrong with the progress of a project. It can also point to future bottlenecks. The tool is easy to develop and maintain, manually or by computer. It forces the manager to make a plan for the program's completion, and it presents graphical information, which is sometimes unnoticeable in a large volume of data.

LOB is a dynamic tool that tells the manager what is wrong while the project is still going on. It is a simple technique, requiring no equations or models. It does not attempt to optimize operations, but it is a sound basic tool.

The main purpose of the LOB method is to prepare a progress study on critical operations at given times during the actual progress of the job. Each operation is checked against some target; that is, we find where each operation is with respect to where it ought to be. Operations that fall short of target are pointed out for further analysis. LOB uses the principles of "management by exception." *LOB allows the manager to pay special attention only to those activities which are both critical and do not conform to the schedule.*

The LOB technique involves four steps.

1. Developing an objective chart or delivery schedule
2. Preparing a program chart or plan of operation
3. Developing a progress chart including the line of balance
4. Performing analysis

The **objective chart** presents the cumulative delivery schedule of finished goods or services for the entire project in a graphical form. The LOB is graphically derived from the objective chart. It can also be calculated analytically, manually, or by computer.

The **program chart** is best constructed by working backwards, starting with the delivery of the finished product as lead time zero. It will show the schedule of each of the critical operations with completion dates and the source and/or responsibility for each operation.

The **progress char**t is a flow process with all critical operations performed from receipt of raw materials to completion.

The objective chart and the program chart are constructed only once whereas the progress charts must be developed from scratch each time the project is analyzed. The progress chart is therefore good only for a specified date. **Performing analysis** of the progress chart is the core of LOB. The analysis pinpoints "out-of-balance" operations. *It is customary to draw the objective chart, the program chart, and the progress chart on one sheet to get a big, quick picture of the entire project.*

LOB and PERT/CPM are complementary, although each can be used effectively by itself. The distinction between them is that PERT is primarily a planning and evaluation tool for "one-unit type" projects such as research and development with one completion date. PERT's major objective is to identify critical operations, but it can also be used as a control tool by pinpointing deviations from actual performance and rescheduling accordingly.

The line-of-balance monitors a project involving many units to be shipped at certain intervals. LOB can also be used in large projects with one completion date. LOB deals both with operations and components and inventories. PERT deals with only one unit and its critical operations. PERT in general requires a computer while LOB is essentially a graphic, manual tool.

LOB and PERT are related to each other. LOB can complement PERT in the following way: Once the critical path has been identified, it can be used as part of the "program" or the "production

plan" of LOB. Other thinking is that these two techniques can be integrated into a single management planning and control system that can be employed from planning stages through production and delivery for a given quantity of items.

Major assumptions of LOB include: that the production method is independent of quantities, that critical operations do not change with time, and that lead time is constant or known with certainty. These assumptions can be related, making the LOB method more complex.

Reasons for low popularity of LOB:

- Lack of awareness of the technique and its potential applicability and advantages
- Management skepticism, which is common to all new managerial techniques
- The lack of a "canned" computer program for LOB
- Lack of a sound delivery forecast which is necessary and which is difficult to obtain considering the difficulty of obtaining market demand and supply forecast
- Requires deterministic lead times (i.e., a single estimate) when in fact, a range is better

PERT VS. CPM VS. LOB

- PERT considers time domain only.
- CPM considers cost information only.
- LOB considers quantity information only.
- PERT is good for production prototype construction, assembly, and test of final production equipment that are still "high on the learning curve."
- PERT can be applied to smaller projects, single projects, large projects, and multi-projects.
- PERT, CPM, and LOB can be integrated to get maximum benefits.

(iv) **Graphical evaluation and review technique.** The Graphical Evaluation and Review Technique (GERT) system permits the modeling of a wide variety of situations not possible with traditional PERT\CPM models. Simulation programs can be used to implement GERT, since it uses "stochastic" networks, that is, networks in which certain arcs (representing activities) have designated probabilities of occurrence. GERT allows the performance of alternative, mutually-exclusive activities, which are not allowed in the PERT/CPM method. In GERT, activity performance times can be expressed as probability distributions. Heuristic sequencing rules are used to give good resource-feasible schedules.

(v) **Work breakdown structure.** The work breakdown structure (WBS) was first intended as the common link between schedules and costs in PERT cost application. Later, it became an important tool for conceptual organization of any project. The WBS provides the necessary logic and formalization of task statements. The WBS prepares the work packages, which usually represent the lowest division of the end items.

(vi) **Gantt chart.** The Gantt chart is a bar chart and is essentially a column chart on its side, and is used for the same purpose. The bar chart is horizontal. The bar chart is a tool that allows a manager to evaluate whether existing resources can handle work demand or whether activities should be postponed. The Gantt chart is used for milestone scheduling where each milestone has a start and completion date. A milestone represents a major activity or task to be accomplished (e.g., a design phase in a computer system development project).

The Gantt chart is a graphical illustration of a scheduling technique. The structure of the chart shows output plotted against units of time. It does not include cost information. It highlights activities over the life of a project and contrasts actual times with projected times using a horizontal (bar) chart. It gives a quick picture of a project's progress in knowing the status of actual time lines and projected time lines. Exhibit 1.19 presents advantages and disadvantages of PERT and Gantt charts.

Advantages

PERT

- A good planning aid.
- Interdependencies between activities can be shown.
- Network diagram is flexible to change.
- Activity times are probabilistic.
- A good scheduling tool for large, nonroutine projects.
- A good tool in predicting resource needs, problem areas, and the impact of delays on project completion.

Gantt chart

- A good planning tool.
- A graphical scheduling technique, simple to develop, use and understand.
- Useful for large projects.
- Shows a sequencing of steps or tasks.
- Actual completion times can be compared with planned times.

Disadvantages

PERT

- Difficult to apply to repetitive assembly-line operations where scheduling is dependent on the pace of machines.
- Large and complex projects are difficult to draw manually.
- Requires computer hardware and software to draw a complex network.
- Requires training to use the computer program.

Gantt chart

- Interrelationships among activities are not shown on the chart.
- Inflexible to change.
- Activity times are deterministic.
- Difficult to show very complex situations.
- Cannot be used as a procedure documenting tool.
- Does not show the critical path in a chain of activities.

Exhibit 1.19: Advantages and disadvantages of PERT and Gantt charts

WHAT ARE SOPHISTICATED TECHNIQUES FOR PROJECT MANAGEMENT?

- PERT, GERT, and CPM techniques are more sophisticated scheduling methods due, in part, to the consideration of probabilities.
- LOB, WBS, Gantt charts, bar charts, and milestones are less sophisticated scheduling methods due, in part, to not considering the probabilities.
- GERT handles alternate, mutually exclusive activities, while PERT/CPM cannot.

There may be a lower probability of a cost/schedule overrun if PERT is used because of its sophistication as a scheduling method compared to less sophisticated scheduling methods such as Gantt charts, milestone scheduling, line of balance, and bar charts. If there is a slack time, there is no need to use sophisticated and tight scheduling methods such as PERT.

1.5 Business Process Analysis

In a manufacturing company, the scope of process analysis starts from raw materials and ends up with finished goods shipping to customers. It includes all the transformation (processing) stages, inspection steps, and transportation stages. Similarly, in a service company the scope of process analysis starts, for example, with claims application and ends up with making payment to the claimant. The goal of process analysis is to facilitate change for improvement. This requires looking at not only the individual processes where problems exist but also the upstream and downstream processes that are related to the process in question. Process improvements can be made by rearranging equipment layout, plant layout, inspection points, and testing stages with the help of motion study, material study, time study, and material handling studies. In this effort, both product processes and service processes should be examined for waste, delays, and improvement.

(a) **Workflow Analysis.** Workflow analysis looks at the overall flow of work to find ways of improving this flow. It can reveal value-added and non-value-added activities (e.g., waste and delays) and identify interdependence among departments. The outcome would be eliminating the non-value-added activities and waste and improving efficiency and effectiveness. Assembling tasks, whether subassembly or final assembly, and process time are value-added activities of a manufactured product, while other activities are non-value-added activities. Examples of non-value-added activities from a customer's viewpoint include inspection time, move time, reporting time, governmental compliance time, storage time, wait time, and queue time.

Workflow systems would make organizations undergo huge managerial and cultural changes, help employees apply business rules, enable process reengineering, provide parallel processing of documents, eliminate information float or overload, and ensure that established policies and procedures are followed.

Workflow software allows business processes to be redesigned and streamlined and automatically routes work from employee to employee.

Interdependence means the extent to which departments depend on each other for resources or materials to accomplish their tasks. Low interdependence means that departments can do their work independent of each of other and have little need for interaction, consultation, or exchange of materials. High interdependence means departments must constantly exchange resources and materials.

There are three types of interdependence that influence organization structure: (1) pooled, (2) sequential, and (3) reciprocal. Pooled interdependence is the lowest form of interdependence among departments. Work does not flow between units. Each department is part of the organization and contributes to the common good of the organization, but works independently. When interdependence is of serial form, with parts or documents produced in one department becoming inputs to another department, then it is called sequential interdependence. Here departments exchange resources and depend upon others to perform well. The management requirements for sequential interdependence are more demanding than for pooled interdependence. These requirements include coordination, communication, integrators, and task forces. The highest level of interdependence is reciprocal interdependence. This exists when the output of operation A is the input to operation B, and the output of operation B is the input back again to operation A. The outputs of departments influence those departments in reciprocal fashion. Management requirements for the complex reciprocal interdependence include greater planning, coordination, communication, permanent teams, and frequent adjustments in the work and its associated plans.

(b) **Bottleneck Management.** Bottleneck is a constraint in a facility, function, department, or resource whose capacity is less than the demand placed upon it. For example, a bottleneck machine or work center exists where jobs are processed at a slower rate than they are demanded. Another example is where the demand for a company's product exceeds the ability to produce the product.

Bottleneck influences both product profitability and product price. The contribution margin per bottleneck hour or the value of each bottleneck hour should be analyzed. This measure is better than the normal contribution margin per unit. The contribution margin per hour of bottleneck can be used to adjust the product price to better reflect the value of the product's use of a bottleneck. Products that use a large number of bottleneck hour per unit require more contribution margin than products that use few bottleneck hours per unit.

(c) **Theory of Constraints.** Theory of constraints (TOC) is a manufacturing strategy that attempts to remove the influence of bottlenecks on a process. According to Dr. Eliyahu M. Goldratt, TOC consists of three separate but interrelated areas: (1) logistics, (2) performance measurement, and (3) logical thinking. Logistics include drum-buffer-rope scheduling, buffer management, and VAT analysis. Performance measurement includes throughput, inventory and operating expense, and the five focusing steps. Logical thinking process tools are important in identifying the root problems (current reality tree), identifying and expanding win-win solutions (evaporating cloud and future reality tree), and developing implementation plans (prerequisite tree and transition tree).

Drum-buffer-rope scheduling is the generalized process used to manage resources to maximize throughput. The drum is the rate or pace of production set by the system's constraint. The buffers establish the protection against uncertainty so that the system can maximize throughput. The rope is a communication process from the constraint to the gating operation that checks or limits material released into the system to support the constraint.

Buffer management is a process in which all expediting in a factory shop is driven by what is scheduled to be in the buffers (constraint, shipping, and assembly buffers). By expediting this material into the buffers, the system helps avoid idleness at the constraint and missed customer due dates. In addition, the causes of items missing from the buffer are identified, and the frequency of occurrence is used to prioritize improvement activities.

VAT analysis is a procedure for determining the general flow of parts and products from raw materials to finished products (the logical product structure). A "V" logical product structure starts with one or few raw materials, and the product expands into a number of different products as it flows through divergent points in its routings. The shape of an "A" logical product structure is dominated by converging points. Many raw materials are fabricated and assembled into a few finished products. A "T" logical product structure consists of numerous similar finished products assembled from common assemblies, subassemblies, and parts. Once the general parts flow is determined, the system control points (gating

operations, convergent points, divergent points, constraints, and shipping points) can be identified and managed.

The five focusing steps is a process to continuously improve organizational profit by evaluating the production system and the marketing mix to determine how to make the most profit using the system constraint. The steps consist of (1) identifying the constraint to the system, (2) deciding how to exploit the constraint to the system, (3) subordinating all nonconstraints to the system, (4) elevating the constraint to the system, and (5) returning to step 1 if the constraint is broken in any previous step, while not allowing inertia to set in.

1.6 Inventory Management Techniques and Concepts

From inventory management viewpoint, demand is of two types: independent demand and dependent demand. Independent demand inventory systems are based on the premise that the demand or usage of a particular item is independent of the demand or usage of other items. Examples include finished goods; spare parts; material, repair, and operating (MRO) supplies; and resale inventories.

(a) **Independent Demand Inventory Systems.** Independent demand inventory systems are "pull" systems in that materials are pulled from the previous operation as they are needed to replace materials that have been used. An example: finished goods are replaced as they are sold. These types of inventory systems answer the question of when to place the replenishment order and how much to order at one time. Reorder point models and fixed/variable order quantity models (e.g., Economic order quantity, or EOQ) are examples of independent demand inventory systems as they do review inventory either continuously or periodically. Four possibilities exist, including

- Continuous review and fixed order quantity
- Periodic review and fixed order quantity
- Continuous review and variable order quantity
- Periodic review and variable order quantity

(b) **Dependent Demand Inventory Systems.** Dependent demand inventory systems are based on the premise that the demand or usage of a particular item is dependent on the demand or usage of other items. Examples include raw materials, work-in-process inventories, and component parts.

(c) **Inventory Levels and Investment Levels.** A company manages its inventory by using various methods and approaches (e.g., EOQ). Inventory consists of raw materials, work in process, and finished goods. Efficient inventory management is needed to support sales, which is necessary for profits. Benefits such as high turnover rate, low write-offs, and low lost sales can be attributed to efficient inventory management. These benefits, in turn, contribute to a high profit margin, a higher total asset turnover, a higher rate of return on investment, and a strong stock price. Inventory management is a major concern for product-based organizations (e.g., manufacturing, retail), since 20 to 40% of their total assets is inventory and as such, poor inventory control will hurt the profitability of the organization.

KEY CONCEPTS TO REMEMBER: INVENTORY MANAGEMENT

- The larger the amount of inventories held, the longer the inventory conversion period, hence the longer the cash conversion cycle.
- The smaller the amount of inventories held, the shorter the inventory conversion period, hence the shorter the cash conversion cycle.
- A shorter cash conversion cycle is preferred over a longer cash conversion cycle.
- Errors in establishing inventory levels can lead to lost sales, lost profits, or increased costs.
- A lower investment in inventories will increase the rate of return on investment, and the value of the firm's stock increases.
- Too much of reduced investment in inventories could lead to lost sales due to stockouts or to costly production slowdowns.

Inventory levels and account receivables levels directly depend upon sales levels. Receivables arise after sales have been made while inventory must be acquired or produced ahead of sales. Inventory managers have the responsibility to maintain inventories at levels which balance the benefits of reducing the level of investment against the costs associated with lowering inventories. A company's inventory is re-

lated to the amount of expected sales. The company's financial forecasting of inventory in the following year would be most accurate when applying simple linear regression method.

(d) **Efficient Inventory Management.** Efficient inventory management focuses on three areas: (1) investment in inventory, (2) optimal order quantity, and (3) reorder point (see Exhibit 1.20).

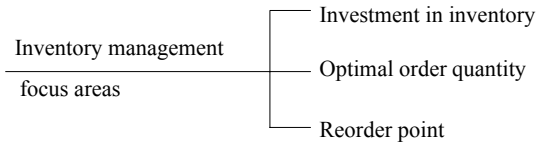


Exhibit 1.20: Inventory management focus areas

(e) **Investment in Inventory.** Investment in inventory depends on the actual level of inventory carried. The relevant question is how many units of each inventory item the firm should hold in its stock. Two types of stock concepts must be understood: (1) working stock and (2) safety stock. The actual level of inventories carried will equal the sum of the working stocks and safety stocks.

Working stock. A working stock is needed to meet normal, expected production and sales demand levels. Producing more goods than are currently needed increases the firm's carrying costs and exposes it to the risk of obsolescence if demand should fall. Remember that demand for sales is uncertain. Economic order quantity (EOQ) establishes the working stock amount. EOQ is discussed later in this section.

Safety stock. A safety stock is needed to guard against changes in sales rates or delays in production and shipping activities. Safety stock is additional stock beyond the working stock and satisfies when demand is greater than expected. The additional costs of holding the safety stock must be balanced against the costs of sales lost due to inventory shortages. Safety stock will not affect the reorder quantities.

KEY CONCEPTS TO REMEMBER: SAFETY STOCK

- The optimum safety stock increases with the uncertainty of sales forecasts, lost sales resulting from inventory shortages, and probability of delays in receiving shipment.
- The optimum safety stock decreases as the cost of carrying it increases.

Effective management requires close coordination and communication among the various functional departments of the organization such as the marketing, sales, production, purchasing, and finance departments. Sales plans need to be converted into purchasing and production plans producing finished goods and for acquiring raw materials; financing plans are needed to support the inventory build-up.

Since inventories need to be available prior to sales, an increase in production to meet increased sales requires an increase in notes payable (a liability account). Since assets (inventories) are increasing, liability (notes payable) must also increase.

Investment in inventory is not complete without discussing the various costs associated with inventories due to their direct relationships. The cost structure affects the amount and type of investment needed. Three types of inventory-related costs are: (1) carrying costs, (2) ordering costs, and (3) stock-out costs, as shown in Exhibit 1.21.

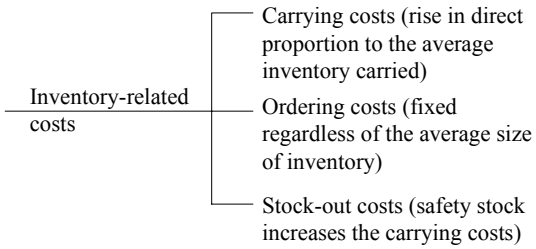


Exhibit 1.21: Inventory-related costs

(i) **Carrying costs.** The costs associated with carrying inventories, including storage, capital, and depreciation costs are known as carrying costs. Carrying costs rise in direct proportion to the average

amount of inventory carried which, in turn, depends on the frequency with which orders are placed. That is, an increase in the frequency of inventory ordering will reduce total carrying costs.

$$\text{Annual total carrying costs} = (C)\,(P)\,(A)$$

Where C = Percentage cost of carrying inventory, that is, capital cost + storage cost + insurance + depreciation and obsolescence cost + property taxes divided by average inventory value. P = Percentage price per unit. A = Average number of units, i.e., (annual sales\number of orders) divided by 2. (P). (A) = Average inventory value.

(ii) **Ordering costs.** The cost of placing and receiving an order is known as the ordering costs, which is fixed regardless of the average size of inventories.

$$\text{Total ordering costs} = (F)\,(N) = (F)\,(S\backslash Q)$$

Where F = Fixed costs associated with ordering inventories, N = Number of orders per year, S = Sales in units, and Q = Quantity ordered in units.

$$\text{Total inventory cost} = \text{Total carrying cost} + \text{Total ordering cost}$$

(iii) **Stock-out costs.** Safety stock reduces stock-out costs. The safety stock is useful in protecting against delays in receiving orders. However, safety stock has a cost. The increase in average inventory resulting from the safety stock causes an increase in inventory carrying costs.

CARRYING COSTS VS. ORDERING COSTS VS. STOCK-OUT COSTS

- The components of **carrying costs,** which increase in proportion to the average amount of inventory held, include the costs of capital tied up in inventory, storage, and handling costs, insurance premiums, property taxes, depreciation, and obsolescence cost.
- The components of **ordering costs,** which are fixed regardless of the average size of inventories, include the cost of placing orders including production setup and shipping and handling costs.
- The components of **stock-out costs,** which are costs of running short, include the loss of sales, the loss of customer goodwill, and problems or delays in production schedules.

(f) **Optimal Order Quantity.** How many units should be ordered or produced at a given time is a major question faced by the inventory manager. Either too much or too little inventory is not good. An optimum inventory level is designed and is found through the use of the economic order quantity (EOQ) model. EOQ provides the optimal, or least-cost, quantity of inventory that should be ordered.

If a company's cost of ordering per order increases while carrying costs per order remain the same, the optimal order size as specified by the EOQ model would increase.

EOQ cost characteristics.

- The point at which the total cost curve is minimized represents the EOQ, and this, in turn, determines the optimal average inventory level. Here, total cost is the sum of ordering and carrying costs.
- Some costs rise with larger inventories whereas other costs decline.
- The average investment in inventories depends on how frequently orders are placed.
- Ordering costs decline with larger orders and inventories due to reduced order frequency.

If Q is the order quantity, then the how-much-to-order decision involves finding the value of Q that will minimize the sum of holding and ordering costs.

$$\text{Q} = \text{EOQ} = \sqrt{\frac{2\text{D Co}}{\text{Ch}}}$$

Where D is annual sales demand in units, Co is cost of placing one order, Ch is cost of holding (or carrying) one unit in inventory for the year.

Note that the data needed to calculate EOQ includes: the volume of product sales, the purchase price of the products, the fixed cost of ordering products, and carrying costs. It does not include: the volume of products in inventory, inventory delivery times, delays in transportation, or quality of materials.

Due to the square root sign, a given increase in sales will result in a less than proportionate increase in inventories, and the inventory turnover ratio will thus increase as sales grow.

(g) **Reorder Point.** Another major problem facing the inventory manager is at what point should inventory be ordered or produced. The point at which stock on hand must be replenished is called "reorder point." It is also the inventory level at which an order should be placed. The formula is

$$\text{Reorder point} = \text{Lead time} \times \text{Usage rate}$$

Where lead time is the time lag required for production and shipping of inventory. Usage rate is the usage quantity per unit of time (note: the time period should be the same in both lead time and usage rate (i.e., days, weeks, or months).

A complication in the calculation of the reorder point arises when we introduce a concept of "goods-in-transit." This situation occurs when a new order must be placed before the previous order is received. The formula for a reorder point when goods-in-transit is considered is

$$\text{Reorder point} = (\text{Lead time} \times \text{Usage rate}) - (\text{Goods-in-transit})$$

KEY CONCEPTS TO REMEMBER: REORDER POINT

- Goods-in-transit are goods that have been ordered but have not been received.
- A goods-in-transit situation exists if the normal delivery lead time is longer than the time between orders.

(h) **Inventory Decisions.** Inventory managers face two decision rules in the management of inventories: "how-much-to-order" and "when-to-order" that will result in the lowest possible total inventory cost. The how-much-to-order decision rule can be satisfied with the use of an economic order quantity (EOQ). This decision rule involves selecting an order quantity that draws a compromise between (1) keeping smaller inventories and ordering frequently (results in high ordering costs), and (2) keeping large inventories and ordering infrequently (results in high holding costs). The when-to-order decision rule can be satisfied with the use of a reorder point.

ORDERING COST VS. HOLDING COST

- Ordering costs are the costs associated with placing an order and include salaries of the purchasers, paper, postage, telephone, transportation, and receiving costs.
- Holding costs are the costs associated with carrying a given level of inventory; these costs are dependent on the size of the inventory. They include interest cost for the capital tied up in inventory, opportunity cost associated with not being able to use the money for investment, insurance fees, taxes, pilferage, and damage, as well as other warehouse overhead costs.

(i) **Calculating How Much to Order.** The focus of EOQ method is on the quantity of goods to order that will minimize the total cost of ordering and holding (storing) goods. EOQ is a decision model that focuses on the trade-off between carrying costs and ordering costs. It calculates the order quantity that minimizes total inventory costs. Calculus is used in determining the EOQ.

EOQ is appropriate for managing the finished goods inventories, which have independent demands from customers or from forecasts. The holding cost, the ordering cost, and the demand information are the three data items that must be prepared prior to the use of the EOQ model. If Q is the order quantity, then the how-much-to-order decision involves finding the value of Q that will minimize the sum of holding and ordering costs.

$$Q = EOQ = \sqrt{\frac{2D\,Co}{Ch}}$$

Where *D* is annual demand, *Co* is cost of placing one order, *Ch* is cost of holding one unit in inventory for the year.

Annual inventory holding cost is directly related to the amount of inventory carried. The EOQ will rise following an increase in the fixed costs of placing and receiving an order.

Exhibit 1.22 describes costs for inventory. Line A represents annual total cost, Line B represents total annual inventory holding costs, Line C represents the minimum-total-cost order quantity, and Line D represents total annual ordering cost.

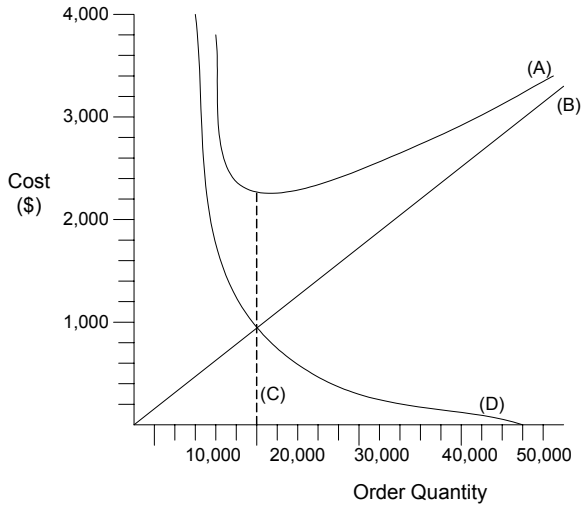


Exhibit 1.22: Cost for inventory

CALCULATION OF OPTIMUM ORDER SIZE

Example

A firm expects to sell 1,000 units of product X during the coming year. Ordering costs are $100 per order and carrying costs (holding costs) are $2 per unit per year.

Question: Using the EOQ model, what is the optimum order size?

Answer: The optimum order size is 217, as shown below.

The answer is to find the square root of (2 × $100 × 1,000)/$2. This is the square root of 100,000, or 317.

(j) **EOQ Assumptions.** Two major assumptions of EOQ include the following: (1) The demand for an item is constant. Since the constant demand assumption is not realistic, managers would have to be satisfied with the near-minimum-cost order quantity instead of a minimum-total-cost order quantity. (2) The entire quantity ordered arrives at one point in time. Again, this may not be realistic because some vendors will deliver partial shipments. Managers usually add a judgmental value-based order quantity to the EOQ suggested order quantity to accommodate unrealistic assumptions of constant demand rate by the EOQ model.

Specific assumptions of the EOQ model include

- Sales can be forecasted perfectly. This is unreal.
- Sales are evenly distributed throughout the year. This is not real. What about seasonal or cyclical demands?
- Orders are received without delay. This is also unreal.
- Fixed costs, carrying costs, and purchase prices are all fixed and independent of the ordering procedures. This is not possible either.

Controls in Material Requirement Cycle

EOQ models, ABC inventory analysis, JIT, and Kanban systems are commonly used controls in material requirements cycle.

(k) **Sensitivity Analysis and EOQ.** It is good to know how much the recommended order quantity would change if the estimated ordering and holding costs had been different. Depending on whether the total

annual cost increased, decreased, or remains the same, we can tell whether the EOQ model is sensitive or insensitive to variations in the cost estimates.

(l) **Calculating When to Order.** The when-to-order decision rule is expressed in terms of a reorder point as follows:

$$r = d\ m,$$

Where r is reorder point, d is demand per day, m is lead time for a new order in days.

The cycle time answers how frequently the order will be placed, and it can be calculated as follows: cycle time is number of working days in a year *divided by* number of orders that will be placed in a year.

(m) **Safety Stock and Stockouts.** Safety stock is the amount of extra stock that is kept to protect against stockouts. Running out of an inventory item is called a stockout situation. Safety stock is the inventory level at the time of reordering minus the expected usage while the new goods are in transit.

The goal is to minimize both the cost of holding a safety stock and the cost of stockouts. EOQ is not relevant to stockouts. Production bottlenecks leads to a stockout. Factors to be considered in controlling stockouts include time needed for delivery, rate of inventory usage, and safety stock.

(n) **ABC Inventory Control System.** ABC is a method of classifying inventory based on usage and value. Expensive, frequently used, high stock-out cost items with long lead times are most frequently reviewed in an ABC inventory control system. Inexpensive and infrequently used items are reviewed less frequently.

APPLICATION OF ABC INVENTORY SYSTEM

Example

A firm uses an ABC inventory control system. About 10% of inventory items are classified into group A. Another 20% are in group B. The remainder are in group C. Which classification is most likely to hold the greatest number of days of supply?

a. Group C
b. Group B
c. Group A
d. All groups are likely to have an equal number of days of supply

Answer **(a)** is the correct answer. Group C items are low-dollar-value items and receive less management attention. Extensive use of models and records is not cost effective. It is cheaper to order large quantities infrequently. Group A items are high-dollar value and management would try to keep investment in such items low. Therefore, by definition, choices b, c, and d are incorrect.

(o) **Effects of Inflation on Inventory Management.** There is no evidence that inflation either raises or lowers the optimal level of inventory of firms in the aggregate level. It should be considered since it will raise the individual firm's optimal inventory holdings if the rate of inflation is above average, and vice versa.

Decision rules and consequences of inflation are

- For a moderate inflation, it is safe to ignore inflation and the benefit is not worth the effort.
- For a relatively constant inflation, subtract the expected annual rate of inflation from the carrying cost percentage (C) in the EOQ model and recalculate the EOQ. Since the carrying cost will be smaller, the recalculated EOQ and the average inventory will increase.
- For higher inflation, the higher the rate of inflation, the higher the interest rates will be, and this will cause carrying cost to increase and thus lower the EOQ and average inventories.

(p) **Just-in-Time Systems.**

(i) **JIT strategy.** Just-in-time (JIT) is a production strategy to continuously improve productivity and quality. It is based on the belief that small could be better, not "more" is better. An effective JIT strategy encompasses the entire product life cycle from the acquisition of raw materials to delivery of the end product to the final customer. *The scope includes topics such as JIT purchasing, processing, inventory, and transportation.* Each topic is discussed next.

JIT is based on management principles such as eliminate waste; produce to demand and one-at-a-time; think long-term; develop, motivate, trust, and respect people; and achieve continuous im-

provement. This is made possible when the focus is "quality at the source" and the tools used are statistical process control methods, fail-safe methods, and problem-solving methods. Quality at the source means producing perfect parts every time and all the time. The major benefits of JIT strategy are improved productivity, quality, service, and flexibility and reduced costs, inventory investment, lead times, lot sizes, and physical space.

(ii) **JIT purchasing.** JIT purchasing requires a partnership between a supplier and a customer, which is a major departure from the traditional purchasing. JIT supplier relations call for long-term partnerships with single source suppliers who provide certified quality materials while continuously reducing costs. The JIT supplier's manufacturing processes must be under statistical process control and their capability should be certified by the customer. The statistical process control charts serve as the documentation to assure that the process stayed in control during the time the parts were made.

Just-in-Time (JIT) Purchasing

Under JIT purchasing, competitive bidding may not occur prior to selecting a supplier because of sole sourcing, single sourcing, or dual sourcing approaches taken. The supplier is selected based on quality, commitment to excellence, and performance, not cost.

A JIT supplier is expected to support the production flow with frequent, small lot shipments, which can be used immediately by the customer. Usually, no inspection is required at the receiving side of the materials.

A JIT supplier will have to become a JIT producer with the idea of pushing costs out of the supply chain, not to pass costs down to the next supplier. Since the JIT supplier is considered as a partner, the customer must notify plant disruptions, temporary shutdowns, or anticipated engineering changes so that the supplier can make adjustments to his production schedules and inventory plans. This requires sharing of information and open communications.

TRADITIONAL PURCHASING PRACTICES VS. JIT PURCHASING PRACTICES

- Traditional purchasing practices call for infrequent, large-lot shipments.
- JIT purchasing practices call for frequent, small-lot shipments.
- Traditional purchasing practices call for inspection, since they focus on continuous checking by the customer. These practices are reactive due to their focus on "after the fact."
- JIT purchasing practices call for no inspection, since they focus on continuous improvement by the supplier. JIT is proactive due to its focus on "before the fact."

(iii) **JIT production processing.** JIT production processing requires setup reduction, focused factory, group technology, uniform scheduling and mixed model scheduling, and the pull system. The objective here is to produce many varieties of products in small quantities on short notice. Manufacturing flexibility is the hallmark of the JIT production processing strategy.

(A) ***Setup reduction.*** Traditional production systems require large lot sizes due to excessive setup or changeover time. JIT suggests reduced setup time so that lot sizes are reduced or evolve to lot size of one with first piece made good every time. The goal is to accomplish any setup in single minutes (i.e., at less than ten minutes). Setup reduction requires eliminating equipment downtime and machine adjustments as much as possible combined with good housekeeping in the manufacturing plant.

With reduction in setup time comes many other benefits such as increased quality due to closer tie-in between the machine operator and the setup, increased productivity and profitability due to elimination of many non-value-added activities associated with moving, storing, inspecting, and reworking, reduced manufacturing lead time resulting in lower inventories and associated physical space requirements, and reduced scrap, lowering unit costs.

(B) ***Focused factory.*** Focused factory is a concept where the plant layout is dedicated to a single product family that maximizes overall productivity and quality while minimizing space and re-

source requirements. It is intended to physically link all the involved manufacturing operations together to minimize the distance between them, minimize the complexity, maximize the integration of tasks, and enhance the interaction between the workers. This approach eliminates waste and increases communications.

(C) ***Group technology.*** While focused factory is a macro approach, group technology is a micro approach where equipment is laid out to produce a family of parts, one at a time, by physically linking all possible operations in the process. It can be viewed as self-contained, integrated parts factories within the focused factory.

Group technology uses a "cell" concept where the shape of the cell is a "U" or "C" so the starting and ending points are near each other to save walking time. The idea is that a single worker performs every operation, in the proper sequence, to make one finished unit at a time. All operations are close together as much as possible with little or no staging space between workstations. A worker in a group technology cell not only performs every operation in the process but also sees how they relate to one another. This improves productivity and quality.

GROUP TECHNOLOGY VS. TRADITIONAL TECHNOLOGY

- Group technology is a low-volume, high-mix work center for an entire family of similar parts.
- Traditional technology is a high-volume, single-part work center.

(D) ***Uniform and mixed model scheduling.*** Uniform scheduling calls for smaller lot sizes, eventually making every part every day. It is a variable flow management concept instead of trying to coordinate "lumps" of production. It provides level loading for manufacturing operations, building the same product mix every day during a given month. Levels may change from month to month, and hence the term "variable" flow. Under uniform scheduling the interval between like units is called cycle time. The shorter the cycle time, the faster the parts will be made.

Mixed model scheduling is employed to produce parts every hour the same. Yet, production levels will change from month to month to meet customer demand.

(E) ***Pull system.*** Conventional scheduling systems pushes orders through the production shop, making it difficult to synchronize the diverse activities required to produce the end products. This results either in excess inventory or insufficient inventory.

Like uniform scheduling, the pull system is based on the variable flow manufacturing principle to make parts repetitively in a low-volume production. The pull system links every process in the plant using simple signaling cards to synchronize production with changing customer demands. It uses a production signal to authorize the machine center to produce parts that have been taken from the storage area next to it. It uses a withdrawal signal as a permission to consume.

THE PUSH SYSTEM VS. THE PULL SYSTEM

- The push system is based on a fixed flow manufacturing principle.
- The pull system is based on a variable flow manufacturing principle.
- The traditional (push) production system has a "contingency" (i.e., safety stock) mentality.
- The JIT (pull) production system has "no contingencies" (i.e., no safety stock) mentality.

The pull system uses standard lot sizes and employs standard size containers to enhance visual control on the factory floor. This sets the stage for a "precision" mentality. The pull system ensures that right parts will be in the right place at the right time with a minimal investment in inventory. The pull system provides better production control for less cost.

(iv) **JIT inventory.** A misconception about JIT is that it is just a program to reduce inventory. Fortunately, JIT does more than that. JIT purchasing is called "stockless inventory" since the customer has

no inventory to stock as it is used up in the production right after it was received. The major goal is to reduce or eliminate work in process inventory so that all raw materials are consumed in the production process.

(v) **JIT transportation.** While JIT purchasing is the starting point of a JIT cycle, the JIT transportation is the execution part of the JIT cycle. JIT transportation is the physical linkage between the inside and the outside processes. It is a process that starts at a supplier location and ends at a customer location. It requires the analysis of all transport events and eliminating the non-value-added events. The basic value-added events include: move load to dock at a supplier location, load carrier, move load to customer location, return empty trailer to terminal, unload by the customer, and move load to assigned customer location.

Similar to JIT supplier–customer partnership, JIT transportation requires that all three parties—the supplier, the carrier, and the customer—work together more closely than ever before. With frequent, small quantities moved each time, the traffic at both the supplier and the customer plants will increase, creating a demand for rapid load and unload capabilities.

To support JIT flow of production, frequent, time-of-day deliveries will be required. This means receiving parts at a specific customer location on specific days at specific times during those days.

Reusable containers and small delivery windows are new approaches. Reusable containers save money when compared with expendable containers. Small delivery windows means rapid loading and unloading which can be enhanced by using point-of-use doors, driver self-unloading, and innovative equipment such as portable ramps and end-loading trailers.

(q) **Materials Requirements Planning.** Materials requirements planning (MRP) is suitable for managing raw materials, components, and subassemblies, which have dependent demands that may be calculated from the forecasts and scheduled production of finished goods. In other words, the order for component inventory is placed based on the demand and production needs of other items that use these components.

Benefits of MRP include reduced investment in inventory, improved workflow, reduced shortage of raw materials and components, and reliable delivery schedules.

DETERMINISTIC INVENTORY VS. PROBABILISTIC INVENTORY

- Deterministic inventory models assume that the rate of demand for the item is constant (e.g., EOQ).
- Probabilistic inventory models assume that the rate of demand for the item is fluctuating and can be described only on probability terms.

In addition to considering dependent demand in the determination of net requirements for components, an MRP system also determines when the net requirements are needed by using the time-phasing concept. This concept works by starting with the time that the finished product must be completed and working backward to determine when an order for each component must be placed based on lead times.

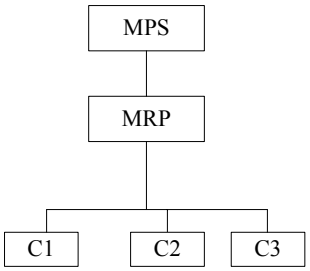
The approach to determining net requirements whenever a dependent demand situation exists is: Net component requirement = Gross component requirement – Scheduled receipts – Number of components in inventory, where the gross component requirement is the quantity of the component needed to support production at the next higher level of assembly.

EOQ VS. MRP

- The EOQ model is focusing on finished goods inventories, which have an independent demand from customers or from forecasts.
- The demand for raw materials and components in the MRP model is directly dependent on the demand for the finished goods in the inventory system.

OVERVIEW OF MASTER PRODUCTION SCHEDULE AND MATERIAL REQUIREMENTS PLANNING

MRP systems are used to project inventory stock levels because they depend on the amount and timing of finished goods to be produced and then determine the requirements for raw materials, parts, components, and subassemblies at each of the prior stages of finished goods production. Working backward, each end product is sequentially exploded or separated into its necessary components and raw materials (i.e., to project inventory stock levels needed). MRP can also be used to do resource planning (capacity planning and labor scheduling) and materials planning. The relationship between MRP system, Master Production Schedule (MPS) system, and Bill of Materials (BOM) is shown in Exhibit 1.23.



- MPS indicates units of finished goods to be produced each time period.
- BOM defines the components required by each finished product. RMRP uses the BOM to determine the number of components (C1, C2, C3...Cn) required.
- Shows forecasted quantity for each component with dates.

Exhibit 1.23: Relationship between MRP, MPS, and BOM

The inputs to MPS are forecast orders and actual orders. The inputs to MRP are MPS data, BOM data, and the current inventory file. The outputs from the MRP system are the requirements for each item in the BOM along with the dates each item is needed, which, in turn, is used to plan order releases for production and purchasing.

BOM is a structured parts (components) list showing the hierarchical relationship between the finished product and its various components. BOM indicates exactly how many components are needed to produce the quantity of finished goods recommended by the MPS system.

MRP is a computer-based application system and an example of the dependent demand inventory system. It is a system to determine quantity and timing requirements of materials used in a manufacturing operation. Materials can be purchased externally or produced in-house. MRP utilizes a master production schedule, a product bill of materials, and current inventory data to determine current new requirements and timing of materials.

The **objectives** of the MRP system are to determine what, how much, and when to order and also when to schedule deliveries and to keep priorities current for inventory planning, capacity requirements planning, and shop floor control.

The **benefits** of an MRP system come from doing a better job of managing the planning process. Specifically, benefits include lower inventories, better scheduling, early warning system about capacity and supply problems, and long-range plans in terms of equipment and labor needs.

The **prerequisites** for a successful implementation of an MRP system include a feasible master production schedule, accurate inventory records, accurate bill of materials, known lead times, and unique part numbers.

Feasible master production schedule means that the resulting production schedule is practical in terms of material availability, labor capacity, and machine capacity. The planning horizon for the master production schedule should be at least equal to the longest cumulative procurement and manufacturing lead time for an end item. The master production schedule is based upon confirmed customer orders, interplant orders, forecast sales, and current inventory levels. The result is a plan of end items production that translates into the needs for all subassemblies, component parts, and raw materials.

Accurate inventory records are necessary to determine the appropriate quantity and timing of each item to order or manufacture. Cycle counting is generally used to maintain the required inventory accuracy.

Accurate bill of materials (BOM) tells the MRP system what items are used to produce the finished product or subassembly and in what quantity. A variety of display formats exists for BOM, including the single-level BOM, indented BOM, modular (planning) BOM, transient BOM, matrix BOM, and costed BOM. The BOM may also be called the formula, recipe, or ingredient list in certain process industries.

The MRP system requires a lead-time estimate for every part number in the system. This is called *known lead-times.* Incorrect lead-time information leads to incorrect purchasing decisions. It is essential that lead times be updated promptly for all internally produced or externally supplied parts and raw materials.

The MRP system requires that each part be identified with a *unique part number* no matter where it is used in the company. Duplicate part numbers and incorrect part numbers are common problems.

(r) **Distribution Systems.** Inventory in a distribution system can be managed through the use of independent demand models such as continuous and periodic review models. Examples of these models include single order point, double order point, periodic review system, and sales replacement system, which are described below.

The primary **advantage** of the distribution models is that they allow the various levels in the distribution chain to manage their inventories autonomously. The primary **disadvantage** of these models is that they ignore the other stages in the supply chain leading to stockouts and back orders. Excess shipping costs can be incurred since no one is coordinating the movement of materials within the system. Also the demand for replenishment occurs without any regard for what is currently being produced or being planned to be produced. Under these situations, the need for an item incurs extra setup costs, lost productivity, and excess transportation costs.

(i) **Single order point system.** The single order point system basically ignores the fact that the order takes place in a chain and assumes that each element in the distribution system is independent of all other components. This independent behavior can cause large swings caused by a phenomenon called "lumpy demand" at the next level down in the distribution chain. The lumpy demand comes from the lack of communication and coordination between the factory, warehouse(s), distributors, and retailers.

(ii) **Double order point system.** The double order point system considers two levels down in the distribution system, hence the name "double." For example, if a distributor is quoted a lead time from the factory warehouse of two weeks and it takes the factory warehouse three weeks to have stock replenished, the reorder point is set based on the demand for a five-week period. It does not produce lumpy demand, as does the single order point system. An advantage is that it reduces the risk of stockouts. Increasing the safety stock is its disadvantage.

