I. Definition of ENGINEERING

- **Engineering** is the profession in which a knowledge of the mathematical and natural sciences, gained by study, experience, and practice, is applied with judgement to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.

- Engineers turn ideas into reality; i.e. they create useful products and systems (through design and manufacturing/construction).
- **Creativity** is playing with imagination and possibilities, leading to new and meaningful connections and outcomes while interacting with ideas, people, and the environment. This is what engineers do (another possible definition of engineering) - in regard to the man-made environment.

- **Art** - something we create
- **Fine art** - Created mainly for aesthetic purpose
- **Craft** - Created for functional and aesthetic purposes

II. Historical Perspective

- **Technology** - Manifestation of engineering creativity with a purpose (innovation)
  - Example: Problem of sending someone to the moon and returning to earth (1968). The technology needed for this purpose had to be created by engineers
  - Materials
  - Vehicle
  - Control Systems
  - Etc.

- When did engineering begin? Whenever there was an invention and innovation
  - First tools in ancient times (hunting)
  - Agricultural / farming processes
  - Invention of fire, wheel, woven materials
  - Use of metal / alloys
Ancient civil engineering achievements
- Great wall of China; Egyptian pyramids
- Roman roads, aqueducts, structures
- Technological advances related to military ventures

Dark ages and Middle ages
- Arabs developed paper, chemistry, optics
- Chinese developed clock, astronomical instruments, spinning wheel, gunpowder
- Leonardo Da Vinci - designed catapults, bridges and buildings, and sketched future engineering devices such as the machine gun, tanks, helicopter, drawbridge, etc.

Developing industrial age
- 15th century: Gutenberg’s printing press
- 1600’s: Galileo discovered gravity and studied the solar system
- Pascal’s barometer (with Toricelli)
- Newton’s law of motion; differential calculus
- 18th century: Steam engine; capacitor; battery
- 19th century: Electrical current; electromagnetic waves

20th Century
- Rapid advances in materials (e.g. plastics), manufacturing (automotive), nuclear power, space program, computers (information technology), biotechnology

III. Future Challenges
- Global warming
- Sustainable development
- Environment
- Infrastructure
- Human health and welfare
- Education & training
- Globalization of economy

IV. Technology Team
- In the past the knowledge of research, development, design and manufacture of a product or system usually concentrated in a single person, and this person “directed” all associated work

Today, technology has become very advanced and sophisticated, so a technological team is needed to study and solve the problems. This technology team is compromised of:
- Scientists
- Engineers
- Technologists
- Technicians
- Craftpersons

Scientists pursue new knowledge through research; focus on understanding nature and associated phenomena
- The scientific method is the essence of research work conducted by the scientists. Its steps are:
  1. Formulate a hypothesis (describing a natural phenomena)
  2. Conceive and conduct experiments to test the hypothesis
  3. Analyze results and state conclusions
  4. Generalize hypothesis into a law or theory (if results are valid)
  5. Publish the new knowledge
• Engineers apply mathematical and scientific knowledge to the solution of problems and the development of devices, processes, structures, and systems for the benefit of all humans

• Scientist seeks to know, whereas engineer aims to do. However, often the distinction between the two is blurred.

• The end result of an engineering effort is usually a design, which must be accomplished through a systematic process. The design process involves:
  1. Identification of a need
  2. Problem definition
  3. Search
  4. Constraints
  5. Criteria
  6. Alternative solutions
  7. Analysis and synthesis
  8. Decision
  9. Specification
  10. Communication

The process is usually iterative, and may be modified as circumstances dictate.

• Technologists and technicians perform much of the work of converting the ideas of scientists and engineers into tangible results. A technologist generally possesses a bachelors degree (4 years) and a technician an associate degree (2 years). Technologists and technicians typically obtain a basic knowledge of a specific engineering field along with manual skills to perform tasks such as drafting, estimating, model building, data recording and reduction, troubleshooting, servicing and specification writing.

• Members of the skilled trades possesses the skills to produce and assemble the parts, components and systems specified by scientists, engineers, technologists and technicians. Welders, machinists, electricians, carpenters, plumbers, and masons are typical of the skilled trades.

V. Functions of the Engineer

The engineering functions can be listed as:

- Research
- Development
- Design
- Production
- Testing
- Construction
- Operations
- Sales
- Management
- Consulting
- Teaching

