Design Thinking Laboratory

Origin of The Word -Engineer

- The word ‘engine’ comes from the Latin ‘ingenerare’, meaning ‘‘to create.’’
- The Latin word ingenium (‘‘the product of genius’’) was used to describe the design of a new machine.
- In English, ‘‘ingen’’ was spelled ‘‘engine,’’ and people who designed creative things were known as ‘‘engine-ers.’’
- what is an engineer? :

An engineer is a creative, ingenious person.

- What does an engineer do? :

Engineers create (i.e., design) ingenious solutions to societal problems.

Engineering – A moving Target

- The World is changing fast with the advancement of Technology in every sphere.
- IT has made the speed of change phenomenal in recent years.
- This makes knowledge and skills required by an engineer a ‘Moving Target’
- Also engineering has become multidisciplinary in nature.

  e.g. a smart Car- is a convergence of many technologies

Multidisciplinary nature of Engineering Problems

- Engineering problems are becoming more and more interdisciplinary in nature

  - Discussion on Car Manufacturing
  - Discussion on any Food Processing
  - Discussion on Simulation and analysis by engineer (Need of Computers)
  - Discussion on Satellite as a product
  - Discussion on Space technology, rocket launching
  - Discussion on Ship building industry

Science as a foundation for Engineering

- Laws of Nature
  - Gravity
  - Viscosity
  - Heat transfer
  - Atomic structure, atomic forces
  - Speed of light
  - Electrons, protons, neutrons
  - Condensation, evaporation, Gas Laws
- Quantification is the Engineers way of using science.
  - Engineers works with numbers, mathematics and units
  - Fundamental laws of nature are independent of the system of units but engineers use them with units.

Science as a foundation for Engineering

- Engineers use the laws of science and develops a technology
  e.g: Rocket technology on Newton's third law of motion

- Engineers molds laws of science into appropriate mathematics to develop the technology or explore unknown areas. (Hypersonic- unknown area)

- Engineers extensively use the experiments to establish relation between science and the reality, so that technology can be made trust worthy and safe. (wind tunnel tests , Drop test etc.)

Engineers sometimes help science to prove certain fundamental scientific hypothesis

e.g. “God Particle Experiment”, “Things fall on earth at same time irrespective of mass.”

(Experimental set up of both)

Engineering Tasks

Following are some examples of engineering tasks which an engineer or his team is suppose to perform

- Build the highest building in the world in a given geographical location.
- Design a Fuel cell car of certain capacity.
- Design a Roti making machine.
- Design a technology for Recycling a particular type of waste from a process.
- Achieve a maximum speed of train with given conditions.
- Reduce the fatal accidents happening on road due to over speeding.
- Reduce failure rate of processor fans.
- Increase the life of a smartphone battery.

Refer the programs like “Mega structures” , “Extreme Engineering” on Discovery channel.

What is Design…?

- *Design is to pull together something new or to arrange existing things in a new way to satisfy a recognized need of society.*

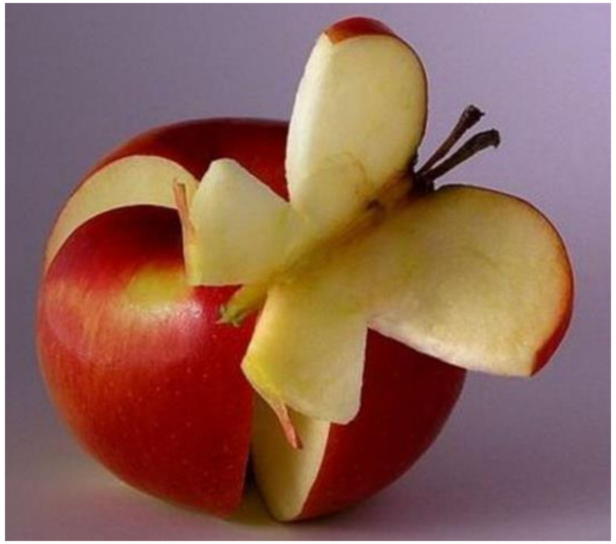
- *The ability to design is both a science and an art.*
  - *The science can be learned through techniques and methods, but the art is best learned by doing design itself.*

- Good design requires both Analysis and Synthesis.
  - *Analysis* is an exercise done to know facts regarding the design with some specific approach or objective.
  - *Synthesis* involves the identification of the right design elements that will comprise the product.