(iii) **Periodic review system.** In a periodic review system, orders are placed on a predetermined time schedule. The advantage is that the order times can be staggered throughout the chain to smooth the demand at each point in the distribution chain. This reduces peaks and valleys caused by several customers ordering at the same time.

(iv) **Sales replacement system.** In the sales replacement system, the supplier ships only what the customer used or sold during the period. The objective is to maintain a stable inventory level in the system. This does require having enough inventory to cover the potential demand during the replenishment cycle. In essence, the sales replacement system is a periodic review model with variable order quantities.

(v) **Distribution requirements planning.** Distribution requirements planning (DRP) is an application of the time-phasing logic of MRP applied to the distribution system. The purpose of DRP is to forecast the demand by distribution center to determine the master production scheduling needs. It uses forecasts and known order patterns from customers in the distribution chain to develop the demand on the master schedule.

DISTRIBUTION REQUIREMENT PLANNING VS. ORDER POINT-BASED DISTRIBUTION SYSTEM

- The DRP anticipates the future needs throughout the distribution chain and plans deliveries accordingly.
- The order point-based distribution system does not anticipate future needs. It simply reacts to the current needs.

(vi) **Inventory distribution methods.** The functions of warehouse distribution, production, and purchasing are closely interrelated and constantly interacting with each other in a manufacturing firm. The decision problems considered during inventory distribution strategy are when, what, and how much of it to ship to a warehouse; when, what, and how much of it to produce at the factory, with what size work force; and when, what, and how much of it to purchase as inputs to the factory warehouse system.

(vii) **Warehouse inventory control.** Warehouses usually stand in a distribution system between a factory and final customers or other warehouses, as shown in Exhibit 1.24.

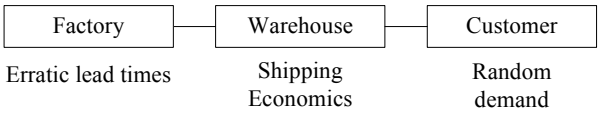


Exhibit 1.24: Warehouse inventory control

On the sales side, the warehouses face a demand from customers that usually is subject to random demand fluctuations, and usually requires fast service. On the supply side, the warehouse usually faces a significant and sometimes erratic lead-time for receiving shipments of products from factories.

The payments to carriers for making shipments to the warehouse are frequently of major importance in designing the warehouse ordering and distribution system. Economies can usually be achieved by increasing the size of shipment up to some upper limit such as a full truckload or carload. Efforts to economize on shipping costs by increasing the size of shipments have the result of increasing the time between shipments and hence decrease the speed of service.

(viii) **Types of warehouse shipments.** Warehouses usually stock a very large number of products—the larger the shipment size, the more products are involved, and the greater are the problems of controlling the inventories of different products jointly. These are some of the considerations involved in decisions to order shipment to warehouses. Two basic types of shipments can take place: (1) periodic shipments and (2) trigger shipments (see Exhibit 1.25).

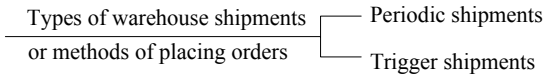


Exhibit 1.25: Types of warehouse shipments

(A) ***Periodic shipments.*** The periodic system of placing orders has the virtue of automatically synchronizing the decisions on many products. Under this system of operation, warehouse shipping decisions can be handled in two steps. First, the product can be considered in the aggregate, and next the shipping costs for different sizes of shipping lot can be weighed against the cost of holding inventory that is associated with each size lot. On this basis, the optimum shipping lot can be determined. By using the forecasted aggregate shipping rate the decision period can be determined.

The shipment received at the beginning of a period is associated with the period because that shipment must carry the warehouse through the period. However, because the lead time *Tl* is required to obtain the shipment, the order for the *t*'th period must be initiated a length of time *Tl* before the beginning of the *t*'th period. When the time arrives for placing an order the inventory records for the products involved are brought up to date. The position of inventories on hand and on order is then known. The orders can then be placed for the amount of each product to be included in the shipment on the basis of the expected product sales, initial inventory position at the time of ordering, and the expected final inventory position at the end of the period.

In calculating the distribution of forecast errors, the forecast span is ($Tl + Td$) where *Td* is the length of the decision period, which is equal to the interval between the receipt of shipments. It should be noted that with a decision made in advance on the timing of a shipment, any random fluctuations in aggregate sales tend to cause the size of the shipment to vary randomly. This may be quite satisfactory in situations where less than truckload or carload shipments are being made and variations in the size of the shipment can be accommodated readily. If the fluctuations in the size of the shipment exceed the available capacity, a supplementary shipment may be required or alternatively the aggregate inventory buffer changed.

(B) ***Trigger shipments.*** A warehouse may aggregate its products and decide on the optimal size of shipment, but allow timing to be triggered by sales. Because the timing of shipments is irregular, orders for individual products cannot depend on a simple constant lead-time. Instead, *the lead-time for any single product is a random variable, which depends partly upon the orders that are placed for other products.* When the total orders for all products have reached the total desired for a shipping lot, the orders will be placed for a shipment. Under this system the lead-time for any one product is a random variable that depends upon the random sales of other products. The outcome for an individual product depends upon the correlation between its sales and the aggregate sales.

(C) ***Advantages and disadvantages.*** This trigger system is more responsive to fluctuations in sales than the corresponding periodic system. It has the further advantage that the shipment size is predetermined rather than random; hence problems of overburdening carrier capacity are minimized. However, the costs of administering the continuous review of inventory position for a trigger system are usually somewhat higher than under the periodic system.

(ix) **Other warehouse considerations.** In estimating the cost of alternative shipping carriers, the cost of having valuable inventory tied up while the vehicle is in transit should be considered. While this cost will usually not be large, taking it into account will systematically lower the costs of using faster rather than slower carriers. Another economy associated with fast shipments that may be overlooked is the fact that time in transit is one component of the lead-time. *Shortening the lead-time allows a reduction in the inventory buffers, and hence a decrease in inventory holding costs.*

A warehouse may be put under a financial constraint in response to the working-capital needs of the company; the warehouse also may be constrained by the production-smoothing requirements of the factory, and the warehouse itself may have certain constraints on its capacity to receive shipment or its storage space. Some of these may be equality constraints on the exact amount of inventory that should be held, and some constraints may be inequality restraints that establish upper or lower limits. Briefly stated, if an inequality restraint is not violated when the corresponding variable is set to zero, then the constraint can be ignored. If it is violated, then the solution is carried through as if an exact constraint applied.

In estimating the costs of stockouts at the warehouse the least costly alternative should be used. If the warehouse is out of stock on a product it may disappoint a customer, or it may initiate a rush order from another warehouse or from the factory. In the latter cases the cost of depletion may well be the cost of making a special rush shipment, taking into account the communication and expediting costs. Although few warehouses keep adequate records on stockouts and failures to render customer service, this data could be useful in estimating depletion costs as well as costs associated with customer service.

When estimating the cost of holding inventory, the cost of obsolescence should be considered. The indirect costs of having very large inventories in a warehouse may be increased because of product damage resulting from high stacking. Also, increased handling costs from crowded aisles and poor housekeeping and access may show up as overtime payments.

A single warehouse may utilize several different decision systems on different types of products, or products from different suppliers according to particular needs. For example, fast-moving products might be segregated from slow-moving products, and a different decision system used for each.

(s) **Production Scheduling and Control Systems.** Four types of production scheduling and control systems will be discussed in this section. These include: (1) just-in-time systems, (2) traditional systems, (3) Kanban systems, and (4) bar coding systems (see Exhibit 1.26).

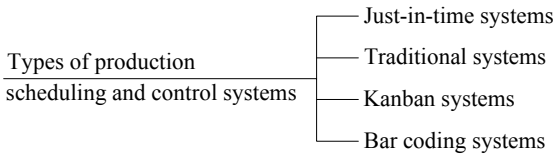


Exhibit 1.26: Types of production scheduling and control systems

(i) **Just-in-time production systems.** Just-in-time (JIT) represents a management philosophy whose objective is to eliminate all sources of waste including unnecessary inventory. The basic principle

of JIT is to produce the right products in the right quantity at the right time in the right place. JIT's primary goal is to minimize production inventory levels while providing needed raw materials, parts, and components just before they are used. To facilitate this goal, JIT purchasing places the orders such that delivery immediately precedes usage.

With JIT, products are manufactured or assembled only when they are needed. This means the number of parts produced or purchased at any one time should be just enough to produce one unit of the finished product. Therefore, inventories are better managed to the extent that they are not needed, or at least are minimized.

JIT and Risk

JIT requires a fundamental change in traditional production systems. These changes encompass production layout, material flows, setup times, employee attitudes, and work culture. A risk of JIT is the critical dependency on a few vendors.

JIT requires a commitment to continuously improve activities and the quality of products while eliminating all non-value-added activities and work-in-process inventory. Lead times, waiting time for materials or other, and inspection are grouped as non-value-added activities.

Production flow in a JIT system is "demand-pulled" through the plant by the downstream workstations ordering subassemblies and parts from upstream workstations. These pull-orders are controlled by a Kanban system, which is a system of cards and empty bins. Kanban is explained later in the section.

JIT can be viewed as an intermediate step toward more advanced manufacturing technologies such as computer-integrated manufacturing (CIM). Producing one unit of a finished product at a time allows the implementation of strict quality control standards. The worker under JIT is fully responsible for ensuring that the subassemblies that are received or produced are error-free. If errors are detected, production stops and errors are immediately corrected. *Therefore, the JIT system relies on employee involvement in production operations, quality control, and productivity improvements.*

KEY CONCEPTS TO REMEMBER: BENEFITS OF JIT

- Increased inventory turnover measured as sales divided by inventory. Increased inventory turnover is an indication of increased productivity.
- Increased production rates due to little or no waiting time and increased productivity
- Lower storage space due to lower inventory levels required
- Lower spoilage costs due to high-quality products
- Lower material handling costs since the materials are delivered directly to the assembly floor
- Reduced production lead times due to shorter setup times and better coordination with suppliers
- Reduced indirect labor since most or all non-value-added activities are removed
- Reduced warranty claim costs due to better quality products

The total quality control system developed by D. Deming is an integral part of the JIT philosophy. Frederick Taylor's principles of scientific management influenced the development of the JIT system. Reduction of waste, zero inventories, quality circles, and the use of computer robotics are seen as management tools to increase efficiency and output—a theme familiar to scientific management and JIT production systems.

Raw material and work in process (WIP) inventories are reduced significantly, thereby decreasing carrying costs and floor space requirements. JIT production systems are most appropriate in repetitive assembly type of manufacturing such as automobiles or appliances.

The JIT system requires the setting of daily production targets, so that feedback on worker performance is timely. Workers are given more responsibility for building perfect quality into the product and to produce the desired quantity. The detailed variance reports are no longer needed in the JIT system because defects are becoming fewer and fewer.

JIT promotes work simplification procedures and relies on few suppliers to deliver raw materials and parts on time. Competitive bids are not common. Close ties tend to develop between two parties (customers and suppliers) as they work closely together to improve quality and to implement the JIT philosophy. JIT requires mutual trust between the vendor and the customer. A greater reliance is placed on the vendor to perform and deliver as expected by the customer.

(ii) **Traditional production systems.** Traditional production systems practice a "push" production system concept where each worker produces a subassembly at his own pace and passes the output to the next worker until the final product is completed. A WIP inventory is commonly maintained at each workstation. Plant workers are controlled by work standards and motivated by piece-rate incentive system. This approach leads to producing quantity rather than quality products. Workers have little or no incentive to correct errors or problems.

Workers are encouraged to make good-quality products, not punished for the production of poor-quality work. Under a traditional production system, quality control is the responsibility of a quality control inspector, not the production worker. This quality control inspection is not done quickly enough to trace production problems. Inspection is not done continuously; it is often done for the finished goods only.

Work standards or standards of performance are established by using either imposition or via participation techniques, where the latter approach is more motivating for the worker than is the former. A performance report is issued periodically. A variance investigation occurs when significant discrepancies exist between the standard and the actual output. Investigation could reveal that either the worker is inefficient or the standard is not set properly. Exhibit 1.27 shows a comparison between traditional production systems and JIT production systems.

Characteristics of traditional production systems	*Characteristics of JIT production systems*
• Quality is seen as a hit-or-miss event, and there is no explicit commitment to continuous improvement and production of quality products.	• Quality is a planned event, and there is an explicit commitment to continuous improvement and production of quality products.
• The system is evolutionary.	• The system is revolutionary since long-held beliefs are discarded.
• More WIP is maintained.	• Little or no WIP is maintained.
• No reliance on employee involvement and participation in decision making.	• Relies on high employee involvement and participation in decision making.
• Quality control inspector is responsible for the quality of the product.	• Production worker is responsible for ensuring the quality of the product.
• The push system begins with the first worker on the assembly line dictating the flow of work.	• The pull system begins with the last worker on the assembly line dictating the flow of work.
• Workers are compensated based on a piece-rate incentive system.	• Workers are compensated based on a group incentive system.
• Inventory investment is increased.	• Inventory investment is decreased.
• Need for detailed variance reports is great due to many defects. Reports will prove more useful as problem detectors.	• Little or no need for detailed variance reports due to fewer defects. Reports will prove less useful as problem detectors.
• Long production runs and long setup times are typical.	• Short production runs and short setup times are common.

Exhibit 1.27: Characteristics of traditional production systems and JIT production systems

(iii) **Kanban production and inventory system.** Working under a "pull" system, production procedures and work instructions are communicated by a system of signals sent among workers through the use of a series of cards called *Kanbans*. The JIT production system and Kanban inventory system work together. In Kanban, the last workstation is informed of the day's production needs; all other workstations respond to the Kanban cards and containers, that is, all other workstations are pulled in.

KEY CONCEPTS TO REMEMBER: BENEFITS OF KANBAN INVENTORY SYSTEM

- Paperwork-free system
- Product is made to order
- Diminished need to take physical inventory for income determination purposes
- Lower finished goods inventory amounts

- Simple procedures for taking physical inventory, when needed
- Lower work in process inventory amounts
- Zero or fewer defective products

After the Kanban system informs the final assembly production needs, each workstation then "orders" products or parts from the preceding workstation. This chain moves back to the point of purchasing raw materials. A condition is that a workstation cannot produce unless an order has been placed.

Two kinds of Kanban cards are used for posting and tracking inventory activity and to communicate among workers at the workstation: (1) move card and (2) production card (see Exhibit 1.28).

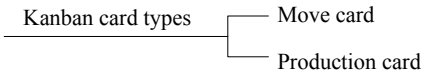


Exhibit 1.28: Kanban card types

The **move card** allows the worker to take one standard container of a specific part from one work center to another. The **production card** tells another production work center to produce the number of parts that will fit a standardized container. There is only one card with each container at any point in time.

Material requirements planning (MRP) is a widely used computerized system that operates under the "push" principle, while Kanban represents the "pull" system. The newer version of MRP is MRP II, which takes the bill of materials for the products to be produced, calculates all subassembly and raw materials needed by time and quantity. Then the workstations are informed as to the number of units to be produced. This method is equated to the "push" system where the work is pushed through the plant.

TRADITIONAL PRODUCTION SYSTEMS VS. MRP VS. JIT VS. KANBAN SYSTEMS

- Traditional manufacturing system practices a "push" production system.
- Materials requirements planning system operate under "push" production system.
- JIT manufacturing system practices a "pull" production system.
- Kanban manufacturing system practices a "pull" production system since it responds to the JIT production plan.

(iv) **Bar coding systems.** Sadhwani and Tyson[3] found that more and more managers are focusing on solutions that collect data in real time, at the point of origin, in a way that ensures the captured data are right the first time. One such solution is the use of automatic identification technologies, such as bar coding, optical character recognition (OCR), voice recognition (VR), and radio frequency (RF) identification. Of these methods, bar coding is the most popular and cost-effective. Bar codes can be used in manufacturing environments such as shop floor and receiving as well as in office environments such as purchasing, inventory, billing, accounts payable, and payroll time-clocking.

Bar codes are symbols that can be processed electronically to identify numbers, letters, or special characters on a receiving report, invoice, time card, or part. They are used to improve data accuracy and increase speed of updating the supporting data in all interfacing systems.

Removing the human element from the data collection process greatly improves data accuracy and updating speed.

Bar code technology supports the JIT production philosophy and continuous improvement program. This is because bar code technology is paperless, which is one of the goals of JIT. Bar codes support continuous improvement due to increased accuracy of data available in the system and establishment of production standards based on such data. This also improves quality of decision making. Exhibit 1.29 presents advantages and disadvantages of bar code technology.

[3] *"Bar Coding Technology, A Research Report," Sadhwani and Tyson, Institute of Management Accountants, Montvale, NJ, 1990.*

Advantages of bar coding technology	*Disadvantages of bar coding technology*
• Improved employee productivity	• High cost of equipment
• Timeliness of data collection	• Long implementation times
• Accuracy of data collection	• Continual support in education and training
• Ability to trace labor and material costs directly to specific departments and jobs	• Resistance to change by current employees

Exhibit 1.29: Advantages and disadvantages of bar coding technology

For example, the use of bar codes on raw materials will reduce the amount of paperwork that is required to track inventories. Movement of raw materials, subassemblies, and finished products are monitored electronically using bar codes. In addition to speed, accuracy is increased since there is little or no human involvement in reading and interpreting the bar code data. Key entry of data is eliminated.

1.7 Marketing—Pricing Objectives and Policies

Pricing decisions that integrate the firm's costs with its marketing strategy, business conditions, competition, consumer demand, product variables, channels of distribution, and general resources can determine the success or failure of a business. Pricing of products or services is the cornerstone of the marketing function. *If the price is too high, buyers may purchase competitive brands leading to a loss of sales and profits. If the price is too low, profitability may suffer despite increases in sales.*

Effective pricing should consider the following factors: demand influences, supply influences, and environmental influences (see Exhibit 1.30).

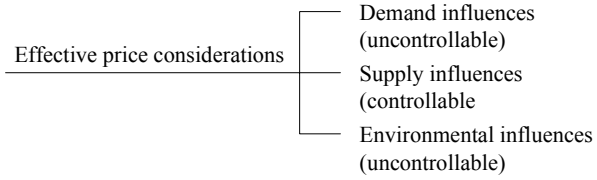


Exhibit 1.30: Effective price considerations

(a) **Demand Influences.** From a demand perspective, three primary considerations are: (1) demographic factors, (2) psychological factors, and (3) price elasticity. **Demographic factors** include: number, location, and economic strength of potential buyers, type of consumer (i.e., resellers or final), and expected quantity of purchases by type of consumer. These demographic factors help determine market potential and are useful for estimating expected sales at various price levels.

The heart of **psychological factors** focuses on how consumers perceive various prices or price changes. It is difficult to predict: how much will potential buyers be willing to pay for the product? and whether potential buyers use price as an indicator of product quality. The best way to find out answers to these questions is to conduct marketing research. Although not conclusive, many research studies have found that persons who choose high-priced product categories and see the consequences of a poor choice as being undesirable. They believe that quality is related to price and see themselves as good judges of product quality. In general, the reverse is true for persons who select low-priced items in the same product categories.

Both demographic and psychological factors affect **price elasticity**. Price elasticity is a measure of consumers' price sensitivity, which is estimated by dividing relative changes in the quantity sold by the relative changes in price. This is expressed as

$e =$ ($\Delta Q/Q$) divided by ($\Delta P/P$) = Change in quantity/Q divided by (Change in price/P)

Price elasticity can be estimated from historical data or from price/quantity data across different sales districts and by sampling a group of consumers from the target market and surveying them concerning various price/quantity relationships. However, bear in mind that surveying the consumers can be expensive and time consuming.

(b) **Supply Influences.** Supply influences can be understood in terms of pricing objectives, costs, and nature of the product. To be effective, pricing objectives need to be derived from corporate objectives via marketing objectives as shown in Exhibit 1.31.

Corporate objectives ⟶ Marketing objectives ⟶ Pricing objectives

Exhibit 1.31: Pricing objectives

Marketing research has found that the most common pricing objectives are pricing to achieve a target return on investment, stabilization of price and margin, pricing to achieve a target market share, and pricing to meet or prevent competition.

Additional Pricing Objectives

- Target return on investment and market share
- Maximum short-run and long-run profits
- Growth and stabilization of market
- Desensitize customers to price
- Maintain price-leadership arrangement
- Discourage new entrants with low prices
- Speed exit of marginal firms

The marketing manager focuses on multiple objectives when making pricing decisions. This becomes even more important considering that the manager does not have perfect information about cost, revenue, and market.

Every profit-oriented organization must make a profit after covering production, marketing, and administrative costs. Cost-oriented pricing is the most common approach in practice, and there are at least three basis variations: market pricing, cost-plus pricing, and rate-of-return pricing. This is shown in Exhibit 1.32.

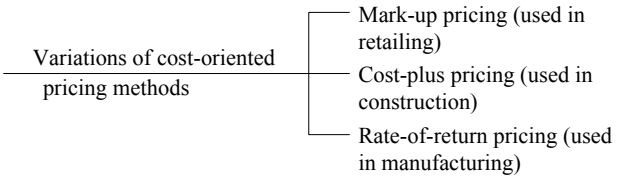


Exhibit 1.32: Variations of cost-oriented pricing methods

Markup pricing is used in the retail industry, where a percentage is added to the retailer's invoice price to determine the final selling price. In **cost-plus pricing,** the costs of producing a product or completing a project are totaled and profit amount or percentage is added on. It is used in job-oriented and nonroutine and difficult to "cost" in advance situations such as military installations. In the **rate-of-return or target pricing**, price is determined by adding a desired rate of return on investment to total costs. Generally, a breakeven analysis is performed for expected production and sales levels and a rate of return is added on.

Advantages of cost-oriented approach	*Disadvantages of cost-oriented approach*
• Simple to calculate	• Cost approaches give little or no consideration to demand factors
• Simple to understand	• Price determined by a markup or cost-plus method has no necessary relationship to what people will be willing to pay for the product
• Simple to explain	• Little emphasis placed on estimating sales volume in the rate-of-return pricing
• Simple to trace	• Cost approaches fail to reflect competition adequately considering the fact that costs and markups are different to each producer
• Provides objective evidence	
• Yields a good pricing decision	

Exhibit 1.33: Advantages and disadvantages of cost-oriented approach to pricing

Three important product characteristics that can affect pricing are (1) perishability, (2) distinctiveness, and (3) stage in the product life cycle. Goods that are very perishable in a physical sense (e.g., food, flowers) must be priced to promote sales without costly delays. Perishable items also include high-fashion and seasonal products since their demand is based on time. One of the primary marketing objectives of any firm is to make its product distinctive in the minds of buyers and charge higher prices. Homogeneous goods such as bulk wheat and whole milk are perfect substitutes for each other while most consumer goods are heterogeneous goods.

The price of a product often depends on the stage of the life cycle that a product is in and explained in terms of price skimming and price penetration (see Exhibit 1.34).

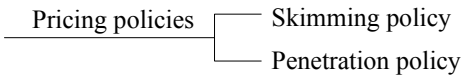


Exhibit 1.34: Pricing policies

A **skimming policy** is one in which the seller charges a relatively high price on a new product. The price may be lowered later as the competition moves in. This pricing strategy is good for monopoly companies and where the demand for the product is price inelastic.

A **penetration policy** is one in which the seller charges a relatively low price on a new product to discourage competition. This pricing strategy is good where competitors can move in rapidly and where demand for the product is price elastic. Regardless of what pricing strategy is used when a new product is introduced, the price may have to be altered later to accommodate changes in the market forces.

(c) **Environmental Influences.** Competitive and government regulations are two uncontrollable variables that have environmental influence on pricing. Many factors help determine whether the firm's selling price should be at, below, or above competition. **Competitive factors** include: number, size, location, and cost structure of competitors, conditions of entry into the industry, degree of vertical integration of competition, number of products sold by competitors, and historical reaction of competitors to price changes.

KEY CONCEPTS TO REMEMBER: COMPETITION AND PRICING

- **Pricing a product** at **competition.** It is called "going-rate pricing," which is the average price charged by the industry and is widely used for homogeneous products.
- **Pricing a product** below **competition.** It can be found in "sealed-bid pricing" where the firm is bidding directly against competitors for project contracts. It is an intentional move to obtain the job contract.
- **Pricing a product** above **competition.** This pricing strategy is used when firm has a superior product or because the firm is the price leader in the industry.

Governmental regulation includes both state and federal government. The scope of state regulation includes pricing by public utility companies while the scope of federal regulation covers price fixing, deceptive pricing, price discrimination, and promotional pricing.

(d) **General Pricing Decision Model.** As mentioned earlier, pricing decisions require the consideration of many factors. Peter and Donnelly[4] suggests a nine-step pricing decision model even though it is difficult to generalize an exact sequence of when each factor is to be considered. *These nine steps include* (1) define target markets, (2) estimate market potential, (3) develop product positioning, (4) design the marketing mix, (5) estimate price elasticity of demand, (6) estimate all relevant costs, (7) analyze environmental factors, (8) set pricing objectives, and (9) develop the price structure.

The *advantages* of this model are that it breaks the pricing decision into nine measurable steps, it recognizes that pricing decisions need to be integrated into overall marketing strategy, and it considers both qualitative and quantitative factors in pricing decisions.

The fact that all pricing decisions will not fit the framework suggested above is its major limitation and *disadvantage.*

1.8 Marketing—Supply Chain Management

(a) **Managing the Supply Chain.** The supply chain is seen as equivalent to an input-transformation-output system. In this context, both customer and supplier goodwill are to be viewed as a key asset to an organization. The supply chain becomes a value chain when all of the transforming activities performed upon an input provide value to a customer. The real challenge is to ensure that value is added at every step of

[4] ***Marketing Management: Knowledge and Skills,*** *J. Paul Peter and James H. Donnelly, Jr. Third Edition, Richard D. Irwin, Homewood, IL, 1992.*

the chain to achieve customer satisfaction. Both purchasing and the supplier play a large role in the value chain.

Managing the supply base includes integration of suppliers, involvement of suppliers, supplier reduction strategies, supplier performance, and supplier certification. The purpose of managing the supply base is to manage quality, quantity, delivery, price, and service.

Integrating suppliers means reducing or balancing the number of suppliers available so that they become part of the buyer operation to lower inventories, to increase response time and quality, and to decrease total cost.

Early *involvement of suppliers* in the product design process reduces cost, improves quality, and shortens product development cycle time. This is achieved through review of product specifications and production standards by the supplier.

Characteristics of Supply Chain Management

Honesty, fairness, and trust have to be the driving values for effective supply management.

Supplier reduction strategies include deciding who will be single sourcing or second sourcing. Approaches to improving *supplier performance* include improved communication, early supplier involvement in the buyer product design, and measuring supplier performance indicators. Improved communication is achieved through designating one or two individuals for all communication that takes place between the buying and supplying firms and conducting supplier conferences and workshops to share information common to both parties (cost, design specifications, and profit).

The supplier performance is measured in terms of quality, delivery, service, and cost/price. **Quality measures** may include incoming defect rate, product variability; number of customer complaints, use of statistical process control, documented process capabilities, and supplier's quality philosophy. **Delivery measures** include on-time delivery, percentage and availability of product within quoted lead time, and quantity accuracy. **Service measures** include invoice accuracy and length of time required to settle claims, availability of a supply plan, and availability of engineering support. **Cost/price measures** include product cost, price reductions, transportation cost, willingness to participate in price reviews, and minimum buy requirements.

Paradigm Shift for Auditors

Internal auditors may not be comfortable with reducing or eliminating incoming inspection of goods, and this requires a paradigm shift on the part of auditors.

Supplier certification is a certification process conducted by the purchasing organization in that their major suppliers are certified so that shipments go directly into use, inventories, or production. The goal of certification is to reduce or eliminate incoming inspection of goods coming from a supplier by a purchaser.

Certification involves evaluating the supplier's quality systems, approving the supplier's processes, and monitoring incoming product quality. The advantages of supplier certification are increased product quality, reduced inspection costs, and reduced process variation.

(b) **Alternative Market Channels.** It takes a considerable amount of time, money, and effort to set up channels of distribution. Because of this heavy commitment of resources, once decisions are made about the channel of distribution they are not easy to retract. Yet these decisions are very critical to the success of the firm. Decisions based on inaccurate or incomplete information can be very costly to the firm. Whether it is a consumer good or industrial good, channels of distribution provide the ultimate consumer or industrial user with time, place, and possession value (utility). *Thus, an efficient channel is one that delivers the product when and where it is wanted at a minimum total cost. Marketing intermediaries exist to bring about product exchanges between buyers and sellers in a reasonably efficient manner.*

(i) **Marketing intermediaries.** The primary role of intermediaries is to bring supply and demand together in an efficient and orderly manner (see Exhibit 1.35).

Exhibit 1.35: Primary role of intermediaries

Since it would be very difficult for each consumer to deal with each manufacturer directly for products, the need for intermediaries becomes apparent considering the distance between the seller and the buyer and the product complexity. Therefore, marketing intermediaries can perform product exchange functions more cheaply and more efficiently than the manufacturer can. Also, competition among intermediaries will result in lower costs to the consumer. There are many types of marketing intermediaries, many of which are specialized by function and industry.

Major Types of Marketing Intermediaries

Middleman, merchant middleman, agent, wholesaler, retailer, broker, sales agent, distributor, jobber, and facilitating agent are various types of marketing intermediaries.

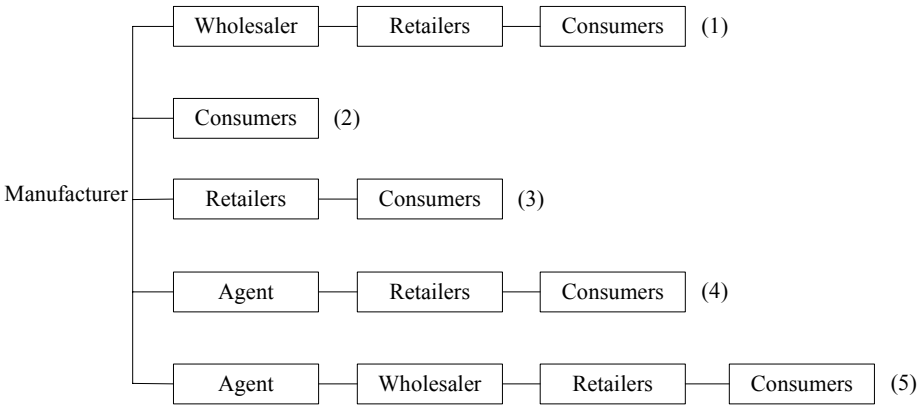
(ii) **Channels of distribution.** A channel of distribution is the integration of intermediaries through which a seller markets his products to users or consumers. Agents, wholesalers, and retailers are called intermediaries. These intermediaries are also called middlemen. Channels with one or more intermediaries are referred to indirect channels. The risks assumed and the functions performed by these parties vary as shown in the list that follows.

MARKETING FUNCTIONS PERFORMED IN CHANNELS OF DISTRIBUTION

- **Buying.** Purchasing products from sellers for use or for resale.
- **Selling.** Promoting the sale of products to ultimate consumers or industrial buyers.
- **Sorting.** Function performed by intermediaries in order to bridge the discrepancy between the assortment of goods and services generated by the producer and the assortment demanded by the consumer. This function includes four distinct processes: sorting out, accumulation, allocation, and assorting.
- **Accumulation.** A sorting process that brings similar stocks from a number of sources together into a larger homogeneous supply.
- **Allocation.** A sorting process that consist of building an assortment of products for use in association with each other.
- **Assorting.** A sorting process that consist of building an assortment of products for use in association with each other.
- **Concentration.** The process of bringing goods from various places together in one place.
- **Financing.** Providing credit or funds to facilitate a transaction.
- **Storage.** Maintaining inventories and protecting products to provide better customer service.
- **Grading.** Classifying products into different categories on the basis of quality.
- **Transportation.** Physically moving products from where they are made to where they are purchased and used.
- **Risk-taking.** Taking on business risks involved in transporting and owning products.
- **Marketing.** Collecting information concerning such things as market conditions, research expected sales, consumer trends, and competitive forces.

SOURCE: *Dictionary of Marketing Terms, American Marketing Association, Chicago, IL, 1988.*

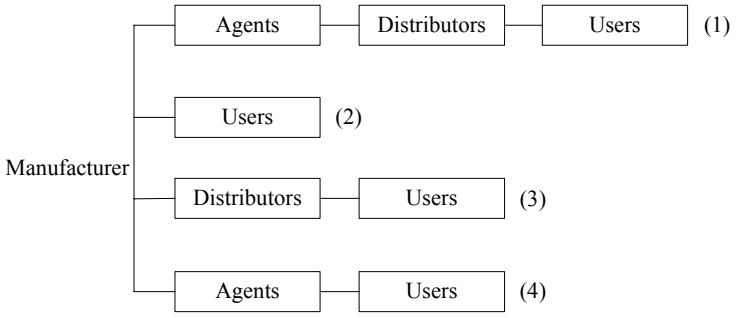
For convenience, the channels of distribution are classified into consumer goods and industrial goods (see Exhibits 1. 36 and 1.37).



Legend

1. Selling a product through wholesalers to retailers to consumers is the most common channel in the consumer market.
2. Some products are sold directly to consumers.
3. Some private brands are sold to consumers through retailers.
4. Some products are sold to agents to retailers to consumers.
5. Some products are sold to agents to wholesalers to retailers to consumers when intermediaries are few in number.

Exhibit 1.36: Channels of distribution for consumer goods



Legend

1. Used by a small manufacturer or when the market consists of many small customers. The manufacturer cannot afford to have a direct sales staff.
2. Used by most manufacturers to market the product to few but large customers. The products require presale and postsale service.
3. Used by manufacturer when the number of buyers is large and the size of the buying firm is small.
4. Used by small manufacturers who do not wish to have their own sales staff contract with agents. Suitable for users who are geographically dispersed.

Exhibit 1.37: Channels of distribution for industrial goods

Selecting the right channels of distribution is not an easy task when considering the geography of consumers and willingness of the intermediary to accept the seller's products. For most products, the intermediaries were well established doing business for many years. Exhibit 1.38 presents six basic considerations in the initial development of channel strategy.

1. **Customer characteristics** include number, geographical dispersion, purchasing patterns, and susceptibilities to different selling methods.
2. **Product characteristics** include perishability, bulkiness, degree of standardization, installation and maintenance services required, and unit value.
3. **Intermediary characteristics** include availability, willingness to accept product or product line, strengths, and weaknesses.
4. **Competitive characteristics** include geographic proximity and proximity in outlet.
5. **Company characteristics** include financial strength, product mix, past channel experience, and present company marketing policies.

6. Environmental characteristics include economic conditions and legal regulations and restrictions.

Exhibit 1.38: Considerations in channel planning

In addition, the choice of channels can be improved by considering distribution coverage required, degree of control desired, total distribution cost, and channel flexibility. These are explained next.

(A) ***Distribution coverage required.*** Since the needs and expectations of the potential buyer vary, distribution coverage can be viewed as a range from intensive to selective to exclusive distribution (see Exhibit 1.39).

Intensive	Selective	Exclusive
• Many wholesalers • Many retailers • Applicable to most convenience goods • Applicable to low unit price items • Applicable to high frequency of purchase	• Limited number wholesalers • Limited number of retailers • Service is key factor • Applicable to home furnishings, better clothing, and home appliances • Reputation of the intermediary is very important	• Severely limited number of intermediaries • Exclusive rights given to intermediaries • Product characteristics are key factor • Applicable to products requiring specialized selling effort and heavy investment (e.g., retail paint stores)

Exhibit 1.39: Distribution coverage

(B) ***Degree of control desired.*** The degree of control desired by the seller is proportional to the directness of the channel. When the market is concentrated in a limited geographic area, with many small buyers, the seller selling directly can influence the buyer significantly with his own policies and procedures. The control by the seller is somewhat diluted when indirect channels are used and the control is more indirect rather than direct. The indirect control can be exercised through sharing promotional expenditures, providing sales training, and sharing the computer-based application system for quick response.

(C) ***Total distribution cost.*** A total cost concept is suggested for the channels of distribution to avoid suboptimization. The concept states that a channel of distribution should be viewed as a total system composed of interdependent subsystems, with the objective to optimize total system performance. Cost minimization is a part of total system performance. The following is a list of major distribution cost factors to be minimized:

- Order processing and transportation costs
- Cost of lost business (an "opportunity" cost due to inability to meet customer demand)
- Inventory carrying cost including storage-space charges, cost of capital invested, taxes, insurance, obsolescence, and deterioration
- Packaging and materials handling costs

Other factors that must be considered include level of customer service desired, sales volume, profit levels, and the marketing mix desired.

(D) ***Channel flexibility.*** This involves forecasting and/or adapting the channels of distribution in relation to changing buyer habits and population moves such as inner cities to suburbs or north to south relocation. Change from individual stores to shopping centers and malls is also a consideration. Under these changing conditions, establishing a new channel of distribution is not that easy and takes time, money, and effort.

(c) **Selecting Intermediaries.** *The two basic methods of selecting intermediaries (middlemen) are* ***pushing*** *and* ***pulling***. Pushing a product through the channel means using normal promotional effort—personal skills and advertising—to help sell the whole marketing mix to possible channel members. This is a common approach with the producer working through a team to get the product to the user. By contrast, pulling means getting consumers to ask intermediaries for the product. This involves distributing samples and coupons to final consumers. If the promotion works, the intermediaries are forced to carry the product to satisfy their customer needs.

Push vs. Pull

- Pushing a product through the channel means using normal promotional effort—personal skills and advertising.
- Pulling a product means getting consumers to ask intermediaries for the product.

(d) **Managing Channels of Distribution.** From a management point of view, entire channels of distribution should be treated as a social system since each party plays a defined role and each has certain expectations of the other. The interaction with each other is very critical for all parties involved and the behavioral implications are many.

The channels of distribution do not manage themselves. Someone needs to manage or exert primary leadership in the channel. Even though the question is obvious, the answer is not, as indicated by the following arguments:

- Some marketers believe the manufacturer or the owner of the brand name should be the channel leader. This is because the owner has the most to lose if the system fails, has the most technical expertise, and has greater resources than others.
- Some marketers believe the retailer should be the channel captain or leader, since the retailer is the closest link to the consumer and, therefore, can judge better the consumer needs and wants.
- Some marketers argue the wholesaler should seek to gain channel control.
- Some marketers suggest that the locus of control should be at the level where competition is greatest.
- Some marketers believe that the powerful member whether it is a manufacturer, wholesaler, or retailer, should assume channel leadership.

Although there are exceptions, the tendency appears to lean toward channels controlled by the manufacturer.

1.9 Human Resources Management

A policy is a statement of how an organization intends to handle an issue or a situation.[5] A policy statement can be brief or expanded. A key element of a policy is that it is a predetermined guideline providing a specified course of action for dealing with prescribed circumstances. Some organizations operate without written policies because they want to handle issues on a case-by-case basis. Employees may see this as a way to show favoritism or discrimination. Unwritten practices tend to become informal policies causing confusion and chaos.

Two choices are available for companies who want to develop written policies: (1) develop policies on a department level or (2) an organization level. Policies developed at the individual department level could create conflicting practices for common items such as attendance, promotions, vacations, sick leave, and employee discipline, leading to low productivity and high morale problems.

Policies developed on an organization level would provide: consistency in handling similar issues, improved communication of policy issues, control over personnel costs, prevention or response to administrative claims and litigations, compliance with government laws and regulations, and delegation of routine personnel decisions to supervisors and managers. Exhibit 1.40 presents various types of organizational policies.

- Recruiting policy
- Employee selection policy
- Equal employment opportunity policy
- Transfers and promotions policy
- Performance appraisals policy
- Pay administration policy
- Bonus incentives policy
- Wage garnishments policy
- Records retention policy
- Safety policy

Exhibit 1.40: Types of organizational policies

[5] ***Personnel Policy Handbook,*** *William S. Hubbartt, McGraw-Hill, New York, 1993.*

(a) **Recruiting Policy.**

(i) **Policy guidance.** A human resource policy on recruiting will guide managers to hire the right person for the job. The primary purpose of the recruiting policy is to attract qualified candidates at a minimum cost and time. A recruiting policy also will enable the organization to contact a diverse variety of recruiting resources, which helps to avoid charges of bias in recruiting practices.

In the absence of a defined recruiting policy, hiring managers will do whatever method works best for attracting candidates. Some will ask employees for referrals, some will talk to employment agencies, while others place an advertisement in the local paper. These efforts will produce varying results. Some recruiting methods will be more costly than others. A recruiting policy will help managers to achieve the best results.

(ii) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risks and exposures. They include

- Although hiring of applicants referred by current employees is a low-cost and effective means for recruiting employees, excessive reliance on this method can be counterproductive and even result in legal problems for the employer. Employee cliques would result in excessive turnover because newly hired workers would feel like outsiders.
- Failure to attract a diverse applicant pool could result in charges of employment discrimination by the Equal Employment Opportunity Commission (EEOC) as discriminating between minority and nonminority applicants. It is a good practice to communicate job opening information to all employees and to all outside communities through various media available.
- Conflict between recruiting policy and promotion-from-within policy could slow down and complicate the hiring process. For example, promotion policies complicate the hiring process by delaying the filling of the job or requiring the promotion of a marginally qualified worker when a fully qualified applicant from outside the company is available.

(b) **Employee Selection Policy.**

(i) **Policy guidance.** Careful employee selection is an important activity because capable, hardworking employees affect the productivity and profitability of the organization. This involves employee screening, testing, physical exam, and orientation. Costs are incurred during selection, termination, and rehiring.

The objective of a policy on employee selection and testing is to provide guidelines on selection procedures that will help managers in selecting a qualified employee while avoiding legal liabilities. Policy guidance facilitates a uniform and thorough approach to employee selection. With selection guidelines, there is a great likelihood that supervisors will make better selection decisions.

In the absence of guidelines, managers will try different employee selection techniques. Some managers conduct detailed interviews. Others may ask only a few questions about job skills or personal interests and then make a hiring decision based on applicant personality. Some managers devise tests for applicants or ask applicants to demonstrate their skill at running a machine used on the job. At best, these techniques will have varying degrees of success and, at worst, such practices have been shown to be improper and discriminatory selection devices. EEOC provides guidelines about employment tests, interviewer rating scales, and the regulation requirements that the test be a valid measure of required performance on the job.

Job Descriptions

A job description is useful in employee recruiting, screening, training, compensating, and evaluating performance. A written job description is needed to effectively analyze the job to determine its exempt or nonexempt status. Management is responsible for developing, using, and maintaining the job description. They should not include gender-based terms (e.g., salesperson), or arbitrary requirements (e.g., high school or college degree), which could be viewed as discriminatory and in violation of antibias laws. Job descriptions should include a disclaimer which asserts management's right to change job duties.