VI. Engineering Disciplines

Electrical / Computer Engineering __________ 33.1 %
Mechanical / Aerospace Engineering __________ 27.5 %
Civil / Environmental Engineering __________ 15.8 %
Chemical / Petroleum Engineering __________ 8.6 %
Industrial/Manufacturing Engineering/Management __ 5.3 %
Others ___________________________ 9.7 %
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<th>Field</th>
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| Electrical / Computer Engineering | - Communications: Telephone, TV, radio, radar  
                                - Power: generation and distribution of electricity  
                                - Electronics: Solid-state circuits, microprocessors  
                                - Measurement and control: sensors  
                                - Computers: wide range of applications |
| Mechanical Engineering       | - Energy utilization: Refrigeration, heating, ventilating  
                                - Machines and mechanisms: Automotive, robotics, work machines, tools  
                                - Materials: composites |
| Aerospace Engineering        | - Aerodynamics  
                                - Propulsion  
                                - Orbital mechanics  
                                - Stability and control  
                                - Structures |
| Industrial Engineering       | - Production: optimization (time, method)  
                                - Human factors: man/environment  
                                - CAD / CAM  
                                - Engineering Management |
| Chemical Engineering         | - Use of chemical / physical principles to create and maintain a suitable environment  
                                - CHE’s create, design, and operate processes that produce useful materials such as fuels, plastics, structural materials, food products, health products, fibers, and fertilizers.  
                                - They might work in:  
                                    - A laboratory (research)  
                                    - A pilot plant (feasibility with unit operations)  
                                    - A full scale plant (fire time unit operating)  
                                    - Unit operations are fundamental chemical and physical processes that are utilized by the chemical engineer to produce a desired system. (examples: separation, recrystallization, oxidation/reduction) |
Civil Engineering

Civil Engineers
• Plan
• Design
• Evaluate
• Construct
• Integrate

LARGE FACILITIES, such as:
• Buildings
• Industrial Plants
• Bridges
• Transportation / Highway Networks
• Harbors, Airports
• Recreation Parks
• Water / Sewer Networks
• Waste Disposal Systems
• Space Stations
• ETC.

Professional Services of CE’s Include:
• Real Estate Development
• Infrastructure Evaluation
• Environment Quality / Public Health
• Project / Facilities / Program Management
• Natural Disaster Management
• Teaching / Training / R & D

Specializations:
• Structures
• Transportation
• Geotechnical
• Environmental
• Construction

Careers:
• Government
  - Federal
  - State
  - Local
• Industry
  - Manufacturing
  - Automotive
  - Computers / IT
  - Power / Energy
  - Chemicals
  - Insurance and Banking
  - Miscellaneous

Consulting
- A/E; Design
- Construction Services
- Testing and Evaluation
- Forensic Work / Arbitration
- Management

Construction Enterprises
- Contractor
- Subcontractor
- Supplier
ENGINEERING EDUCATION

- BSE → Professional Practice
- BSE → MSE → Professional Practice
- BSE → MSE → Ph.D → Academic Professional
- Academic study and professional career can be combined
- Academic study and professional career can be combined with professional practice

Baccalaureate Curriculum (per ABET):

Engineering programs must demonstrate that their graduates have:
(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments as well as to analyze and interpret data
(c) an ability to design a system, component or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively.

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in lifelong learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

- Undergraduate education - Broad based
- Graduate education - specialized
- “Master’s” as the first Professional Degree

Professional Practice

Professionalism and ethics

Profession: “The pursuit of a learned art in the spirit of public service”, ASCE

Attributes: AAES
- It must satisfy an indispensable and beneficial social need
- Its work must require the exercise of discretion and judgement, and not be subject to standardization
- It is a type of activity conducted upon a high intellectual plane
  - Its knowledge and skills are not common possessions of the general public; they are the results of tested research and experience and are acquired through a special discipline of education and practice.

Code of Ethics for Engineers _ NSPE

Preamble: Engineering is an important and learned profession. The members of the profession recognize that their work has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness and equity, and must be dedicated to the protection of the public health, safety and welfare. In the practice of their profession, engineers must perform under a standard of professional behavior which requires adherence to the highest principles of ethical conduct on behalf of the public, clients, employers and the profession.
**Fundamental Canons:**

Engineers, in the fulfillment of their professional duties, shall:
1. Hold paramount the safety, health and welfare of the public in the performance of their professional duties.
2. Perform services only in the areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act in professional manner for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts in the solicitation of professional employment.

**Why Ethics Codes?**

- Collective recognition of the responsibilities of the individual practitioners
- Guide or reminder with respect to behavior in specific situations
- Support or enforcement procedures of professional societies or licensing agencies
- "Excuse" for ethical behavior when there are countervailing pressures to meet a deadline, cut costs, cover up a blunder, make a sale, etc.

**Professional Engineer Registration/Licensure**

**Why PE Licensure?**

- Admission to the engineering profession
- Must be PE to perform consulting work, engage in private practice, enter into contracts, submit original designs, plans, specifications for approval.
- Promotion to supervisory position; professional advancement; bonus, etc.

**How to become a PE?**

1. Graduate from a four-year ABET-accredited engineering program
2. Passing the FE (EIT) exam*
3. Completion of a required number of years of acceptable engineering practice
4. Passing the PE Exam**

* PE Exam: 8 hrs AM, 4 hrs PM, multiple choice
  PM part - Choice out of six: Chemical, Civil, Electrical, Mechanical, Industrial, or General (like AM)

** PE Exam: Discipline specific - 8 hrs; 4 hrs AM, 4 hrs PM
  AM part - Essays
  PM part - Problems (multiple choice)
Licensure is administered by individual state engineering registration boards.