    Synthesis is a scheme to generate a possible way the product work. It will also be called as concept design. In the design process a number of concepts will be identified and then the best concept is chosen for further development.

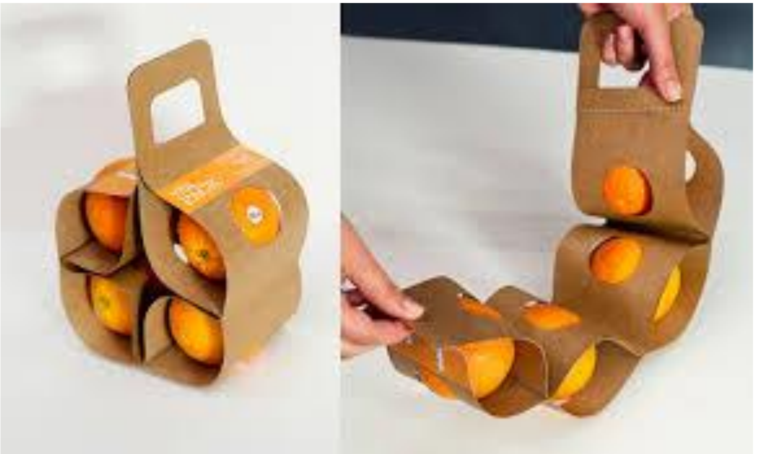
The Four C’s of Design:

- **Creativity :** Requires creation of something that has not existed before or has not existed in the designer’s mind before