(ii) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risks and exposures. They include

- Be aware that polygraph testing for preemployment screening of applicants by nongovernmental employees is now a prohibited employment practice under the Polygraph Protection Act of 1990.
- Be aware of the Americans with Disabilities Act (ADA) of 1990 which states that in the event that an applicant with a disability is unable to complete a test due to his disability, the employer is responsible for making a reasonable accommodation by identifying an alternative means to permit the applicant to demonstrate the skill or knowledge that the test purports to measure.
- Avoid inquiries about physical or mental handicaps, age, sex, national origin, or other protected categories on the employment application.
- Avoid misunderstandings by confirming job offers in a letter, which specifies job, start date, and pay rate.
- Use objective, job-related criteria throughout the selection process. Job descriptions are a useful tool in the selection process.
- Be consistent in the use of selection techniques. If a selection procedure, such as reference checks, physical exam, or drug screen, is used on one candidate, it should be used on all candidates for the same job or similar class of jobs. Sporadic use of a selection procedure could be viewed as a discriminatory hiring practice.
- Check employment classifications (e.g., exempt or nonexempt employee) to ensure that they do not create a category that groups employees by race, age, sex, or other protected class defined by antibias laws. Employment classifications help to sort out issues such as eligibility for benefits, payments of salaries, and entitlement to overtime pay.
- Be aware that the preemployment physical exam is now prohibited by ADA. A postoffer physical exam is allowed as long as it is not used to screen out qualified disabled applicants. However, Occupational Safety and Health Administration (OSHA) requires preemployment physical exams on certain jobs such as employees working in a noisy environment. These applicants require a hearing test and periodic retesting.
- Avoid placing a new employee on a new job without complete orientation and training.
- Avoid telling a new employee that he will receive a salary adjustment after 30 or 60 days. Use the term performance appraisal instead of a salary adjustment, where the latter term would imply an automatic increase in the salary.

KEY CONCEPTS TO REMEMBER: JOB ANALYSIS, JOB DESCRIPTIONS, AND JOB SPECIFICATIONS

- A **job analysis** is used to develop job descriptions and job specifications. The **development** function is the place where job analyses are done. The scope of a job analysis includes: (1) analyzing workflows and tasks, (2) observing employees work, (3) studying the methods used to attain work-unit objectives, and (4) interviewing employees about how they accomplish their tasks. The administration of a fair and equitable compensation program should be based on a current job analysis.

Job analysis → Job descriptions → Job specifications

- A **job/position description** is developed based on a job analysis. A job description includes a listing of job title, job duties, job requirements, and reporting relationships. It summarizes the duties that the employee will be held accountable for performing. Compensation rates are not included in job descriptions although they are developed simultaneously.
- A **job specification** document will contain the job requirements in detail (which becomes a "core" of the job) and the minimum qualifications (e.g., education, experience, other skills) necessary to perform the job satisfactorily.

(c) **Equal Employment Opportunity Policy.**

(i) **Policy guidance.** A policy statement asserting equal employment opportunity, by itself, is not enough to prevent discriminatory practices. Since equal employment laws cover all employment decisions, specific guidelines are needed to guide managers in effectively implementing this policy.

A policy on equal employment opportunity must accomplish a variety of purposes. It must identify protected class employees, specify covered employment decisions, outline guidelines for managers, provide a mechanism for individuals to present claims, and define procedures for resolution of those claims.

(ii) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risk and exposures. Some of them are

- Avoid using "boilerplate" equal employment policy and expect to be in full compliance with the law. For employees, management actions will speak much louder than words.
- Address nondiscrimination issues when writing personnel policies for recruiting, selection, training, promotions, pay administration, discipline, appraisals, discharges, and other policy areas.
- Implement all policies consistently for all employees. For example, excessive attention to or documentation of the discharge of a minority when other cases are not similarly documented could be viewed as a discriminatory practice. Likewise, a company's failure to document the performance problems of a minority female because of fear of a discrimination claim, and then subsequently terminating that individual, was judged to be a discriminatory employment practice.
- Issue separate policies on preventing sexual harassment or complying with disabilities act provisions in order to get special attention instead of combining with other policies of the organization.

Courts have held that a hostile or offensive working environment constitutes unlawful sexual harassment even if the employee bringing the suit suffers no economic or job benefit losses as a result of such harassment. The EEOC holds the employer accountable for controlling sexual harassment occurring between employees, supervisors, and subordinates, or customers if the employer knows or should have known of the conduct. The EEOC recommends that companies should take proactive measures to prevent sexual harassment by developing a policy and communicating information to employees.

AFFIRMATIVE ACTION VERSUS EQUAL EMPLOYMENT OPPORTUNITY

- Firms having a specified dollar volume of contracts with the federal government or some other government jurisdictions are subject to affirmative action requirements. These require a race–sex breakout of the workforce, compared to a race–sex breakout of the area labor force.
- Equal employment opportunity policies specify nondiscriminatory and nonpreferential treatment for all candidates and employees.

(d) **Transfers and Promotions Policy.**

(i) **Policy guidance on transfers.** Employee transfers can occur between jobs, work locations, operating shifts, or departments. Transfers may be initiated by the organization to move an employee to another assignment in response to staffing requirements. Employees may also request transfers. Transfers may be temporary or permanent.

A personnel policy on transfers helps to sort out these various issues and guide the reassignment of employees to other jobs. The process of transferring employees raises questions about pay rates, shift differential pay, reporting relationships, and duration of assignments. Transfers can also result in relocation for employees and their families. If these issues are not resolved properly, the employee will not be fully effective and productive on the new job assignment, thus costing more than its benefits.

(ii) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risks and exposures. Some of these are

- Do not give up the flexibility to make temporary transfers when needed to respond to unique business conditions. Protect the management prerogative to assign employees to special tasks.
- Make sure that employee availability for transfer is a condition of employment.
- Avoid hardships to employees by allowing employees to accept or reject the transfer.
- Customize the transfer policies to be responsive to employee needs as well as business requirements.

(iii) **Policy guidance on promotions.** For many employees, career advancements and the opportunity for greater earnings is a significant motivator, which can contribute to organizational loyalty. Promotion policies are generally seen as good for morale. Often, employees seek employment at a particular firm because of career advancement potential. For these reasons, many organizations have a philosophy of trying to promote from within whenever possible (see Exhibit 1.41).

Advantages and disadvantages of promoting from within	*Advantages and disadvantages of hiring an outsider*
• Advantages include increased motivation among employees, less expensive than hiring an outsider, and not difficult to identify proven performers • Disadvantages include possibility of social inbreeding	• Advantages include bringing a new perspective to or fresh look at the problem, and current experience, training, skill, and education • Disadvantages include more expensive than promoting from within and difficult to identify proven performers

Exhibit 1.41: Advantages and disadvantages of promoting from within and hiring an outsider

While advantages of promoting from within are low cost and timeliness, some disadvantages include promotion dilemma (i.e., when two equally qualified subordinates were under consideration for the job), low employee morale, and low productivity if the company disregards qualified employees to hire an outsider.

(iv) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risks and exposures. Some of them are

- Use job bidding promotion procedures so that only interested employees will come forward to apply.
- Post all jobs covered by the policy on the bulletin board. Failure to post jobs would lead to charges of favoritism. Posting the job and interviewing all candidates allows management to evaluate candidates and counsel those who are not selected.

(e) **Performance Appraisals Policy.**

(i) **Policy guidance.** A performance appraisal is a structured discussion between employee and supervisor. It provides an opportunity for the supervisor to recognize an employee's achievements, offer suggestions for improvement when needed, discuss job responsibilities, define job objectives, counsel on career advancements, and justify a pay adjustment.

A policy on performance appraisals provides guidelines for managers to conduct effective performance appraisal. The policy can identify when performance appraisals should be scheduled, who is responsible for preparation of the appraisal, how the appraisal influences pay adjustments, and how to prepare for and conduct performance appraisals.

(ii) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risks and exposures. Some of them are

- Use the objective data of performance results rather than subjective opinions. Recognition of good performance can be a motivation for employees. Likewise, when the employee performs poorly, the manager should rate the employee accordingly. If the manager fails to identify poor performance, the employee is likely to assume that performance is satisfactory, unless told otherwise.
- Consider separating performance appraisals and pay discussion. Otherwise, there is a great likelihood that the employee may think that the both of them are the same.
- Avoid low rating from "hard" managers compared to high ratings from "easy" managers. One way to reduce this kind of inconsistency is to include performance-level definitions in the per-

formance appraisal policy guidelines. Another approach is to have the appraisal form reviewed by the human resource specialist.

- Conduct the performance appraisals on time to reduce employee anxiety and tension. This can be achieved by having the human resource specialist remind the functional manager about due dates and monitor appraisal for on-time completion.

(f) **Pay Administration Policy.**

(i) **Policy guidance.** A pay administration policy provides instructions to aid supervisors in understanding the organization's compensation philosophy, formulating pay offers, and having salary adjustments. Further, it can define guidelines which allow supervisors to make pay decisions within prescribed limits. Exceptions to pay policy can be referred to human resources management for approval.

Sequence of Activities in Pay Administration

- Perform job analysis
- Develop job description
- Conduct job evaluation
- Determine salary ranges or pay levels
- Conduct performance appraisal

An organization's compensation philosophy sets the direction for its pay policy. The pay philosophy determines whether the firm is going to be a pay leader or follower, or match competitive norms. Many large firms tend to have defined compensation programs with formalized job evaluation systems and salary ranges. A plan of job classification is the basic element of compensation analysis and job evaluation.

A carefully defined pay administration policy also helps an organization comply with the Equal Pay Act of 1963. This Act prohibits unequal wages for women and men who work in the same company performing substantially equal work with respect to skill, effort, and responsibility under similar working conditions.

(ii) **Ways to minimize potential risks and exposures**. There are various ways to minimize potential risks and exposures. Some of them are

- Minimize the likelihood of inequity in pay rates by having a human resource or compensation specialist review all pay offers and pay adjustments. The specialist should advise the supervisor if pay rates or pay ranges are unusually high or low.
- Improve control and consistency by defining a pay structure. The process for preparing a pay structure includes job evaluation, comparison of pay to an area salary survey, and creation of pay ranges. This process provides an objective basis to define job levels.

KEY CONCEPTS TO REMEMBER: PAY PLANS

Four different pay plans exist: all-salary, skill-based evaluation, lump-sum salary increases, and cafeteria benefits. Advantages, disadvantages, and possible outcomes for each pay plan are presented below.

- **All-salary.** Advantages include: promotes a climate of trust and produces increased satisfaction and job attraction. Disadvantages include: possible higher costs of administration and possible greater absenteeism. Possible favorable outcomes include: supervisors will deal with absenteeism, will produce participative climate, will create a responsible workforce, and jobs will be well designed.
- **Skill-based evaluation.** Advantages include: promotes a more flexible and skilled workforce, promotes increased satisfaction, and promotes a climate of growth. Disadvantages include: higher costs of training and higher salaries. Possible favorable outcomes include: employees will want to develop themselves, and pay would be related to performance.

- **Lump-sum salary increases.** Advantages include: provides increased pay satisfaction and provides greater visibility of pay increases. Disadvantages include: higher cost of administration and short-term salary inequities. Possible favorable outcomes include: provides fair pay rates and pay would be related to performance.
- **Cafeteria benefits.** Advantages include: provides increased pay satisfaction and provides greater job attraction. Disadvantages include: higher cost of administration and possible lack of employee knowledge on various options. Possible favorable outcomes include: will provide a well-educated, heterogeneous work force and provides good data processing.

SOURCE: *CIA Exam, Questions and Suggested Solutions, May 1989, Part III, Question 51. The Institute of Internal Auditors, Altamonte Springs, Florida.*

(g) **Bonus Incentives Policy.**

(i) **Policy guidance.** Many organizations have considered bonus or incentive pay plans as a way to stimulate desired improvements in productivity and quality levels. The goal of a bonus incentive plan is to reward employees for achievement of specified performance results. It is a win-win situation—the employees benefit from higher compensation based upon their attainment of plan objectives. The employer benefits because increased productivity (or lower costs) promotes higher profits. A good bonus plan should pay for itself.

Varieties of incentive pay plans follow. Premium pay is used by some firms to provide an incentive for certain kinds of work. Premium pay is added to the employee's base pay when certain specified conditions are met. Piece rate is often used in manufacturing firms where employee productivity is measured by the number of pieces produced. Many sales people are compensated on a commission basis. The commission is a designated percent of the selling price or profits on the items sold. Bonus incentives can be an informal payout to employees after a profitable year based on management discretion.

(ii) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risks and exposures. Some of them are

- A poorly designed bonus plan or unattainable incentive goals will be demotivating.
- Recognize that a bonus incentive plan can cause employees to focus activities solely toward the specified bonus incentive factor, at the expense of other job activities. To balance this conflict situation, both quality and quantity goals should be emphasized.
- Consider implementing two types of bonus incentive plans: one on an individual basis and the other based on group. An individual incentive coupled with a group incentive plan helps promote teamwork throughout the organization and achieve a balance between individual and group goals.

(h) **Wage Garnishments Policy.**

(i) **Policy guidance.** Wage garnishments are a court-ordered process for an employer to withhold a portion of an employee's earnings for payment of a debt. Therefore, the garnishments impose a legal obligation upon the employer. An employer's failure to withhold monies as directed could create financial obligations on the company. Further, failure to properly handle deductions can create legal liabilities for the firm. For these reasons, it is important to define a policy to guide the handling of wage deduction orders.

There are a variety of wage deduction orders: tax liabilities (back taxes) to tax authorities, spouse or dependent (child) support payments, and creditors based on wage assignment agreement when granting credit.

The Consumer Credit Protection Act is one law that defines employer obligations relating to wage garnishments. The Act prohibits employers from discharging an employee whose earnings have been subjected to any one indebtedness. Further the law limits the amount of an employee's wages that can be subject to garnishments.

Until the Hatch Act was amended in February 1994, the federal government agencies were exempted to collect wages from federal government employees for debts incurred outside their em-

ployment. The new Act requires federal agencies to honor court orders for withholding amounts of money from an employee's wages, and to make payment of that withholding to another person or organization for the specific purpose of satisfying a legal debt of the employee. The total debt can include recovery of attorney's fees, interest, or court costs.

(ii) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risks and exposures. Some of them are

- The employer will incur extra costs for handling the wage garnishment orders. As a result, employers may be upset with the employee or with the system and take inappropriate action creating legal liabilities.
- Do not be tempted to fire the employee when a wage garnishment order is received.
- Be alert for official-looking letters from collections agencies demanding wage deductions to pay off indebtedness.
- Specify a priority sequence for handling multiple garnishments received on the same employee. For example, an IRS tax garnishment takes priority over all others, then support garnishment, and then garnishment for other debts. Garnishment orders should be processed one at a time in the order received. When two or more garnishments are received, notify the creditor that their demand notice will be satisfied upon completion of prior notices.

(i) **Records Retention Policy.**

(i) **Policy guidance.** Federal government labor laws, wage hour laws, and many similar state laws specify certain minimum records that must be maintained by employers. These laws define minimum records retention requirements. Some states have laws that deal with the issues of personnel records privacy and employee access to personnel files.

A policy on human resources records is important for the following reasons: to maintain accurate records, to retain records required by law, and to protect records' confidentiality. For example, with accurate personnel records that reflect the individual's education, experience, job history, and performance levels, management can make more informed personnel decisions. Other advantages of accurate personnel records include: helping a company to prevail in unemployment compensation hearings, and providing a basis for defending against discrimination charges or wrongful discharge lawsuits.

(ii) **Ways to minimize potential risks and exposures.** There are various ways to minimize potential risks and exposures. Some of them are

- Protect the confidentiality of personnel records by keeping files in locked drawers or file cabinets and requiring access codes to access computer-based records, and by changing these access codes periodically.
- Avoid the tendency to allow supervisors unrestricted latitude in responding to reference check inquiries by other area employers. A former employee can file a lawsuit because of poor handling of employment references. An untrained supervisor carelessly giving a bad reference about a former employee could create a liability for a libel or defamation lawsuit. The best preventative action is to send reference inquiries to the personnel records specialist. Release references only in response to written inquiries. Limit the reference check to verifying dates of employment and job title(s) and confirming salary if the other employer provided data given by the employee. Avoid detailed subjective evaluation of unverifiable performance information.
- Avoid unnecessary restrictions on employees viewing their own files. When permitting the employee to view the file, the viewing should take place in the presence of a supervisor, manager, or human resource specialist. This prevents unauthorized removal of documents from or insertion of documents into the employee file.

(j) **Safety Policy.** Firms that have successful safety programs typically share three common characteristics: a management commitment to safety, active employee participation in safety activities, and thorough investigation of accidents. Successful safety programs reduce accidents. Fewer accidents mean less work interruptions, fewer worker's compensation claims, and lower insurance costs.

The US Occupational Safety and Health Administration (OSHA) is the federal government agency responsible for defining and enforcing job standards. The OSHA law covers all employers engaged in a

business affecting commerce, but excludes self-employed individuals, family firms, and workplaces covered by other federal safety laws. Employers covered by OSHA have a general duty to maintain a safe and healthful workplace. The general duty requirements mean that the employer must become familiar with safety standards that affect the workplace, educate employees on safety, and promote safe practices in the daily operation of the business.

Manufacturing Operations Audit

In a manufacturing operations audit, the audit objective was to determine whether all legal and regulatory requirements concerning employee safety are being properly implemented. The audit procedure would be examining documentation concerning the design and operation of the relevant systems and observing operations for compliance.

(i) **Safety responsibility.** A safety responsibility policy serves as the framework for additional policy guidelines that direct safety activities. Typical safety activities include safety orientation, safety training, safety committee, workplace inspections, and accident investigations. Also effective in promoting safe work practices are safe operating procedures, job safety analysis, and publishing of safety rules. In order to implement this policy, a safety manager should be designated to coordinate day-to-day safety activities, and should be supported by higher-level management for having ultimate responsibility for directing workplace safety.

Safety policy guidelines provide a basis for promoting employee participation in safety activities. Active participation in safety is one important way to keep safety in everyone's mind. A safety mindset helps to prevent accidents.

Some risks that could result from noncompliance, or pitfalls to avoid, include: not holding supervisors and managers accountable for safety in their respective work areas, and not including safety results on a supervisor's performance evaluation, and tendency to publish a few safety rules and then let things slide. Under the law, an employer will be held liable for failing to enforce safety rules. If a company publishes a safety rule, but neglects to require employees to comply with the rule, the firm may be subject to a citation.

(ii) **Accident investigation.** The purpose of accident investigation is to identify the accident's cause so that future accidents can be avoided. In addition to prevention of accidents, accident investigations serve several other important functions such as: eliminating unsafe conditions, identifying training needs, redesigning jobs, preventing or combating fraud related to unethical worker's compensation claims, analyzing accident data, and reporting to government.

1.10 Balanced Scorecard System

Objectives. Most businesses have traditionally relied on organizational performance based almost solely on financial or accounting-based data (e.g., return on investment [ROI] and earnings per share) and manufacturing data (e.g., factory productivity, direct labor efficiency, and machine utilization). Unfortunately, many of these indicators are inaccurate and stress quantity over quality. They reward the wrong behavior; lack predictive power; do not capture key business changes until it is too late; reflect functions, not cross-functional processes; and give inadequate consideration to difficult-to-quantify resources such as intellectual capital. Most measures are focused on cost, not so much on quality.

Kaplan and Norton[6] of Harvard Business School coined the term "balanced scorecard" in response to the limitations of traditional financial and accounting measures. They recommend that key performance measures should be aligned with strategies and action plans of the organization. They suggest translating the strategy into measures that uniquely communicate the vision of the organization. Setting targets for each measure provides the basis for strategy deployment, feedback, and review.

The balanced scorecard system is a comprehensive management control system that balances traditional financial measures with nonfinancial measures (e.g., customer service, internal business processes, and the organization's capacity for innovation and learning). This system helps managers focus on key performance measures and communicate them clearly throughout the organization.

Kaplan and Norton divided the strategy-balanced scorecard into four perspectives or categories as follows:

[6] ***The Strategy-Focused Organization,*** *Robert Kaplan and David Norton, Harvard Business School Press, Boston, MA, 2001.*

1. **Financial perspective.** The financial strategy focuses on matters from the perspective of the shareholder. It measures the ultimate results that the business provides to its shareholders, including profitability, revenue growth (net income), return on investment, economic-value-added, residual income, costs, risks, and shareholder value. Financial measures are lagging measures (lag indicators); they report on outcomes, the consequences of past actions. They tell what has happened. The financial perspective is looking back.
2. **Internal business process perspective.** The internal business process focuses on strategic priorities for various business processes, which create customer and shareholder satisfaction. It focuses attention on the performance of the key internal processes that drive the business, including such measures as quality levels, efficiency, productivity, cycle time, production and operating statistics such as order fulfillment or cost per order. Internal process measures are leading measures (lead indicators); they predict what will happen. The internal process theme reflects the organization value chain. The internal process (operations) perspective is looking from the inside out.
3. **Customer perspective.** The customer strategy is aimed at creating value and differentiation from the perspective of the customer. It focuses on customer needs and satisfaction as well as market share, including service levels, satisfaction ratings, loyalty, perception, and repeat business. The customer perspective is looking from the outside in.
4. **Innovation and learning perspective.** The innovation and learning strategy sets priorities to create a climate that supports organizational change, innovation, and growth. It directs attention to the basis of a future success—the organization's people and infrastructure. Key measures might include intellectual assets, employee satisfaction and retention, market innovation (new product introductions), employee training and skills development, research and development (R&D) investment, R&D pipeline, and time to market a product or service. Innovation and learning perspective is looking ahead.

Measures should include both financial and nonfinancial. Financial measures include ROI, residual income, earnings per share, profit, cost, and sales. Nonfinancial measures include customer measures, internal business process measures, innovation and learning measures, and manufacturing measures. Customer measures include satisfaction, perception, and loyalty. Internal business process measures include efficiency, quality, and time. Innovation and learning measures include research and development (R&D) investment, R&D pipeline, skills and training for employees, and time to market a product or service. Manufacturing measures include factory productivity, direct labor efficiency, and machine utilization.

A good balanced scorecard system contains both leading and lagging indicators, and both financial and nonfinancial measures. For example, customer survey (performance drivers) about recent transactions might be a leading indicator for customer retention (a lagging indicator); employee satisfaction might be a leading indicator for employee turnover (a lagging indicator), and so on. These measures and indicators should also establish cause-and-effect relationships across the four perspectives. The cause-and-effect linkages describe the path by which improvements in the capabilities of intangible assets (people) get translated into tangible customer satisfaction and financial outcomes.

The balanced scorecard provides graphical representation on strategy maps and provides a logical and comprehensive way to describe strategy. They communicate clearly the organization's desired outcomes and describe how these outcomes can be achieved. Both business units and their employees will understand the strategy and identify how they can contribute by becoming aligned to the strategy.

WHICH SCORECARD PERSPECTIVE IS WHICH?

- The financial perspective is looking back.
- The internal process perspective is looking from inside out.
- The customer perspective is looking from outside in.
- The innovation and learning perspective is looking ahead.

MULTIPLE-CHOICE QUESTIONS (1-430)

Quality Management

1. Customers consistently rank which of the following service-quality dimensions as the most important?
a. Reliability.
b. Assurance.
c. Tangibles.
d. Responsiveness.

2. Which of the following is at the core of the definition of total quality management (TQM)?
a. Customer surveys.
b. Continuous improvement.
c. Employee satisfaction.
d. Supplier inspections.

3. The total quality management (TQM) program needs to be anchored to an organization's
a. Policy.
b. Procedure.
c. Culture.
d. Standards.

4. Which of the following service-quality dimensions deals with the employees' knowledge, courtesy, and ability to convey trust and confidence?
a. Empathy.
b. Assurance.
c. Tangibles.
d. Responsiveness.

5. Which of the following is **not** one of the principles of total quality management (TQM)?
a. Do it right the first time.
b. Strive for zero defects.
c. Be customer-centered.
d. Build teamwork and empowerment.

6. In the context of total quality management (TQM), a cause-and-effect analysis can be carried out with
a. Kaizen.
b. A flow chart.
c. A fishbone diagram.
d. Interrelationship digraph.

7. In the context of total quality management (TQM), "vital few and trivial many" analysis can be carried out with a
a. Pareto diagram.
b. Run chart.
c. Fishbone diagram.
d. Control chart.

8. In the context of total quality management (TQM), the correlation between two product characteristics is carried out with a
a. Run chart.
b. Histogram.
c. Scatter diagram.
d. Control chart.

9. In the context of total quality management (TQM), the best way to view Kaizen is that it is a
a. Program.
b. Procedure.
c. Destination.
d. Journey.

10. In the context of total quality management (TQM), the best way to identify and eliminate unnecessary work steps in a process is carried out with a
a. Flowchart.
b. Control chart.
c. Run chart.
d. Pareto chart.

11. Total quality management (TQM) should be viewed as
a. Customer centered and employee driven.
b. Management centered and technology driven.
c. Policy centered and procedure driven.
d. Goal centered and standard driven.

12. When a product conforms to its design specifications, it is called
a. Product-based quality.
b. Value-based quality.
c. Transcendent quality.
d. Manufacturing-based quality.

13. Which of the following TQM process improvement tools tracks the frequency or amount of a given variable over time?
a. A run chart.
b. A histogram.
c. A scatter diagram.
d. A control chart.

14. Which of the following TQM process improvement tools monitors the actual versus desired quality measurements during repetitive operations?
a. A run chart.
b. A histogram.
c. A scatter diagram.
d. A control chart.

15. Which of the following TQM process improvement tools indicates deviations from a standard bell-shaped curve?
a. A run chart.
b. A histogram.
c. A scatter diagram.
d. A control chart.

16. The costs of providing training and technical support to the supplier in order to increase the quality of purchased materials are examples of
a. Prevention costs.
b. Appraisal costs.
c. Internal failure costs.
d. External failure costs.

17. The costs of repairs made under warranty or product recalls are examples of
a. Prevention costs.
b. Appraisal costs.
c. Internal failure costs.
d. External failure costs.

18. The costs of inspecting raw materials, testing goods throughout the manufacturing process, and testing the final product are examples of
a. Prevention costs.
b. Appraisal costs.
c. Internal failure costs.
d. External failure costs.

19. The costs of the material, labor, and other manufacturing costs incurred in reworking defective products and the costs of scrap and spoilage are examples of
a. Prevention costs.
b. Appraisal costs.
c. Internal failure costs.
d. External failure costs.

20. Services can be characterized by all of the following characteristics **except** for:
a. Intangibility.
b. Homogeneity.
c. Perishability.
d. Inseparability.

21. There are four unique characteristics that distinguish goods from services. The one that is the primary source of the other three characteristics is
a. Intangibility.
b. Heterogeneity.
c. Perishability.
d. Inseparability.

22. Customers have a difficult time objectively evaluating services due to which of the following?
a. Intangibility.
b. Heterogeneity.
c. Perishability.
d. Inseparability.

23. The service characteristic that reflects the variation in consistency from one service transaction to the next is
a. Intangibility.
b. Heterogeneity.
c. Perishability.
d. Inseparability.

24. The unique service characteristic that deals specifically with the inability to store inventory of services is
a. Intangibility.
b. Heterogeneity.
c. Perishability.
d. Inseparability.

25. In the six-sigma methodology, the "analyze" stage serves as an outcome of which of the following stages?
a. Define.
b. Control.
c. Measure.
d. Improve.

26. In the six-sigma methodology, the mistake-proofing tool is used in which of the following stages?
a. Define.
b. Control.
c. Measure.
d. Improve.

27. In which of the following six-sigma methodology stages do process or product improvements become institutionalized?
a. Define.
b. Control.
c. Measure.
d. Improve.

28. A process-mapping tool is **not** used in which of the following six-sigma methodology stages?
a. Define.
b. Control.
c. Measure.
d. Analyze.

29. The cause-and-effect diagram is used in which of the following six-sigma methodology stages?
a. Define.
b. Analyze.
c. Improve.
d. Control.

30. Brainstorming techniques are used in which of the following six-sigma methodology stages?
a. Define.
b. Analyze.
c. Measure.
d. Control.

31. Which of the following will be useful throughout the process in the six-sigma methodology?
a. "As is" process map.
b. "Should be" process map.
c. "Could be" process map.
d. "May be" process map.

32. An "as is" process map is used in which of the following stages of the six-sigma methodology?
a. Define.
b. Measure.
c. Analyze.
d. Improve.

33. A "should be" process map is used in which of the following stages of the six-sigma methodology?
a. Define.
b. Measure.
c. Analyze.
d. Improve.

34. Both common causes and special causes are identified in which of the following stages of the six-sigma methodology?
a. Define.
b. Measure.
c. Analyze.
d. Improve.

35. In the six-sigma training environment, which of the following roles is primarily dependent on others to acquire data?
a. Green belts.
b. Black belts.
c. Master black belts.
d. Sponsors.

36. In the six-sigma training environment, which of the following roles is based on the principle of contributing independently and applying the tools and techniques?
a. Green belts.
b. Black belts.
c. Master black belts.
d. Sponsors.

37. In the six-sigma training environment, which of the following roles is based on motivating others so they may contribute to the success of the organization?
a. Green belts.

b. Black belts.
c. Master black belts.
d. Sponsors.

38. In the six-sigma methodology, the quality function deployment (QFD) technique is used to
a. Improve product design and reliability.
b. Measure process capabilities.
c. Implement statistical process control.
d. Improve organizational processes.

39. In the six-sigma methodology, process-mapping techniques are used to
a. Improve product design and reliability.
b. Measure process capabilities.
c. Implement statistical process control.
d. Improve organizational processes.

40. In the six-sigma methodology, mistake-proofing techniques are used to
a. Improve product design and reliability.
b. Measure process capabilities.
c. Implement statistical process control.
d. Improve organizational processes.

41. All of the following are effective ways to prevent service mistakes from occurring **except:**
a. Source inspections.
b. Self-inspections.
c. Sequence checks.
d. Mass inspections.

Items 42 through 44 are based on the following:

After experiencing decreases in performance levels, a company implemented several changes in its management and production methods to improve product quality and productivity. As its first change, management organized quality circles. These groups of employees, including supervisors, met weekly to identify and discuss problems, investigate causes, and recommend and implement corrective actions.

All of the company's products involve high technology, specialized raw materials, and skilled labor. In the past, manufacturing was organized around highly trained, specialized employees. In an effort to further improve production, the company became less specialized by expanding production horizontally. This change meant that both the variety and number of tasks an individual performed increased. As a result, the average number of products for each employee to produce was reduced from seven to four.

42. The implementation of quality circles as described above is an application of which of the following motivational concepts?
a. Participative management.
b. Management by objectives.
c. Offering extrinsic rewards.
d. Motivation-hygiene theory.

43. Grouping production activities by having employees perform more than one task in the horizontal expansion of jobs is an example of job
a. Rotation.
b. Sharing.
c. Enlargement.
d. Enrichment.

44. When making these changes, management told employees that if the company was to stay in business, productivity and product quality needed vast improvement. Management tried to convince employees that by learning additional skills and working within quality circles, both production and quality would be increased. They assured employees that additional training and hard work would enable them to perform new skills and achieve success in quality circles. Management's explanation and arguments are an application of which of the following?
a. Reinforcing positive behavior.
b. Letting employees know what is expected of them.
c. Using identified employee needs to motivate employees.
d. Assuming that employees will work as hard as needed in order to be treated fairly.

45. In an organization with empowered work teams, organizational policies
a. Should define the limits or constraints within which the work teams must act if they are to remain self-directing.
b. Become more important than ever. Without clear rules to follow, empowered work teams are almost certain to make mistakes.
c. Should be few or none. The work teams should have the freedom to make their own decisions.
d. Should be set by the teams themselves in periodic joint meetings.

46. Empowerment is a process that increases an employee's motivation to perform well. Empowerment is **not** facilitated if management
a. Uses participative decision-making.
b. Uses standard (downward) performance appraisals.
c. Decreases the degree of formalization.
d. Educates and trains its employees.

47. Which of the following is a key to successful total quality management?
a. Training quality inspectors.
b. Intense focus on the customer.
c. Creating appropriate hierarchies to increase efficiency.
d. Establishing a well defined quality standard, then focusing on meeting it.

48. One of the main reasons that implementation of a total quality management program works better through the use of teams is
a. Teams are more efficient and help an organization reduce its staffing.
b. Employee motivation is always higher for team members than for individual contributors.
c. Teams are a natural vehicle for sharing ideas, which leads to process improvement.
d. The use of teams eliminates the need for supervision thereby allowing a company to reduce staffing.

49. One of the main reasons total quality management (TQM) can be used as a strategic weapon is that
a. The cumulative improvement from a company's TQM efforts cannot readily be copied by competitors.
b. Introducing new products can lure customers away from competitors.

c. Reduced costs associated with better quality can support higher stockholder dividends.
d. TQM provides a comprehensive planning process for a business.

50. A manager is putting together a new team. What is the most productive action this manager could take to help the team become a long-term high-performing group?
a. Assign a strong team leader from the beginning to help the group determine its goals and to divide up tasks so that the team does not waste time.
b. Select members who have similar backgrounds so that they get along well.
c. Stay out of the team's way and let them develop their own goals.
d. Provide the team with clear goals and give the team time to mature.

51. Which of the following situations would result in the **lowest** productivity for a group of workers?
a. High group cohesion with low alignment with organizational goals.
b. Low group cohesion with moderate alignment with organizational goals.
c. High amount of diversity within the team along with moderate conflict.
d. Weak leadership and strong commitment to organizational goals.

52. Focusing on customers, promoting innovation, learning new philosophies, driving out fear, and providing extensive training are all elements of a major change in organizations. These elements are aimed primarily at
a. Copying leading organizations to better compete with them.
b. Focusing on the total quality of products and services.
c. Being efficient and effective at the same time, in order to indirectly affect profits.
d. Better management of costs of products and services, in order to become the low-cost provider.

53. Total quality management in a manufacturing environment is best exemplified by
a. Identifying and reworking production defects before sale.
b. Designing the product to minimize defects.
c. Performing inspections to isolate defects as early as possible.
d. Making machine adjustments periodically to reduce defects.

54. Which statement best describes the emphasis of total quality management (TQM)?
a. Reducing the cost of inspection.
b. Implementing better statistical quality control techniques.
c. Doing each job right the first time.
d. Encouraging cross-functional teamwork.

55. Which of the following is a characteristic of total quality management (TQM)?
a. Management-by-objectives.
b. On-the-job training by other workers.
c. Quality by final inspection.
d. Education and self-improvement.

56. In which of the following organizational structures does total quality management (TQM) work best?
a. Hierarchical organizational structure.
b. Teams of people from the same specialty.
c. Teams of people from different specialties.
d. Specialists working individually.

57. If a company is customer-centered, its customers are defined as
a. Only people external to the company who have purchased something from the company.
b. Only people internal to the company who directly use its product.
c. Anyone external to the company and those internal who rely on its product to get their job done.
d. Everybody external to the company who is currently doing, or may in the future do, business with the company.

58. The basic underlying principle of the quality-of-work-life view of motivation suggests that an organization should unlock the creative potential of its people by
a. Involving them in decisions affecting their lives and providing them with more control over their work.
b. Providing fair and equitable reward systems that are clearly linked to the employees' effort and performance.
c. Focusing on employees' higher-level needs.
d. Using job enrichment techniques that increase skill variety, task identity and significance, autonomy, and feedback.

59. In a quality cost report, the category of internal failure costs is for costs incurred to correct defects and problems within the production, distribution, and marketing systems. Which one of the following costs is **not** relevant to internal failure?
a. Rework.
b. Union grievance arbitration fees.
c. Freight on returned goods.
d. Scrap.

Items 60 and 61 are based on the following:

Listed below are costs of quality that a manufacturing company has incurred throughout its operations. The company plans to prepare a report that classifies these costs into the following four categories: preventive costs, appraisal costs, internal-failure costs, and external-failure costs.

Cost items	*$ Amount*
Design reviews	275,000
Finished goods returned due to failure	55,000
Freight on replacement finished goods	27,000
Labor inspection during manufacturing	75,000
Labor inspection of raw materials	32,000
Manufacturing product-testing labor	63,000
Manufacturing rework labor and overhead	150,000
Materials used in warranty repairs	68,000
Process engineering	180,000
Product-liability claims	145,000
Product-testing equipment	35,000
Repairs to equipment due to breakdown	22,000
Scheduled equipment maintenance	90,000
Scrap material	125,000
Training of manufacturing workers	156,000

60. The costs of quality that are incurred in detecting units of product that do not conform to product specifications are referred to as
a. Preventive costs.
b. Appraisal costs.
c. Internal-failure costs.
d. External-failure costs.

61. The dollar amount of the costs of quality classified as preventive costs for the manufacturing firm would be
a. $643,000
b. $701,000
c. $736,000
d. $768,000

62. The most important component of quality control is
a. Ensuring goods and services conform to the design specifications.
b. Satisfying upper management.
c. Conforming with ISO-9000 specifications.
d. Determining the appropriate timing of inspections.

63. Under a total quality management (TQM) approach
a. Measurement occurs throughout the process, and errors are caught and corrected at the source.
b. Quality control is performed by highly trained inspectors at the end of the production process.
c. Upper management assumes the primary responsibility for the quality of the products and services.
d. A large number of suppliers are used in order to obtain the lowest possible prices.

64. Quality control circles are now used all over the world. They typically consist of a group of five to ten employees who meet regularly. The primary goal of these circles is
a. To improve the quality of leadership in the organization.
b. To tap the creative problem-solving potential of every employee.
c. To improve communications between employees and managers by providing a formal communication channel.
d. To allow for the emergence of team leaders who can be targeted for further leadership development.

65. A traditional quality control process in manufacturing consists of mass inspection of goods only at the end of a production process. A major deficiency of the traditional control process is that
a. It is expensive to do the inspections at the end of the process.
b. It is not possible to rework defective items.
c. It is not 100% effective.
d. It does not focus on improving the entire production process.

66. Quality control programs employ many tools for problem definition and analysis. A scatter diagram is one of these tools. The objective of a scatter diagram is to
a. Display a population of items for analysis.
b. Show frequency distribution in graphic form.
c. Divide a universe of data into homogeneous groups.
d. Show the vital trend and separate trivial items.

Items 67 and 68 are based on the following:

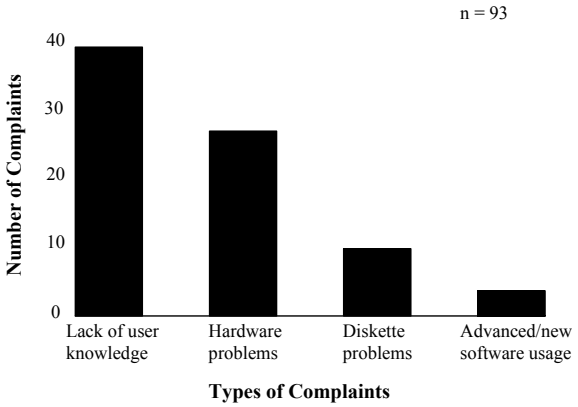
The management and employees of a large household goods moving company decided to adopt total quality management (TQM) and continuous improvement (CI). They believed that if their company became nationally known as adhering to TQM and CI, one result would be an increase in the company's profits and market share.

67. The primary reason for adopting TQM was to achieve
a. Greater customer satisfaction.
b. Reduced delivery time.
c. Reduced delivery charges.
d. Greater employee participation.

68. Quality is achieved more economically if the company focuses on
a. Appraisal costs.
b. Prevention costs.
c. Internal failure costs.
d. External failure costs.

Items 69 and 70 are based on the following:

An organization has collected data on the complaints made by personal computer users and has categorized the complaints.



69. Using the information collected, the organization should focus on
a. The total number of personal computer complaints that occurred.
b. The number of computer complaints associated with diskette problems and new software usage.
c. The number of computer complaints associated with the lack of user knowledge and hardware problems.
d. The cost to alleviate all computer complaints.

70. The chart displays
a. The arithmetic mean of each computer complaint.
b. The relative frequency of each computer complaint.
c. The median of each computer complaint.
d. The absolute frequency of each computer complaint.

71. Quality cost indices are often used to measure and analyze the cost of maintaining a given level of quality. One example of a quality cost index, which uses a direct labor base, is computed as

Quality cost index = (Total quality costs)/(Direct labor costs) x 100.

The following quality cost data were collected for May and June:

	May	*June*
Prevention costs	$4,000	$5,000
Appraisal costs	6,000	5,000
Internal failure costs	12,000	15,000
External failure costs	14,000	11,000
Direct labor costs	90,000	100,000

Based upon these cost data, the quality cost index
a. Decreased 4 points from May to June.
b. Was unchanged from May to June.
c. Increased 10 points from May to June.
d. Decreased 10 points from May to June.

72. Which one of the following statements about quality circles is **false**?
a. A quality circle is typically comprised of a group of eight to 10 subordinates and supervisors.
b. Part of the quality circle concept includes teaching participants communication skills, quality strategies, and problem analysis techniques.
c. Quality circles meet on the company premises and on company time.
d. The quality circle has the final control over implementation of recommended solutions.

73. A company is experiencing a high level of customer returns for a particular product because it does not meet the rigid dimensions required. Each return is reworked on a milling machine and sent back through all of the subsequent finishing steps. This is a costly process. Identify the best method for reducing the quality failure costs.
a. Customer surveys.
b. Increased finished goods inspections.
c. Defect prevention.
d. Increased work-in process inspections.

74. Which statement best describes Total Quality Management (TQM)?
a. TQM emphasizes reducing the cost of inspection.
b. TQM emphasizes better statistical quality control techniques.
c. TQM emphasizes doing each job right the first time.
d. TQM emphasizes encouraging cross-functional teamwork.

Items 75 through 77 are based on the following:

The costs of quality can be categorized as follows:

a. **Prevention costs.** This involves eliminating the production of products which do not conform to quality requirements. Costs include product and process design and testing, supplier evaluation and training, employee training, and preventative maintenance.
b. **Appraisal costs.** This involves detecting products which do not conform to quality requirements. Costs include inspection, testing, and statistical quality control.
c. **Internal failure costs.** This involves correcting or scrapping nonconforming products before they are shipped. Costs include rework, scrap, retesting, and changes in the design of the product or process.
d. **External failure costs.** This involves customers detecting nonconforming products after shipment. Costs include allowances, customer complaints, service, warranty, product liability, lost customer goodwill, and returned products.

75. Management of a company is attempting to build a reputation as a world-class manufacturer of quality products. On which of the four costs should it spend the majority of its funds?
a. Prevention costs.
b. Appraisal costs.
c. Internal failure costs.
d. External failure costs.

76. Management of a company is attempting to build a reputation as a world-class manufacturer of quality products. Which of the four costs would be the **most** damaging to its ability to build a reputation as a world-class manufacturer?
a. Prevention costs.
b. Appraisal costs.
c. Internal failure costs.
d. External failure costs.

77. Management of a company is attempting to build a reputation as a world-class manufacturer of quality products. Which of the following measures would **not** be used by the firm to measure quality?
a. The percentage of shipments returned by customers because of poor quality.
b. The number of parts shipped per day.
c. The number of defective parts per million.
d. The percentage of products passing quality tests the first time.

78. Which of the following is **least** related to product or service quality?
a. ISO 9000.
b. Continual Improvement.
c. Economic Order Quantity.
d. Quality Circles.

79. Manufacturing operations which use just-in-time (JIT) inventory delivery must develop a system of total quality control (TQC) over parts and material. The objective of TQC is to
a. Provide an early warning system that detects and eliminates defective items.
b. Statistically estimate the potential number of defective items.
c. Detect and eliminate maintenance and processing problems, which cause bottlenecks.
d. Ensure that the "pull" exerted by each assembly stage includes correct quantities and specifications.

