Summary of Key Points and Terminology – Module 12

- **Design for Six Sigma (DFSS)** represents a set of tools and methodologies used in the product development process for ensuring that goods and services will meet customer needs and achieve performance objectives, and that the processes used to make and deliver them achieve Six Sigma capability. DFSS consists of concept development, design development, design optimization, and design verification.
- **Concept development** is the process of applying scientific, engineering, and business knowledge to produce a basic functional design that meets both customer needs and manufacturing or service delivery requirements. This involves developing creative ideas, evaluating them, and selecting the best concept.
- **Quality Function Deployment (QFD)** is a planning process to guide the design, manufacturing, and marketing of goods by integrating the voice of the customer throughout the organization. A set of matrices is used to relate the voice of the customer to a product's technical requirements, component requirements, process control plans, and manufacturing operations. The first matrix, the customer requirement planning matrix, which is often called the **House of Quality**, provides the basis for the QFD concept.
- **Concept engineering (CE)** is a focused process for discovering customer requirements and using them to select superior product or service concepts that meet those requirements. Steps include understanding the customer's environment, converting understanding into requirements, operationalizing what has been learned, concept generation, and concept selection
- Manufacturing specifications consist of *nominal dimensions* and *tolerances*. **Nominal** refers to the ideal dimension or the target value that manufacturing seeks to meet; **tolerance** is the permissible variation, recognizing the difficulty of meeting a target consistently. **Tolerance design** involves determining the permissible variation in a dimension.

- **Design Failure Mode And Effects Analysis (DFMEA)** is a methodology to identify all the ways in which a failure can occur, to estimate the effect and seriousness of the failure, and to recommend corrective design actions.
- **Reliability—**the ability of a product to perform as expected over time—is one of the principal dimensions of quality. Formally, reliability is defined as the probability that a product, piece of equipment, or system performs its intended function for a stated period of time under specified operating conditions. In practice, reliability is determined by the number of failures per unit time during the duration under consideration (called the **failure rate**).
- Two types of failures can occur: **functional failure** at the start of product life due to manufacturing or material defects such as a missing connection or a faulty component, and **reliability failure** after some period of use.
- Many components exhibit a high, but decreasing, failure rate early in their life, followed by a period of a relatively constant failure rate, and ending with an increasing failure rate. The early failure period is sometimes called the **infant mortality period**.
- Reliability is often modeled using an exponential probability distribution. Not only is this model mathematically justified, but it has been empirically validated for many observable phenomena, such as failures of light bulbs, electronic components, and repairable systems such as automobiles, computers, and industrial machinery. The reliability function, specifying the probability of survival, is $R(T) = 1 - e^{-\lambda T}$.
- Many systems are composed of individual components with known reliabilities. The reliability data of individual components can be used to predict the reliability of the system at the design stage. Systems of components may be configured in *serie*s, in *parallel*, or in some mixed combination. Many techniques are used to optimize the reliability of products. These include standardization, redundancy, and physics of failure.
- Design optimization includes setting proper tolerances to ensure maximum product performance and making designs **robust**; that is, insensitive to variations in manufacturing or the use environment.

- A scientific approach to tolerance design uses the **Taguchi loss function.** Taguchi assumes that losses can be approximated by a quadratic function so that larger deviations from target correspond to increasingly larger losses. For the case in which a specific target value, T, is determined to produce the optimum performance, and in which quality deteriorates as the actual value moves away from the target on either side (called "nominal is best"), the loss function is represented by

$$L(x) = k(x - T)^2$$

- Techniques for design verification include formal reliability evaluation. These include **accelerated life testing,** which involves overstressing components to reduce the time to failure and find weaknesses; and **burn-in**, or *component stress testin*g, which involves exposing integrated circuits to elevated temperatures in order to force latent defects to occur.
- Six Sigma performance depends on reliable measurement systems. Common types of measuring instruments used in manufacturing today fall into two categories: "low-technology" and "high-technology." Low-technology instruments are primarily manual devices that have been available for many years; high-technology describes those that depend on modern electronics, microprocessors, lasers, or advanced optics.
- **Metrology--**the science of measurement **–** is defined broadly as the collection of people, equipment, facilities, methods, and procedures used to assure the correctness or adequacy of measurements, and is a vital part of global competitiveness.
- **Accuracy** is defined as the closeness of agreement between an observed value and an accepted reference value or standard. **Precision** is defined as the closeness of agreement between randomly selected individual measurements or results.
- **Repeatability**, or **equipment variation**, is the variation in multiple measurements by an individual using the same instrument. **Reproducibility**, or **operator variation**, is the variation in the same measuring instrument when it is used by different individuals to measure the same parts, and indicates how robust the measuring process is to the operator and environmental conditions.

Repeatability and reproducibility require a study of variation and can be addressed through statistical analysis.

- **Calibration** is the comparison of a measurement device or system having a known relationship to national standards against another device or system whose relationship to national standards is unknown. Measurements made using uncalibrated or inadequately calibrated equipment can lead to erroneous and costly decisions. Many government regulations and commercial contracts require regulated organizations or contractors to verify that the measurements they make are *traceable* to a reference standard.
- **Process capability** is the range over which the natural variation of a process occurs as determined by the system of common causes; that is, what the process can achieve under stable conditions. The relationship between the natural variation and specifications is often quantified by a measure known as the **process capability index,** C_p.
- A **process capability study** is a carefully planned study designed to yield specific information about the performance of a process under specified operating conditions. Three types of studies are a *peak performance study*, *process characterization study*, and *component variability study*.