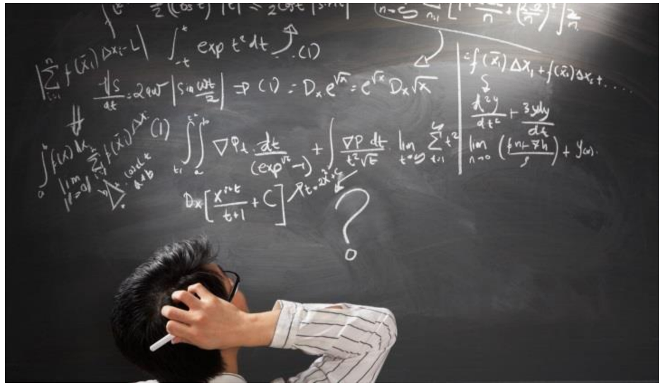
Creativity

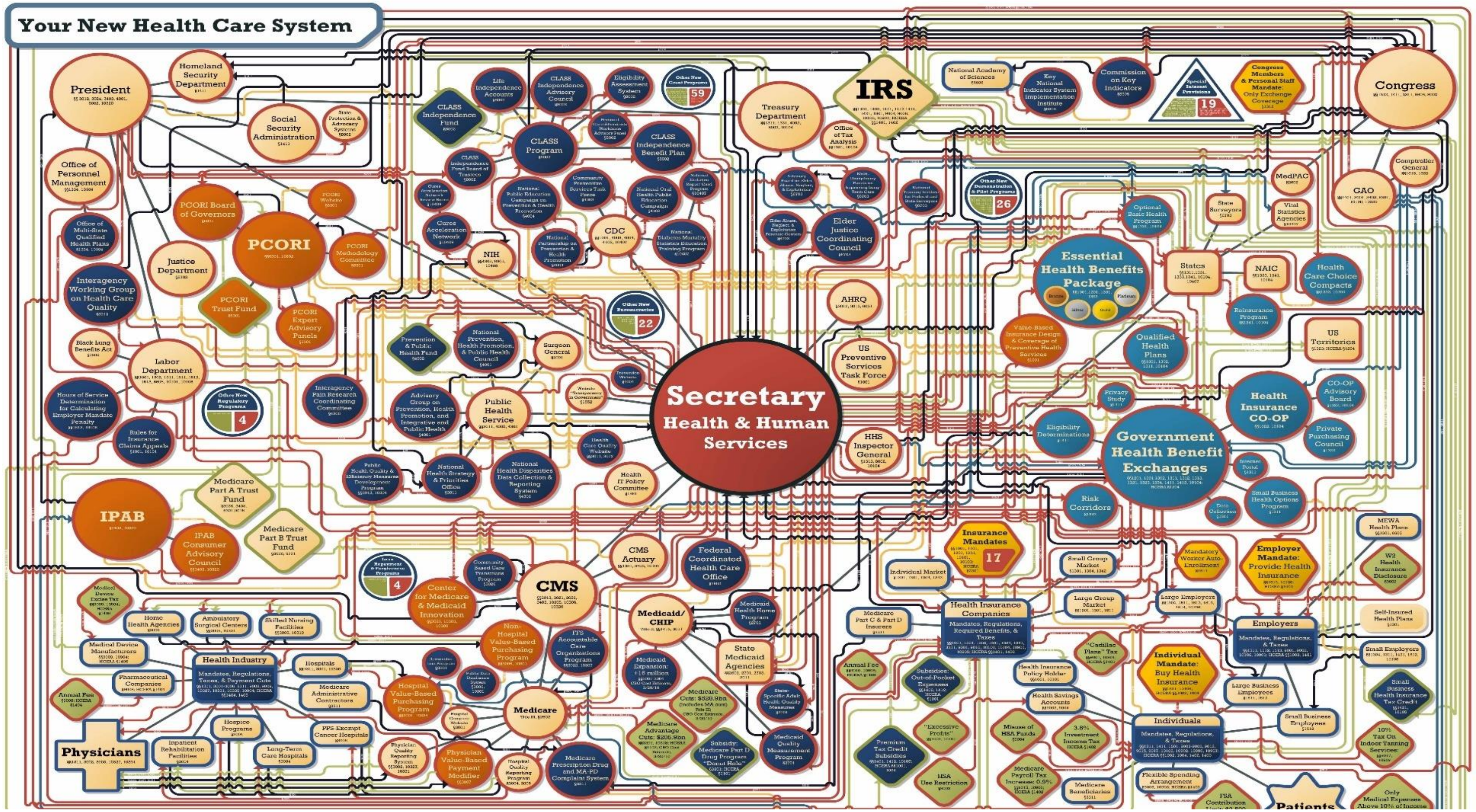
Creativity



The Four C’s of Design:

- **Complexity/CriticalThinking:** Requires decisions on many variables and parameters





The Four C's of Design:

- **Choice :** Requires making choices between many possible solutions at all levels, from basic concepts to the smallest detail of shape

The Four C's of Design:

- **Compromise:** Requires balancing multiple and sometimes conflicting requirements

Airplane (Stronger & Lighter)

Size (Smaller & Easy to handle,
impressive)

Cost (low & high reliability, quality)