80. Statistical quality control is often used to distinguish between random variation and other sources of variation in an operating process. A control chart that shows the fraction defective of a sample is a(n)
a. R chart.
b. X-bar chart.
c. P-chart.
d. Cusum chart.

81. Because of the difficulty and high cost of measuring the dimensions of the product produced in a certain manufacturing process, statistical quality control is done by classifying sampled products into two categories, acceptable and unacceptable. The appropriate control chart for

controlling the proportion of unacceptable units in this process is the
a. P-chart.
b. X-bar chart.
c. R chart.
d. SQC chart.

82. The costs of quality that are incurred in detecting units of product that do not conform to product specifications are referred to as
a. Prevention costs.
b. Appraisal costs.
c. Rework costs.
d. Failure costs.

83. Which of the following would minimize defects in finished goods caused by poor-quality raw materials?
a. Documented procedures for the proper handling of work-in-process inventory.
b. Required material specifications for all purchases.
c. Timely follow-up on all unfavorable usage variances.
d. Determination of the amount of spoilage at the end of the manufacturing process.

84. The use of teams in total quality management is important because
a. Well-managed teams can be highly creative and are able to address complex problems better than individuals can.
b. Teams are quicker to make decisions, thereby helping to reduce cycle time.
c. Employee motivation is higher for team members than for individual contributors.
d. The use of teams eliminates the need for supervision, thereby allowing a company to become leaner and more profitable.

International Organization for Standardization (ISO) Framework

85. Which of the following is **not** a basic requirement of the ISO 9001 quality standard?
a. Establishing and maintaining procedures for controlling documentation.
b. Procedures to verify, store, and maintain purchased items.
c. Reviewing contracts to assess whether requirements are adequately defined.
d. Simultaneous application for the Malcolm Baldrige National Quality award.

86. Which of the following is **not** a reason that firms seek ISO 9000 certification?
a. To met contractual obligations.
b. To market goods in Europe.
c. To remove tariffs.
d. To gain competitive advantage.

87. The ISO 9000 registration process includes all of the following **except:**
a. Rectification.
b. Document review.
c. Preassessment.
d. Assessment.

88. Which of the following is **not** true regarding the ISO 9000 quality standard?
a. ISO 9000 does not guarantee a quality product.
b. Its objective is to ensure conformance to documented procedures and standards.
c. Third-party auditors cannot be used.
d. Recertification is required every three years.

89. Which of the following is true about the ISO 9000 quality standards?
a. The scope of the standards aligns more closely with the US Malcolm Baldrige criteria.
b. Emphasis has shifted toward evaluating product quality.
c. The previous focus on customer expectations has been reduced.
d. The requirements for quality system documentation have increased.

90. Which of the following was specifically designed for automotive suppliers?
a. QS-9000
b. ISO 9001:2000
c. TL 9000
d. AS 9000

91. Which of the following best describes the ISO 9000 standards?
a. They are product quality standards.
b. They are quality system standards.
c. They are environmental quality standards.
d. They are people quality standards.

92. The ISO 9000 standards for quality program focuses most on which of the following areas?
a. Customer satisfaction.
b. Business results.
c. Internal processes.
d. Productivity improvements.

93. Which of the following is designed for environmental standards?
a. ISO 10012
b. ISO 10011
c. ISO 14000
d. ISO 10013

Forecasting

94. Which of the following forecasting techniques refers to the preparation and study of written descriptions of alternative but equally likely future conditions?
a. Informed judgment.
b. Scenario analysis.
c. Surveys.
d. Trend analysis.

95. Which of the following is **not** a type of forecasts?
a. Event input forecasts.
b. Event outcome forecasts.
c. Event timing forecasts.
d. Time series forecasts.

96. "Timing questions" in the event timing forecast can be answered by identifying which of the following?
a. Lagging indicators.
b. Leading indicators.
c. Coincident indicators.
d. Composite indicators.

97. Extrinsic forecasts are based on which of the following?
a. Lagging indicators.
b. Leading indicators.
c. Coincident indicators.
d. Composite indicators.

98. Which of the following is based on the assumption that the future will be an extension of present and past results?
a. Scenario analysis.
b. Survey analysis.
c. Trend analysis.
d. Market analysis.

99. Judgmental forecasts are
a. Fast and expensive.
b. Slow and inexpensive.
c. Fast and inexpensive.
d. Reliable and accurate.

100. Gradual shifting of a time series over a long period of time is called
a. Periodicity.
b. Cycle.
c. Regression.
d. Trend.

101. Seasonal components
a. Cannot be predicted.
b. Are regular repeated patterns.
c. Are long runs of observations above or below the trend line.
d. Reflect a shift in the series over time.

102. Short-term, unanticipated, and nonrecurring factors in a time series provide the random variability known as the
a. Irregular component.
b. Residual.
c. Forecast error.
d. Mean squared error.

103. Causal forecasting models
a. Should avoid the use of multiple regression analysis.
b. Attempt to explain a time series' behavior.
c. Do not use time series data.
d. Should avoid the use of linear regression analysis.

104. Which of the following seasonal indices shows a positive effect?
a. Above one.
b. Exactly one.
c. Less than one.
d. Exactly zero.

105. A deseasonalized time series is calculated by
a. Dividing each original time series observation by the corresponding seasonal index.
b. Subtracting each original time series observation from the corresponding seasonal index.
c. Multiplying each original time series observation with the corresponding seasonal index.
d. Adding each original time series observation to the corresponding seasonal index.

106. Which of the following is **not** an appropriate time series forecasting technique?
a. Least squares.
b. Exponential smoothing.
c. The Delphi technique.
d. Moving averages.

107. To remove the effect of seasonal variation from a time series, original data should be
a. Increased by the seasonal factor.
b. Reduced by the seasonal factor.
c. Multiplied by the seasonal factor.
d. Divided by the seasonal factor.

108. All of the following are useful for forecasting the needed level of inventory **except:**
a. Knowledge of the behavior of business cycles.
b. Internal accounting allocations of costs to various segments of the company.
c. Information about seasonal variations in demand.
d. Econometric modeling.

109. Solution strategies such as "what if" are used with
a. Statistical sampling.
b. Econometric forecasting.
c. Queuing theory.
d. Simulation.

110. A cost-volume-profit model developed in a dynamic environment determined that the estimated parameters used may vary between limits. Subsequent testing of the model with respect to all possible values of the estimated parameters is termed
a. A sensitivity analysis.
b. Statistical estimation.
c. Statistical hypothesis testing.
d. A time-series study.

111. A company is deciding whether to purchase an automated machine to manufacture one of its products. Expected net cash flows from this decision depend on several factors, interactions among those factors, and the probabilities associated with different levels of those factors. The method that the company should use to evaluate the distribution of net cash flows from this decision, and changes in net cash flows resulting from changes in levels of various factors is
a. Simulation and sensitivity analysis.
b. Linear programming.
c. Correlation analysis.
d. Differential analysis.

112. Which of the following is **not** true about simulation models?
a. They are deterministic in nature.
b. They may involve sampling.
c. They mathematically estimate what actual performance would be.
d. They emulate stochastic systems.

113. A large fishing operation has information on the interval, time, and probabilities of shrimp schools staying beneath their fishing boats. In order to use this information to predict when and where to send their boats, which of the following techniques should be used?
a. Simulation.
b. Least squares.
c. Queuing theory.
d. Exponential smoothing.

114. Because of the large number of factors that could affect the demand for its new product, interactions among these factors, and the probabilities associated with different values

of these factors, the marketing department would like to develop a computerized model for projecting demand for this product. By using a random-number procedure to generate values for the different factors, it will be able to estimate the distribution of demand for this new product. This method of estimating the distribution of demand for the new product is called

a. Monte Carlo simulation.
b. Linear programming.
c. Correlation analysis.
d. Differential analysis.

115. As part of a risk analysis, an internal auditor wishes to forecast the percentage growth in next month's sales for a particular plant using the past thirty months' sales results. Significant changes in the organization affecting sales volumes were made within the last nine months. The **most** effective analysis technique to use would be

a. Unweighted moving average.
b. Exponential smoothing.
c. Queuing theory.
d. Linear regression analysis.

116. To facilitate planning and budgeting, management of a travel service company wants to develop forecasts of monthly sales for the next twenty-four months. Based on past data, management has observed an upward trend in the level of sales. There are also seasonal variations with high sales in June, July, and August, and low sales in January, February, and March. An appropriate technique for forecasting the company's sales is

a. Time series analysis.
b. Queuing theory.
c. Linear programming.
d. Sensitivity analysis.

117. Recent events caused the time series used by an electric utility to become too unpredictable for practical use. As a result, the utility developed a model to predict the demand for electricity based on factors such as class of service, population growth, and unemployment in the area of service. The discipline that deals with such models is called

a. Linear programming.
b. Network analysis.
c. Operations research.
d. Econometrics.

118. A forecast of time-series data one period ahead using weights, which minimize the error between the actual data and the forecast made of the actual data is termed

a. Time series analysis.
b. Dynamic programming.
c. Exponential smoothing.
d. Econometrics.

119. The statistical analysis of relationships between economic variables is referred to as

a. Macroeconomics.
b. Econometrics.
c. Microeconomics.
d. Socioeconomic.

120. If a firm has a goal of developing a predictive model for sales based on linear, multiple regression analysis and the inherent assumptions embodied within, the science involved is

a. Goal programming.
b. Business statistics.
c. Linear programming.
d. Econometrics.

121. The manager of the assembly department of a company would like to estimate the fixed and variable components of the department's cost. To do so, the manager has collected information on total cost and output for the past twenty-four months. To estimate the fixed and variable components of total cost, the manager should use

a. Regression analysis.
b. Game theory.
c. Sensitivity analysis.
d. Queuing theory.

122. The internal auditor of a bank has developed a multiple regression model, which has been used for a number of years to estimate the amount of interest income from commercial loans. During the current year, the auditor applies the model and discovers that the R^2 value has decreased dramatically, but the model otherwise seemed be working okay. Which of the following conclusions are justified by the change?

a. Changing to a cross-sectional regression analysis should cause the R^2 to increase.
b. Regression analysis is no longer an appropriate technique to estimate interest income.
c. Some new factors, not included in the model, are causing interest income to change.
d. A linear regression analysis would increase the model's reliability.

123. In regression analysis, which of the following correlation coefficients represents the strongest relationships between the independent and dependent variables?

a. 1.03
b. -0.02
c. -0.89
d. 0.75

124. An auditor asks accounting personnel how they determine the value of the organization's real estate holdings. They say that valuations are based on a regression model that uses 17 different characteristics of the properties (square footage, proximity to downtown, age, etc.) to predict value. The coefficients of this model were estimated using a random sample of 20 company properties, for which the model produced an R^2 value of 0.92. Based on this information, which one of the following should the auditor conclude?

a. The model's high R^2 is probably due in large part to random chance.
b. 92% of the variables that determine value are in the model.
c. The model is very reliable.
d. This sample of properties is probably representative of the overall population of company holdings.

125. An internal auditor for a large automotive parts retailer wishes to perform a risk analysis and wants to use an appropriate statistical tool to help identify stores that would be out of line compared to the majority of stores. The most appropriate statistical tool to use would be

a. Linear time series analysis.
b. Cross-sectional regression analysis.
c. Cross tabulations with chi-square analysis of significance.
d. Time series multiple regression analysis to identify changes in individual stores over time.

126. A division uses a regression in which monthly advertising expenditures are used to predict monthly product sales (both in millions of dollars). The results show a regression coefficient for the independent variable equal to 0.8. This coefficient value indicates that

a. The average monthly advertising expenditure in the sample is $800,000.
b. When monthly advertising is at its average level, product sales will be $800,000.
c. On average, for every additional dollar in advertising you get $0.80 in additional sales.
d. Advertising is not a good predictor of sales because the coefficient is so small.

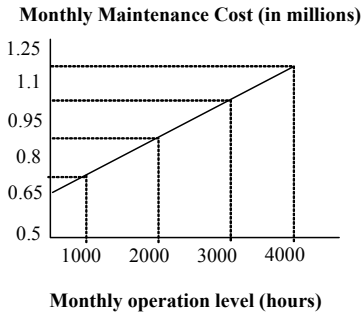
127. An audit manager has just returned from an executive training program and has suggested that the audit department develop a mathematical model to help identify factors that may be causing changes in the cost of production. According to the manager, the model should recognize that the company currently has three separate production (cost) centers. Which of the following approaches would best provide the analysis suggested by the audit manager?

a. Develop a classical variables-sampling estimate of cost of production per department, with the sample stratified by the dollar value of each product produced.
b. Develop a three-year ratio analysis of cost of production compared to cost of raw inventory, across the three departments.
c. Develop a multiple regression analysis of production costs including such variables as raw material inventory costs, number of employees in the department, and overtime pay.
d. Develop a linear regression analysis relating cost of production to cost of goods sold.

128. A chain retailer has outlets in forty nonoverlapping though similar local markets. Recently, the retailer conducted its largest promotional campaign ever. Each outlet was unrestricted in allocating its promotional budget between local print, radio, or television advertising or in underspending the budget. The internal auditor wishes to evaluate the effectiveness of these tactics. In this case

a. Time series analysis should be used since the promotion occurred over time.
b. Multiple regression analysis may be an effective tool for modeling the relationship between sales and promotional tactics.
c. Discriminant analysis would be the best tool for discriminating between effective and ineffective promotional tactics.
d. Since the relationships between promotional expenditures and sales are probably nonlinear, regression analysis should not be used.

129. The management of an airline is interested in the relationship between maintenance costs and the level of operations of its aircraft. Using regression analysis on cost and activity data collected over the past twelve months, the relationship depicted below was estimated.



The estimated increase in the monthly maintenance cost for each additional hour of operation is

a. $150 per hour.
b. $300 per hour.
c. $450 per hour.
d. $750 per hour.

130. What coefficient of correlation would result from the following data?

X	Y
1	10
2	8
3	6
4	4
5	2

a. 0
b. -1
c. +1
d. Cannot be determined from the data given.

131. The manager of the shipping department of a company believes that estimation of the fixed and variable components of the department's costs will facilitate forecasting these costs for planning and budgeting purposes. An appropriate technique for estimating fixed and variable cost components is

a. Regression (least squares) analysis.
b. Game theory.
c. Sensitivity analysis.
d. Queuing analysis.

132. A university admissions committee believes that standardized test scores, high school grade point average, and the rigor of high school courses are the most important variables in predicting undergraduate grade point average (GPA). The technique appropriate for modeling expected undergraduate GPA would be

a. Multiple regression analysis.
b. Exponential smoothing.
c. Bivariate regression analysis.
d. Auto-regressive model.

Items 133 through 137 are based on the following:

Many firms have site location models to predict future sales (Y) at locations yet to be developed. Some explanatory variables that could be used are: population density within a specific radius (X1), traffic flow (X2), the number of competitors (X3), and the ease of entry into and out of the proposed site (X4). An abbreviated computer printout of a linear analysis yields:

Dependent variable: Y N: 12
R: .986 R squared: .972
Standard error: 3800

Variable	Coefficient
Constant	124,000
X1	5
X2	350
X3	-1,700
X4	4,000

133. The technique being used is called
a. Integrated auto-regressive-moving average (ARIMA) modeling.
b. Exponential smoothing, multiple parameters.
c. Multiple regression analysis.
d. Linear programming.

134. The relationships existing between the dependent variable and the independent variables can best be described as
a. Three direct relationships and one inverse relationship.
b. Three indirect relationships and one direct relationship.
c. Two direct and two indirect relationships.
d. Four direct relationships.

135. One of the variables (X4) is very unusual because either there is a problem with entry into the site or there is not. We may then assign a "0" for no entry problems and a "1" for having entry problems. Such a variable is called a(n)
a. Multicollinear variable.
b. Dummy variable.
c. Omitted variable.
d. Outlier.

136. According to the computer printout, if traffic flow increased by one more unit, sales would
a. Decrease by 1,700.
b. Increase by 350.
c. Increase by 5.
d. Increase by 4,000.

137. If, for a site being considered, X1=10,000, X2=300, X3=9, and X4=1, the predicted sales would equal
a. 124,000
b. 126,655
c. 143,700
d. 267,700

138. The following data on variables x and y was collected from June to October:

	June	July	August	September	October
x	24	31	19	15	22
y	104	76	124	140	112

The correlation coefficient between variables x and y is nearest to
a. 1.00
b. -1.00
c. 0.50
d. 0.00

139. The linear regression equation, Y=15.8 + 1.1(x), was used to prepare the table below.

Actual X	Predicted Y	Actual Y	Residual
0	15.8	10	-5.8
1	16.9	18	1.1
2	18.0	27	9.0
3	19.1	21	1.9
4	20.2	14	-6.2

The best description of the existing problem is that
a. Autocorrelation is exhibited.
b. The relationship is not linear.
c. The data is simply not related.
d. The data is inversely related.

140. A company wishes to forecast from time series data covering 20 periods. Which of the following is not an appropriate forecasting technique?
a. Weighted least squares
b. Exponential smoothing
c. The Delphi technique
d. The moving average process

141. A firm plans to develop a sales forecasting model. The requirements are that the model be able to forecast accurately and relate sales to a set of predictor variables, such as, the product's price, advertising expenditures, consumer income per capita, and the price of a competing product. Based on the information given, which of the following quantitative techniques would be most appropriate?
a. Linear programming.
b. Exponential smoothing.
c. Trend extrapolation.
d. Multiple regression.

Project Management Techniques

142. A project is defined as a
a. Temporary endeavor.
b. Continuous endeavor.
c. Expensive endeavor.
d. Endless endeavor.

143. The most important skill for setting priorities and managing time is
a. Learning to say no.
b. Establishing ABC priority system.
c. Following the 80/20 principle.
d. Performing the Pareto analysis.

144. Which of the following is the first stage of the project life cycle?
a. Termination.
b. Conceptualization.
c. Planning.
d. Execution.

145. Budget demands are the highest in which of the following stage of the project life cycle?
a. Termination.
b. Conceptualization.
c. Planning.
d. Execution.

146. Project-based organizations are becoming common today due to
a. Lack of middle management layer.
b. Need for quick response to customers.
c. Vertical organization structure.
d. Profitability goals.

147. Eliminating wasted activities, tasks, and steps is called
a. Job elimination.
b. Work simplification.
c. Job specification.
d. Work measurement.

148. Which of the following is the least desirable skill of a project manager?

a. Leadership skill.
b. Technical skill.
c. Conflict resolution skill.
d. Negotiation skill.

149. Establishing project priorities remains a(n)
a. Subjective process.
b. Objective process.
c. Centralized process.
d. Decentralized process.

150. In the ABC priority system used in project time management, the 'B' system deals with which of the following?
a. "Must do" objectives.
b. "Should do" objectives.
c. "Nice to do" objectives.
d. "Could do" objectives.

151. In which of the following project organizational structures does each group or component concentrate on performing its own activities in support of the company's business mission?
a. Matrix.
b. Functional.
c. Progressive.
d. Project.

152. In which of the following project organizational structures does the project manager **not** have complete authority over the project team?
a. Matrix.
b. Functional.
c. Functional and matrix.
d. Project.

153. In which of the following project organizational structures is the project manager responsible for the project results while functional managers are responsible for providing the resources needed to achieve the results?
a. Matrix.
b. Functional.
c. Mixed-mode.
d. Project.

154. All of the work that must be done in order to satisfy the customer that the deliverables meet the requirements or acceptable criteria agreed upon at the onset of the project is called
a. Scope.
b. Plan.
c. Schedule.
d. Objective.

155. Ultimately, the responsibility of the project manager is to
a. Finish the project as quickly as possible.
b. Finish the project as cheaply as possible.
c. Make sure the customer is satisfied.
d. Make independent decisions.

156. Which of the following describes a hierarchical tree of network elements or end items that will be accomplished or produced by the project team during the project?
a. Workload structure.
b. Project breakdown diagram.
c. Work breakdown structure.
d. Project task distribution list.

157. Which of the following measures actual progress of a project and compares it to planned progress on a timely and regular basis and taking corrective action immediately?
a. Project planning.
b. Work breakdown.
c. Project control.
d. Quality control.

158. The project control process starts with establishing which of the following?
a. A baseline plan.
b. A work order form.
c. A schedule assignment.
d. A time-cost tradeoff.

159. When modifying a project schedule, which of the following activities usually presents the opportunity for larger time reductions?
a. Shorter duration.
b. Longer duration.
c. Near term.
d. Future.

160. Which of the following tradeoffs is used to incrementally reduce the project duration with the smallest increase in cost?
a. Schedule-quality.
b. Cost-production time.
c. Time-quality.
d. Time-cost.

161. In project management, the two basic types of contracts include which of the following?
a. Flat price and cost analysis.
b. Fixed price and incremental cost.
c. Flat price and cost reimbursement.
d. Fixed price and cost reimbursement.

162. Which of the following contracts is most appropriate for projects that involve risk?
a. Fixed price.
b. Flat price.
c. Time and profit.
d. Cost reimbursement.

163. For a project, the objective is usually defined in terms of scope, cost, and which of the following?
a. Plan.
b. Schedule.
c. Controls.
d. Tasks.

164. In project management, each activity has two pairs of duration called
a. Normal and crash time.
b. Normal and budget time.
c. Actual and crash time.
d. Quantity and quality time.

165. In project management, which of the following measures the cost efficiency with which the project is being performed?
a. Cost efficiency index.
b. Cost quality index.
c. Cost production index.
d. Cost performance index.

166. In project management, which of the following computes the difference between the cumulative earned value of the work performed and the cumulative actual cost?
a. Cost performance index.
b. Cost variance.
c. Budgeted costs.
d. Cost quality index.

167. In project management, the cost performance analysis should include identifying those work packages that have a negative cost variance or a cost performance index of less than which of the following?
a. 1.0
b. 1.5
c. 2.0
d. 2.5

168. Which of the following determines a project's duration based on technological and resource contention constraints?
a. Critical parameters.
b. Critical chain.
c. Critical ratio.
d. Critical success factors.

169. In project management, which of the following includes the total value, including overhead, of approved estimates for completed activities?
a. Earned value.
b. Critical value.
c. Planned value.
d. Noncritical value.

170. Which of the following is heavily weighted in calculating a Program Evaluation and Review Technique's (PERT's) expected time?
a. Optimistic time.
b. Most likely.
c. Pessimistic time.
d. Actual time.

171. Which of the following shows the appropriate sequence and interrelationship of activities to accomplish the overall project work scope?
a. Bubble diagram.
b. Network ladder.
c. Network diagram.
d. Responsibility chart.

172. The Gantt chart used in project management combines which of the following functions?
a. Planning and leveling
b. Scheduling and evaluating
c. Planning and scheduling
d. Scheduling and controlling

173. Which of the following techniques used in project management separate the planning and scheduling functions?
a. Gantt chart.
b. Work breakdown structure.
c. Network diagram.
d. Responsibility matrix.

174. In project management, activities are linked in which of the following order?
a. Linear order.
b. Parallel order.
c. Precedential order.
d. Regressive order.

175. Which of the following is used for projects that have a set of activities that are repeated several times?
a. Truncation.
b. Looping.
c. Laddering.
d. Transitions.

176. In project management, which of the following times are determined by calculating forward through the network?
a. Earliest start time and earliest finish time.
b. Latest start time and latest finish time.
c. Earliest start time and latest start time.
d. Earliest finish time and latest finish time.

177. Which of the following describes the latest time by which a particular activity must be finished in order for the entire project to be completed by its required completion time?
a. Earliest start time.
b. Earliest finish time.
c. Latest start time.
d. Latest finish time.

178. Which of the following equations can calculate total slack in a project?
a. Latest finish time minus earliest finish time.
b. Latest finish time minus latest start time.
c. Earliest finish time minus earliest start time.
d. Latest finish time minus earliest start time.

179. In project management, which of the following uses only one time estimate for an activity?
a. Deterministic model.
b. Stochastic model.
c. Probabilistic model.
d. Steady-state model.

180. Which of the following measures planned and completed work for each stage of a project by time elapsed?
a. Time and work chart.
b. Gantt chart.
c. Time and motion chart.
d. Production and delivery chart.

181. One of the drawbacks to the traditional Gantt chart used in project management is that it does not graphically display which of the following?
a. Order of activities.
b. Timeframe of activities.
c. Interrelationships of activities.
d. Structure of activities.

182. The critical path in a program evaluation and review technique (PERT) network is the most
a. Efficient path.
b. Time-consuming path.
c. Labor-intensive path.
d. Expensive path.

183. Program evaluation and review technique (PERT) is most appropriate for
a. Small, routine projects.
b. Small, unique projects.
c. Large, nonroutine projects.
d. Large, repetitive projects.

184. Which of the following Gantt chart features is an improvement over the flowchart?
a. Dollar amounts.
b. Time elements.
c. Task descriptions.
d. Resource requirements.

185. Working from the last node to the start node through the network logic of a project in order to determine late start dates and late finish dates is called
a. Forward pass.
b. Backward pass.
c. Backward integration.
d. Vertical integration.

186. Which of the following would be a long-range rather than a short-range planning topic?
a. Production scheduling.
b. Inventory policy.
c. Product quality.
d. Advertising budget.

187. The process of adding resources to shorten selected activity times on the critical path in project scheduling is called
a. Crashing.
b. The Delphi technique.
c. ABC analysis.
d. A branch-and-bound solution.

188. The following information applies to a project:

Activity	*Time (days)*	*Immediate predecessor*
A	5	None
B	3	None
C	4	A
D	2	B
E	6	C, D

The earliest completion time for the project is
a. 11 days.
b. 14 days.
c. 15 days.
d. 20 days.

189. A bank is designing an on-the-job training program for its branch managers. The bank would like to design the program so that participants can complete it as quickly as possible. The training program requires that certain activities be completed before others. For example, a participant cannot make credit loan decisions without first having obtained experience in the loan department. An appropriate scheduling technique for this training program is
a. PERT/CPM.
b. Linear programming.
c. Queuing theory.
d. Sensitivity analysis.

190. Which of the following terms is **not** used in project management?
a. Dummy activity.
b. Latest finish.
c. Optimistic time.
d. Lumpy demand.

191. Various tools are employed to control large-scale projects. They include all of the following **except:**
a. PERT.
b. CPM.
c. Statistical process control.
d. Gantt charts.

192. Activity scheduling information for the installation of a new computer system is given below.

Activity	*Immediate predecessor*	*Duration (days)*
A	--	4
B	--	3
C	A	9
D	A	6
E	B, D	5

For this project, the critical path is
a. A-C
b. B-E
c. A-D-E
d. B-D-C

193. In a critical path analysis, if slack time in an activity exists, it refers to the fact that the activity
a. Is not essential to the overall project.
b. Is a backup activity to replace a main activity should it fail.
c. Could be delayed without delaying the overall project.
d. Involves essentially no time to complete.

194. A Gantt chart is a graphical scheduling technique typically applied to production applications. The structure of the chart shows
a. Cost in dollars plotted against units of output.
b. The sequencing and relationship of steps in a production process.
c. Output plotted against units of time.
d. The "critical path" in a chain of activities.

195. A corporation uses CPM/PERT to plan the development of a new cordless food processor. The primary purpose of determining the "critical path" related to this project is to identify
a. Those activities that must be completed exactly as scheduled if the development of the new cordless food processor is to be completed on time.
b. The maximum amount of time an activity on the critical path may be delayed without delaying the scheduled development of the new food processor.
c. The optimal size of the new food processor.
d. What features should be incorporated in the new food processor.

Business Process Analysis

196. Which of the following is **not** one of the areas of the theory of constraints?
a. Bottleneck management.
b. Logistics.
c. Performance measurement.
d. Logical thinking.

197. Which of the following is **not** part of the logistics area of the theory of constraints?
a. Drum-buffer-rope scheduling.
b. Problem solving.
c. Buffer management.
d. VAT analysis.

198. Which of the following is **not** part of the performance measurement area of the theory of constraints?
a. Throughput.

b. Inventory.
c. Current reality tree.
d. Operating expense.

199. Which of the following starts with one or a few raw materials in the theory of constraints?
a. A "V" logical structure.
b. An "A" logical structure.
c. A "T" logical structure.
d. A general structure.

200. Which of the following is appropriate for discovering delays or possibilities for mistakes in conveying information in the way office and administrative tasks are carried out?
a. Clerical process analysis.
b. Joint process analysis.
c. Operator process analysis.
d. Product process analysis.

201. A process delivers value through all of the following items **except:**
a. Selling.
b. Quality.
c. Cost reduction.
d. Flexibility.

202. Which of the following structures yields greater efficiency and production and is achieved by reengineering or process redesign?
a. Functional organization.
b. Hierarchical organization.
c. Horizontal organization.
d. Vertical organization.

203. An organization should **not** have which of the following business process orientations?
a. Functional view.
b. Process jobs.
c. Process management and measures.
d. Process structure.

204. Which of the following dimensions of business process orientations is the most important one?
a. Process view.
b. Process jobs.
c. Process management and measures.
d. Process structure.

205. A radical redesign of the entire business cycle is called
a. Business process reengineering.
b. Benchmarking.
c. Best practices.
d. Business process improvement.

206. Which of the following involves identifying, studying, and building upon the best practices of other organizations?
a. Kaizen.
b. Benchmarking.
c. Plan, do, check, and act cycle.
d. Total quality management.

207. Cycle time can be either reduced or speeded up with
a. Business process reengineering.
b. Benchmarking.
c. Best practices.
d. Business process improvement.

208. "The time between when an order is placed and when it is received by the customer" is known as
a. Arrival time.
b. Order cycle time.
c. Shipping time.
d. Order time.

209. "The time it takes to deliver a product or service after an order is placed" is called
a. Order cycle time.
b. Customer response time.
c. Order process time.
d. Inspection time.

210. "The time between when an order is placed and when the order is ready for setup" is called
a. Order receipt time.
b. Order wait time.
c. Order process time.
d. Efficiency time.

211. "The time between when an order is ready for setup and the setup is complete" is called
a. Order receipt time.
b. Order wait time.
c. Order process time.
d. Efficiency time.

212. Which of the following refers to eliminating unnecessary procedures and activities in a business process?
a. Work standardization.
b. Work simplification.
c. Work customization.
d. Work measurement.

213. A company faces a constraint when
a. Its operating fixed costs are excessive.
b. The capacity to manufacture a product is limited.
c. Its capital costs are excessive.
d. It is highly leveraged.

214. If a company is faced with a limited resource, which of the following is **not** a feasible choice for alleviating the constraint?
a. Increase the capacity of the limited resource.
b. Ignore the constraint.
c. Reduce the use of the limited resource in production.
d. Focus on products that require less of the limited resource.

215. The theory of constraints
a. Is best associated with horizontal integration.
b. Is best associated with vertical integration.
c. Identifies bottlenecks in the production process.
d. Identifies throughput in the production process.

216. Which of the following statements is **not** true about bottlenecks?
a. Bottlenecks limit throughput.
b. Bottlenecks should be ignored during crisis situations.
c. Bottlenecks are managed using the theory of constraints.
d. Bottlenecks should be relieved to increase production efficiency.

Items 217 to 219 are based on the following:

A manufacturing company has the following estimates for a specific customer order to produce 50 toy sets.

Wait time	10 hours
Inspection time	1 hour
Processing time	36 hours
Move time	1.5 hours

217. Using these time estimates, what is the value-added time?
a. 36 hours.
b. 37 hours.
c. 38.5 hours.
d. 48.5 hours.

218. Using these time estimates, what is the non-value-added time?
a. 2.5 hours.
b. 10.0 hours.
c. 11.0 hours.
d. 12.5 hours.

219. Using these time estimates, what is the manufacturing cycle time?
a. 36.00 hours.
b. 46.00 hours.
c. 47.00 hours.
d. 48.50 hours.

220. Regarding the theory of constraints, which of the following bonds cause-and-effect relationships and connects all the existing major undesirable effects?
a. The current reality tree.
b. The future reality tree.
c. The prerequisite tree.
d. The transition tree.

221. Regarding the theory of constraints, which of the following is **not** an example of an undesirable effect?
a. Too much production.
b. Too much inventory.
c. Too many orders that are not shipped as scheduled.
d. Too much expediting of orders.

222. Regarding the theory of constraints, each entry to the current reality tree does **not** identify which of the following?
a. A root cause.
b. Most desirable effects.
c. A core problem.
d. Most undesirable effects.

223. Which of the following actions does **not** help in reducing the cycle time?
a. Changing from parallel flow to linear flow in a process.
b. Using alternate flow paths in a process.
c. Changing the layout of a process.
d. Using technology to improve process flow.

224. In reducing cycle time, speed flows from which of the following?
a. Complexity.
b. Simplicity.
c. Homogenity.
d. Heterogeneity.

225. Which of the following is **not** generally associated with reducing cycle time?
a. Expanding work steps.
b. Eliminating work steps.
c. Minimizing work steps.
d. Combining work steps.

226. Which of the following is caused by exceeding the capacity limitation of key resources?
a. Fault points.
b. Check points.
c. Critical points.
d. Choke points.

227. Which of the following actions does **not** help in reducing the cycle time?
a. Eliminating process waste.
b. Creating continuous workflow.
c. Using self-managed teams.
d. Providing the right resources.

228. Which of the following accounting systems aggressively exploits the constraint(s) to make more money for a firm?

I. Constraint accounting.
II. Activity-based accounting.
III. Direct cost accounting.
IV. Throughput accounting.

a. I and II.
b. II and III.
c. I and IV.
d. III and IV.

229. In the theory of constraints, the drum-buffer-rope scheduling system maximizes
a. Inventory.
b. Throughput.
c. Nonconstraints.
d. Constraints.

230. All of the following are effective ways to shorten the cycle time **except:**
a. Small lot sizes.
b. Synchronized production plans.
c. Just-in-time manufacturing.
d. “Push” production method.

231. All of the following are effective methods to alleviate bottleneck production cells in a synchronized production plan **except:**
a. Moving the production to other cells.
b. Increasing the capacity by overtime.
c. Increasing the capacity by overloading the cell.
d. Decreasing the production cell utilization significantly.

232. Input material that does not become part of the finished product and has relatively minor economic value is classified as
a. Scrap.
b. Spoilage.
c. Defective product.
d. Waste.

233. A company has excess capacity in production-related fixed assets. If in a given year these fixed assets were being used to only 80% of capacity and the sales level in that year was $2,000,000, the full capacity sales level is
a. $ 1,600,000

b. $ 2,000,000
c. $ 2,500,000
d. $10,000,000

234. Which of the following is true of benchmarking?
a. It is typically accomplished by comparing an organization's performance with the performance of its closest competitors.
b. It can be performed using either qualitative or quantitative comparisons.
c. It is normally limited to manufacturing operations and production processes.
d. It is accomplished by comparing an organization's performance to that of the best-performing organizations.

235. A means of limiting production delays caused by equipment breakdown and repair is to
a. Schedule production based on capacity planning.
b. Plan maintenance activity based on an analysis of equipment repair work orders.
c. Pre-authorize equipment maintenance and overtime pay.
d. Establish a preventive maintenance program for all production equipment.

236. An internal auditor's involvement in reengineering should include all of the following **except:**
a. Determining whether the process has senior management's support.
b. Recommending areas for consideration.
c. Developing audit plans for the new system.
d. Directing the implementation of the redesigned process.

237. Which of the following will allow a manufacturer with limited resources to maximize profits?
a. The Delphi technique.
b. Exponential smoothing.
c. Regression analysis.
d. Linear programming.

238. Reengineering is the thorough analysis, fundamental rethinking, and complete redesign of essential business processes. The intended result is a dramatic improvement in service, quality, speed, and cost. An internal auditor's involvement in reengineering should include all of the following **except:**
a. Determining whether the process has senior management's support.
b. Recommending areas for consideration.
c. Developing audit plans for the new system.
d. Directing the implementation of the redesigned process.

239. An example of an internal nonfinancial benchmark is
a. The labor rate of comparably skilled employees at a major competitor's plant.
b. The average actual cost per pound of a specific product at the company's most efficient plant becomes the benchmark for the company's other plants.
c. The company setting a benchmark of $50,000 for employee training programs at each of the company's plants.
d. The percent of customer orders delivered on time at the company's most efficient plant becomes the benchmark for the company's other plants.

240. Auditors are operating in organizations in which management is in the process of "reengineering" operations with strong emphasis on total quality management techniques. In their quest to gain efficiency in processing, many of the traditional control procedures are being deleted from the organization's control structure. As part of this change, management is
a. Placing more emphasis on monitoring control activities.
b. Making different assumptions about human performance and the nature of human motivation than was done under traditional control techniques.
c. Placing more emphasis on self-correcting control activities and process automation.
d. All of the above.

241. A company, which has many branch stores, has decided to benchmark one of its stores for the purpose of analyzing the accuracy and reliability of branch store financial reporting. Which one of the following is the most likely measure to be included in a financial benchmark?
a. High turnover of employees.
b. High level of employee participation in setting budgets.
c. High amount of bad debt write-offs.
d. High number of suppliers.

242. An organization has decided to reengineer several major processes. Of the following reasons for employees to resist this change, which is **least** likely?
a. Threat of loss of jobs.
b. Required attendance at training classes.
c. Breakup of existing work groups.
d. Imposition of new processes by top management without prior discussion.

Inventory Management Techniques and Concepts

243. A company's attempt to hold the lowest level of inventory that will still enable it to meet customer demand is known as
a. Order cycle time.
b. Just-in-time management.
c. Supply-chain management.
d. Inventory control.

244. Inventory carrying costs include which of the following?
a. Storage costs.
b. Advertising costs.
c. Packaging costs.
d. Sales promotion costs.

245. Which of the following is defined as the point where inventory carrying costs and ordering costs are at their lowest?
a. Breakeven point.
b. Order cycle time.
c. Economic order quantity.
d. Marginal price.

246. Effective inventory management is key to improving all of the following **except:**
a. Purchasing.
b. Customer service.

c. Cash flow.
d. Profitability.

247. Which of the following shows the dichotomies of inventory control?
a. Customer service.
b. Inventory costs.
c. Stock levels.
d. Operating costs.

248. The primary reason for maintaining safety stock is due to
a. Failure on the supply side.
b. Inability to predict demand.
c. Technical and mechanical breakdowns.
d. Information and communication failures.

249. A company's inventory stockholding practices depend on which of the following?
a. Customer service levels.
b. Inexpensive purchases.
c. Objectives and policies.
d. Volume discount purchases.

250. Which of the following elements of inventory demand management affects customer service?
a. Order receipts.
b. Order processing.
c. Product delivery.
d. Customer feedback.

251. All of the following are effective ways of managing the inventory **except:**
a. Pareto analysis.
b. ABC analysis.
c. JIT approach.
d. Safety stock.

252. In the ABC analysis, class "C" inventory consists of which of the following?
a. Many items and low turnover rate.
b. Few items and high turnover rate.
c. Many items and medium turnover rate.
d. Few items and medium turnover rate.

253. In the ABC analysis, class "B" inventory consists of which of the following?
a. Managed with tight control.
b. Managed by JIT approach.
c. Managed by exception.
d. Managed with minimum supervision.

254. In the ABC analysis, class "A" inventory uses a(n)

I. Sophisticated forecasting system.
II. Simple tracking system.
III. Infrequent ordering rules.
IV. Service level policy.

a. I and II.
b. II and III.
c. I and IV.
d. III and IV.

255. Which of the following buries defects in the manufacturing process?
a. Raw materials.
b. Parts and components.
c. Work-in-process.
d. Finished goods.

256. Which of the following does **not** help in meeting customer expectations and reducing inventories?
a. Reducing cycle time.
b. Reducing inventory levels.
c. Eliminating waste in all processes.
d. Lowering interest rates.

257. Which of the following inventory recordkeeping method reduces the inventory of components before issue at the time a scheduled receipt for their parents or assemblies is created via a bill-of-material explosion?
a. Prededuct inventory transaction processing.
b. Backflush inventory method.
c. Explode-to-deduct inventory method.
d. Postdeduct inventory transaction processing.

258. Which of the following uses more than one level of bill-of-material and extending back to the previous points where production was counted?

I. Count point method.
II. Count point backflush method.
III. Key point backflush method.
IV. Pay point method.

a. I and II.
b. II and III.
c. I and IV.
d. III and IV.

259. In an economic order quantity (EOQ) model, both the costs per order and the holding costs are estimates. If those estimates are varied to determine how much the changes affect the optimal EOQ, such analysis would be called a
a. Forecasting model.
b. Sensitivity analysis.
c. Critical path method analysis.
d. Decision analysis.

260. An appropriate technique for planning and controlling manufacturing inventories, such as raw materials, components, and subassemblies, whose demand depends on the level of production, is
a. Materials requirements planning.
b. Regression analysis.
c. Capital budgeting.
d. Linear programming.

261. If a just-in-time (JIT) purchase policy is successful in reducing the total inventory costs of a manufacturing company, which of the following combinations of cost changes would be most likely to occur?
a. An increase in purchasing costs and a decrease in stockout costs.
b. An increase in purchasing costs and a decrease in quality costs.
c. An increase in quality costs and a decrease in ordering costs.
d. An increase in stockout costs and a decrease in carrying costs.

262. A company sells 1,500 units of a particular item each year and orders the items in equal quantities of 500 units at a price of $5 per unit. No safety stocks are held. If the company

has a cost of capital of 12%, its annual cost of carrying inventory is
a. $150
b. $180
c. $300
d. $900

263. The internal auditor of a retailing company is auditing the purchasing area. To evaluate the efficiency of purchase transactions, the auditor decides to calculate the economic order quantity for a sample of the company's products. To calculate the economic order quantity, the internal auditor would need data for all of the following **except:**
a. The volume of product sales.
b. The purchase prices of the products.
c. The fixed cost of ordering products.
d. The volume of products in inventory.

264. A company has a specified inventory that it maintains even if no sales occur. It also maintains additional inventory that is positively related to the amount of expected sales. The company's financial forecasting of inventory in the following year would be most accurate when applying
a. Last year's inventory items as the forecast.
b. Last year's inventory as a percentage of total assets to derive the forecast.
c. The percentage of sales method.
d. Simple linear regression.

265. Which of the following is **not** considered a cost of carrying inventory?
a. Shipping and handling.
b. Property tax.
c. Insurance.
d. Depreciation and obsolescence.

266. The economic order quantity (EOQ) for inventory is higher for an organization that has
a. Lower annual unit sales.
b. Higher fixed inventory ordering costs.
c. Higher annual carrying costs as a percentage of inventory value.
d. A higher purchase price per unit of inventory.

267. An organization has an inventory order quantity of 10,000 units and a safety stock of 2,000 units. The cost per unit of inventory is $5 and the carrying cost is 10% of the average value of inventory. The annual inventory carrying cost for the organization is
a. $3,000
b. $3,500
c. $5,000
d. $6,000

268. As a company increases its inventory order size, the total (List A) cost of inventory (List B)

	List A	*List B*
a.	Carrying	Decreases
b.	Carrying	Is unchanged
c.	Ordering	Decreases
d.	Ordering	Is unchanged

269. When the economic order quantity (EOQ) decision model is employed, the (List A) are being offset or balanced by the (List B).

