Session 6 - LABOR AND APPLICATION OF MECHANICAL ENGINEERING

ENGINEERING VERSUS SCIENCE

- Scientists
  - Understand why our world behaves the way it does ("laws of nature")
  - Study the world as it is
  - Thinkers
- Engineers
  - Apply established scientific theories and principles to develop cost-effective solutions to practical problems
    - Cost effective
      - Consideration of design trade-offs (esp. resource usage)
      - Minimize negative impacts (e.g. environmental and social cost)
    - Practical problems
      - Problems that matter to people
  - Change the world
  - Doers

ABET's Definition of Engineering

- ABET (The Accreditation Board for Engineering and Technology)
  - Recognized in the United States as the sole agency responsible for accreditation of educational programs leading to degrees in engineering
- "Engineering is the profession in which a knowledge of the mathematical and natural sciences, gained by study, experience, and practice, is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of [hu]mankind"

Engineering Disciplines

- Mechanical engineering
- Electrical engineering
- Civil engineering
- Chemical engineering
- Industrial engineering
- Computer engineering
  - A subspecialty within electrical engineering at many institutions

- Specialized, Non-Traditional Fields
  - Aerospace engineering
  - Materials engineering
  - Biomedical engineering
  - Nuclear engineering

        - etc.

Electrical/Computer Engineering (ECE)

- Largest of All Engineering Disciplines
    - About 353,000 or 26% (out of 1.4 million engineers) were electrical and computer engineers (U.S. Department of Labor Statistics in 2005)
- Concerned with electrical devices and systems and with the use of electrical energy
- Specialties
    - Electronics
        - Design of circuits and electric devices to produce, process, and detect electrical signals
    - Communications
        - A broad spectrum of applications from consumer entertainment to military radar
- Specialties (Cont.)
    - Power
        - Generation, transmission, and distribution of electric power
            - Conventional generation systems (e.g. hydroelectric, steam, and nuclear)
            - Alternative generation systems (e.g. solar, wind, fuel cells)
    - Controls
        - Design of systems that control automated operations and processes
    - Instrumentation
        - Use of electronic devices to measure parameters (e.g. pressure, temperature, flow rate, speed, etc)
        - Processing, storing, and transmitting the collected data

Mechanical Engineering

- Second Largest Engineering Discipline
    - About 221,000 or 16% (out of 1.4 million engineers) were mechanical engineers (U.S. Department of Labor Statistics in 2005)
- Concerned with designing tools, engines, machines, and other mechanical equipment
- Areas
    - Energy
        - Production and transfer of energy and conversion of energy from one form to another
    - Structures and motion in mechanical systems
        - Design of transportation vehicles, manufacturing machines, office machines, etc.
    - Manufacturing
        - Design and build requisite equipment and tools to convert raw materials into final products

Industrial Engineering

- "Industrial Engineering is concerned with the design, improvement, and installation of integrated systems of people, material, information, equipment, and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems (IIE (Institution of Industrial Engineering), 1985)
- Also known as systems engineering, production engineering, operations management
- Fields
  - Operations research
  - Human factors
  - Quality control
  - etc.
- Operations Research
  - Uses methods like mathematical modeling, statistics, and algorithms to arrive at optimal or good decisions in complex problems
- Human Factors (or Ergonomics)
  - Application of scientific information concerning humans to the design of objects, systems and environment for human use (IEA (International Ergonomics Association), 2007)
  - Physical human factors
    - Deals with the human body's responses to physical and physiological stress
  - Cognitive human factors
    - Mental processes (e.g. perception, attention, cognition, motor control, and memory storage and retrieval) as they affect interactions among humans and other elements of a system
  - Organizational human factors (macroergonomics)
    - The optimization of socio-technical systems, including their organizational structures, policies, and processes
- Quality Control
  - Ensure products or services are designed and produced to meet or exceed customer requirements
- Similarity to Other Engineering Disciplines
  - Trained in the same basic ways as other engineers
    - Take foundation courses in mathematics, physics, chemistry, humanities, and social sciences
- Difference from Other Engineering Disciplines
  - Emphasis on both people and technology
    - Focuses on how people interact with a system
    - Concern for the human element leads to system designs that enhance the quality of life for all people

Design

- Wikipedia Definition

  - Process of originating and developing a plan for a product, structure, system, or component
- Achieve Goals with Constraints
  - Goals
    - The purposes of the design
      - What is for? Who is it for? Why do they want it?
  - Constraints
    - Material, cost, time, regulation, etc.
  - Trade-off
    - Which goals or constraints can be relaxed so that others can be met
- Understand the Material
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How to Make Good Design

- Recognize that systems are built for users and thus must be designed for the users
- Recognize individual differences
- Recognize that the design of things and procedures can influence human behavior and well-being
- Emphasize empirical data & evaluation
- Rely on scientific method
- Recognize that things, procedures, environments, and people do not exist in isolation

What Is NOT Good Design

- NOT just applying checklists and guidelines
  - These can help, but user-centered design (UCD) is a design philosophy and process
- NOT using oneself as the model user
  - Know your real users; recognize variation in humans
- NOT just common sense
  - e.g. “a picture is worth a thousand words” does not always hold