	List A	*List B*
a.	Ordering costs	Carrying costs
b.	Purchase costs	Carrying costs
c.	Purchase costs	Quality costs
d.	Ordering costs	Stockout costs

270. One of the elements included in the economic order quantity (EOQ) formula is
a. Safety stock.
b. Yearly demand.
c. Selling price of item.
d. Lead time for delivery.

Items 271 and 272 are based on the following:

Using an EOQ analysis (assuming a constant demand) it is determined that the optimal order quantity is 2,500. The company desires a safety stock of 500 units. A five-day lead time is needed for delivery. Annual inventory holding costs equal 25% of the average inventory level. It costs the company $4 per unit to buy the product which it sells for $8. It costs the company $150 to place a detailed order and the monthly demand for the product is 4,000 units.

271. Annual inventory holding costs equal
a. $ 850
b. $1,250
c. $1,750
d. $2,250

272. Total inventory ordering costs per year equal
a. $1,250
b. $1,800
c. $2,880
d. $4,130

273. In forecasting purchases of inventory for a firm, all of the following are useful **except:**
a. Knowledge of the behavior of business cycles.
b. Internal allocations of costs to different segments of the firm.
c. Information on the seasonal variations in demand.
d. Econometric modeling.

274. An organization sells a product for which demand is uncertain. Management would like to ensure that there is sufficient inventory on hand during periods of high demand so that it does not lose sales (and customers). To do so, the organization should
a. Keep a safety stock.
b. Use a just-in-time inventory system.
c. Employ a materials requirement planning system.
d. Keep a master production schedule.

275. The economic order quantity (EOQ) is the size of the order that minimizes total inventory costs, which include ordering and holding costs. It can be calculated using the formula

$$Q = \sqrt{\frac{2Dp}{s}}$$

where Q = order size in units, D = annual demand in units, p = cost per purchase order, s = carrying cost per year for one unit of inventory. If the annual demand decreases by 36% the optimal order size will
a. Decrease by 20%.
b. Increase by 20%.

c. Increase by 6%.
d. Decrease by 6%.

276. The purpose of the economic order quantity model is to
a. Minimize the safety stock.
b. Minimize the sum of the order costs and the holding costs.
c. Minimize the inventory quantities.
d. Minimize the sum of the demand costs and the backlog costs.

277. To be even more effective, the company was considering investing in automated equipment to decrease setup times. The payback period was not considered quick enough to justify the investment. The company could refine the analysis of the investment by considering
a. No other factors since the only benefit from the equipment is to decrease setup times.
b. Reductions in inventory permitted by reducing average batch sizes.
c. Efficiencies gained by getting suppliers to deliver better-quality raw materials.
d. Economies achieved by bar coding batches of raw materials before production.

278. Which of the following inventory items would be the **most** frequently reviewed in an ABC inventory control system?
a. Expensive, frequently used, high stock-out cost items with short lead times.
b. Expensive, frequently used, low stock-out cost items with long lead times.
c. Inexpensive, frequently used, high stockout cost items with long lead times.
d. Expensive, frequently used, high stock-out cost items with long lead times.

279. If a company's cost of ordering (per order) increases while carrying costs per order remain the same, the optimal order size as specified by the economic order quantity model would
a. Be unaffected.
b. Increase.
c. Decrease.
d. Be affected, but the direction of change cannot be determined without additional information.

280. A local charitable organization orders and sells Christmas trees to raise funds. They want to know the optimum quantity to order. Any merchandise not sold will be discarded without scrap value. This is an example of a single-period inventory model, which is solved using
a. Economic order quantity.
b. Payoff tables.
c. Material requirements planning.
d. Game theory.

281. Which of the following inventory control techniques divides items into subclassifications and uses different control systems for each classification?
a. ABC method.
b. Economic order quantity model.
c. Just-in-time system.
d. Material requirements planning system.

282. What are the three factors a manager should consider in controlling stockouts?
a. Holding costs, quality costs, and physical inventories.
b. Economic order quantity, annual demand, and quality costs.
c. Time needed for delivery, rate of inventory usage, and safety stock.
d. Economic order quantity, production bottlenecks, and safety stock.

283. Reordering of specific items from vendors should be based on
a. Computations on the basis of economic order quantities.
b. Demand forecasting based on early orders for the items.
c. Market demographics.
d. Vendor quantity discounts and warehouse space.

284. A company has the following requirement for a part during production of a finished product:

Daily requirement for part	*Probability*
50	0.2
60	0.5
70	0.2
80	0.1
	1.0

To ensure a 90% probability of sufficient stockage the daily beginning balance of the part should be
a. 50
b. 60
c. 70
d. 80

285. A manufacturer is considering using bar-code identification for recording information on parts used by the manufacturer. A reason to use bar codes rather than other means of identification is to ensure that
a. The movement of all parts is recorded.
b. The movement of parts is easily and quickly recorded.
c. Vendors use the same part numbers.
d. Vendors use the same identification methods.

286. A manufacturing company is attempting to implement a just-in-time (JIT) purchase policy system by negotiating with its primary suppliers to accept long-term purchase orders which result in more frequent deliveries of smaller quantities of raw materials. If the JIT purchase policy is successful in reducing the total inventory costs of the manufacturing company, which of the following combinations of cost changes would be most likely to occur?

	Cost category to increase	*Cost category to decrease*
a.	Purchasing costs	Stockout costs
b.	Purchasing costs	Quality costs
c.	Quality costs	Ordering costs
d.	Stockout costs	Carrying costs

287. A risk associated with just-in-time (JIT) production is the
a. Increased potential for early obsolescence of inventories of finished goods.
b. High cost of material handling equipment.
c. Potential for significant costs associated with reworking defective components.
d. Critical dependency on a few vendors.

288. An inventory planning method that minimizes inventories by arranging to have raw materials and subcomponents arrive immediately preceding their use is called
a. A safety stock planning system.
b. An economic order quantity model.
c. A just-in-time inventory system.
d. A master budgeting system.

289. The owner of a large automobile repair facility wants to implement a just-in-time (JIT) system of inventory control for the spare parts inventory. That system would be **inappropriate** because
a. It would be too difficult to identify the items that have to be most closely controlled.
b. An auto parts inventory is too diverse to use JIT inventory control techniques.
c. Both sales rates and order lead times must be known for certain.
d. Delivery of raw material or components has to be coordinated to a schedule.

290. Just-in-time (JIT) inventory systems have been adopted by large manufacturers to minimize the carrying costs of inventories. Identify the primary vulnerability of JIT systems
a. Computer resources.
b. Materials supply contracts.
c. Work stoppages.
d. Implementation time.

291. A manufacturing cell's partial productivity can be measured using data on
a. Inventory shrinkage.
b. Inventory turnover.
c. Direct material usage.
d. Scrap.

292. Increased competition, technological innovation, and a shift from mass production of standardized products to custom-produced products in many industries have increased the need for productivity improvement and flexibility of production systems. In response to these demands, organizations have increased their reliance on automation and the use of advanced technologies in their operations. Which of the following is an example of the use of automation and advanced technologies?
a. Flexible manufacturing system.
b. Just-in-time system.
c. Master budgeting system.
d. Economic order quantity.

293. A major justification for investments in computer integrated manufacturing (CIM) projects is
a. Reduction in the costs of spoilage, reworked units, and scrap.
b. Lower book value and depreciation expense for factory equipment.
c. Increased working capital.
d. Stabilization of market share.

294. Which of the following is an advantage of adopting a just-in-time (JIT) inventory system?
a. A formal receiving department may be eliminated.
b. A bill of materials outlines when all materials will be needed on a week-by-week basis.
c. There will be greater emphasis on reducing per unit purchase costs.
d. Late deliveries of materials are less of a problem.

295. Which of the following is **not** involved with facility layout and design issues?
a. Cellular manufacturing.
b. Operations sequence analysis.
c. Program Evaluation and Review Technique (PERT).
d. Line balancing.

Items 296 and 297 are based on the following:

The following types of electronic advancements might be used by financial service organizations, manufacturing firms, and/or service organizations. In answering these two questions you will be asked to identify which of the following items are used in each type of organization.

I. Flexible manufacturing systems.
II. Automated teller machines.
III. Automated storage and retrieval systems.
IV. Computer-aided design.
V. Computer-integrated manufacturing.
VI. CAT scanners.
VII. Bar code systems.
VIII. Electronic funds transfer.
IX. Autopilot systems.
X. Magnetic-ink character recognition codes.
XI. Automated reservations systems.
XII. Document imaging systems.

296. Which of the above examples of automated systems are used in financial services firms?
a. II, III, IV, and VII.
b. II, VIII, X, and XII.
c. II, III, IV and X.
d. VIII, X, XI, and XII.

297. Which of the above automated systems are used in manufacturing firms and which are used in service firms?

	Manufacturing	*Service*
a.	I, II, III, and IV.	VII, VIII, IX, and X.
b.	II, IV, V, and XII.	VI, IX, X, and XII.
c.	III, IV, V, and VII.	I, VI, VII, and VIII.
d.	I, III, IV, and VII.	VII, X, XI, and XII.

298. A materials requirements planning (MRP) system would be most difficult to apply for a manufacturer which
a. Uses relatively few direct materials.
b. Has long set-up times for its manufacturing equipment.
c. Is in a highly volatile industry.
d. Faces high downtime costs.

299. An appropriate technique for planning and controlling manufacturing inventories such as raw materials, components, and subassemblies whose demand depends on the amounts of finished goods scheduled to be produced is
a. Material requirements planning.
b. Regression analysis.
c. Capital budgeting.
d. Linear programming.

300. The company uses a planning system that focuses first on the amount and timing of finished goods demanded and then determines the derived demand for raw material, components, and subassemblies at each of the prior stages of production. This system is referred to as
a. Economic order quantity.
b. Material requirements planning.

c. Linear programming.
d. Just-in-time purchasing.

301. A company has produced two product lines as though they are separate businesses. The accounting and finance functions were common to both products. A change was made to integrate inventory, purchasing, and production planning and control. Such a change would come under the title of
a. Inventory control.
b. Material requirements planning.
c. A Monte Carlo analysis.
d. Linear programming.

302. Which of the following is a characteristic of just-in-time (JIT) inventory management systems?
a. JIT users determine the optimal level of safety stocks.
b. JIT is applicable only to large companies.
c. JIT does not really increase overall economic efficiency because it merely shifts inventory levels further up the supply chain.
d. JIT relies heavily on good-quality materials.

303. A company stocks, maintains, and distributes inventory. The company decides to add to the safety stock and expedite delivery for several product lines on a trial basis. For the selected product lines the company will experience a(n)
a. Increase in some costs but no change in the service level.
b. Change in the service level.
c. Increase in ordering, carrying, and delivery costs.
d. Decrease in ordering, carrying, and delivery costs.

304. The economic order quantity (EOQ) model calculates the cost minimizing quantity of a product to order, based on a constant annual demand, carrying costs per unit per annum, and costs per order. For example, the EOQ is approximately 447 units if the annual demand is 10,000 units, carrying costs are $1 per unit per annum, and the cost of placing an order is $10. What will the EOQ be if the demand falls to 5,000 units per annum and the carrying and ordering costs remain at $1 and $10 respectively?
a. 316
b. 447
c. 483
d. 500

305. A firm expects to sell 1,000 units of product X during the coming year. Ordering costs are $100 per order and carrying costs are $2 per unit per year. Using the EOQ model, what is the optimum order size?
a. 217
b. 224
c. 317
d. 448

306. A firm uses an ABC inventory control system. About 10% of inventory items are classified into group A. Another 20% are in group B. The remainder are in group C. Which classification is most likely to hold the greatest number of days of supply?
a. Group C.
b. Group B.
c. Group A.
d. All groups are likely to have an equal number of days of supply.

307. With regard to inventory management, an increase in the frequency of ordering will normally
a. Reduce the total ordering costs.
b. Have no impact on total ordering costs.
c. Reduce total carrying costs.
d. Have no impact of total carrying costs.

308. The company uses a planning system that focuses first on the amount and timing of finished goods demanded and then determines the derived demand for raw material, components, and subassemblies at each of the prior stages of production. This system is referred to as
a. Economic order quantity.
b. Material requirements planning.
c. Linear programming.
d. Just-in-time purchasing.

309. A company manufactures banana hooks for retail sale. The bill of material for this item and the parts inventory for each material required are as follows:

Bill of materials		*Parts on hand*
Raw material	*Quantity required*	
Wooden neck	1	0
Wooden base	1	0
Swag hook	1	300
Wood screws	2	400
Foot pads	4	1,000

An incoming order calls for delivery of 2,000 banana hooks in two weeks. The company has 200 finished banana hooks in current inventory. If no safety stocks are required for inventory, what are the company's net requirements for swag hooks and screws needed to fill this order?

	Swag hooks	*Wood screws*
a.	1,500	1,400
b.	1,500	3,200
c.	1,700	3,600
d.	1,800	3,600

Marketing—Pricing Objectives and Policies

310. The most fundamental flaw of cost-plus pricing is that it
a. Fails to account for competition.
b. Ignores demand.
c. Ignores industry-wide standard markup policies.
d. Places too much emphasis on competition.

311. "Selling price = Unit cost + Desired profit" represents which of the following pricing approaches?
a. Profit-maximization.
b. Demand-based pricing.
c. Target return pricing.
d. Standard markup.

312. Assume that the unit cost of making a product is $1.32. For every unit sold, the firm wants 20% to represent profit. Applying the standard markup approach, what should the selling price be?
a. $1.65
b. $1.58
c. $2.38
d. $2.90

313. A retail store sells CDs for $15.00. If the cost per CD is $11.00, what is the store's markup on selling price?
a. 22%
b. 27%

c. 66%
d. 73%

314. A retail store sells CDs for $15.00. What is the cost per CD if the markup on selling price is 25%?
a. $10.50
b. $10.75
c. $11.00
d. $11.25

315. A 50% markup on cost is equivalent to a markup on price of
a. 25%
b. 33%
c. 50%
d. 100%

316. A 50% markup on price is equivalent to a markup on cost of
a. 25%
b. 33%
c. 50%
d. 100%

317. If a firm charges a price of $6 for a product with a cost of $4, the markup on cost equals
a. 33%
b. 50%
c. 67%
d. 150%

318. If a firm charges a price of $5 for a product with a cost of $2, the markup on price equals
a. 40%
b. 60%
c. 150%
d. 250%

319. In the classic economic model, the best price is the
a. Breakeven price.
b. Marginal profit price.
c. Profit-maximizing price.
d. Elastic price.

320. By examining how revenues and costs change for a series of prices, a manager can determine the
a. Breakeven price.
b. Marginal profit price.
c. Profit-maximizing price.
d. Elastic price.

321. Which of the following strategic factors will pay a role in setting a base price?

I. Company objectives.
II. Positioning strategy.
III. New product pricing strategies.
IV. Price-quality differences.

a. I and II.
b. II and III.
c. III and IV.
d. I, II, III, and IV.

322. When there is no patent protection on a product, firms pursue a pricing strategy aimed at
a. Stabilizing of price and margin.
b. Achieving a target ROI.
c. A market share target.
d. Profit maximization.

323. Which of the following objectives requires the most substantial cost and demand information?
a. Stabilization of price and margin.
b. Pricing to achieve a target ROI.
c. Market share target.
d. Profit maximization.

324. The two classic pricing strategies for new products are known as skimming and
a. Penetration.
b. Pricing to achieve a target ROI.
c. Profit maximization.
d. Market share maximization.

325. A consumer relying on price to suggest quality is
a. Price promoting.
b. Quality discounting.
c. Making a price-quality judgment.
d. Making an informed judgment.

326. When introducing an easily copied new product, a marketer would be likely to use a(n)
a. Price penetration strategy.
b. Odd-even pricing strategy.
c. Price skimming strategy.
d. High pricing strategy.

327. A skimming pricing policy works best when demand is
a. Inelastic.
b. Declining.
c. Elastic.
d. Growing.

328. Which of the following pricing strategies is used when a company has developed a clearly differentiated product?
a. Price penetration.
b. Odd-even pricing.
c. Price skimming.
d. High/low pricing.

329. Competitors cannot quickly enter with similar products at lower prices with which of the following strategy?
a. Price penetration.
b. Odd-even pricing.
c. Price skimming.
d. High/low pricing.

330. Which of the following pricing strategy is pursued in the introduction phase of the product life cycle?
a. Elastic price.
b. Odd-even pricing.
c. Price skimming.
d. High/low pricing.

331. A choice between skimming and penetration pricing strategies is most likely to be made in which of the following stages of the product life cycle?
a. Mature.
b. Introductory.
c. Growth.
d. Decline.

332. Stable, competitive prices and price wars are both common in which of the following stages of the product life cycle?
a. Mature.
b. Introductory.
c. Growth.
d. Decline.

333. Prices are kept as high as possible before harvesting in which of the following stages of the product life cycle?
a. Mature.
b. Introductory.
c. Growth.
d. Decline.

334. A company introducing a new product should use a price penetration strategy if
a. Investment costs are low.
b. There is little threat of copycat competition.
c. The price elasticity of demand is inelastic.
d. More volume means lower production costs.

335. A company can effectively set its prices higher than its competitors when the
a. Company's costs are higher.
b. Competitors' costs are higher.
c. Competitors' products are perceived as low-priced alternatives.
d. Company's product is perceived as superior quality.

336. Which of the following is **not** a common reason for a company to change a product's price?
a. Competitive price moves.
b. Sales tax rates change.
c. Price promotion.
d. Unique pricing for different customers.

337. A salesperson who reduces the price during negotiations is
a. Price shading.
b. Geographic pricing.
c. Cash discounting.
d. Volume discounting.

338. When a company reduces the price for customers paying promptly it is called
a. Price shading.
b. Geographic pricing.
c. Cash discounting.
d. Volume discounting.

339. Pricing which leaves the cost and responsibility of transportation to the customer is called
a. Zone pricing.
b. Cargo pricing.
c. Free-on-board pricing.
d. Forward pricing.

340. Discounts given to retailers for putting a manufacturer's goods on sale to consumers for a particular period of time are called
a. Cash discounts.
b. Volume discounts.
c. Price shaded discounts.
d. Sales promotion allowances.

341. Which of the following is **not** a form of price flexing to consumers?
a. Reduction bonuses.
b. Couponing.
c. Segmented pricing.
d. Price promotion.

342. As price promotions increase over time, consumers
a. Switch brands for consistency.
b. Grow more sensitive to advertising.
c. Become more sensitive to price.
d. Find alternatives with lower value.

343. Which of the following is **not** a popular way marketers commonly divide price segments?
a. Political segments.
b. Geographic segments.
c. Usage segments.
d. Demographic segments.

344. Sellers charging different prices to different buyers is called
a. Price differentiation.
b. Price discrimination.
c. Price flexing.
d. Price haggling.

345. A company experiencing financial trouble may seek to just produce an acceptable cash flow to cover marginal costs. This pricing objective is known as
a. Survival.
b. Stabilization of prices and margins.
c. Market share target.
d. Pricing to achieve a target ROI.

346. Which of the following is a negative consequence of price-quality judgments?
a. They can lead to reduced profit for businesses.
b. Low price can harm a high-quality brand name.
c. They make advertising ineffective.
d. A high price can harm a low-quality brand name.

347. Price discrimination exists when
a. Costs vary among customers.
b. Markups vary among customers.
c. Markups are constant among customers.
d. Prices vary among customers.

348. Successful price discrimination require
a. The ability to prevent transfers among customers in different submarkets.
b. Inelastic demand in each submarket.
c. Constant marginal costs.
d. Identical price elasticities among submarkets.

349. With price discrimination, lower prices are charged when the
a. Price elasticity of demand is high.
b. Price elasticity of demand is low.
c. Cross-price elasticity of demand is high.
d. Cross-price elasticity of demand is low.

350. Change in the quantity demanded is caused by a change in
a. Advertising.
b. Wage rates.
c. Price.
d. Raw material costs.

351. Change in the quantity supplied is caused by a change in
a. Income.
b. Weather.
c. Energy costs.
d. Price.

352. With elastic demand, a price increase will
a. Lower marginal revenue.
b. Lower total revenue.
c. Increase total revenue.
d. Lower marginal and total revenue.

353. With inelastic demand, a price increase produces
a. Less than a proportionate decline in quantity demanded.
b. Lower total revenue.
c. Lower marginal revenue.
d. Lower marginal and total revenue.

354. Which of the following is true about pricing during peak periods?
a. Incremental costs are relevant for pricing purposes.
b. Fully allocated costs are relevant for pricing purposes.
c. Facilities are underutilized.
d. Expansion is not required to further increase production.

355. The most prevalent pricing practice employed by business firms is setting price equal to
a. Average revenue.
b. Average cost.
c. Average variable cost plus a charge for overhead and profit margin.
d. Marginal revenue.

356. For which type of product is it appropriate for the seller to accept any price that exceeds the storage and delivery costs for the product?
a. By-product
b. Optional product
c. Captive product
d. Product bundle

Marketing—Supply-Chain Management

357. The process of linking a manufacturer's operations with those of its suppliers and customers is called
a. Just-in-time system.
b. Relationship marketing.
c. Supply-chain management.
d. Vendor marketing.

358. Which of the following describes the logistical system, which emphasizes close cooperation and comprehensive interorganizational management to integrate the logistical operations of the different firms in the marketing channel?
a. Marketing channel power.
b. Supply-chain management.
c. Marketing channel design.
d. Horizontal integration.

359. Each organization in a supply-chain is typically involved in

I. The creation of a product.
II. Marketing processes.
III. Delivery of a product.
IV. Postsale service.

a. I and II.
b. II and III.
c. III and IV.
d. I, II, III, and IV.

360. Buyers involved in a supply-chain management strategy
a. Sometimes reach several tiers back in the supply-chain link to assist second-tier suppliers in meeting their goals.
b. Will work with vendors to find suitable additional sales outlets for their products.
c. Will strive to assist their customers to find alternative sources for competitive products.
d. Sometimes find that short-term relationships are more rewarding.

361. The primary goal of supply-chain management is to
a. Lower all costs of marketing, sales, and logistics.
b. Provide the most effective information to all firms in the supply chain.
c. Reduce the dependence on any single supplier.
d. Improve speed, accuracy, and efficiency in manufacturing and delivery.

362. The reward of becoming a valued partner in a customer's supply-chain is
a. Having fewer demands placed on the marketing staff.
b. Being viewed as an extension of the customer's company.
c. Sharing joint advertising costs with all the firms in the supply chain.
d. Enhancing the ability of the supply chain to use technology.

363. To achieve the reward of being viewed as an extension of a company's customers, a business marketer must be able to
a. Sell their products at lower costs than competitors.
b. Meet quality, delivery, service, and informational requirements.
c. Respond to requests for lower prices.
d. Compromise on the time spent with the customer's top management.

364. Companies that adopt the just-in-time approach to purchasing will typically
a. Decrease the number of suppliers with which they deal.
b. Rely on short-term contracts with their suppliers.
c. Increase the number of inspectors checking incoming materials.
d. Have a streamlined accounts payable system.

365. The essence of the just-in-time concept is to
a. Reduce expenditures on materials and parts.
b. Deliver defect-free parts and materials to the production process just at the moment they are needed.
c. Increase the responsiveness to supplier's needs.
d. Eliminate unnecessary suppliers.

366. The goals of just-in-time concepts are generally focused on
a. Quality, inventory cost, and customer service.

b. Costs, service, price, and quality.
c. Customer service, inventory costs, and production efficiency.
d. Quality, customer service, inventory costs, and production efficiency.

367. The value offerings developed by business marketers must be based on
a. The offerings to close competitors.
b. The value proposition specified by the buyer's purchasing agents.
c. The skills and resources that provide value as perceived by the customer.
d. How the marketing department defines the customer's needs.

368. The purchasing method that involves weighing the comparative value of materials, parts, components, and manufacturing processes from the standpoint of their purpose, relative merit, and cost is called
a. Value analysis.
b. Material analysis.
c. Cost analysis.
d. Vendor analysis.

369. Which of the following is **not** true about value analysis?
a. It looks at ways to improve products.
b. It is an approach for lowering costs.
c. It evaluates the most cost-efficient way of accomplishing a function.
d. It points the way to elimination and reengineering.

370. One of the results of value analysis is that
a. Suppliers may be charged for lost or damaged merchandise.
b. The purchasing department may find materials at competing suppliers at a lower cost.
c. Product design alternatives will produce significant cost savings.
d. Ideas from suppliers are integrated into the firm's marketing strategy.

371. The value of a function is determined by
a. Supply and demand factors.
b. What sellers are asking for it.
c. How it is organized and implemented.
d. The most cost-efficient way of fully accomplishing the function.

372. The evaluation of supplier performance is used
a. As a tool for attracting more suppliers.
b. As a negotiation tool to gain leverage in buyer-seller relationships.
c. To leverage the firm's buying power with other suppliers.
d. To penalize suppliers who are delinquent with deliveries.

373. From the supplier's evaluation perspective, the weighted-point plan is useful in that it
a. Provides evidence of the nature and importance of the evaluative criteria used by the buyer.
b. Can be used as a marketing tool if the scores are high enough.
c. Shows how important a good evaluation forecasting system is.
d. Measures whether the buyer is interested in a long-term relationship.

374. Customers in business markets are interested in a supplier's
a. Ability to reduce prices.
b. Relationship with competitors.
c. Capabilities and contributions.
d. Financial position and capital.

375. Which of the following is concerned with the holding of products until they are ready to be sold?
a. Transportation.
b. Materials handling.
c. Warehousing.
d. Packaging.

376. What is the most important factor to consider when deciding whether to single source or multiple source a critical component?
a. Available supplier capacity.
b. Desire to maintain competition for the business.
c. Cost of tooling and setup.
d. Number of suppliers in the marketplace.

377. Which of the following will be useful in competitive analysis when evaluating the worthiness of a potential supplier?
a. Financial stability.
b. Other customers of the suppliers.
c. Management integrity.
d. Available supplier capacity.

378. What other factors should be considered in addition to supplier rating score prior to making the final selection of a supplier?

I. Management integrity.
II. Financial stability.
III. Design flexibility.
IV. Production standards.

a. I and II.
b. II and III.
c. I, II, and III.
d. I, II, III, and IV.

379. Vendor analysis should be conducted

I. On a periodic basis.
II. When significant changes occur to scoring factors.
III. When frequent changes occur in vendor location.
IV. On a vendor-requested basis.

a. I only.
b. II only.
c. I and II.
d. III and IV.

380. Which of the following would **not** usually be a main factor in selecting a vendor?
a. Price.
b. Quality.
c. Inventory usage.
d. Service.

381. Choosing vendors solely based on which of the following factors is detrimental to the long-term success of a buying firm?
a. Quality.

b. Service.
c. Price.
d. Delivery.

382. Supplier audits are an important first step in
a. Supplier certification.
b. Supplier relationships.
c. Supplier partnerships.
d. Strategic partnerships.

383. Supplier audits usually do **not** focus on which of the following?
a. Supplier capabilities.
b. Quality programs.
c. Delivery programs.
d. Human resource programs.

384. Supplier audits usually do **not** cover which of the following?
a. Management style.
b. Industrial engineering.
c. Quality assurance.
d. Materials management.

385. Certified suppliers mean
a. Less risk.
b. Buyer can eliminate all inspections.
c. Buyer can eliminate all tests.
d. More audits.

386. Supplier certification does **not** mean
a. All vendors are ISO 9000 certified.
b. Some vendors are referred to as world-class suppliers.
c. Some suppliers meet the needs of a buyer.
d. Some suppliers exceed the needs of a buyer.

387. Examination of functions and costs of a finished product, part, or component in an effort to reduce costs and/or to improve performance is called
a. Value analysis.
b. Vendor analysis.
c. Materials analysis.
d. Cost analysis.

388. Value analysis has the greatest potential for cost savings for parts, raw materials, and components that have

I. Low unit cost.
II. High unit cost.
III. Low annual usage.
IV. High annual usage.

a. II only.
b. IV only.
c. I and III.
d. II and IV.

389. Which of the following parties should **not** drive the implementation of value analysis program in a company?
a. Product design engineering.
b. Manufacturing operations.
c. Purchasing or supply chain.
d. Sales and marketing.

390. Which of the following are involved in the bullwhip effect in the supply chain process?

I. Nonvalue stream.
II. Value stream.
III. Upstream.
IV. Downstream.

a. I only.
b. II only.
c. III and IV.
d. II and III.

391. The bullwhip effect in the supply chain can be eliminated by
a. Replenishing the supply chain.
b. Synchronizing the supply chain.
c. Resizing the supply chain.
d. Mixing the supply chain.

392. The inventory situation during the bullwhip effect in the supply chain is at a(n)
a. Excess level.
b. Backordered level.
c. Moderate level.
d. Low level.

393. When suppliers are involved in the design, development, and manufacturing of a new product, component, part, or system, it is called
a. Presourcing.
b. Insourcing.
c. Outsourcing.
d. Cosourcing.

394. Which of the following refers to when manufacturing companies do not own equity of their largest suppliers?
a. Japanese keiretsu.
b. American keiretsu.
c. Kanban.
d. Kaizen.

395. What technique would a company use to determine which advertising mix of radio, television, and newspaper offers the optimal increase in sales and improved public image?
a. Pareto analysis.
b. Value analysis.
c. Linear regression.
d. The Markov process.

Human Resources Management

396. The major shortcoming of the traditional employee's performance measurement process is that it
a. Rarely includes broader organizational criteria.
b. Is usually static in nature.
c. Focuses on reaching agreement on the results of the evaluation.
d. Determines actions that need to be taken.

397. Organizations are moving from an employee's performance measurement process to a performance management process in order to
a. Meet competitive challenges.
b. Refine the job analysis.
c. Increase the employee's performance ratings.
d. Rebut the appraiser's assessment.

398. The major difference between employee's performance measurement system and performance management system is the emphasis on
a. Management.
b. Report card.

c. Evaluation tool.
d. Measurement.

399. Which of the following is **not** an element of an employee's performance management system?
a. Promoting shared responsibility.
b. Molding employee's performance.
c. Establishing effective reward and recognition programs.
d. Measurement is seen as an end in itself.

400. Which of the following is **not** a major part of the human resource management process?
a. Employee selection and recruiting.
b. Employee communication.
c. Employee performance appraisal.
d. Employee training and development.

401. Which of the following is the most frequently used but least successful job-searching method?
a. Internal job posting.
b. Employment agencies.
c. Corporate Web sites.
d. Job fairs.

402. Which of the following is the best way to find a job?
a. Internal job posting.
b. Employment agencies.
c. Newspaper advertisements.
d. Job referrals.

403. Which of the following identifies basic task and skill requirements through observation?
a. Job analysis.
b. Job description.
c. Job specifications.
d. Job matrix.

404. Which of the following should be done before job descriptions are developed?
a. Job analyses.
b. Job rotation.
c. Job specifications.
d. Job matrix.

405. Which of the following outlines the role expectations and skill requirements for a specific job?
a. Job analysis.
b. Job rotation.
c. Job specifications.
d. Job descriptions.

406. Which of the following is the most common tool used for employee selection?
a. Background checks.
b. Interviews.
c. Drug testing.
d. Personality tests.

407. Which of the following is defined as a set of job-related questions with standardized answers?
a. Preinterview.
b. Postinterview.
c. Structured interview.
d. Unstructured interview.

408. Which of the following defines the process of evaluating an individual's contribution as a basis for making objective personnel decisions?
a. Performance appraisal.
b. Environmental factors.
c. Facilitation skills.
d. Training and development.

409. Which of the following is **not** a criterion for legally defensible performance appraisals in the United States?
a. Results reviewed with rates.
b. Performance based on job analysis.
c. Results linked with compensation decisions.
d. Written instructions given to evaluators.

410. In which of the following performance appraisal techniques do managers describe the performance of employees in narrative form?
a. Graphic rating scales.
b. Written essays.
c. Ranking and comparison.
d. Goal setting.

411. In which of the following performance appraisal techniques do managers write down specific examples of employees' good and bad performance as they occur and later use them during performance appraisal?
a. Graphic rating scales.
b. Critical incidents.
c. Multirater appraisals.
d. Weighted checklist.

412. Both graphic rating scales and behaviorally anchored rating scales (BARS) are effective for appraising an employee's job performance when they focus on
a. Traits.
b. Skills.
c. Behavior.
d. Scales.

413. Which of the following employees' performance appraisal techniques take input from multiple raters such as one's supervisor, peers, and subordinates?
a. Ranking and comparisons.
b. A top-down review.
c. A bottom-up review.
d. A 360-degree review.

414. Supervisors and managers need more training in which of the following areas?
a. Workplace substance abuse.
b. Referral and rehabilitation approaches.
c. Employee performance appraisals.
d. Sexual harassment problems.

415. Which of the following is the most preferred instructional and training method?
a. Role playing.
b. Case studies.
c. Computer-based training.
d. Live classroom lectures.

Balanced Scorecard System

416. The balanced scorecard system is a(n)
a. Internal control system.
b. Tactical control system.

c. Management control system.
d. Operational control system.

417. Which of the following is the heart of a balanced scorecard system?
a. Strategic management system.
b. Tactical management system.
c. Functional management system.
d. Operational management system.

418. The balanced scorecard system is a reflection of

I. Lag indicators.
II. Lead indicators.
III. Financial indicators.
IV. Nonfinancial indicators.

a. I and II.
b. II and III.
c. III and IV.
d. I, II, III, and IV.

419. Which of the following is **not** a perspective of the balanced scorecard approach?
a. Timeliness.
b. Productivity.
c. Efficiency.
d. Quantity.

420. The balanced scorecard approach does **not** require looking at performance from which of the following perspectives?
a. Financial.
b. Competitor.
c. Customer.
d. Internal business processes.

421. All of the following are critical success factors under the customer perspective of the balanced scorecard approach **except:**
a. Increasing customer service.
b. Reducing prices.
c. Increasing quality.
d. Reducing delivery time.

422. Which of the following perspectives of the balanced scorecard deal with objectives across a company's entire value chain?
a. Financial.
b. Customer.
c. Internal business processes.
d. Learning and growth.

423. Which of the following perspectives of the balanced scorecard deal with objectives of increasing market share and penetrating new markets?
a. Financial.
b. Customer.
c. Internal business processes.
d. Learning and growth.

424. Which of the following perspectives of the balanced scorecard deal with objectives of product improvement?
a. Financial.
b. Customer.
c. Internal business processes.
d. Learning and growth.

425. Which of the following items represent nonfinancial measures under the balanced scorecard approach?

I. Costs.
II. Sales margins.
III. Quality.
IV. Customer service.

a. III only.
b. IV only.
c. I and II.
d. III and IV.

426. Which of the following statements is **not** true about non-financial measures of performance under the balanced scorecard approach?
a. At times quality may be more important than cost.
b. At times timeliness may be more important than meeting budget.
c. At times customer service may be more important than financial returns.
d. At times traditional measures may be more important than nontraditional measures.

427. Which of the following perspectives of the balanced scorecard deal with the objective of shortening the time to market a new product?
a. Financial.
b. Customer.
c. Internal business processes.
d. Learning and growth.

428. All of the following are examples of customer-performance scorecard measures **except:**
a. Lost customers.
b. Dissatisfied customers.
c. Product or service quality.
d. Machine downtime.

429. Which of the following balanced scorecard measure is difficult to identify and implement?
a. Market-based performance scorecard.
b. Production-based performance scorecard.
c. Stakeholder-based performance scorecard.
d. Human resource-based performance scorecard.

430. A good balanced scorecard system contains

I. Lag measures.
II. Lead measures.
III. Interlinking.
IV. Interrelationship digraph.

a. I and II.
b. III and IV.
c. I, II, and III.
d. I, II, III, and IV.

MULTIPLE-CHOICE ANSWERS AND EXPLANATIONS

1. a		63. a		125. b		187. a		249. c		311. c	
2. b		64. b		126. c		188. c		250. c		312. a	
3. c		65. d		127. c		189. a		251. d		313. b	
4. b		66. a		128. b		190. d		252. a		314. d	
5. b		67. a		129. a		191. c		253. c		315. b	
6. c		68. b		130. b		192. c		254. c		316. d	
7. a		69. c		131. a		193. c		255. c		317. b	
8. c		70. d		132. a		194. c		256. d		318. b	
9. d		71. a		133. c		195. a		257. a		319. c	
10. a		72. d		134. a		196. a		258. b		320. c	
11. a		73. c		135. b		197. b		259. b		321. d	
12. d		74. c		136. b		198. c		260. a		322. c	
13. a		75. a		137. d		199. a		261. d		323. d	
14. d		76. d		138. b		200. a		262. a		324. a	
15. b		77. b		139. b		201. a		263. d		325. c	
16. a		78. c		140. c		202. c		264. d		326. a	
17. d		79. a		141. d		203. a		265. a		327. a	
18. b		80. c		142. a		204. c		266. b		328. c	
19. c		81. a		143. a		205. a		267. b		329. c	
20. b		82. b		144. b		206. b		268. c		330. c	
21. a		83. b		145. d		207. a		269. a		331. b	
22. a		84. a		146. b		208. b		270. b		332. a	
23. d		85. d		147. b		209. b		271. c		333. d	
24. c		86. c		148. b		210. a		272. c		334. d	
25. c		87. a		149. a		211. b		273. b		335. d	
26. b		88. c		150. b		212. b		274. a		336. b	
27. b		89. a		151. b		213. b		275. a		337. a	
28. b		90. a		152. c		214. b		276. b		338. c	
29. a		91. b		153. a		215. c		277. b		339. c	
30. a		92. c		154. a		216. b		278. d		340. d	
31. a		93. c		155. c		217. a		279. b		341. a	
32. a		94. b		156. c		218. d		280. b		342. c	
33. d		95. a		157. c		219. d		281. a		343. a	
34. b		96. b		158. a		220. a		282. c		344. b	
35. a		97. b		159. b		221. a		283. b		345. a	
36. b		98. c		160. d		222. b		284. c		346. b	
37. c		99. c		161. d		223. a		285. b		347. b	
38. a		100. d		162. d		224. b		286. d		348. a	
39. d		101. b		163. b		225. a		287. d		349. a	
40. d		102. a		164. a		226. d		288. c		350. c	
41. d		103. b		165. d		227. c		289. d		351. d	
42. a		104. a		166. b		228. c		290. c		352. b	
43. c		105. a		167. a		229. b		291. c		353. a	
44. b		106. c		168. b		230. d		292. a		354. b	
45. a		107. d		169. a		231. d		293. a		355. c	
46. b		108. b		170. b		232. a		294. a		356. a	
47. b		109. d		171. c		233. c		295. c		357. c	
48. c		110. a		172. c		234. d		296. b		358. b	
49. a		111. a		173. c		235. d		297. d		359. d	
50. d		112. a		174. c		236. d		298. c		360. a	
51. a		113. a		175. c		237. d		299. a		361. d	
52. b		114. a		176. a		238. d		300. b		362. b	
53. b		115. b		177. d		239. d		301. b		363. b	
54. c		116. a		178. a		240. d		302. d		364. a	
55. d		117. d		179. a		241. c		303. b		365. b	
56. c		118. c		180. b		242. b		304. a		366. d	
57. c		119. b		181. c		243. d		305. c		367. c	
58. a		120. d		182. b		244. a		306. a		368. a	
59. c		121. a		183. c		245. c		307. c		369. d	
60. b		122. c		184. b		246. a		308. b		370. c	
61. b		123. c		185. b		247. c		309. b		371. d	
62. a		124. a		186. c		248. b		310. b		372. b	

373. a __ __	383. d __ __	393. a __ __	403. a __ __	413. d __ __	423. b __ __
374. c __ __	384. b __ __	394. b __ __	404. a __ __	414. c __ __	424. d __ __
375. c __ __	385. a __ __	395. b __ __	405. d __ __	415. d __ __	425. d __ __
376. d __ __	386. a __ __	396. a __ __	406. b __ __	416. c __ __	426. d __ __
377. b __ __	387. a __ __	397. a __ __	407. c __ __	417. a __ __	427. d __ __
378. c __ __	388. d __ __	398. a __ __	408. a __ __	418. d __ __	428. d __ __
379. c __ __	389. c __ __	399. d __ __	409. c __ __	419. d __ __	429. c __ __
380. c __ __	390. c __ __	400. b __ __	410. b __ __	420. b __ __	430. c __ __
381. c __ __	391. b __ __	401. c __ __	411. b __ __	421. b __ __	1st: __/430 =__%
382. a __ __	392. a __ __	402. d __ __	412. c __ __	422. c __ __	2nd: __/430 =__%

Quality Management

1. (**a**) Service quality can be measured in terms of five factors (RATER): reliability (R), assurance (A), tangibles (T), empathy (E), and responsiveness (R). Customers consistently ranked reliability as the most important factor. Reliability is the ability to perform the desired service dependably, accurately, and consistently.

Subject Area: Business processes—quality management. Source: Author.

2. (**b**) Continuous improvement is at the core of the definition of TQM and its principles.

Subject Area: Business processes—quality management. Source: Author.

3. (**c**) TQM involves creating an organizational culture committed to continuous improvement of products or services.

Subject Area: Business processes—quality management. Source: Author.

4. (**b**) Assurance is employees' knowledge, courtesy, and ability to convey trust and confidence.

Subject Area: Business processes—quality management. Source: Author.

5. (**b**) Striving for zero defects is the goal of manufacturing management achieved through statistical process control and six-sigma methodologies, which are subsets of TQM. Striving for zero defects is not one of the principles of TQM.

Subject Area: Business processes—quality management. Source: Author.

6. (**c**) The fishbone diagram helps TQM teams visualize important cause-and-effect relationships.

Subject Area: Business processes—quality management. Source: Author.

7. (**a**) The Pareto diagram helps TQM teams to analyze vital few and trivial many (80/20 pattern or rule). It is most efficient to focus on the few things that make the biggest difference.

Subject Area: Business processes—quality management. Source: Author.

8. (**c**) A scatter diagram is used to plot the correlation between two variables.

Subject Area: Business processes—quality management. Source: Author.

9. (**d**) Kaizen practitioners view quality as an endless journey, not a final destination.

Subject Area: Business processes—quality management. Source: Author.

10. (**a**) A flowchart is a graphic representation of a sequence of activities and decisions. The flowchart identifies unnecessary work steps so that they can either be combined or eliminated.

Subject Area: Business processes—quality management. Source: Author.

11. (**a**) Customers can be internal and external to an organization. Building teamwork and empowerment are employee driven. TQM empowers employees at all levels in order to tap their full potential of creativity, motivation, and commitment.

Subject Area: Business processes—quality management. Source: Author.

12. (**d**) Manufacturing-based quality deals with conformance to requirements such as design specifications, customer requirements, or blueprints.

Subject Area: Business processes—quality management. Source: Author.

13. (**a**) A run chart is also called a time series or trend chart, which tracks the frequency or amount of a given variable over time. Significant deviations from the standard signal the need for corrective action.

Subject Area: Business processes—quality management. Source: Author.

14. (**d**) A control chart helps operations maintain key quality measurements within an acceptable range of upper control limit and lower control limit. It monitors the actual versus desired quality measurements during repetitive operations.

Subject Area: Business processes—quality management. Source: Author.

15. (**b**) A histogram is a bar chart showing whether repeated measurements in an operation conform to a standard bell-shaped curve (normal curve).

Subject Area: Business processes—quality management. Source: Author.

16. (**a**) Prevention costs are costs incurred to prevent defects from occurring during the design and delivery of products or services. Prevention costs can keep both appraisal and failure costs to a minimum.

Subject Area: Business processes—quality management. Source: Author.

17. (**d**) External failure costs are associated with defects found during or after delivery of the product or service to the customer.

Subject Area: Business processes—quality management. Source: Author.

18. (**b**) Appraisal costs are costs to detect, measure, evaluate, and audit products and processes to ensure that they conform to customer requirements and performance standards.

Subject Area: Business processes—quality management. Source: Author.

19. (**c**) Internal failure costs are the costs associated with defects that are discovered before the product is shipped or before the service is delivered to the customer.

Subject Area: Business processes—quality management. Source: Author.

20. (**b**) Services are characterized by their intangibility, inseparability, heterogeneity, and perishability.

Subject Area: Business processes—quality management. Source: CBM, Volume two.

21. (**a**) Of the four unique characteristics that distinguish goods from services, intangibility is the primary source from which the other three characteristics emerge.

Subject Area: Business processes—quality management. Source: CBM, Volume two.

22. (**a**) Because of the service's intangibility, the customer's evaluation of a service will extend beyond what was experienced, the behavior of other customers, and the way the service was delivered.

Subject Area: Business processes—quality management. Source: CBM, Volume two.

23. (**d**) One of the most frequently stressed differences between goods and services is the lack of ability to control service quality before it reaches the consumer. Heterogeneity, almost by definition, makes it impossible for a service operation to achieve 100% perfect quality on an ongoing basis.

Subject Area: Business processes—quality management. Source: CBM, Volume two.

24. (**c**) Perishability distinguishes goods and services. It refers to the fact that services cannot be inventoried in the traditional sense.

Subject Area: Business processes—quality management. Source: CBM, Volume two.

25. (**c**) The five stages of six-sigma include define, measure, analyze, improve, and control. The third stage "analyze" serves an outcome of the "measure" stage. These five stages are a modified adoption of the Deming plan-do-study-act (PDSA) approach.

Subject Area: Business processes—quality management. Source: Author.

26. (**b**) A mistake-proofing tool removes the opportunity for error before it happens. It is a way to detect and correct an error where is occurs and avoid passing the error to the next worker or the next operation. This tool prevents an error from becoming a defect in the process.

Subject Area: Business processes—quality management. Source: Author.

27. (**b**) The control stage monitors the ongoing performance of a process. This stage is a transition from improvement to controlling the process. It ensures that new improvements are implemented.

Subject Area: Business processes—quality management. Source: Author.

28. (**b**) Process mapping is a very useful tool in the "define, measure, analyze, and improve" stages but not in the control stage because the process is already in control. In the control stage, systems and structures are in place to institutionalize the improvements. Process mapping is a high-level visual representation of the current process step looking beyond the functional activities and rediscovering core processes. The objective of the process mapping is to understand the process.

Subject Area: Business processes—quality management. Source: Author.

29. (**a**) The cause-and-effect diagram is a tool for analyzing process variables. The diagram shows the main cause and subcauses leading to an effect (symptom). This tool is used in both the "define and measure" stages.

Subject Area: Business processes—quality management. Source: Author.

30. (**a**) Brainstorming techniques are used to define the problem and to make improvements. It is a way to identify bottlenecks, process/machine breakdowns, and non-value-added work steps.

Subject Area: Business processes—quality management. Source: Author.

31. (**a**) An "as is" process map identifies process inputs and outputs and acts as a benchmark against future improvements. This map is being referred throughout the process, including implementation. The "may be" process map does not exist since it signals uncertainty.

Subject Area: Business processes—quality management. Source: Author.

32. (**a**) The "as is" process map is developed in the define stage of the six-sigma methodology.

Subject Area: Business processes—quality management. Source: Author.

33. (**d**) The "as is" process map is changed to "should be" process map in the "improve" stage to reflect new improvements.

Subject Area: Business processes—quality management. Source: Author.

34. (**b**) Common causes affect everyone working in a process and affect all of the outcomes of a process. They are always present and thus are generally predictable. Special causes are not always present in a process, do not affect everyone working in the process, and do not affect all the outcomes of the process. Special causes are not predictable. The stage "measure" collects data about current performance that pinpoints opportunities and provides a structure for making improvements.

Subject Area: Business processes—quality management. Source: Author.

35. (**a**) Six-sigma green belts work directly with black belts and the cross-functional project leaders to carry out identified improvement projects. They implement six-sigma improvement tools by being competent at detailed and routine tasks and by collecting the required data.

Subject Area: Business processes—quality management. Source: Author.

36. (**b**) The role of six-sigma black belts is based on the principle of contributing independently and applying the appropriate tools and techniques in the process of resolving quality problems and issues in the organization. They assume responsibility for definable projects and posses technical competence and ability.

Subject Area: Business processes—quality management. Source: Author.

37. (**c**) Master black belts will ensure that they contribute through others based on their leadership skills. They are involved as a manager, mentor, or idea leader in developing others. They have the technical breadth, can build a strong network of people, and can resolve conflicts. Sponsors are the champions having project management skills, understand the risk management techniques, and have leadership skills. They have the vision and knowledge of their organization's culture.

Subject Area: Business processes—quality management. Source: Author.

38. (**a**) The quality function deployment (QFD) is a structured method in which customer requirements are translated into appropriate technical requirements for each stage of product development and production. QFD improves product design and reliability. The QFD process is often referred to as listening to the voice of the customer, and it is also called house of quality.

Subject Area: Business processes—quality management. Source: Author.

39. (**d**) Process-mapping techniques are used to improve organizational processes.

Subject Area: Business processes—quality management. Source: Author.

40. (**d**) Mistake-proofing techniques are used to improve organizational processes. Typical mistakes in production are omitted processing, processing errors, setup errors, missing parts, wrong parts, and machine adjustment errors. Poka-yoke is an approach for mistake-proofing processes using automatic devices or methods to avoid simple human or machine errors.

Subject Area: Business processes—quality management. Source: Author.

41. (**d**) Mistake-proofing a service requires identifying when and where failures occur. Once a failure is identified, the source must be found. The final step is to prevent the mistake occurring through source inspections, self-inspections, or sequence checks. Mass or final inspections are expensive, time-consuming, and ineffective as it is too late in the game.

Subject Area: Business processes—quality management. Source: Author.

42. (**a**) Participative management includes subordinates in the decision-making process. A quality circle is an example of participative management. Choice (b) is incorrect because management by objectives (MBO) is a process of goal setting, not decision making and problem solving. Choice (c) is incorrect because quality circles are not rewards; they are work-groups. Choice (d) is incorrect because this theory differentiates between motivator and hygiene factors: those, which satisfy and those, which lead to dissatisfaction.

Subject Area: Business processes—quality management. Source: CIA 597, II-25.

43. (**c**) Job enlargement is a horizontal expansion of the job. It requires an individual to perform multiple jobs, not just one task. Choice (a) is incorrect because job rotation involves shifting a worker from task to task (at the same job level), during different periods of time. Choice (b) is incorrect because job sharing requires two or more people to split the same job, and is an alternative work schedule. Choice (d) is incorrect because job enrichment is a vertical expansion of the job. It involves task combining, establishing client relationships, and opening feedback channels.

Subject Area: Business processes—quality management. Source: CIA 597, II-26.

44. (**b**) The theory behind this response is expectancy theory which is a function of three beliefs: (1) the outcome is attractive (the company stays in business), (2) a particular level of performance will lead to the outcome (new skills and quality circles will lead to productivity and quality increases), and (3) a level of effort will lead to the performance level (training and hard work will lead to skills and success of quality circles). Choice (a) is incorrect because the theory behind this response suggests that reinforcement conditions behavior. Reinforcement theorists argue that behavior is environmentally caused. Choice (c) is incorrect because the theory behind this response suggests that a person's needs motivate the individual to work for success. Choice (d) is incorrect because the theory behind this response holds that employees act in such a way as to bring "equity" to the job, that is, an individual's inputs and outputs are "fair" when compared to others at the same level.

Subject Area: Business processes—quality management. Source: CIA 597, II-27.

45. (**a**) Work teams are not "empowered" to do anything they please. The organization has certain expectations for what is to be accomplished and how the teams are to go about accomplishing these things. Once the organization defines the objectives (what is to be accomplished) and sets appropriate policies (how it is to be done), the work teams can be free to make and implement decisions within those boundaries. Policies in this context are usually quite broad (e.g., relating to ethical business conduct) but nevertheless important. Choice (b) is incorrect because they are important but not "more important than ever." Policies in this context should not be "rules" and the distrust implicit in "is almost certain to make mistakes" is inconsistent with empowerment. Choices (c) and (d) are incorrect because work teams are not "empowered" to do anything they please.

Subject Area: Business processes—quality management. Source: CIA 1196, III-17.

46. (**b**) Downward performance appraisals are more structured and formal than upward performance appraisals. They also decrease the meaningfulness of the task when the reviewer is more interested in measuring performance than the employee is. Choice (a) is incorrect because this is an action management would take to empower employees because it allows employees some self-determination in performing their

tasks. Choice (c) is incorrect because this is an action management would take to empower employees because it increases the meaningfulness of the task. Choice (d) is incorrect. Again, this is an action management would take to empower employees because it increases the competency of the employees which, in turn, empowers them to perform the task at hand.

Subject Area: Business processes—quality management. Source: CIA 597, III-16.

47. (**b**) Customer focus, both internal and external, is one of the keys of TQM. Choice (a) is incorrect because TQM deemphasizes specialized quality inspectors. Choice (c) is incorrect because centralization often needs to be reduced to successfully implement a TQM process. Choice (d) is incorrect because TQM involves continuous improvement; once a standard is reached, continuous improvement requires its constant reevaluation.

Subject Area: Business processes—quality management. Source: CIA 597, III-23.

48. (**c**) Teams are an excellent vehicle for encouraging the sharing of ideas and removing process improvement obstacles. Choice (a) is incorrect because teams are often inefficient and costly. Choice (b) is incorrect because although employee motivation may be high for some teams members, such potential high motivation does not directly affect the process improvement which is key to quality improvement. Choice (d) is incorrect because the use of teams in total quality management is not aimed at less supervision and reduced staffing although that may be a by-product.

Subject Area: Business processes—quality management. Source: CIA 597, III-24.

49. (**a**) The cumulative effect of TQM's continuous improvement process can attract and hold customers and cannot be duplicated by competitors. Choice (b) is incorrect because new products can be quickly copied by competitors and therefore do not provide a sustained competitive advantage. Choice (c) is incorrect because TQM does not focus on cost reduction. Choice (d) is incorrect because TQM is only one tool of strategic management; other tools have to be used for proper strategic management.

Subject Area: Business processes—quality management. Source: CIA 597, III-20.

50. (**d**) Clear goals and time to go through the early necessary, but not task-focused, stages of development are key to the long-term productivity of a team. Choice (a) is incorrect because assignment of a strong leader and individual tasks are likely to undermine the benefits of participation that are expected from a team. Choice (b) is incorrect. Although similarity may help ease initial conflict, it can be a strong detriment to long-term productivity, which requires diversity of opinion, background, and skills. Choice (c) is incorrect because clear goals provided by a manager are key to a team's success.

Subject Area: Business processes—quality management. Source: CIA 597, III-30.

51. (**a**) In this situation the group is likely to pursue its own agenda at the expense of the organizational goals. Choice (b) is incorrect because although not ideal, this situation will still lead to moderate productivity. Choice (c) is incorrect because high diversity and moderate conflict are both likely to lead to high productivity. Choice (d) is incorrect because this situation is likely to lead to moderate productivity due to commitment to organizational goals.

Subject Area: Business processes—quality management. Source: CIA 597, III-31.

52. (**b**) All the elements presented in the questions are part of the total quality movement in both the manufacturing and service sectors. Choice (a) is incorrect because competition with leading organizations is not the only goal of the total quality movement. Choice (c) is incorrect because the goal is quality first and foremost. A total quality movement may reduce some costs in the long run. Choice (d) is incorrect because the focus of the elements presented is not cost management.

Subject Area: Business processes—quality management. Source: CIA 597, III-3.

53. (**b**) This response describes the "design-it-in" approach, which promotes keeping quality in mind right from the start. Choice (a) is incorrect because this response describes the "fix-it-in" approach. It was the first approach to develop. Inspectors identify defects and have them reworked. Choice (c) is incorrect because this response describes the "inspect-it-in" approach, which applies the "fix-it-in" approach to in-process work. Choice (d) is incorrect because this response describes the "adjust-it-in" approach, which is the same as the "inspect-it-in" approach.

Subject Area: Business processes—quality management. Source: CIA 597, III-4.

54. (**c**) Superior product quality is not attained just through more inspection, better statistical quality control, and cross-functional team work. Manufacturers must make fundamental changes in the way they produce products and do each job right the first time. Choices (a), (b), and (d) are incorrect because each is only a part of the TQM emphasis.

Subject Area: Business processes—quality management. Source: CIA 596, III-23.

55. (**d**) Education and self-improvement should be the number-one career objective for everyone in the organization. Choice (a) is incorrect because management-by-objectives (MBO) causes aggressive pursuance of numerical quotas. Choice (b) is incorrect because on the job training serves to entrench bad work habits. Choice (c) is incorrect because quality by final inspection is unnecessary if quality is built in from the start.

Subject Area: Business processes—quality management. Source: CIA 596, III-29.

56. (**c**) Small teams of people from different specialties empowered to make decision are highly effective. Choice (a) is incorrect because hierarchical organizational structure actually stifles TQM. Choice (b) is incorrect because TQM works best with teams of people from different specialties. Choice (d) is incorrect because teamwork is essential for TQM.

Subject Area: Business processes—quality management. Source: CIA 596, III-30.

57. (**c**) All employees who deal with outsiders must be customer oriented; in addition customers internal to the organization who depend on you to get their job done are considered internal customers. Choice (a) is incorrect because this

is an incomplete response. It doesn't include those within the company who depend on it to get jobs done. Choice (b) is incorrect because influence and reliance can be indirect. Choice (d) is incorrect because internal customers are also included

Subject Area: Business processes—quality management. Source: CIA 596, III-32.

58. (**a**) Involving them in decisions affecting their lives. The quality-of-work-life movement is based on the principle of involving employees in the decision and actions that are likely to affect their lives. The methods used include flexible work schedules, participative management, and workplace democracy, all of which aim at increasing the employees' sense of control. Choice (b) is incorrect because providing fair and equitable reward systems that are clearly linked to the employees' effort and performance is one of the keys to motivation. However, it is much narrower than the overall quality-of-work-life concept and is not the key defining characteristic of the movement. Choice (c) is incorrect because focusing on employees' higher-level needs is also one aspect of motivation according to Maslow. Once again, it is a narrow view of motivation and does not fit within the quality-of-work-life concept. Choice (d) is incorrect because using job enrichment techniques that increase skill variety, task identity and significance, autonomy and feedback can address motivation if there is a need to enrich the job in order to match employees' desire and need for growth. Even when effective, such an approach does not aim at reshaping the workplace and does not constitute a basic principle of the quality-of-work-life movement.

Subject Area: Business processes—quality management. Source: CIA 596, III-34.

59. (**c**) This is incurred as a result of customer dissatisfaction. Choice (a) is incorrect because rework corrects defects caused during manufacture. Choice (b) is incorrect because these arise from internal labor disputes. Choice (d) is incorrect because this results from production processes operating out of specification limits.

Subject Area: Business processes—quality management. Source: CIA 596, III-81.

60. (**b**) Appraisal costs are those costs incurred to detect which products do not conform to specifications. Choice (a) is incorrect because preventive costs are incurred to prevent the production of products that do not conform to specifications. Choice (c) is incorrect because internal-failure costs are incurred when a nonconforming product is detected before it is shipped to a customer. Choice (d) is incorrect because external-failure costs are incurred when a nonconforming product is detected after it is shipped to a customer.

Subject Area: Business processes—quality management. Source: CIA 597, III-96.

61. (**b**) This response identifies the appropriate four costs, which are preventive quality costs. See table and supporting calculations below. Choice (a) is incorrect because this response omits scheduled equipment maintenance from the preventive costs and includes labor inspection of raw materials (appraisal cost) as a preventive cost; the other three costs included are appropriate. See table and supporting calculations below. Choice (c) is incorrect because this response includes product-testing equipment as a preventive cost in addition to the four appropriate preventive costs; product-testing equipment is an appraisal cost. See table and supporting calculations below. Choice (d) is incorrect because this response includes both product-testing equipment and labor inspection of raw materials as preventive costs in addition to the four appropriate preventive costs; both of these costs are appraisal costs. See table and supporting calculations below.

Supporting calculations

Cost items	*Choice a*	*Choice b*	*Choice c*	*Choice d*
Design engineering	$275,000	$275,000	$275,000	$275,000
Labor inspection of raw materials	32,000			32,000
Process engineering	180,000	180,000	180,000	180,000
Product-testing equipment			35,000	35,000
Scheduled equipment maintenance		90,000	90,000	90,000
Training of manufacturing workers	156,000	156,000	156,000	156,000
Total preventive costs	$643,000	$701,000	$736,000	$768,000

Table showing correct classification of costs of quality (COQ)

Cost items	*Amount*	*COQ type*
Design reviews	$275,000	Preventive
Finished goods returned due to failure	55,000	External
Freight on replacement finished goods	27,000	External
Labor inspection during manufacturing	75,000	Appraisal
Labor inspection of raw materials	32,000	Appraisal
Manufacturing product-testing labor	63,000	Appraisal
Manufacturing rework labor and overhead	150,000	Internal
Materials used in warranty repairs	68,000	External
Process engineering	180,000	Preventive
Product-liability claims	145,000	External
Product-testing equipment	35,000	Appraisal
Repairs to equipment due to breakdowns	22,000	Internal
Scheduled equipment maintenance	90,000	Preventive
Scrap material	125,000	Internal
Training of manufacturing workers	156,000	Preventive

Subject Area: Business processes—quality management. Source: CIA 597, III-97.

62. (**a**) The major component of quality is to minimize defects and stay true to design. Choice (b) is incorrect because management satisfaction is not the way organizations measure quality. Choice (c) is incorrect because this is compliance audit, not a component of quality control. Choice (d) is incorrect because in many cases, quality is achieved without any formal quality control inspectors and without formal inspection points, but rather through employee control of their own work on a continuous basis.

Subject Area: Business processes—quality management. Source: CIA 1196, III-23.

63. (**a**) The question addresses one of the key components of TQM which is continuous improvement and control for quality by people who produce the goods and services. Under a TQM approach, all employees, not only managers, are responsible for quality. Choice (b) is incorrect because quality control is performed throughout the process by all concerned. Choice (c) is incorrect because this statement is too broad and applies to anything, not just TQM. Choice (d) is incorrect because TQM philosophy recommends limiting the number of suppliers and considering quality and service in addition to price as criteria for selection of suppliers.

Subject Area: Business processes—quality management. Source: CIA 1196, III-24.

64. (**b**) Although choices (a), (c), and (d) may all be by-products of quality circles, they are not the primary goal of quality circles. Quality circles are aimed primarily at creative problem solving and benefiting from employee creativity and knowledge.

Subject Area: Business processes—quality management. Source: CIA 1196, III-27.

65. (**d**) The process that is used to produce the manufactured goods is not thoroughly reviewed and evaluated for efficiency and effectiveness. Choice (a) is incorrect because the process is expensive, but other quality control processes can also be expensive. Choice (b) is incorrect because it may be possible, although costly, to rework defective items. Choice (c) is incorrect because no quality control system will be 100% effective.

Subject Area: Business processes—quality management. Source: CIA 1195, III-28.

66. (**a**) This defines the objective of a scatter diagram. Choice (b) is incorrect because this defines a histogram. Choice (c) is incorrect because this defines stratification. Choice (d) is incorrect because this defines a Pareto chart.

Subject Area: Business processes—quality management. Source: CIA 1195, III-11.

67. (**a**) TQM is an integrated system that anticipates, meets, and exceeds customers' needs, wants, and expectations. Choice (b) is incorrect because this is too specific. Delivery time is one of many potential activities that needs improvement. Choice (c) is incorrect because this is too specific. Delivery charge is one of many potential activities that needs improvement. Choice (d) is incorrect because increased employee participation is necessary to achieve TQM, but it is not the primary purpose for establishing the program.

Subject Area: Business processes—quality management. Source: CIA 1195, III-12.

68. (**b**) Prevention costs prohibit poor-quality services from being performed in the first place. Choice (a) is incorrect because appraisal costs are a corrective action that is costly. Choice (c) is incorrect because internal failure costs are a corrective action that is costly. Choice (d) is incorrect because external failure costs are a corrective action that is costly.

Subject Area: Business processes—quality management. Source: CIA 1195, III-13.

69. (**c**) These are the most frequent problems. Choice (a) is incorrect because more detailed information is not available. The chart does not focus on the total quantity of computer complaints. Choice (b) is incorrect because the organization should first focus on the more frequent complaints. Choice (d) is incorrect because this information is not provided.

Subject Area: Business processes—quality management. Source: CIA 1195, III-15.

70. (**d**) The chart does display the absolute frequency of each computer complaint. Choice (a) is incorrect because the chart does not display the arithmetic mean. Choice (b) is incorrect because the chart does not display the relative frequency. Choice (c) is incorrect because the chart does not display the median.

Subject Area: Business processes—quality management. Source: CIA 1195, III-16.

71. (**a**) Quality cost index percentage for June = (5,000 + 5,000 + 15,000 + 11,000)/100,000 = 36,000/100,000 = 0.36 × 100 = 36%. Quality cost index percentage for May = (4,000 + 6,000 + 12,000 + 14,000)/90,000 = 36,000/90,000 = 0.40 × 100 = 40%. Decrease in index from May to June = 40% – 36% = 4%. Therefore, by definition, choices (b), (c), and (d) are incorrect.

Subject Area: Business processes—quality management. Source: CIA 1195, III-98.

72. (**d**) Management retains the right to make the final decisions. Choice (a) is incorrect because a quality circle is a small group of subordinates and supervisors—usually eight to ten people. Choice (b) is incorrect because each member is responsible for the success of the circle, and success depends on members having these skills. Choice (c) is incorrect because quality circles are the way work is accomplished in companies that use them. Participation is part of each worker's job.

Subject Area: Business processes—quality management. Source: CIA 1195, II-33.

73. (**c**) Prevention of a defect is felt in reduced costs throughout the entire manufacturing and quality inspection cycle. Choices (a), (b), and (d) are incorrect because they are examples of feedback controls and are not as effective as a feedforward (preventive) control.

Subject Area: Business processes—quality management. Source: CIA 1190, III-14.

74. (**c**) Superior product quality is not attained just through more inspection, better statistical quality control, and cross-functional teamwork. Manufacturers must make fundamental changes in the way they produce products and do each job right the first time. Choice (a) is incorrect because this is only a part of the TQM emphasis. Choice (b) is incorrect because this is only a part of the TQM emphasis. Choice (d) is incorrect because this is only a part of the TQM emphasis.

Subject Area: Business processes—quality management. Source: CIA 594, III-53.

75. (**a**) The firm would do well to spend the bulk of their funds on prevention through better product and process design and testing, supplier evaluation and training, employee training, and preventative maintenance. That is, prevent quality breakdowns before the product is produced. Choices (b), (c), and (d) are incorrect. While spending funds in these areas will improve quality, the funds are better spent on prevention than on appraisal, internal failure, or external failure.

Subject Area: Business processes—quality management. Source: CIA 594, III-54.

76. (**d**) The firm must avoid external failures. If low-quality products are discovered by a firm's customers, it will not be able to build a reputation as a world-class manufacturer. The firm should spend their funds on prevention, appraisal, and internal failure, in that order. That is, prevent quality breakdowns before the product is produced and shipped so that the customer never receives poor-quality products. Choices (a), (b), and (c) are incorrect because de-

tecting poor-quality products at these earlier stages prevents the customer from ever receiving the poor-quality products.

Subject Area: Business processes—quality management. Source: CIA 594, III-55.

77. (**b**) The number of parts is not a measure of quality. Choices (a), (c), and (d) are incorrect because each one is a measure of the quality of the product.

Subject Area: Business processes—quality management. Source: CIA 594, III-56.

78. (**c**) The economic order quantity model is related to what quantity (not quality) of a product should be purchased to minimize ordering and holding costs. Choice (a) is incorrect because ISO 9000 is an international standard of quality which any firm's products need to meet. Choice (b) is incorrect because TQM is the process of changing organization structure and climate and redirecting product quality programs towards becoming a global quality leader. Choice (d) is incorrect because a quality circle is a small group of workers who volunteer to meet regularly to undertake work-related projects designed to advance the company, improve working conditions, and spur mutual self development through using quality concepts.

Subject Area: Business processes—quality management. Source: CIA 594, III-64.

79. (**a**) This is the purpose of a TQC system. Choice (b) is incorrect because it represents a means to achieve the objective of choice (a). Choice (c) is incorrect because this does not relate to parts and material. Choice (d) is incorrect because this is the purpose of another control in a JIT system.

Subject Area: Business processes—quality management. Source: CIA 1191, I-11.

80. (**c**) P-charts are appropriate when the inspection process classifies products into just two categories. In such processes, the distribution of items in each category follows a binomial distribution. The P-chart is based on the binomial distribution. Choices (a) and (b) are incorrect because X-bar and R charts rely on sampling from the normal distribution. Therefore, they are inappropriate for controlling the proportion of unacceptable items. Choice (d) is incorrect because Cusum charts require that dimensions of the product that are of interest can be measured easily.

Subject Area: Business processes—quality management. Source: CIA 592, III-66.

81. (**a**) P-Charts are appropriate when the inspection process classifies products into just two categories. In such processes, the distribution of items in each category follows a binomial distribution. The p-chart is based on the binomial distribution. Choice (b) is incorrect because X-bar and R charts rely on sampling from the normal distribution. Therefore, they are inappropriate for controlling the proportion of unacceptable items. Choice (c) is incorrect because it is the same as choice (b). Choice (d) is incorrect because SQC charts include X-bar and p-charts.

Subject Area: Business processes—quality management. Source: CIA 591, III-45.

82. (**b**) Appraisal costs are those costs (such as test equipment maintenance and destructive testing) incurred to detect which products do not conform to specifications. Choice (a) is incorrect. Prevention costs are incurred to prevent the production of products that do not conform to specifications. Choice (c) is incorrect. Rework costs, a type of failure cost, are incurred when a nonconforming product is detected and corrections are made. Choice (d) is incorrect. Failure costs are incurred in the repair of nonconforming products.

Subject Area: Business processes—quality management. Source: CIA Model Exam 1998, III-1.

83. (**b**) Specifications for materials purchased provide an objective means of determining that the materials meet the minimum quality level required for production. Choice (a) is incorrect. This would not ensure that raw materials are of sufficient quality. Choice (c) is incorrect. This would only help ensure that raw materials are used in the proper quantities. Choice (d) is incorrect. This would only permit proper determination of spoilage after raw materials have been used in production.

Subject Area: Business processes—quality management. Source: CIA Model Exam 2002, III-25.

84. (**a**) Teams can use the diverse knowledge and skills of all team members. Choice (b) is incorrect because teams are often inefficient and costly. Choice (c) is incorrect. Although employee motivation may be high in teams, the high motivation does not always translate directly to quality improvement. Choice (d) is incorrect. Although need for supervision may be reduced, it is not eliminated.

Subject Area: Business processes—quality management. Source: CIA Model Exam 2002, III-3.

International Organization for Standardization (ISO) Framework

85. (**d**) The work involved in implementing the ISO 9001 quality standards is completely different and separate from applying for the US Malcolm Baldrige National Quality award. There is no connection between these two programs in terms of filing applications.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

86. (**c**) Removing tariffs between countries is handled by each country's economic and political system, not by the ISO certification process. The other three are valid reasons.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

87. (**a**) After an application for certification is filed, registrars will conduct on-site audits. They review documents and conduct interviews. Prior to that, each applicant will do his own preassessment work. The final step is assessment by the registrars. There is no step of rectification.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

88. (**c**) Third-party auditors or registrars are used in the certification process. A national quality board will accredit the auditors.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

89. (**a**) The ISO 9000 has four quality measures including (1) leadership, (2) human resource developments and management, (3) management of process quality, and (4) customer focus and satisfaction. The US Malcolm Baldrige

has seven categories including (1) leadership, (2) strategic planning, (3) customer and market focus,(4) information and analysis, (5) human resources focus, (6) process management, and (7) business results. Both of them are aligned very closely with each other.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

90. (**a**) The QS-9000 standard was developed to make it easier for suppliers to do business with auto manufacturers and other original equipment manufacturers.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

91. (**b**) ISO 9000 addresses quality system standards focusing on processes, not on products or people.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

92. (**c**) The goal of the ISO 9000 standards is to eliminate non-value-added functions by focusing on improving internal processes such as manufacturing, sales, and technical services. Customer satisfaction and business results are the focus of the Malcolm Baldrige National Quality Award program. Productivity improvement is the focus of the Shingo Prize in quality.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

93. (**c**) The ISO-14000 is the international standard for environmental management. The other three are examples of product quality standards.

Subject Area: Business processes—ISO framework. Source: CBM, Volume two.

Forecasting

94. (**b**) Scenario analysis is the preparation and study of written descriptions of alternative but equally likely future conditions. Scenarios are visions of what "could be" and are of two types: longitudinal (describes how the present is expected to evolve into the future) and cross-sectional (describes possible future situations at a given point in time).

Subject Area: Business processes—forecasting. Source: Author.

95. (**a**) There are three types of forecasts: (1) event outcome forecasts, (2) event timing forecasts, and (3) time series forecasts. Event outcome forecasts are used to predict the outcome of highly probable future events. Event timing forecasts predict when given events will occur. Time series forecasts seek to estimate future values in a sequence of periodically recorded data such as sales and inventory levels.

Subject Area: Business processes—forecasting. Source: Author.

96. (**b**) "Timing questions" in the event timing forecast can be answered by identifying leading indicators that historically have preceded the events in question. For example, a declining inflation rate (a leading indicator) prompts banks to lower their prime interest rates.

Subject Area: Business processes—forecasting. Source: Author.

97. (**b**) Extrinsic forecasts are based on correlated leading indicators, such as estimating furniture sales based on housing starts. These forecasts are more useful for large aggregations such as total company sales than for individual product line sales. The intrinsic forecast method is a forecast based on internal factors such as an average of past sales.

Subject Area: Business processes—forecasting. Source: Author.

98. (**c**) Trend analysis is the hypothetical extension of a past pattern of events or time series into the future. An underlying assumption of trend analysis is that past and present tendencies will continue into the future.

Subject Area: Business processes—forecasting. Source: Author.

99. (**c**) Judgmental forecasts are both fast and inexpensive but their accuracy depends on how informed the manager is.

Subject Area: Business processes—forecasting. Source: Author.

100. (**d**) Trend is the long-run shift or movement in the time series observable over several periods of data.

Subject Area: Business processes—forecasting. Source: Author.

101. (**b**) A seasonal component is the component of the time series model that shows a periodic pattern over one year or less. Seasonal components are regular repeated patterns. A cyclical component is the component of the time series model that results in periodic above-trend and below-trend behavior of the time series lasting more than one year (choice c.).

Subject Area: Business processes—forecasting. Source: Author.

102. (**a**) The irregular component is the component of the time series model that reflects the random variation of the actual time series values beyond what can be explained by the trend, cyclical, and seasonal components. The irregular component is short-term, unanticipated, and nonrecurring factors in a time series that provide the random variability. Smoothing methods are used to smooth the irregular component. The residual is the difference between the actual value of the dependent variable and the value predicted by the regression equation. The forecast error is the difference between actual and forecasted values. The mean squared error is an approach to measuring the accuracy of a forecasting mode. This measure is the average of the sum of the squared differences between the actual time series values and the forecasted values.

Subject Area: Business processes—forecasting. Source: Author.

103. (**b**) The causal forecasting model is a forecasting method that relates a time series to other variables that are believed to explain or cause its behavior. A simple linear regression is a method for analyzing the relation between one independent variable and one dependent variable. In multiple regression, there can be several independent variables and one dependent variable.

Subject Area: Business processes—forecasting. Source: Author.

104. (**a**) A seasonal index is a measure of the seasonal effect on a time series. A seasonal index above one indicates

a positive effect; exactly one indicates no seasonal effect; and less than one indicates a negative effect.

Subject Area: Business processes—forecasting. Source: Author.

105. (**a**) A deseasonalized time series is a time series that has had the effect of season removed by dividing each original time series observation by the corresponding seasonal index.

Subject Area: Business processes—forecasting. Source: Author.

106. (**c**) The Delphi technique is a qualitative technique, not a quantitative technique. Choice (a) is incorrect. The least squares technique is used in regression models to produce a line that best fits the data. Choice (b) is incorrect. The exponential smoothing technique (single parameter) is appropriate for such a database. Choice (d) is incorrect. The moving average process is used to decompose the time series components

Subject Area: Business processes—forecasting. Source: CIA Model Exam 1998, III-36.

107. (**d**) If the original data (with the four trends) is divided by the seasonal norm, the seasonal component is factored out of the data.

Subject Area: Business processes—forecasting. Source: CIA Model Exam 1998, III-38.

108. (**b**) Internal accounting allocations of costs to different segments of the company are arbitrary assignments of already incurred costs which do not have anything to do with forecasting demand. Choices (a), (c), and (d) are incorrect because knowing the behavior of business cycles, understanding seasonal variations in demand for the product, and using econometric models can be valuable when forecasting the required purchases of inventory.

Subject Area: Business processes—forecasting. Source: CIA Model Exam 1998, III-39.

109. (**d**) Solution strategies of the "what if" class are the essence of simulation. Choice (a) is incorrect because statistical sampling does not involve solution strategies. Choice (b) is incorrect because econometric forecasting uses economics to predict the behavior of selected data. Choice (c) is incorrect because queuing theory is used to solve waiting-line problems.

Subject Area: Business processes—forecasting. Source: CIA Model Exam 1998, III-40.

110. (**a**) Sensitivity analysis reveals the impact of changes in one or more input variables on the output or results. Choice (b) is incorrect because statistical estimation involves the estimation of parameters. Choice (c) is incorrect because statistical hypothesis testing involves testing of hypotheses concerning estimated parameters. Choice (d) is incorrect because a time series study involves forecasting data over time.

Subject Area: Business processes—forecasting. Source: CIA 593, III-66.

111. (**a**) Simulation is a technique used to describe the behavior of a real-world system over time. Most often this technique employs a computer program to perform the simulation computations. Sensitivity analysis examines how outcomes change as the model parameters change. Choice (b) is incorrect because linear programming is a mathematical technique for maximizing or minimizing a given objective subject to certain constraints. Choice (c) is incorrect because correlation analysis is a statistical procedure for studying the relation between variables. Choice (d) is incorrect because differential analysis is a method used for decision making that compares differences in costs (and revenues) under two or more alternatives.

Subject Area: Business processes—forecasting. Source: CIA 1194, III-61.

112. (**a**) Simulation models are probabilistic not deterministic. Choice (b) is incorrect because simulation models may involve sampling. Choice (c) is incorrect because simulation models mathematically estimate what performance would be under various conditions. Choice (d) is incorrect because simulation models are stochastic or probabilistic models.

Subject Area: Business processes—forecasting. Source: CIA 594, III-60.

113. (**a**) A model is designed to understand the behavior of the simulation model. The characteristics that are learned from the model are then used to make inferences about the real system. Choice (b) is incorrect because least squares is a prediction and estimation technique utilizing a single dependent and single or multiple independent variables. Choice (c) is incorrect because a waiting-line technique is used to balance desirable service levels against the cost of providing more service. Choice (d) is incorrect because it is a forecasting technique utilizing arbitrary weights.

Subject Area: Business processes—forecasting. Source: CIA 593, III-65.

114. (**a**) Simulation is a technique in which a probabilistic process is first modeled. The inputs to the model are then varied a large number of times to estimate the distribution of possible outcomes from the model of the variable of interest. Simulations that use a random-number procedure to generate values for the inputs are referred to as Monte Carlo simulations. Choice (b) is incorrect because linear programming is a mathematical technique for maximizing or minimizing a given objective subject to certain constraints. Choice (c) is incorrect because correlation analysis is a statistical procedure for studying the relation between variables. Choice (d) is incorrect because differential analysis is a method used for decision making that compares differences in costs (and revenues) under two or more alternatives.

Subject Area: Business processes—forecasting. Source: CIA 592, III-64.

115. (**b**) Exponential smoothing puts most weight on recent sales data. Choice (a) is incorrect because an unweighted average will not give more importance to more recent data. Choice (c) is incorrect because queuing theory is used to determine waiting time. Choice (d) is incorrect because linear regression analysis is a cross-sectional tool, which does not give more importance to more recent data.

Subject Area: Business processes—forecasting. Source: CIA 594, II-38.

116. (**a**) Time series analysis is a statistical forecasting technique that uses patterns observed in historical data to predict future values. Choice (b) is incorrect because queuing

theory is used to minimize the cost of waiting in line plus the cost of servicing waiting lines when items arrive randomly at a service point and are serviced sequentially. Choice (c) is incorrect because linear programming is a mathematical technique for maximizing or minimizing a given objective subject to certain constraints. Choice (d) is incorrect because sensitivity analysis is a method for studying the effects of changes in one or more variables on the results of a decision model.

Subject Area: Business processes—forecasting. Source: CIA 1193, III-68.

117. (**d**) Econometrics is a forecasting model that uses a number of economic and demographic time series. Choice (a) is incorrect because linear programming is a problem-solving approach developed for situations involving maximizing or minimizing a linear function based on certain linear constraints. Choice (b) is incorrect because network analysis is used to solve management problems in areas such as system design and project scheduling. Choice (c) is incorrect because operations research is a term used interchangeably with management science, an approach to managerial decision making based upon scientific methods and extensive use of quantitative analysis.

Subject Area: Business processes—forecasting. Source: CIA 593, III-71.

118. (**c**) There are many situations where each observation should not be given equal input in establishing the trend line. In such cases, exponential smoothing technique is good to use since it incorporates the more recent observations. Choice (a) is incorrect because time series analysis uses trend projections. Choice (b) is incorrect because dynamic programming involves linear programming. Choice (d) is incorrect because econometrics is an analysis involving two or more variables.

Subject Area: Business processes—forecasting. Source: CIA 593, III-72.

119. (**b**) Econometrics deals with statistical inferences about relationships between economic data. Choice (a) is incorrect because macroeconomic and microeconomics do not deal with statistical analysis. They refer to classifications of economic theory. Macroeconomics deals with the behavior of economic aggregates like GNP and the level of employment. Choice (c) is incorrect because microeconomics deals with economic behavior of individual units like consumers and firms. Choice (d) is incorrect because socioeconomics combines social and economic factors.

Subject Area: Business processes—forecasting. Source: CIA 1191, III-99.

120. (**d**) Econometrics is the application of statistical methods to economic or business data. It analyzes the relationships between variables and uses multiple regression analysis. Choice (a) is incorrect because it does not involve regression analysis. Choice (b) is incorrect because it does not involve model assumptions. Choice (c) is incorrect because it does not involve regression analysis.

Subject Area: Business processes—forecasting. Source: CIA 1193, III-74.

121. (**a**) Regression analysis is a statistical technique for measuring the relationship between variables. It estimates the component of the dependent variable that varies with changes in the independent variable and component that does not vary (fixed) with changes in the independent variable. Choice (b) is incorrect because game theory is a mathematical approach to decision making in which each decision maker takes into account the courses of action of competitors. Choice (c) is incorrect because sensitivity analysis is a method for studying how changes in one or more variables affect the optimal solution in a linear programming model. Choice (d) is incorrect because queuing theory consists of waiting line models, which can be used to determine the operating characteristics for a waiting line.

Subject Area: Business processes—forecasting. Source: CIA 1194, III-59.

122. (**c**) The R^2 explains the amount of variation in the dependent variable (interest income) that is explained by the independent variables. In this case, less of the change in interest income is explained by the model, thus, some other factor must be causing the interest income variable to change. This would merit audit investigation. Choice (a) is incorrect. Cross sectional regression analysis would not be appropriate because the auditor is trying to estimate changes in a single account balance over time. Choice (b) is incorrect. Regression analysis may still be the most appropriate methodology to estimate interest income, but the auditor should first understand the factors that may be causing R^2 to be decreasing. It may be caused because there is a systematic error in the account balance. Choice (d) is incorrect. Linear regression models are simpler models. The problem is that the auditor should be looking for either a systematic error in the account balance or to a more complex model.

Subject Area: Business processes—forecasting. Source: CIA 595, II-46.

123. (**c**) This answer is only 0.11 from the maximum value of -1.0. The negative sign indicates the direction relationship (e.g., inverse) between the independent and dependent variables. Choice (a) is incorrect. The range for the correlation coefficient is between -1.0 and +1.0, inclusive. Thus, this answer is not possible even though it is the largest value among the four alternative answers. Choice (b) is incorrect. This is the weakest correlation coefficient among the four alternative answers. This answer is so close to 0.00 that no relationship exists between the independent and dependent variables. Choice (d) is incorrect. This answer is only 0.25 from the maximum value of +1.0 but answer (c) is closer and therefore, stronger.

Subject Area: Business processes—forecasting. Source: CIA 1194, II-46.

124. (**a**) Mathematically, R^2 always approaches 1.0 as the number of variables in the regression approaches the number of observations in the sample (even if the predictors are unrelated to the dependent variable). This model has a very large number of predictors for the small sample size. If the R^2 is adjusted for the number of variables, it drops to only 0.24. Choice (b) is incorrect. We do not know what the "true" model is and therefore cannot make this inference. Choice (c) is incorrect. The model has too many predictors for the small sample size. Choice (d) is incorrect. You can have a high R^2 in a bad sample with a bad model just as easily as in a good sample with a good model.

Subject Area: Business processes—forecasting. Source: CIA 1195, II-50.

125. (**b**) The most appropriate statistical tool is cross section regression analysis because it compares attributes of all store's operating statistics at one point in time. Choice (a) is incorrect. Linear time series analysis would not be applicable because it is a simple model, which compares individual stores over time. Choice (c) is incorrect. Cross tabulations have to be built on a model of expectations. Unless the model is built, the analysis is not useful. Choice (d) is incorrect. The stated objective is to compare stores at one point in time. Multiple regression time series analysis compares the performance of an individual store over a period of time.

Subject Area: Business processes—forecasting. Source: CIA 595, II-47.

126. (**c**) A regression coefficient represents the change in the dependent variable for a unit change in the independent variable. Choice (a) is incorrect because a regression coefficient tells you nothing about the means of the variables. Choice (b) is incorrect because to predict a specific value of sales, you must multiply the independent variable value by the coefficient and add the intercept value. Choice (d) is incorrect because the absolute size of the coefficient bears no necessary relationship to the importance of the variable.

Subject Area: Business processes—forecasting. Source: CIA 1195, II-30.

127. (**c**) A multiple regression analysis would help the auditor identify which factors appear to be driving the changes in the company's cost structure. Choice (a) is incorrect because this procedure does not help quantify the reasons for changes in production costs. It only helps estimate production costs and that data should already be readily available in the client's records. Choice (b) is incorrect because this method only identifies one possible cause. Choice (d) is incorrect because the linear regression only addresses one factor and would not be as useful as multiple regression.

Subject Area: Business processes—forecasting. Source: CIA 1196, I-29.

128. (**b**) Multiple regression is the most effective because we are trying to determine the relative effect of four different variables. Choice (a) is incorrect because the data are cross-sectional. Choice (c) is incorrect because the dependent variable, sales, is continuous. Choice (d) is incorrect because the linearity of the relationships cannot be assessed before the data is analyzed.

Subject Area: Business processes—forecasting. Source: CIA 594, II-39.

129. (**a**) The change in monthly maintenance cost per hour of operation is the slope of the cost function.

$$\text{Slope} = \frac{1{,}200{,}000 - 900{,}000}{4{,}000 - 2{,}000} \quad \text{or} \quad \frac{1{,}200{,}000 - 750{,}000}{4{,}000 - 1{,}000}$$

Or

$$\frac{900{,}000 - 750{,}000}{2{,}000 - 1{,}000} = \$150 \text{ per hour}$$

Therefore, by definition, choices (b), (c), and (d) would be incorrect.

Subject Area: Business processes—forecasting. Source: CIA 1193, III-65.

130. (**b**) We note that as X increases (inverse relationship) Y decreases, forcing the coefficient of correlation to be negative. As X increases by 1, Y consistently decreases by 2, hence a perfect association between the data r must equal to –1. Choice (a) is incorrect. No correlation is incorrect; there is a perfect negative correlation. Choice (c) is incorrect. Correlation is perfect, but an inverse not a direct relationship exists. Choice (d) is incorrect. We are able to determine that r = –1.

Subject Area: Business processes—forecasting. Source: CIA 593, III-64.

131. (**a**) Regression analysis is a statistical technique for measuring the relationship between variables. It estimates the component of the dependent variable that varies with changes in the independent variable and component that does not vary (fixed) with changes in the independent variable. Choice (b) is incorrect because game theory is a mathematical approach to decision making in which each decision maker takes into account the courses of action of competitors. Choice (c) is incorrect because sensitivity analysis is a method for studying the effects of changes in one or more variables on the results of a decision model. Choice (d) is incorrect because queuing theory is a mathematical technique for minimizing the total cost of waiting in line plus the cost of servicing lines when items arrive randomly at a service point and are serviced sequentially.

Subject Area: Business processes—forecasting. Source: CIA 1192, III-43.

132. (**a**) Multiple regression analysis allows you to consider the three variables. Choice (b) is incorrect because exponential smoothing is a time series technique utilizing arbitrary weights. Choice (c) is incorrect. In bivariate regression analysis there is but one independent variable. We have three. Choice (d) is incorrect. Auto regressive models involve bivariate regression analysis where the independent variable is a lagged value for the dependent variable.

Subject Area: Business processes—forecasting. Source: CIA 592, III-75.

133. (**c**) When there are four independent variables such as X1 through X4, multiple regression analysis is the best technique to use. When only one independent variable is involved, it is called simple regression analysis. Choice (a) is incorrect because integrated auto-regressive-moving average (ARIMA) modeling is a time series technique. Choice (b) is incorrect because exponential smoothing is also a time series model. Choice (d) is incorrect because linear programming optimizes outputs given scarce resources.

Subject Area: Business processes—forecasting. Source: CIA 592, III-55.

134. (**a**) Since one slope is negative, X3 is inversely related to Y. Since three slopes are positive, X1, X2, and X4 are directly related to Y. Therefore, by definition, choices (b), (c), and (d) will be incorrect.

Subject Area: Business processes—forecasting. Source: CIA 592, III-56.

135. (**b**) Dummy variables take on values of zero and one, and they represent the qualitative variables (X4) in the regression analysis. When an independent variable (X4) is a nominal or ordinal variable, it is called a qualitative variable. Choice (a) is incorrect because multicollinearity is a dependence between different independent variables. Choice (c) is incorrect because omitted variables impact regression analysis

but do not represent a type of variable. Choice (d) is incorrect because an outlier is an extreme data point not a variable.

Subject Area: Business processes—forecasting. Source: CIA 592, III-57.

136. (**b**) Each of the answers represent the slopes of the four independent variables. The slope asked for was that of independent variable X2. Therefore, by definition, choices (a), (c), and (d) will be incorrect.

Subject Area: Business processes—forecasting. Source: CIA 592, III-57.

137. (**d**) Predicted Y = 124,000 + 5(10,000) + 350(300) – 1,700(9) + 4,000(1) = 267,700. Therefore, by definition, choices (a), (b), and (c) will be incorrect.

Subject Area: Business processes—forecasting. Source: CIA 592, III-59.

138. (**b**) A correlation coefficient of –1.00 implies that the observations fall exactly along a straight line **and** that the value of one variable increases (decreases) as the other decreases (increases). In the above example the equation of the straight line is

$$y = 200 - 4x$$
$$\text{or} \quad x = 50 - 1/4y$$

Choices (a) and (c) are incorrect because a positive correlation coefficient implies that one variable increases (decreases) as the other increases (decreases). The data clearly do not indicate this. Choice (d) is incorrect because a correlation coefficient of zero implies that the two variables are unrelated. The data clearly indicate that the two variables move in opposite directions.

Subject Area: Business processes—forecasting. Source: CIA 591, III-44.

139. (**b**) A linear equation was used with nonlinear relationship. Choice (a) is incorrect. A distractor, autocorrelation is a nonsense response. Choice (c) is incorrect. The data is related, but not linearly. Choice (d) is incorrect. The data is first directly, then inversely related.

Subject Area: Business processes—forecasting. Source: CIA 1190, III-39.

140. (**c**) The Delphi technique is a qualitative technique, not a quantitative technique. Choice (a) is incorrect because weighted least squares is used only in regression models that have the specification problem heteroscedasticity. Choice (b) is incorrect because the exponential smoothing technique (single parameter) is appropriate for such a database. Choice (d) is incorrect because the moving average process is used to decompose the time series components.

Subject Area: Business processes—forecasting. Source: CIA 1190, III-45.

141. (**d**) The end-product of multivariate regression analysis is a mathematical equation that estimates the relationship between a dependent variable such as sales and a set of independent or predictor variables, such as price, advertising expenditures, etc. Given the regression equation, sales can be forecast (predicted) based upon knowledge of the independent variables. Choice (a) is incorrect because it is not a forecasting technique. Linear programming is a mathematical procedure suitable for solving a specific type of optimization problem. Specifically it allows one to solve constrained maxima/minima problems in which the objective function and the constraints are linear. Linear programming is **not** a forecasting technique. Choice (b) is incorrect because exponential smoothing is a forecasting technique but the models only utilize information contained in the series to be forecast (i.e., sales). Thus, in this case an application of exponential smoothing only requires data on sales in order to forecast sales. Thus, the requirement that the model relate sales to a set of predictor variables would not be satisfied. A knowledge of the firm's price and the other specified variables is irrelevant in exponential smoothing methods. Choice (c) is incorrect because trend extrapolation (trend analysis) is a forecasting technique often referred to as curve-fitting. In trend extrapolation, the analyst attempts to determine the mathematical equation that "best" reflects the underlying trend in the series and extrapolates this pattern into the future. However, just as was the case with exponential smoothing, trend extrapolation techniques are pure (naive) time series models and only require data on sales in order to forecast sales. Thus, the requirement that the model relate sales to a set of predictor variables would not be satisfied.

Subject Area: Business processes—forecasting. Source: CIA 590, III-43.

Project Management Techniques

142. (**a**) A project is defined as a temporary endeavor undertaken to achieve a particular objective, aim, or goal. Each project has a beginning date and an end date.

Subject Area: Business processes—project management techniques. Source: Author.

143. (**a**) Managers have competing demands placed on them. Establishing priorities and managing time are not easy. Managers should develop the skill of learning to say "no" to others who are adding more demands on them.

Subject Area: Business processes—project management techniques. Source: Author.

144. (**b**) The project life cycle has four stages of conceptualization, planning, execution, and termination. In the conceptualization stage, ideas are presented, discussed, and finalized. Project goals, budgets, and schedules are prepared. The project is just started to proceed.

Subject Area: Business processes—project management techniques. Source: Author.

145. (**d**) In the execution stage of the project life cycle, budget demands are the highest because the project is being implemented. Pressure is put on the project team to complete the project on time and within the budget.

Subject Area: Business processes—project management techniques. Source: Author.

146. (**b**) Project organizations are common today due to a need for quick response demanded by the customers. Decisions are made quickly leading to faster implementations. Cross-functional teams of people with different technical skills are brought together on a temporary basis to complete a specific project.

Subject Area: Business processes—project management techniques. Source: Author.

147. (**b**) Work simplification means reducing complexity, discontinuing unnecessary and burdensome procedures, and eliminating wasted activities, tasks, and work steps. Work

measurement uses time and motion studies to estimate the time it takes to complete a task, step, or an activity.

Subject Area: Business processes—project management techniques. Source: Author.

148. (**b**) Project managers should have greater amount of "people management skills," which include leadership, communication, motivation, conflict resolution, and negotiation skills. Technical skills (hard skills such as engineering, science, and technology skills) are least important when compared to interpersonal skills (soft skills such as people management skills).

Subject Area: Business processes—project management techniques. Source: Author.

149. (**a**) Establishing project priorities remains a subjective process affected by organizational politics and value conflicts. The subjective process uses qualitative techniques while the objective process uses quantitative techniques.

Subject Area: Business processes—project management techniques. Source: Author.

150. (**b**) In the ABC priority system used in project time management, the "A" system deals with "must do" objectives, which are critical to successful performance. The "B" system deals with "should do" objectives, which are necessary for improved performance. The "C" system deals with "nice to do" objectives, which are desirable for, improved performance.

Subject Area: Business processes—project management techniques. Source: Author.

151. (**b**) In the functional project organizational structure, groups consist of individuals who perform the same function, such as engineering or manufacturing, or have the same expertise or skills, such as electronic engineering or testing. Each functional group or component concentrates on performing its own activities in support of the company's business mission.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

152. (**c**) In a functional project structure, the project manager does not have complete authority over the project team since the team members administratively work for their respective functional managers. In a matrix project structure, the project manager is responsible for achieving the project results while the functional manager is responsible for providing the resources needed to achieve the results. Under the matrix structure, the project manager is the intermediary between the company and the customer.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

153. (**a**) In a matrix-type project organizational structure, the project manager is responsible for the project results, while the functional managers are responsible for providing the resources needed to achieve the results.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

154. (**a**) The scope of a project—also known as the project scope or the work scope—is all the work that must be done in order to satisfy the customer that the deliverables (the tangible product or items to be provided) meet the requirements or acceptance criteria agreed upon at the onset of the project.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

155. (**c**) Ultimately, the responsibility of the project manager is to make sure the customer is satisfied.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

156. (**c**) A work breakdown structure is a hierarchical tree of work elements or items accomplished or produced by the project team during the project. The work breakdown structure usually identifies the organization or individual responsible for each work package.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

157. (**c**) The key to effective project control is measuring actual progress and comparing it to planned progress on a timely and regular basis and taking corrective action immediately. The project control process involves regularly gathering data on project performance, comparing actual performance to planned performance, and taking corrective actions if actual performance is behind planned performance.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

158. (**a**) A baseline plan provides a roadmap showing how the project scope will be accomplished. When changes are agreed upon, a new baseline should be established and used as the benchmark against which actual project performance will be compared.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

159. (**b**) Corrective actions that will eliminate the negative slack from the project schedule must be identified. Activities that have longer duration estimates present the biggest opportunity for larger time reductions. In most cases, eliminating negative slack by reducing duration of activities will involve a tradeoff in the form of an increase in costs or a reduction in scope.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

160. (**d**) In the time-cost tradeoff methodology, the project time can be reduced with an increase in cost.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

161. (**d**) There are basically two types of contracts: fixed-price and cost-reimbursement. The contract must state the terms by which the customer will make payments to the contractor.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

162. (**d**) Cost reimbursement contracts are most appropriate for projects that involve risk. The customer agrees to pay the contractor for all actual cost incurred, regardless of the amount, plus some agreed-upon profit. This type of contract is high risk for the customer due to cost uncertainty.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

163. (**b**) For a project, the objective is usually defined in terms of scope, schedule, and cost. Schedule requires completing the work within budget by a certain time.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

164. (**a**) In project management, each activity has two pairs of duration: normal time and crash time. The normal time is the estimated length of time required to perform an activity, according to the plan. The crash time is the shortest estimated length of time in which the activity can be completed.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

165. (**d**) The cost performance index is a measure of the cost efficiency with which the project is being performed. The formula for determining the index is cumulative earned value divided by cumulative actual cost.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

166. (**b**) The cost variance is the difference between the cumulative earned value of the work performed and the cumulative actual cost.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

167. (**a**) A negative cost variance means that the work performed is not keeping with the actual cost. It also means that there is a gap between the value of the work performed and the actual costs incurred. A cost performance index of less than 1.0 means for every dollar actually expended, less than one dollar of earned value was received. When the index goes below 1.0 or gradually gets smaller, corrective action should be taken.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

168. (**b**) In the theory of constraints, critical chain is the longest route through a project network. It considers both technological and resource contention constraints in completing the project. When no resource contention exists the critical chain would be the same as the critical path. The critical ratio is a job dispatching rule that calculate a priority index number by dividing the time to due date remaining by the expected elapsed time to finish the job.

Subject Area: Business processes—project management techniques. Source: Author.

169. (**a**) Earned value is the total value, including overhead, of approved estimates for completed activities in a project.

Subject Area: Business processes—project management techniques. Source: Author.

170. (**b**) Program evaluation and review technique (PERT) times are estimated times for the completion of PERT activities. PERT times are weighted averages of the separate time estimates (optimistic, most likely, and pessimistic). The formula for calculating estimated PERT time is (optimistic time plus 4 times most likely time plus pessimistic time)/6. Thus, the most likely time is more heavily weighted than the other time estimates.

Subject Area: Business processes—project management techniques. Source: Author.

171. (**c**) A network diagram shows the sequential flow and interrelationships of activities. Network planning is a technique that is helpful in planning, scheduling, and controlling projects that consists of many interrelated activities.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

172. (**c**) The Gantt chart combines the two functions of planning and scheduling. Since these functions are performed simultaneously, it is cumbersome to make changes to the plan manually.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

173. (**c**) Network techniques separate the planning and scheduling functions. A network diagram is the result, or output, of the planning function and is not drawn to a time scale. From the network diagram a schedule is developed. Separating the two functions makes it much easier to revise a plan and calculate an updated schedule.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

174. (**c**) Activities have a precedential relationship; that is, they are linked in a precedential order to show which activities must be finished before others can start. Arrows linking the activity boxes show the direction of precedence. An activity cannot start until all of the preceding activities that are linked to it by arrows have been finished.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

175. (**c**) Some projects have a set of activities that are repeated several times. Laddering is a technique used for these types of projects.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

176. (**a**) The earliest start (ES) time and earliest finish (EF) time are determined by calculating forward, that is, by working through the network diagram from the beginning of the project to the end of the project. There is one rule that must be followed in making these forward calculations. The ES time for a particular activity must be the same as or later than the latest of all the EF times of all the activities leading directly into that particular activity.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

177. (**d**) The latest finish time for a particular activity must be the same as or earlier than the earliest of all the latest start times of all the activities emerging directly from that particular activity.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

178. (**a**) Total slack equals latest finish time minus earliest finish time. Total slack for a particular path of activities is common to and shared among all the activities on that path. If total slack is positive, it represents the maximum amount of time that the activities on a particular path can be delayed without jeopardizing completion of the entire project by its required completion time.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

179. (**a**) When all uncontrollable inputs are known and cannot vary, this situation calls for the use of a deterministic model. Only one time estimate is used for an activity. In a stochastic model, one or more uncontrollable inputs are unknown and subject to variation. A range of time estimates is used for an activity.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

180. (**b**) In the Gantt chart, activities are listed down the left-hand side, and a time scale is shown along the bottom. The estimated time for each activity is indicated by a line or bar spanning the period during which the activity is expected to accomplish. The Gantt chart measures the planned and completed work and indicates the status of each activity.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

181. (**c**) One of the major drawbacks to the traditional Gantt chart is that it does not graphically display the interrelationships of activities. Therefore, it is not obvious which activities will be affected when a given activity is delayed.

Subject Area: Business processes—project management techniques. Source: CBM, Volume two.

182. (**b**) The critical path is the most time-consuming chain of activities and events in a PERT network.

Subject Area: Business processes—project management techniques. Source: Author.

183. (**c**) PERT is a graphic sequencing, planning, and scheduling tool appropriate for large, complex, and nonroutine projects.

Subject Area: Business processes—project management techniques. Source: Author.

184. (**b**) A Gantt chart is a graphic planning and scheduling tool. It improves on the flowchart by specifying the time to be spent on each activity. Both the Gantt chart and the flowchart are cumbersome to draw for large and complex projects. Flowcharts do not show time elements. Gantt charts show time elements.

Subject Area: Business processes—project management techniques. Source: Author.

185. (**b**) The backward pass works from the last node to the start node while the forward pass works from the start node to the last node. Both the forward pass and the backward pass are used in the critical path method of project planning and management. Forward pass calculates early start dates and early finish dates.

Subject Area: Business processes—project management techniques. Source: Author.

186. (**c**) This would be a long-range planning topic because it affects market positioning. Choice (a) is incorrect. This would seldom be a long-range topic. Choice (b) is incorrect. This would rarely be a long-range concern. Choice (d) is incorrect. This is certainly a concern, but not for long-range planning.

Subject Area: Business processes—project management techniques. Source: CIA Model Exam 2002, III-33.

187. (**a**) Crashing is the process of adding resources to shorten activity times on the critical path in project scheduling. Choice (b) is incorrect. The Delphi technique is a qualitative forecasting approach. Choice (c) is incorrect. ABC analysis is an inventory model. Choice (d) is incorrect. The branch-and-bound solution is an integer programming solution.

Subject Area: Business processes—project management techniques. Source: CIA Model Exam 1998, III-30.

188. (**c**) The two paths are 5 + 4 + 6 = 15 days, and 3 + 2 + 6 = 11 days. The longest path, and therefore the earliest completion time, is 15 days. Choice (a) is incorrect. Eleven days is the shortest, not the longest, time to completion. Choice (b) is incorrect. Fourteen days sums 5 + 3 + 6, but is not a path to completion. Choice (d) is incorrect. Twenty days is the sum of all of the activity times.

Subject Area: Business processes—project management techniques. Source: CIA 597, III-100.

189. (**a**) PERT/CPM (Program Evaluation and Review Techniques/Critical Path Method) is a technique for scheduling interrelated time series activities and identifying any critical paths in the series of activities. Choice (b) is incorrect because linear programming is a mathematical technique for maximizing or minimizing a given objective subject to certain constraints. Choice (c) is incorrect because queuing theory is used to minimize the cost of waiting in line plus the cost of servicing waiting lines when items arrive randomly at a service point and are serviced sequentially. Choice (d) is incorrect because sensitivity analysis is a method for studying the effects of changes in one or more variables on the results of a decision model.

Subject Area: Business processes—project management techniques. Source: CIA 1195, III-100.

190. (**d**) Project management deals with managing project teams to deal with special projects. Lumpy demand refers to periodic demand for a product or service from the output of a finished project. Choice (a) is incorrect because a dummy activity is one which consumes no time but shows precedence among activities. Choice (b) is incorrect because the latest finish is the latest that an activity can finish, from the beginning of the project, without causing delay in the completion of the project. Choice (c) is incorrect because optimistic time is the time for completing an activity if all goes well.

Subject Area: Business processes—project management techniques. Source: CIA 594, III-61.

191. (**c**) This is used for quality control. Choices (a), (b), and (d) are incorrect because each one is used to control large-scale projects.

Subject Area: Business processes—project management techniques. Source: CIA 594, II-40.

192. (**c**) The critical path is A-D-E which takes 4 + 6 + 5 = 15 days. This is the longest path. Choice (a) is incorrect. The A-C path length is 13 days (i.e., 4 + 9 =13). Choice (b) is incorrect. The B-E path length is 8 days (i.e., 3 + 5 = 8). Choice (d) is incorrect. The B-D-C is not a valid path due to cycle error, in that path D cannot go back to path C.

Subject Area: Business processes—project management techniques. Source: CIA 592, III-69.

193. (**c**) Slack is the free time associated with each activity. Choice (a) is incorrect because an activity involving slack is essential to the overall project. Choice (b) is incorrect because it is not a backup activity. Choice (d) is incorrect because time is involved in a slack activity.

Subject Area: Business processes—project management techniques. Source: CIA 1191, III-37.

194. (**c**) A Gantt chart shows output (steps in an activity) on one axis and units of time on the other. Choice (a) is incorrect because a Gantt chart does not include cost information. Choice (b) is incorrect. Some information regarding sequencing may be assumed from a Gantt chart but the relationship among steps is not shown. Choice (d) is incorrect. The term "critical path" is related to a PERT network, which is a more sophisticated scheduling technique.

Subject Area: Business processes—project management techniques. Source: CIA 1191, III-6.

195. (**a**) The critical path is the sequence of activities that constrains the total completion time for the project. Any delay in completing the activities along the critical path will delay scheduled completion of the project. Choice (b) is incorrect because only activities not on the critical path may be delayed without delaying scheduled completion of the project. Choices (c) and (d) are incorrect because CPM/PERT is not used for determining the size or features to be included in the new product.

Subject Area: Business processes—project management techniques. Source: CIA 590, III-47.

Business Process Analysis

196. (**a**) Dr. Goldratt developed a management philosophy entitled theory of constraints, which can be viewed as three separate but interrelated areas. These areas include logistics, performance measurement, and logical thinking. Bottleneck management deals with identifying and managing resources (facility or department) whose capacity is less than the demand placed upon it.

Subject Area: Business processes—business process analysis. Source: Author.

197. (**b**) Logistics include drum-buffer-rope scheduling, buffer management, and VAT analysis. Problem solving is a part of logical thinking.

Subject Area: Business processes—business process analysis. Source: Author.

198. (**c**) Performance measurement includes throughput, inventory, and operating expense. Identifying problems and root causes and developing implementation plans are part of the logical thinking of the theory of constraints. The current reality tree, future reality tree, prerequisite tree, and transition tree are used in the logical thinking.

Subject Area: Business processes—business process analysis. Source: Author.

199. (**a**) VAT analysis deals with determining the general flow of parts and products from raw materials to finished goods (logical product structure). VAT analysis is a part of the theory of constraints. A 'V' logical structure starts with one or a few raw materials and the product expands into a number of different products as it flows through divergent points in its routings. The shape of an 'A' logical structure is dominated by converging points. Many raw materials are fabricated and assembled into a few finished products. A 'T' logical structure consists of numerous similar finished products assembled from common assemblies, subassemblies, and parts.

Subject Area: Business processes—business process analysis. Source: Author.

200. (**a**) Clerical process analysis centers on studying and improving the way office and administrative tasks are carried out. Joint process analyses deal with operator-machine analysis which centers on studying and improving the combination of operator work and machine work in a factory or office. Operator process analysis centers on studying and improving the movements of the operator in a factory or office. Product process analysis centers on the flow of products, and the way a product is made as it passes through various processes in a manufacturing plant.

Subject Area: Business processes—business process analysis. Source: Author.

201. (**a**) Selling is not the only one that can deliver value. Others such as production, supply chain, and logistics can deliver value equally. The other three items are essential in delivering value.

Subject Area: Business processes—business process analysis. Source: Author.

202. (**c**) The horizontal organization is described as eliminating both hierarchy and functional boundaries and is operated with multidisciplinary teams. Few layers of management are practiced between the top and the bottom of the hierarchy. There are many layers of management in the vertical organization.

Subject Area: Business processes—business process analysis. Source: Author.

203. (**a**) A process view, not the functional view, of the business is required. All the other three items are required for a proper business process orientation.

Subject Area: Business processes—business process analysis. Source: Author.

204. (**c**) Process-oriented measures are, by definition, cross-functional, which contributes to a common cause. It might also be said that what gets measured and rewarded gets done.

Subject Area: Business processes—business process analysis. Source: Author.

205. (**a**) Business process reengineering requires a radical rethinking and redesigning of a process.

Subject Area: Business processes—business process analysis. Source: Author.

206. (**b**) Benchmarking is identifying, studying, and building upon the best practices of other organizations. Benchmarking establishes standards, which provide feed forward control by warning people when they deviate from standards. Kaizen is continuous improvement. Plan, do, check and act (PDCA) is called Shewhart cycle in quality and later was modified by Deming to plan, do, study, and act (PDSA) cycle.

Subject Area: Business processes—business process analysis. Source: Author.

207. (**a**) Business process reengineering can be used to reduce the cycle time or speed it up.

Subject Area: Business processes—business process analysis. Source: Author.

208. (**b**) The time between when an order is placed and when the customer receives it is known as order cycle time.

Subject Area: Business processes—business process analysis. Source: Author.

209. (**b**) The time it takes to deliver a product or service after an order is placed is called customer response time.

Subject Area: Business processes—business process analysis. Source: Author.

210. (**a**) The time between when an order is placed and when the order is ready for setup is called order receipt time.

Subject Area: Business processes—business process analysis. Source: Author.

211. (**b**) The time between when an order is ready for setup and when the setup is complete is called order wait time.

Subject Area: Business processes—business process analysis. Source: Author.

212. (**b**) Work simplification refers to eliminating unnecessary procedures and activities in a business process. Work measurement uses industrial engineering techniques to estimate labor time and material standards.

Subject Area: Business processes—business process analysis. Source: Author.

213. (**b**) A company faces a constraint when the capacity to manufacture a product is limited.

Subject Area: Business processes—business process analysis. Source: Author.

214. (**b**) If a company is faced with limited resources, management has the following choices: (1) increase the capacity of the limited resource, (2) reduce the use of the limited resource in production, or (3) focus on products that require less of the limited resource. Constraints cannot be ignored since they can lead to loss of sales and profits.

Subject Area: Business processes—business process analysis. Source: Author.

215. (**c**) The theory of constraints identifies bottlenecks in the production process. A bottleneck is a facility, function, department, machine or work center whose capacity is less than the demand placed upon it.

Subject Area: Business processes—business process analysis. Source: Author.

216. (**b**) Bottlenecks (1) limit throughput, (2) are managed using the theory of constraints, and (3) should be relieved to increase production efficiency. Bottlenecks should not be ignored during crisis situations.

Subject Area: Business processes—business process analysis. Source: Author.

217. (**a**) Processing time (36 hours) is the only task that adds value to a specific customer.

Subject Area: Business processes—business process analysis. Source: Author.

218. (**d**) Wait time (10 hours), inspection time (1 hour), and move time (1.5 hours) are examples of non-value-added time (12.5 hours) from a customer's viewpoint.

Subject Area: Business processes—business process analysis. Source: Author.

219. (**d**) The manufacturing cycle time (48.5 hours) is the combination of value-added time (36 hours) and non-value-added time (12.5 hours).

Subject Area: Business processes—business process analysis. Source: Author.

220. (**a**) The current reality tree is a diagram, which presents a logical picture of the subject matter. It bonds cause-and-effect relationships and connects all the existing major undesirable effects. The future reality tree is a logic-based diagram for constructing and testing potential solutions before implementation. Obstacles are identified in the prerequisite tree. The transition tree will show how changes will be evolved from the current tree to the future tree.

Subject Area: Business processes—business process analysis. Source: Author.

221. (**a**) One cannot say that too much production is an undesirable effect without knowing the sales forecast and the production policy. The other choices are examples of undesirable effects.

Subject Area: Business processes—business process analysis. Source: Author.

222. (**b**) Each entry to the current reality tree is a root cause and a core problem. At least one entry leads to the existence of most of the undesirable effects. Also, conflicts will be revealed in the current reality tree.

Subject Area: Business processes—business process analysis. Source: Author.

223. (**a**) Cycle time can be reduced by (1) reducing process complexity through work or process simplification, (2) changing from linear process flow to parallel flow, (3) using alternate process flow paths, (4) changing the sequence or layout of a process, (5) using technology to improve process flow, and (6) letting customer or suppliers share some of the process work.

Subject Area: Business processes—business process analysis. Source: Author.

224. (**b**) Speed flows from simplicity of tasks, activities, and operations. On the other hand, complexity reduces speed.

Subject Area: Business processes—business process analysis. Source: Author.

225. (**a**) The goal of reducing the cycle time is to eliminate, minimize, combine or improve the work steps or time. Expanding the work steps usually increases the cycle time.

Subject Area: Business processes—business process analysis. Source: Author.

226. (**d**) Choke points in a process are caused by exceeding the capacity limitation of key resources. Here capacity is defined as the potential output over a time period. Choke points cause major delays in the cycle time.

Subject Area: Business processes—business process analysis. Source: Author.

227. (**c**) Cross-functional teams, not self-managed teams, focus on completing a specific work activity to reduce the cycle time. Cross-functional work teams are multidisciplined and are an attempt to organize employees around work itself. Self-managed teams are high-performance teams that assume traditional managerial duties such as planning and staffing. Managers should act as facilitators although they can be at times a barrier to self-managed teams. Members in the self-managed team come from one department whereas members in the cross-functional teams come from multiple departments or functions.

Subject Area: Business processes—business process analysis. Source: Author.

228. (**c**) Constraint accounting is synonymous with throughput accounting and is based on the theory of constraints principles. Throughout accounting is concerned with optimizing the flow of materials through a manufacturing plant. It assists managers in deciding on product profitability and production mix by taking account not only of the contribution a product makes but also of the total flow of production through the plant based upon a selected product mix and volume. Direct costing accounting system takes account only of costs that can be directly identified with the manufacture of a product; overhead costs are not included in the product costs. Activity-based accounting is concerned about the cost of indirect activities and costs within a plant and their relationship to the manufacture of specific products.

Subject Area: Business processes—business process analysis. Source: Author.

229. (**b**) The drum-buffer-rope scheduling system is the generalized process used to manage resources to maximize throughput. The drum is the rate of production, the buffer establishes the protection against uncertainty, and the rope is a communication process to support the constraint. The constraint is viewed as a drum and nonconstraints are viewed as soldiers who march to the drumbeat.

Subject Area: Business processes—business process analysis. Source: Author.

230. (**d**) When products are made in large lot sizes, the cycle times must be long because it is necessary to complete a large quantity each step of the process. Synchronized production plans use just-in-time (JIT) manufacturing to organize the shop floor so that each work cell produces components, subassemblies, and final assemblies in the right quantities and at the right time. The use of Kanban cards can help to synchronize production through the "pull" production methods. In the "push" production methods, products are made before they are needed whereas in the "pull" method products are not made until they are needed.

Subject Area: Business processes—business process analysis. Source: Author.

231. (**d**) Bottleneck production cells are those cells that are loaded above their capacity. The problem can be solved by moving the production to other cells or increasing the capacity by overtime or extra crew. It is important to ensure that no cell is overloaded and that no cell is significantly underutilized.

Subject Area: Business processes—business process analysis. Source: Author.

232. (**a**) Scrap is material residue from a manufacturing process that has measurable but relatively minor recovery value. Choice (b) is incorrect. Spoilage is unacceptable units of production that are discarded or sold for disposal value. Choice (c) is incorrect. Defective units are defined as production that does not meet dimensional or quality standards and that is subsequently reworked and sold through regular channels as firsts or seconds. Choice (d) is incorrect. Waste is material that is lost, evaporates, or shrinks in a manufacturing process, or is residue that has no measurable recovery value.

Subject Area: Business processes—business process analysis. Source: CIA Model Exam 2002, IV-54.

233. (**c**) Full capacity sales can be calculated as follows:

> Actual sales/ Percent of capacity at which fixed assets were operated = $2,000,000/ .80 = $2,500,000.

Choice (a) is incorrect. This is 80% of the actual sales, calculated as .80 ($2,000,000) = $1,600,000. Choice (b) is incorrect. This is the actual sales. Choice (d) is incorrect. This is actual sales divided by the proportion of unused, rather than used, capacity, or $2,000,000/.2 = $10,000,000.

Subject Area: Business processes—business process analysis. Source: CIA Model Exam 2002, IV-55.

234. (**d**) Benchmarking is accomplished by comparing an organization's performance to that of the best-performing organizations. Choice (a) is incorrect because benchmarking involves a comparison against industry leaders or "world-class" operations. Benchmarking either uses industry-wide figures (to protect the confidentiality of information provided by participating organizations) or figures from cooperating organizations. Choice (b) is incorrect because benchmarking requires measurements, which involve quantitative comparisons. Choice (c) is incorrect because benchmarking can be applied to all the functional areas in a company. In fact, because manufacturing often tends to be industry-specific whereas things like processing an order or paying an invoice are not, there is a greater opportunity to improve by learning from global leaders.

Subject Area: Business processes—business process analysis. Source: CIA Model Exam 2002, III-15.

235. (**d**) A preventive maintenance program will reduce equipment breakdowns and repairs. Choice (a) is incorrect because scheduling production based on capacity utilization ignores other important factors such as demands. Choice (b) is incorrect because budgeting maintenance department activities based on previous work orders will not prevent equipment breakdowns and repairs. Choice (c) is incorrect because standing authorizations of work orders and overtime will not address the problem posed.

Subject Area: Business processes—business process analysis. Source: CIA Model Exam 2002, III-14.

236. (**d**) Internal auditors should not become directly involved in the implementation of the redesigned process. This would impair their independence and objectivity. Choices (a), (b), and (c) are incorrect because internal auditors should perform these functions.

Subject Area: Business processes—business process analysis. Source: CIA Model Exam 1998, III-8.

237. (**d**) Linear programming is a mathematical technique for maximizing or minimizing a given objective subject to certain constraints. It is the correct technique to optimize the problem of limited resources. Choice (a) is incorrect because the Delphi technique is a qualitative forecasting method that obtains forecasts through group consensus. Choice (b) is incorrect because exponential smoothing is a forecasting technique that uses past time series values to arrive at forecasted values. Choice (c) is incorrect because regression analysis is a statistical technique used to develop forecasts based on the relationship between two or more variables.

Subject Area: Business processes—business process analysis. Source: CIA Model Exam 1998, III-35.

238. (**d**) Internal auditors should not become directly involved in the implementation of the redesign process. This would impair their independence and objectivity. Choices (a), (b), and (c) are incorrect because internal auditors should perform these functions.

Subject Area: Business processes—business process analysis. Source: CIA 597, III-32.

239. (**d**) This is an example of an internal nonfinancial benchmark. Choice (a) is incorrect because this is an example of an external financial benchmark. Choice (b) is incorrect because this is an example of an internal financial benchmark. Choice (c) is incorrect because this is an example of an internal financial benchmark.

Subject Area: Business processes—business process analysis. Source: CIA 595, III-22.

240. (**d**) See responses given for choices (a), (b), and (c). Choice (a) is incorrect because all of the statements are reflective of the differences in approaches to controls in reengineered organizations. Rengineering places more emphasis on monitoring controls to let management know when an operation may be out of control and signals the need for corrective action. Choice (b) is incorrect because most of the reengineering and total quality management techniques assume that humans will be motivated to actively work in improving the process when they are involved from the beginning. Choice (c) is incorrect because there is an increasing emphasis on self-correcting and automated controls.

Subject Area: Business processes—business process analysis. Source: CIA 1195, I-68.

241. (**c**) A high level of bad debt write-offs could indicate fraud and the compromising of the accuracy and reliability of financial reports. Choice (a) is incorrect because high turnover of employees may indicate a morale problem but not necessarily a problem with the accuracy and reliability of financial reports. Choice (b) is incorrect because a high level of employee participation in budget setting is an example of decentralization and would not necessarily impact the accuracy and reliability of financial reports. Choice (d) is incorrect because a high number of suppliers would not necessarily indicate a problem with the accuracy and reliability of financial reports.

Subject Area: Business processes—business process analysis. Source: CIA 596, II-1.

242. (**b**) Employee training programs facilitate doing jobs in a new or different way. Choice (a) is incorrect because real or imagined loss of job(s) is a common reason for employees to resist any change. Choice (c) is incorrect because members of work groups often exert peer pressure on one another to resist change, especially if social relationships are changed. Choice (d) is incorrect because lack of communication and discussion of the need for switching to new processes threatens the status quo.

Subject Area: Business processes—business process analysis. Source: CIA 596, III-18.

Inventory Management Techniques and Concepts

243. (**d**) Inventory control is a company's attempt to hold the lowest level of inventory that will still enable it to meet customer demand.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

244. (**a**) Storage costs are part of inventory carrying costs while advertising, packaging and sales promotion costs are part of sales and marketing costs.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

245. (**c**) Economic order quantity (EOQ) is defined as the point where inventory carrying costs and ordering costs are at their lowest.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

246. (**a**) Purchasing policies and practices can improve inventory management but not the other way around.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

247. (**c**) One of the dichotomies of inventory control is that at an item level, the more stock the better the availability. However, it has been shown that higher stocks are often associated with poor availability. Stockouts result from holding too little stock due to inadequate forecasts, monitoring, or controls. High stock levels arise because too much stock has been purchased through bad forecasting, monitoring, or controls. High stock and poor availability are caused simultaneously as a result of poor control.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

248. (**b**) The primary reason for maintaining the safety (buffer) stock is due to the inability to predict demand. The other choices are secondary reasons for maintaining the safety stock.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

249. (**c**) A company's policies and objectives define the service level provided to customers, the investment to make in the inventory stock, and the flow of order information. Policy guides the inventory operation.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

250. (**c**) Estimating product delivery times and delivering the product on time causes a high level of customer confidence to be gained or lost. Product delivery due dates must reflect the stock availability and replenishment rules. This, in turn, will decide whether customer service is poor or not.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

251. (**d**) The safety stock is a policy matter to meet unexpected product demand. As such it is not an effective tool to manage inventory although it does benefit a company to some extent. The Pareto analysis (80/20 rule) states that 80% of stock value is caused by 20% of stock items. The ABC analysis shows the relative importance of the stock items. The JIT approach focuses on delivering the inventory on time to where it is needed.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

252. (**a**) Class "C" items consist of many items and low inventory rate, with slow movements or low value items. Class "A" represents few items and high turnover rate (choice b.).

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

253. (**c**) Only items requiring management attention are managed in the class "B" inventory items. Class "A" items are managed with tight control and with a JIT approach since they are more valuable and more frequently used. Class "C" items are managed with minimum supervision since they are less valuable and infrequently used.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

254. (**c**) Since class "A" items are few with high turnover rate, they should be managed with sophisticated forecasting systems and with a service level policy to meet customer needs.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

255. (**c**) The plant operator's only concern is whether a defective part or component can be reworked or has to be scrapped. As long as there is work in process (WIP), the manufacturing process exerts no pressure to produce quality parts the first time. The cost of rework of a defective part is hidden in the WIP, which acts as a buffer.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

256. (**d**) Usually, high interest rates in the economy force management to pay attention to inventory reduction. The cycle time management principles can integrate all the other three choices to meet customer expectations and to reduce inventories.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

257. (**a**) In the pre-deduct inventory transaction processing system, the book inventory balance of components is reduced before issue. Choices (b), (c), and (d) are the same. In the case of backflush inventory method, the computer automatically reduces the book inventory of components after completion of activity based on what should have been used as specified on the bill-of-material. All four approaches have the same disadvantage of a built-in differential between the book record and what is physically in the stock.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

258. (**b**) Count point backflush method and the key point backflush method are the same. They use more than one level of the bill-of-materials and extending back to the previous points where production was counted. Count point and pay point are the same. They are specific points in a flow of material or sequence of operations at which parts, subassemblies, or assemblies are counted as being complete. They are also designated as the points at which material transfers from one department to another.

Subject Area: Business processes—inventory management techniques and concepts. Source: Author.

259. (**b**) An EOQ sensitivity analysis involves varying the holding costs per unit and/or the order costs to determine how much the changes affect the optimal EOQ. Choice (a) is incorrect. Forecasting models involve projecting data over time or developing regression models when time series data are not available. Choice (c) is incorrect. Critical path method involves project scheduling. Choice (d) is incorrect. Decision analysis involves selecting the best option from alternatives.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA Model Exam 2002, III-37.

260. (**a**) Materials requirements planning (MRP) is a planning and controlling technique for managing dependent-demand manufacturing inventories. Choice (b) is incorrect. Regression analysis is a statistical procedure for estimating the relation between variables. Choice (c) is incorrect. Capital budgeting is used for analyzing and evaluating long-term capital investments. Choice (d) is incorrect. Linear programming is a mathematical technique for maximizing or minimizing a given objective subject to certain constraints.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA Model Exam 1998, III-32.

261. (**d**) In this situation, the company will be receiving fewer materials at any point in time, increasing the likelihood of stockouts and thereby resulting in an increase in stockout costs. At the same time, the average inventory will be less, resulting in a reduction in carrying costs. Choice (a) is incorrect. The supplier may ask for a concession in its selling price, which would raise the manufacturer's purchasing costs. Also, the manufacturing company will be receiving fewer materials at any point in time, increasing the likelihood of stockouts and thereby resulting in an increase in stockout costs. Choice (b) is incorrect. The supplier may ask for a concession in its selling price, which would raise the manufacturer's purchasing costs. Also, the cost of quality would not necessarily be affected by the just-in-time purchasing system. Choice (c) is incorrect. With fewer purchase orders being processed by the manufacturer, the ordering costs are likely to decrease. However, the cost of quality would not necessarily be affected by the just-in-time purchasing system.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA Model Exam 1998, III-34.

262. (**a**) The annual cost of carrying inventory is the average inventory level times the cost per unit of inventory times the cost of capital. It is calculated as follows: (average in-

ventory level) × (unit cost) × (cost of capital) = (order size/2) × ($5) × (.12) = (500/2) × ($5) × (.12) = $150. Choice (b) is incorrect because this answer is obtained by using the total annual quantity rather than the average inventory level and by neglecting to multiply by the unit price; = (annual quantity) × (.12) = (1500) × (.12) = 180. Choice (c) is incorrect because this answer is obtained by using the order size rather than the average inventory level; = (order size) × ($5) × (.12) = (500) × ($5) × (.12) = $300. Choice (d) is incorrect because this answer is obtained by using the total annual quantity rather than the average inventory level; = (1500) × ($5) × (.12) = $900

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 594, IV-37.

263. (**d**) Economic order quantity (EOQ) formula is related to sales not to inventory. Choices (a), (b), and (c) are incorrect because each choice is a required component of the EOQ formula. In addition, data on carrying costs is needed.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 594, IV-38.

264. (**d**) Simple linear regression can be used to estimate inventories as a constant plus a function of sales: INV = a + b SALES, Where "a" is a constant and "b" is a coefficient estimated by the regression model. Choice (a) is incorrect because this method ignores changes in sales. Choice (b) is incorrect because this method ignores the relationship between sales and inventory. Choice (c) is incorrect because this method ignores the constant dollar amount of inventory.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1193, IV-49.

265. (**a**) Inventory shipping and handling costs are classified as ordering costs, not as carrying costs. Choices (b), (c), and (d) are incorrect because property tax, insurance and depreciation/obsolescence are classified as inventory carrying costs.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1196, IV-43.

266. (**b**) The higher the fixed ordering costs, the greater the economic order quantity. Higher quantity orders are made less frequently, resulting in lower fixed ordering costs for the period. Choice (a) is incorrect because the economic order quantity (EOQ) is higher for a company that has higher, not lower, annual unit sales. Everything else equal, greater sales volume means more inventory is needed. Choice (c) is incorrect because higher carrying costs will result in a lowering of order quantities so that average inventory is reduced. Choice (d) is incorrect because higher unit purchase prices will increase inventory costs and reduce the economic order size.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1195, IV-37.

267. (**b**) The annual inventory carrying cost is calculated as follows:

= Average inventory × Percentage carrying cost
= (Order quantity/2 + Safety stock) (Unit cost) (Percentage carrying cost)
= (10,000/2 + 2,000) ($5) (.10) = 35,000 (.10) = $3,500

Choice (a) is incorrect because this solution is obtained by omitting safety stocks from the calculation of annual inventory carrying cost (see b. for correct solution).

= Average inventory × Percentage carrying cost
= (Order quantity + Safety stock/2) (Unit cost) (Percentage carrying cost)
= (12,000/2) ($5) (.10) = $3,000

Choice (c) is incorrect because this solution is obtained by omitting safety stocks from the calculation and by failing to divide the order quantity by two to calculate average inventory.

Annual carrying cost of inventory = Order quantity (.10) (Unit cost)
= 10,000 (.10) ($5) = $5,000

Choice (d) is incorrect because this solution for the annual carrying cost of inventory is obtained if the order quantity is not divided by two when calculating average inventory.

(Average inventory) (Percentage carrying cost)
= (Order quantity + Safety stock) (Unit cost) (Percentage carrying cost)
= (10,000 + 2,000) ($5) (.10) = $6,000

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1195, III-42.

268. (**c**) As order size increases, the number of orders falls. Total ordering cost of inventory is the fixed costs per order multiplied by the number of orders placed per year. Total ordering cost therefore decreases with an increase in the order size. Choices (a) and (b) are incorrect because average inventory is the order size in units divided by two. As order size increases, the average inventory level rises. Total carrying costs of inventory are calculated as the annual percentage carrying costs multiplied by the average inventory in units. Total carrying costs of inventory will therefore increase with an increase in the average inventory level, rather than decrease or remain unchanged. Choice (d) is incorrect because the total ordering cost of inventory decreases with an increase in the order size.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 595, IV-49.

269. (**a**) The EOQ (economic order quantity) decision model calculates the optimum quantity of inventory to order by incorporating only the ordering costs and carrying costs into the model. These costs behave in the opposite direction of each other. Choice (b) is incorrect because this response is incorrect because only carrying costs are correct; the purchase costs are not directly incorporated into the EOQ model. Choice (c) is incorrect because this response is incorrect because neither the purchase costs nor the quality costs are incorporated into the EOQ model. Choice (d) is incorrect because this response is incorrect because only ordering costs are correct; stockout costs are not directly incorporated into the EOQ model.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 597, III-91.

270. (**b**) Of the four variables mentioned, only yearly demand is required.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 595, III-98.

271. (**c**) Holding costs = Q/2 (holding costs per unit) + Safety Stock. Holding costs = 2,500/2 ($4)(.25) + 500 ($4)(.25) = 1,250 + 500 = $1,750.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 595, III-99.

272. (**c**) Inventory ordering costs = D/Q (order costs). Inventory ordering costs = 48,000/2500 (150) = $2,880.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 595, III-100.

273. (**b**) Internal accounting allocations of costs to different segments of the firm are arbitrary assignments of already incurred costs which do not have anything to do with forecasting demand. Choices (a), (c), and (d) are incorrect because knowing the behavior of business cycles, understanding seasonal variations in demand for the product, and the use of econometric models can be valuable when forecasting the required purchases of inventory.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1196, III-8.

274. (**a**) Safety stock is inventory maintained in order to reduce the number of stockouts resulting from higher-than-expected demand during lead-time. Choice (b) is incorrect because a just-in-time (JIT) inventory system involves the purchase of materials and production of components immediately preceding their use. Choice (c) is incorrect because materials requirement planning (MRP) is a system for scheduling production and controlling the level of inventory for components with dependent demand. Choice (d) is incorrect because a master production schedule (MPS) is a statement of the timing and amounts of individual items to be produced.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1195, III-66.

275. (**a**) If D decreases by 36%, the Economic Order Quantity (EOQ) will be 0.8Q, or a decrease by 20%.

$$Q = \sqrt{\frac{2 * 0.64D * p}{s}} = \sqrt{0.64\left(\frac{2Dp}{s}\right)} = 0.8Q$$

Therefore, by definition, choices (b), (c), and (d) are incorrect.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1195, III-97.

276. (**b**) The purpose of the EOQ model is to minimize the sum of the order costs and the holding costs. Choice (a) is incorrect because although safety stock is important in some versions of the model, one does not want to minimize it (otherwise it would be zero, and the firm may incur substantial stockout costs). Choice (c) is incorrect because in the EOQ model, costs not quantities are the focus of the minimization. Choice (d) is incorrect because quantity demanded is a variable in the model, but order costs not demand costs are relevant to the model. Backlogs are customer orders, which cannot be filled immediately because of stockouts. Backlog costs are not quantified in the model.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 594, III-66.

277. (**b**) Shortening setup times permit smaller average batch sizes which permits reductions in inventory leading to decreased inventory holding costs. Choice (a) is incorrect because there are other factors and not considering them is shortsighted. Choice (c) is incorrect because getting suppliers to deliver better quality raw materials is independent of an investment to decrease setup times. Choice (d) is incorrect because coding batches of raw materials is independent of an investment to decrease setup times.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1193, III-52.

278. (**d**) All of these items prompt a more frequent review in an ABC inventory control system. Choice (a) is incorrect because long, not short, lead times prompt a more frequent review in the ABC inventory control system. Choice (b) is incorrect because high, not low, stockout costs prompt a more frequent review in an ABC inventory control system. Choice (c) is incorrect because expensive, not inexpensive, items prompt a more frequent review in an ABC inventory control system.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1193, IV-26.

279. (**b**) The optimal order size is increased, because economic order quantity (EOQ) shows how average ordering costs is inversely related to the order size, but carrying costs are directly related to the order size. If ordering costs increase, it is better to increase the order size so as to reduce the number of orders per year. Choices (a), (c), and (d) are incorrect because the optimal order size is increased. Total costs are minimized where holding costs and ordering costs equate. Fixed costs have no impact on EOQ. Annual inventory holding costs are a linear function of the amount of inventory carried. Annual ordering costs are inversely related to the order quantity and continually decline.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1193, IV-51.

280. (**b**) Payoff table analysis is appropriate for single-period inventory. Choice (a) is incorrect because economic order quantity (EOQ) models deal with a nearly constant demand. Choice (c) is incorrect because material requirements planning (MRP) is a technique for dependent-demand inventories. Choice (d) is incorrect because game theory is a mathematical approach to decision-making in which each decision-maker takes into account the courses of action of competitors.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1192, III-46.

281. (**a**) This is a description of the ABC method. A-class items are controlled more tightly than C-class items due to their relative values. Choice (b) is incorrect because the economic order quantity (EOQ) model is used to determine the order quantity that minimizes total inventory costs. Choice (c) is incorrect because a just-in-time (JIT) inventory system involves the purchase of materials and production of components immediately preceding their use. Choice (d) is incorrect because material requirements planning (MRP) system is a planning and controlling technique for managing dependent-demand manufacturing inventories.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 592, IV-23.

282. (**c**) Delivery time, usage rate, and level of safety stock are all considerations in controlling stockouts. Choice (a) is incorrect because these are inventory-related terms but none will controls stockouts. Choice (b) is incorrect because the order quantity and annual demand are not factors in the stockout problem. Choice (d) is incorrect because production bottlenecks are the results of a stockout; they are not a method of control. Also, EOQ is irrelevant to stockouts.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1191, IV-25.

283. (**b**) A stated requirement is demand forecasting based on early orders for items, which means that company personnel have learned that the best predictor of subsequent sales of

a specific item is sales in the first few days after it has been made available. Choice (a) is incorrect. Computations on the basis of economic order quantities (EOQ) will minimize the EOQ objective, but EOQ assumes stationary demand, which is not the case here. Choice (c) is incorrect because this is not the critical ordering factor for a specific item. Choice (d) is incorrect because vendor quantity discounts and warehouse space are valid considerations only if the company would order the item in those quantities anyway.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 591, III-92.

284. (**c**) Availability of 70 units ensures 90% of possible daily needs (.2 + .5 + .2 = .9). Choice (a) is incorrect. Availability of 50 units ensures only 20% of possible daily needs (.2). Choice (b) is incorrect. Availability of 60 units ensures only 70% of possible daily needs (.2 + .5 = .7). Choice (d) is incorrect. Availability of 80 units ensures 100% of possible daily needs (.1 + .5 + .2 + .1 = 1).

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 591, IV-28.

285. (**b**) A reason to use bar codes rather than other means of identification is to record the movement of parts with minimal labor costs. Choice (a) is incorrect because the movement of parts can escape being recorded with any identification method. Choice (c) is incorrect because each vendor has its own part-numbering scheme, which is unlikely to correspond to the buyer's scheme. Choice (d) is incorrect because each vendor has its own identification method, although vendors in the same industry often cooperate to minimize the number of bar code systems they use.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 597, III-75.

286. (**d**) In this situation, the company will be receiving fewer materials at any point in time, increasing the likelihood of a stockout; at the same time, the average inventory will be less, resulting in a reduction in the carrying costs. Choice (a) is incorrect. While the supplier may ask for a concession in its selling price which would raise the manufacturer's purchasing costs, the manufacturing company will be receiving fewer materials at any point in time increasing the likelihood of a stockout, thereby resulting in an increase in stockout costs. Choice (b) is incorrect. While the supplier may ask for a concession in its selling price which would raise the manufacturer's purchasing costs, the cost of quality would not necessarily be affected by the JIT purchasing system. Choice (c) is incorrect. With fewer purchase orders being processed by the manufacturer, the ordering costs are likely to decrease. However, the cost of quality would not necessarily be affected by the JIT purchasing system.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 597, III-94.

287. (**d**) Because materials are delivered as needed, it is imperative to establish and maintain good relations with those critical suppliers. Choice (a) is incorrect. To the contrary, finished goods inventories are virtually eliminated. Choice (b) is incorrect. JIT does not necessarily require high-cost material handling equipment. Choice (c) is incorrect. If a defect is discovered, production is stopped.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 593, II-16.

288. (**c**) A JIT inventory system involves the purchase of materials and production of components immediately preceding their use. Choice (a) is incorrect because safety stock is the inventory maintained in order to reduce the number of stockouts resulting from higher-than-expected demand during lead time. Choice (b) is incorrect because economic order quantity is the order quantity that minimizes total inventory costs. Choice (d) is incorrect because the master budget is the detailed financial plan for the next period.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 592, III-62.

289. (**d**) Parts needed for repair could not be predicted in advance. Choice (a) is incorrect because identifying items for close control is an element of the ABC method. Choice (b) is incorrect because diversity of needs is not the issue, it's knowing when they are needed. JIT works well with auto manufacturing. Choice (c) is incorrect because sales rates and order lead times are used to determine safety stock, not an issue with JIT.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 592, IV-51.

290. (**c**) Work stoppages at suppliers or transportation disruptions due to poor weather can cause almost immediate work stoppages at the manufacturer because of the lean inventories. Choice (a) is incorrect because JIT systems can require significant computer resources, but they can also be maintained manually. Choice (b) is incorrect because contracts may have to be renegotiated with strict delivery and quality specifications, but this is usually performed over extended periods of time. Choice (d) is incorrect because JIT can be implemented over an extended period of time or a shorter time frame depending on the manufacturer's immediate needs.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 595, III-32.

291. (**c**) This measures inputs consumed for output produced. Choice (a) is incorrect because this measures effectiveness of internal control. Choice (b) is incorrect because this measures efficiency. Choice (d) is incorrect because this measures economy.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 596, III-90.

292. (**a**) A flexible manufacturing system (FMS) consists of two or more computer-controlled machines linked by automated handling devices such as robots and transport systems. Choice (b) is incorrect because just-in-time (JIT) involves the purchase of materials and production of components immediately preceding their use. Choice (c) is incorrect because a master budget is the detailed financial plan for the next period. Choice (d) is incorrect because economic order quantity (EOQ) model is the order quantity that minimizes total costs.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1195, III-99.

293. (**a**) This is a major emphasis for computer integrated manufacturing (CIM) as well as for the total quality management (TQM) programs which usually proceed it. Choice (b) is incorrect because these may be either higher or lower with CIM. Choice (c) is incorrect because the normal expectation is that working capital will be reduced as investments shift from

current to fixed assets. Choice (d) is incorrect because actual or potential market share changes may trigger investments in CIM.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 596, III-35.

294. (**a**) With a JIT system, a formal receiving department may be eliminated because materials are delivered by the vendor directly to the final user on the factory floor. Choice (b) is incorrect because a bill of materials is important in an MRP system, not JIT. Choice (c) is incorrect because more emphasis is placed on quality and timeliness of raw materials purchases than on price in a JIT system. Choice (d) is incorrect because late deliveries can be a major problem because there is no inventory cushion to rely on.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1191, IV-24.

295. (**c**) PERT is a project management technique; it is not related to facility layout and design (The other three techniques are related). Choice (a) is incorrect. In cellular manufacturing all of the machines are grouped into cells to allow the product to flow easily through this "island" within the larger job shop or process layout. Choice (b) is incorrect. Operations sequencing analysis develops a good scheme for the arrangement of departments by graphically analyzing the layout problem. Choice (d) is incorrect. Line balancing is the analysis of production lines which nearly equally divide the work to be done among work stations so that the number of work stations required on the production line is minimized.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 594, III-62.

296. (**b**) Items II, VIII, X, and XII are related to financial services. Choices (a) and (c) are incorrect because Item III requires the firm to have substantial inventories. Item IV is only used in manufacturing firms not service firms. Choice (d) is incorrect because Item XI is used in the airline industry.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 594, III-58.

297. (**d**) Items I, III, and IV are related to manufacturing firms, items X, XI, and XII are related to service firms, and item VII and XII are related to both manufacturing and services firms. Choices (a) and (b) are incorrect because Item II is only used in the service industry. Choice (c) is incorrect because Item I is only used in the manufacturing industry.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 594, III-59.

298. (**c**) Companies in a highly volatile industry probably experience unstable demand for their finished product. An MRP system starts with the master production schedule for finished goods and works backward to derive direct materials inventory requirements. This requires accurate estimation of the amount of finished goods to be produced, which would be practically impossible if demand (and hence production) is constantly fluctuating. Choice (a) is incorrect because few direct materials would facilitate preparing inventory reports, which are needed for an MRP system. Many direct materials can complicate preparing the information, which is needed for an MRP system. Choice (b) is incorrect because an MRP system would be useful to ensure that there is an adequate amount of direct materials on hand. This would minimize the probability of stockouts. If the inventory of a direct material were depleted, the assembly line might have to be shut down, and the long set-up time would have to be incurred to restart operations. Choice (d) is incorrect. Since an MRP system minimizes direct materials stockouts, there is less chance of having to shut down the assembly line.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1192, IV-25.

299. (**a**) Material requirements planning (MRP) is a planning and controlling technique for managing dependent-demand manufacturing inventories. Choice (b) is incorrect because regression analysis is a statistical procedure for estimating the relation between variables. Choice (c) is incorrect because capital budgeting is used for analyzing and evaluating long-term capital investments. Choice (d) is incorrect because linear programming is a mathematical technique for maximizing or minimizing a given objective subject to certain constraints.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 592, III-61.

300. (**b**) Material requirements planning (MRP) is the system described in the stem. Choice (a) is incorrect because economic order quantity (EOQ) is a decision model that focuses on the trade-off between carrying and ordering costs. Choice (c) is incorrect because linear programming is a decision model concerned with allocating scarce resources to maximize profit or minimize costs. Choice (d) is incorrect because just-in-time (JIT) purchasing involves the purchase of goods such that delivery immediately precedes demand or use.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1193, IV-25.

301. (**b**) MRP is a technique that can be used to manage dependent-demand manufacturing inventories. Choice (a) is incorrect because inventory control specifically deals with inventory. Choice (c) is incorrect because Monte Carlo analysis deals with computer simulations. Choice (d) is incorrect because linear programming is a maximizing or minimizing model.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1191, III-35.

302. (**d**) Poor-quality materials cause major problems to JIT because it retains no safety stock to use to replace defective materials. Substandard materials cause major production disruptions in JIT systems and defeat its whole purpose of lowering cost and lead time while increasing product quality. Choice (a) is incorrect because safety stocks are not held in JIT systems, whose goal is to minimize inventory by insuring that materials arrive at the plant just-in-time for production. Safety stocks raise inventory levels and increase the risk of defective materials through obsolescence and potential damage during storage. Choice (b) is incorrect because many smaller firms are adopting JIT with favorable results. In fact, smaller companies may have an easier time implementing JIT because it can be easier to redefine job functions and retrain workers. Choice (c) is incorrect because the close coordination required between suppliers and customers usually leads to overall inventory reductions throughout the production-distribution chain.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 597, IV-39.

303. (**b**) Since the service level is the average number of stockouts, it must change. Choice (a) is incorrect. Since the service level is the average number of stockouts, it must change. Choice (c) is incorrect. There should be no change in orderings costs as the same number of orders will be made each year. It may increase in the initial year as an additional order may be required to increase the safety stock. Choice (d) is incorrect. Since we will be stocking more inventory, carrying costs will increase as will delivery costs.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1190, III-42.

304. (**a**) The EOQ is the square root of 2 times the rate of demand times the order cost divided by the carrying cost. In this case, the percent of change will be equal to the square root of 1/2, or 0.707. 447 units × 0.707= 316. Therefore, choices (b), (c), (d) will be incorrect.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 590, III-45.

305. (**c**) The answer is to find the square roof of: (2 × $100 × 1,000)/$2. This is the square root of 100,000, or 317. Choice (a) is incorrect because order costs and carrying costs are reversed. Choice (b) is incorrect because it failed to multiply by the constant (2). Choice (d) is incorrect because it failed to divide by carrying costs.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 590, IV-22.

306. (**a**) Group C items are low-dollar-value items and receive less management attention. Extensive use of models and records is not cost effective. It is cheaper to order large quantities infrequently. Group A items are high-dollar value and management would try to keep investment in such items low. Therefore, by definition, choices (b), (c), and (d) will be incorrect.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 590, IV-23.

307. (**c**) As the frequency of ordering increases, total carrying costs are reduced by the average that inventory level is reduced. Choice (a) is incorrect because total ordering costs would increase. Choice (b) is incorrect because total ordering costs would increase. Choice (d) is incorrect because total carrying costs are reduced.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 590, III-51.

308. (**b**) Material requirements planning (MRP) is the system described in the question. Choice (a) is incorrect because economic order quantity (EOQ) is a decision model that focuses on the trade-off between carrying and ordering costs. Choice (c) is incorrect because linear programming is a decision model concerned with allocating scarce resources to maximize profit or minimize costs. Choice (d) is incorrect because just-in-time (JIT) purchasing involves the purchase of goods such that delivery immediately precedes demand or use.

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 1190, IV-26.

309. (**b**)

$$(2{,}000 - 200) - 300 = 1{,}500$$
$$(2{,}000 - 200)(2) - 400 = 3{,}200$$

Choice (a) is incorrect.

$$(2{,}000 - 200) - 300 = 1{,}500$$
$$(2{,}000 - 200) - 400 = 1{,}400$$

Choice (c) is incorrect.

$$(2{,}000 - 0) - 300 = 1{,}700$$
$$(2{,}000 - 0)(2) - 400 = 3{,}600$$

Choice (d) is incorrect.

$$(2{,}000 - 200) = 1{,}800$$
$$(2{,}000 - 200)(2) = 3{,}600$$

Subject Area: Business processes—inventory management techniques and concepts. Source: CIA 596, III-98.

Marketing—Pricing Objectives and Policies

310. (**b**) Price reflects some unit of value given up by one party in return for something from another party. The setting price based on costs has become a common practice. Two approaches include standard markup pricing and target return pricing. Cost-plus pricing method ignores demand since costs are generated internally and since the demand is created externally to an organization.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

311. (**c**) Two pricing approaches based on cost include standard markup pricing and target return pricing. Target return pricing adds both cost per unit and desired profit and is calculated as selling price per unit = Unit cost per unit + Desired profit per unit. A standard markup percentage based on management profit goal is added to the cost in the standard markup pricing approach.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

312. (**a**) With the standard markup approach, the Selling price = Unit cost/(1 – Markup percentage). Selling price = $1.32/(1.00 – 0.20) = $1.32/0.80 = $1.65.

Subject Area: Business processes—marketing/pricing objectives and policies. CBM, Volume two.

313. (**b**) Markup on selling price = (Price – Cost)/Price = ($15 – $11)/$15 = 4/15 = 0.266 = 27%.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

314. (**d**) Markup on selling price = (Price – Cost)/Price = 25% = ($15 – Cost)/$15 = $3.75 = $15 – Cost. Cost = $15 – $3.75 = $11.25.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

315. (**b**) Markup on cost is the profit margin for an individual product or product line expressed as a percentage of unit cost. Markup on price is the profit margin for an individual product expressed as a percentage of price. Markup on price = (Markup on cost)/(1+ Markup on cost) = 50%/150% = 33%.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

316. (**d**) Markup on cost = (Markup on price)/(1 – Markup on price) = 50%/50% = 100%.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

317. (**b**) Markup on cost = (Price – Cost)/Cost = ($6 – $4)/$4 = $2/$4 = 50%.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

318. (**b**) Markup on price = (Price – Cost)/Price = ($5-$2)/$5 = $3/$5 = 60%.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

319. (**c**) Given the information contained in a demand curve (quantity and price), a firm can determine the profit-maximizing price by simply calculating the profit at each point and determining which price produces the highest profit.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

320. (**c**) Profit-maximizing price is established by examining how revenues and costs change for a series of prices.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

321. (**d**) The following strategic factors play a role in setting a base price: (1) company objectives, (2) positioning strategy, (3) new product pricing strategies, and (4) price-quality differences.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

322. (**c**) Companies pursue a pricing strategy aimed at a market share target when there is no patent protection on a specific product.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

323. (**d**) Profit maximization objectives require the most substantial cost and demand information.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

324. (**a**) Two classic pricing strategies for new products are skimming and penetration. Skimming strategy is setting the price at a relatively high level in the beginning and then gradually reducing it over time. The penetration strategy is setting the price at a relatively low level in the beginning where the goal is to obtain market share and expand demand.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

325. (**c**) Price is set at a low level in the penetration strategy. One of the downsides of the penetration pricing is that customers may infer low quality from low price, meaning making a price-quality judgment.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

326. (**a**) When introducing an easily copied new product, a marketer would be likely to use a price penetration strategy hoping to lure customers quickly. Also, research and development costs are little to none.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

327. (**a**) A skimming pricing policy works best when demand is inelastic, meaning a price increase produces a less than proportionate decline in the quantity demanded so that total revenues rise. Many customers are willing to pay the high price for the unique value that a product provides.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

328. (**c**) A firm pursuing a clear differentiation strategy is more likely to follow a price skimming policy by charging a higher price to reflect the product's differentiating features.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

329. (**c**) A price skimming strategy is setting the price at a relatively high level in the beginning and then gradually reducing it over time. Competitors have no incentive to enter the market with similar products at lower prices.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

330. (**c**) Major phases of a product life cycle include introduction, growth, maturity, and decline (commodity). In the introductory phase, paying attention to costs is important, and the firm may choose to pursue a skimming or penetration price strategy. In the growth phase, the firm is faced with the opposing forces of growing demand, yet increasing competition. This necessitates aggressive pricing if the firm cannot hold on to a unique product advantage. Maturity is likely to bring either stable, competitive prices or price wars if some rival firms attempt to get aggressive. The firm should do its best to maintain stable prices and not rock the boat in the maturity phase. Alternatively, some firms will attempt to innovate to break out of the commodity trap. In the decline phase, the firm should try to keep prices up if the decision has been made to harvest the brand. Predicting when and how much to cut prices is an important task.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

331. (**b**) In the introductory stage, paying attention to costs is important, and the firm may choose to pursue a skimming or penetration pricing strategy.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

332. (**a**) During the mature stage, stable, competitive prices and price wars are common.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

333. (**d**) In the decline stage, the firm should try to keep prices up if the decision has been made to harvest the brand.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

334. (**d**) A price penetration strategy makes sense when competitive imitation will occur quickly, costs are likely to drop a good deal with increases in volume, and target consumers are relatively price sensitive. Penetration pricing is the standard strategy followed by low-cost leaders.
Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

335. (**d**) A company can effectively set its prices higher than its competitors when the company's product is perceived as superior quality.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

336. (**b**) Competitive price moves, price promotion, and unique pricing for different customers are the common reasons for a company to change a product's price.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

337. (**a**) A salesperson who reduces the price during negotiations is practicing price shading, which is most common when the customer is a very valuable client.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

338. (**c**) Cash discounting is offered to differentiate between fast- and slow-paying customers.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

339. (**c**) Free-on-board (FOB) pricing leaves the cost and responsibility of transportation of goods to the customer.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

340. (**d**) Discounts given to retailers for putting a manufacturer's goods on sale to consumers for a particular period of time are called sales promotion allowances.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

341. (**a**) Price flexing takes place in the form of a wide variety of discounts and allowances. Price flexing approaches to consumers include couponing, segmented pricing, and price promotion. Price flexing with business market is an increasing trend toward customization.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

342. (**c**) The objective of price promotion is to encourage trial by a customer and to allow the seller to maintain a higher list price. As consumers grow accustomed to low-price specials, any firm that does not price promote is likely to lose sales. As price promotions tend to increase over time, consumers become more sensitive to price.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

343. (**a**) Marketers often have different marketing programs for different consumer segments such as geographic, usage, demographic, and time segments.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

344. (**b**) Sellers charging different prices to different buyers is called price discrimination.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

345. (**a**) Pricing for survival occurs when a company experiencing financial trouble may seek to produce an acceptable cash flow, to cover marginal costs, and simply survive. This may result when competition is especially intense, when consumer needs are changing, and/or when substantial excess capacity exists.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

346. (**b**) One of the downsides of penetration pricing is that customers may infer low quality from low price.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

347. (**b**) Price discrimination occurs whenever different classes of customers are charged different markups for the same product. It occurs when different customers are charged the same price despite underlying cost differences and when price differentials fail to reflect cost discrepancies.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

348. (**a**) For price discrimination to be successful and profitable, different price elasticities of demand must exist in the various submarkets. Also, the firm must be able to efficiently identify relevant submarkets and prevent transfers among affected customers.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

349. (**a**) If there is a high price elasticity of demand, then the customer is price sensitive. As a result, prices must be kept relatively low.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

350. (**c**) A change in the quantity demanded is caused by a change in price.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

351. (**d**) A change in the quantity supplied is caused by a change in price.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

352. (**b**) If demand is elastic, a price increase lowers total revenue, and a decrease in price raises total revenue.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

353. (**a**) With inelastic demand, a price increase produces less than a proportionate decline in quantity demanded, so total revenue rises.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: CBM, Volume two.

354. (**b**) Fully allocated costs can be appropriate when a firm is operating at full capacity. During peak periods, when facilities are fully utilized, expansion is required to increase production. Under such conditions, an increase in production requires an increase in all plant, equipment, labor, materials, and other expenditures.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

355. (**c**) Markup pricing is the most commonly employed pricing method. Markup pricing method is average variable cost plus a charge for overhead and profit margin.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: Author.

356. (**a**) Any amount received above the storage and delivery costs for a by-product allows the seller to reduce the main product's price to make it more competitive. Choice (b) is incorrect. Optional products are those offered for sale along with the main product. They are unlikely to have a zero production cost so the seller must receive a price above the storage and delivery costs for such products. Choice (c) is incorrect. Captive products are those that must be used along with the main product, such as film for use with a camera. Sellers often make their money on the captive products, rather than on the main product which is sold at a low price. The captive products therefore will be priced well above the storage and delivery costs. Choice (d) is incorrect. Product bundles are combinations of products sold together at a reduced price, such as season tickets for a theater. Products are bundled in order to promote the sale of certain items that consumers might not otherwise purchase. The combined price of the bundle must be low enough to encourage consumers to buy the bundle, but must recover production costs and provide some profit for the seller, so the price must exceed storage and delivery costs.

Subject Area: Business processes—marketing/pricing objectives and policies. Source: CIA Model Exam 2002, IV-63.

Marketing—Supply-Chain Management

357. (**c**) The process of linking a manufacturer's operations with those of its suppliers and customers is called supply-chain management.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

358. (**b**) Supply-chain management describes the logistical system, which emphasizes close cooperation and comprehensive interorganizational management to integrate the logistical operations of the different firms in the marketing channel.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

359. (**d**) Each organization in a supply chain is typically involved in developing a product, marketing processes, delivery of a product, and postsale service.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

360. (**a**) Buyers involved in a supply-chain management strategy sometimes reach several tiers back in the supply-chain link to assist second-tier suppliers in meeting their goals.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

361. (**d**) The primary goal of supply-chain management is to improve speed, accuracy, and efficiency in manufacturing and delivery.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

362. (**b**) The reward of becoming a valued partner in a customer's supply chain is being viewed as an extension of the customer's company.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

363. (**b**) To achieve the reward of being viewed as an extension of a company's customers, a business marketer must be able to meet quality, delivery, service, and informational requirements.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

364. (**a**) Companies that adopt the just-in-time approach to purchasing will typically decrease the number of suppliers with which they deal.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

365. (**b**) The essence of the just-in-time concept is to deliver defect-free parts and materials to the production process just at the moment they are needed.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

366. (**d**) The goals of just-in-time concepts are generally focused on quality, customer service, inventory costs, and production efficiency.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

367. (**c**) The value offerings developed by business marketers must be based on the skills and resources that provide value as perceived by the customer.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

368. (**a**) The purchasing method that involves weighing the comparative value of materials, parts, components, and manufacturing processes from the standpoint of their purpose, relative merit, and cost is called value analysis.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

369. (**d**) Value engineering, not value analysis, points the way to elimination and reengineering.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

370. (**c**) One of the results of value analysis is that product design alternatives will produce significant cost savings.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

371. (**d**) The value of a function is determined by the most cost-efficient way of fully accomplishing the function.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

372. (**b**) The evaluation of supplier performance is used as a negotiation tool to gain leverage in buyer-seller relationships.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

373. (**a**) The buying organization weighs each performance factor according to its relative importance to the organization. The results are used by both the seller and the buyer to meet their specific needs and goals.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

374. (**c**) Customers in business markets are interested in a supplier's total capabilities and how they contribute to the customers' success in the market.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

375. (**c**) Warehousing is concerned with the holding of products until they are ready to be sold.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

376. (**d**) The number of suppliers in the marketplace is the most important factor between a single source and multiple sources. If there is only one supplier available for a component, the decision is obvious.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

377. (**b**) Understanding "who the other customers of the supplier are" can help in assessing competitive strengths and weaknesses of a potential supplier.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

378. (**c**) Factors such as management integrity, financial stability, and design flexibility should be considered in addition to supplier rating score. Production standards are already considered as part of the "Function" and "Quality" ratings.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

379. (**c**) Vendor analysis should be conducted on a periodic basis (item I) or whenever there is a significant change in the weights assigned to the scoring factors (item II).

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

380. (**c**) Price, quality, and service are major factors used in selecting a vendor. Inventory usage should not be a concern at the time of selecting a vendor. It may be useful after selecting the vendor.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

381. (**c**) Suppliers should be viewed as outside partners who can contribute to the long-term success of a buying firm. If suppliers are selected on price only, they will be switched continuously, which will destabilize the purchasing process.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

382. (**a**) Supplier audits are an important first step in the supplier certification program.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

383. (**d**) Usually, supplier audits focus on supplier's production or service capabilities as well as quality and delivery programs.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

384. (**b**) Usually, supplier audits cover management style, quality assurance, materials management, product and process design methods, product and process improvement opportunities, and management policies and procedures for problem identification and corrective action. Industrial engineering is useful in setting material and labor time standards.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

385. (**a**) Generally speaking, there is less risk with certified suppliers than with noncertified suppliers due to their increased capabilities.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

386. (**a**) The certification process verifies that a supplier meets or exceeds the requirements of a buyer. Certified suppliers are referred to as world-class suppliers. Some companies rely on standard industry certification such as ISO 9000. Some companies have their own certification either in addition to or as a substitute for the ISO 9000.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

387. (**a**) The scope of value analysis includes examination of functions and costs to determine whether functions can be added, removed, substituted, or improved to reduce costs and to improve overall performance of the finished product. Here, value is related to a product's function and cost.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

388. (**d**) Value analysis is most applicable to parts, raw materials, and components that have high unit cost (item II) and high annual usage (item IV). Since the product of high unit cost and high annual usage is significant in dollar amount, it makes sense to analyze these items for cost reduction.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

389. (**c**) Although purchasing management is actively involved in the value analysis, it should not drive its implementation due to their limited knowledge in engineering and operations. Usually, purchasing gives more importance to cost reduction at the expense of valuable functions needed for customers.

Subject Area: Business processes—marketing/supply-chain management. Source: CBM, Volume two.

390. (**c**) The bullwhip effect is an extreme change in the supply position upstream generated by a small change in demand downstream in the supply chain.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

391. (**b**) The bullwhip effect can be eliminated by synchronizing the supply chain's downstream and upstream positions.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

392. (**a**) The inventory level during a bullwhip effect can quickly move from being backordered to being excess. The effect creates an extreme change.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

393. (**a**) Presourcing means choosing suppliers in the concept-development stage of a new product, including the design, prototype development, and manufacturing of a component, part, product, or complete system. The rationale for presourcing is that it permits many engineering tasks to be carried out simultaneously (concurrently) rather than sequentially, thereby speeding up the new product development process.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

394. (**b**) In the Japanese keiretsu (an informal program), Japanese manufacturers own 20 to 50% of the equity of their largest suppliers. In the American keiretsu (a formal program), American companies could not take similar stakes due to legal restrictions. Kanban is a color-coded production material control system used in the factory floor to signal the demand for and the need for the movement of materials between the upstream and the downstream workstations. Kaizen is a concept of continuous improvement in quality.

Subject Area: Business processes—marketing/supply-chain management. Source: Author.

395. (**b**) Value analysis is primarily designed to optimize performance of a function at a minimum cost. Choice (a) is incorrect because Pareto analysis is a technique for classifying problem areas according to degree of importance, and focusing on the most important. Choice (c) is incorrect because linear regression is used to predict one variable if a correlated variable is known. Choice (d) is incorrect because the Markov process is used in applications such as describing the probability that a machine that is working in one period will work in another.

Subject Area: Business processes—marketing/supply-chain management. Source: CIA Model Exam 1998, III-33.

Human Resources Management

396. (**a**) The traditional employee's performance measurement process is based on a job analysis and rarely includes broader organizational criteria. The process is static in nature in that it captures a summary of an entire year of work at one point in time. The focus of employee feedback is on reaching agreement on the results of the evaluation and determining actions that need to be taken to improve performance.

Subject Area: Business processes—human resources. Source: Author.

397. (**a**) Increased competition leads to innovation in the workplace in an effort to reduce costs and improve product and service quality. Employees are the key to improve business results by producing more at higher levels of quality with fewer resources. Choices (b), (c), and (d) are the elements of the traditional performance measurement system.

Subject Area: Business processes—human resources. Source: Author.

398. (**a**) The major difference between employee's performance measurement and performance management is the emphasis on management rather than measurement. Management includes changing the process from a report card or evaluation tool to an opportunity for a full and fair discussion between manager and subordinates. This discussion includes establishing goals and objectives, noting innovations and efficiencies, reinforcing positive behavior and valuable work efforts, and guiding behavior toward higher achievement.

Subject Area: Business processes—human resources. Source: Author.

399. (**d**) In the employee's performance management system, measurement is continuous, and it is seen as a means to an end rather than an end in itself. It molds employee's performance through employee active participation and continuous feedback. Coupled with effective reward and recognition programs, performance management systems can shape work behavior to reap the benefits desired in the competitive marketplace.

Subject Area: Business processes—human resources. Source: Author.

400. (**b**) The human resource management process includes employee selection and recruiting, employee performance appraisal, and employee training and development. Employee communication is not a major part of the human resource management process because every department or function needs employee communication.

Subject Area: Business processes—human resources. Source: Author.

401. (**c**) A corporate Web site is the most frequently used but least successful job-searching method.

Subject Area: Business processes—human resources. Source: Author.

402. (**d**) Job referrals through friends and colleagues are the best way to find a job because of familiarity of the potential employee.

Subject Area: Business processes—human resources. Source: Author.

403. (**a**) Job analysis identifies basic task and skill requirements through observation.

Subject Area: Business processes—human resources. Source: Author.

404. (**a**) Job analyses should be done before job descriptions are developed.

Subject Area: Business processes—human resources. Source: Author.

405. (**d**) Job descriptions outline the role expectations and skill requirements for a specific job.

Subject Area: Business processes—human resources. Source: Author.

406. (**b**) Interviews are the most common tool used for employee selection because of face-to-face communication.

Subject Area: Business processes—human resources. Source: Author.

407. (**c**) Structured interview is defined as a set of job-related questions with standardized answers.

Subject Area: Business processes—human resources. Source: Author.

408. (**a**) Performance appraisal defines the process of evaluating an individual's contribution as a basis for making objective personnel decisions. Environmental factors include intrinsic and extrinsic rewards. Facilitation skills include diplomacy, negotiating, and communicating skills.

Subject Area: Business processes—human resources. Source: Author.

409. (**c**) The criterion for legally defensible performance appraisals in the United States include (1) results were reviewed with ratees, (2) performance was based on job analysis, and (3) written instructions were given to evaluators.

Subject Area: Business processes—human resources. Source: Author.

410. (**b**) Managers use written essays (narrative form) to describe the performance of an employee.

Subject Area: Business processes—human resources. Source: Author.

411. (**b**) In the critical incident performance appraisal technique, managers write down specific examples of employees' good and bad performance as they occur and later use them during the performance appraisal.

Subject Area: Business processes—human resources. Source: Author.

412. (**c**) Both graphic rating scales and behaviorally anchored rating scales (BARS) are effective for appraising an employee's job performance due to their focus on the employee's behavior.

Subject Area: Business processes—human resources. Source: Author.

413. (**d**) In a 360-degree review technique, a manager takes input from multiple raters such as one's supervisor, peers, and subordinates as part of an employee's performance appraisal.

Subject Area: Business processes—human resources. Source: Author.

414. (**c**) Supervisors and managers need more training in employee performance appraisals since errors can be very costly and risky for both the manager and the employee.

Subject Area: Business processes—human resources. Source: Author.

415. (**d**) Live classroom lectures are the most preferred instructional and training methods due to their face-to-face communication and question and answer session.

Subject Area: Business processes—human resources. Source: Author.

Balanced Scorecard System

416. (**c**) The balanced scorecard system is a comprehensive management control system that balances traditional financial measures with operational (nonfinancial) measures relating to a company's critical success factors.

Subject Area: Business processes—balanced scorecard. Source: CBM, Volume two.

417. (**a**) The balanced scorecard system started as a management control system is now becoming a strategic management system because of its importance to overall progress of a company in terms of long-term value, vision, and strategy.

Subject Area: Business processes—balanced scorecard. Source: Author.

418. (**d**) Financial measures are lag indicators focusing on past actions and promoting short-term behavior. Companies also need lead indicators focusing on value creators or drivers, promoting long-term behavior, and equally emphasizing nonfinancial measures such as quality and service. Examples of financial indicators include return on assets (ROA), net income after taxes, and return on equity (ROE).

Subject Area: Business processes—balanced scorecard. Source: CBM, Volume two.

419. (**d**) The four perspectives of the balanced scorecard approach include measures of quality, productivity, efficiency and timeliness, and marketing success.

Subject Area: Business processes—balanced scorecard. Source: Author.

420. (**b**) The balanced scorecard approach requires looking at performance from four different but related perspectives such as financial, customer, internal business processes, and learning and growth.

Subject Area: Business processes—balanced scorecard. Source: Author.

421. (**b**) Reducing prices has a temporary effect while the other three choices have a permanent effect. The number of product or service warranty claims filed, number of returned products, customer response time, and percentage of on-time deliveries are also critical success factors.

Subject Area: Business processes—balanced scorecard. Source: Author.

422. (**c**) The value chain of a company includes all activities from research and development (R&D) to postsale customer service. The scope of internal business processes also includes improving quality throughout the production process, increasing productivity, increasing efficiency of resources, and timeliness of information.

Subject Area: Business processes—balanced scorecard. Source: Author.

423. (**b**) Customer perspective deals with taking care of interests of customers as well as acquiring and retaining more of them.

Subject Area: Business processes—balanced scorecard. Source: Author.

424. (**d**) Learning and growth perspectives deal with product improvement and innovation, information systems capabilities, efficient and effective use of employees, and overall company growth.

Subject Area: Business processes—balanced scorecard. Source: Author.

425. (**d**) The balanced scorecard approach integrates financial and nonfinancial performance measures of a company. Cost (item I) and sales margins (item II) are financial measures while quality (item III) and customer service (item IV) are nonfinancial measures.

Subject Area: Business processes—balanced scorecard. Source: Author.

426. (**d**) Traditional measures are basically financial and are not adequate to fully assess the performance of companies. Traditional measures mainly deal with historical accounting data and cannot answer questions such as customer satisfaction, quality improvement, productivity, efficient utilization of resources, and employee satisfaction.

Subject Area: Business processes—balanced scorecard. Source: Author.

427. (**d**) Time to market a new product is part of the learning and growth perspective.

Subject Area: Business processes—balanced scorecard. Source: Author.

428. (**d**) Examples of customer-performance scorecard measures include customers (new, dissatisfied, satisfied, or lost); target market awareness or preference; relative product or service quality; and on-time delivery. Machine downtime, rework time, and plant waste are examples of production-performance scorecard measures.

Subject Area: Business processes—balanced scorecard. Source: Author.

429. (**c**) Stakeholder-based performance scorecard measurements are difficult to identify and implement because of (1) various constituents involved (stakeholders, employees, unions, governments, investors and creditors, bankers, distributors, wholesalers and retailers, and suppliers and vendors), (2) difficulty in reaching them on a day-to-day basis, (3) difficulty in communicating with them periodically, (4) difficulty in coordinating them, and (5) difficulty in reaching a conclusion on issues due to their diverging viewpoints and conflicting objectives.

Subject Area: Business processes—balanced scorecard. Source: Author.

430. (**c**) A good balanced scorecard system contains lag measures, lead measures, and interlinking. Financial measures are lag indicators focusing on past actions and promoting short-term behavior. Companies also need lead indicators focusing on value creators or drivers, promoting long-term behavior, and equally emphasizing nonfinancial measures such as quality and service. A good balanced scorecard contains both leading and lagging measures and links them through logical cause-and-effect relationships. Interlinking is the quantitative modeling of cause-and-effect relationships between internal and external performance measures. An interrelationship digraph identifies and explores causal relationships among related concepts or ideas. It shows that every idea can be logically linked with more than one other idea at time, and allows for "lateral thinking" rather than "linear thinking." The graph is used after the affinity diagram has clarified issues and problems.

Subject Area: Business processes—balanced scorecard. Source: Author.