Engineering Design Process

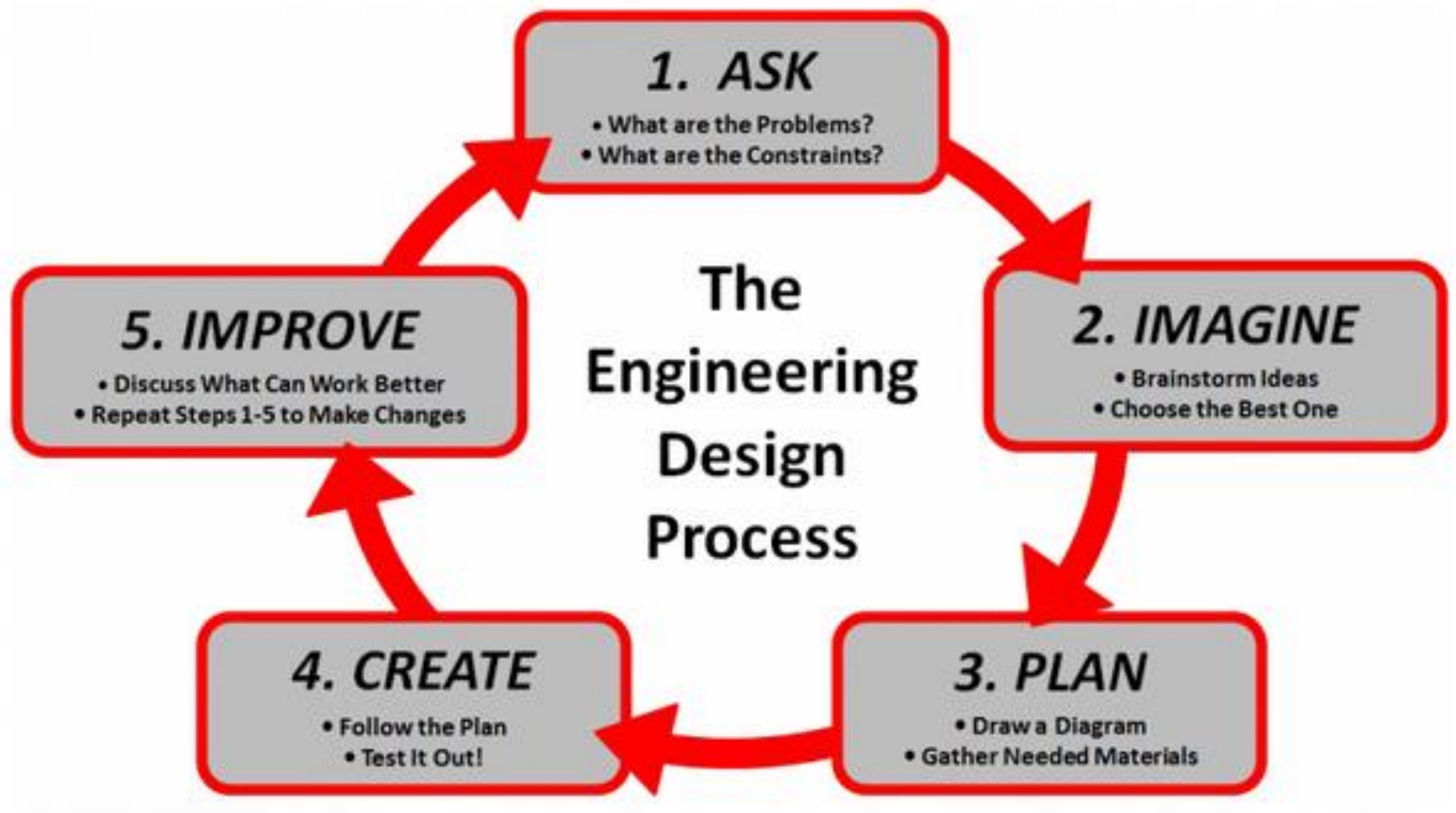


Fig. Engineering Design Process

Types of Designs

1. *Original design/Innovative design:*
   - This form of design is at the top of the hierarchy.
   - It employs an original, innovative concept to achieve a need.

Types of Designs

1. *Adaptive design:*

- This form of design occurs when the design team adapts a known solution to satisfy a different need to produce a *novel application*.
- E.g. Adapting the ink-jet printing concept to spray binder to hold particles in place in a rapid prototyping machine

Types of Designs

1. *Redesign:*
   - The task may be to redesign a component in a product that is failing in service, or to redesign a component so as to reduce its cost of manufacture. Often redesign is accomplished without any change in the working principle or concept of the original design.
   - (Bicycle pump)

Redesign Example

1. Selection design:

- Most designs employ standard components such as bearings, small motors, or pumps that are supplied by vendors specializing in their manufacture and sale.
- Therefore, in this case the design task consists of selecting the components with the needed performance, quality, and cost from the catalogs of potential vendors.
- *(Bulb Holder Assembly)*

Ways To Think About The Engineering Design Process…..

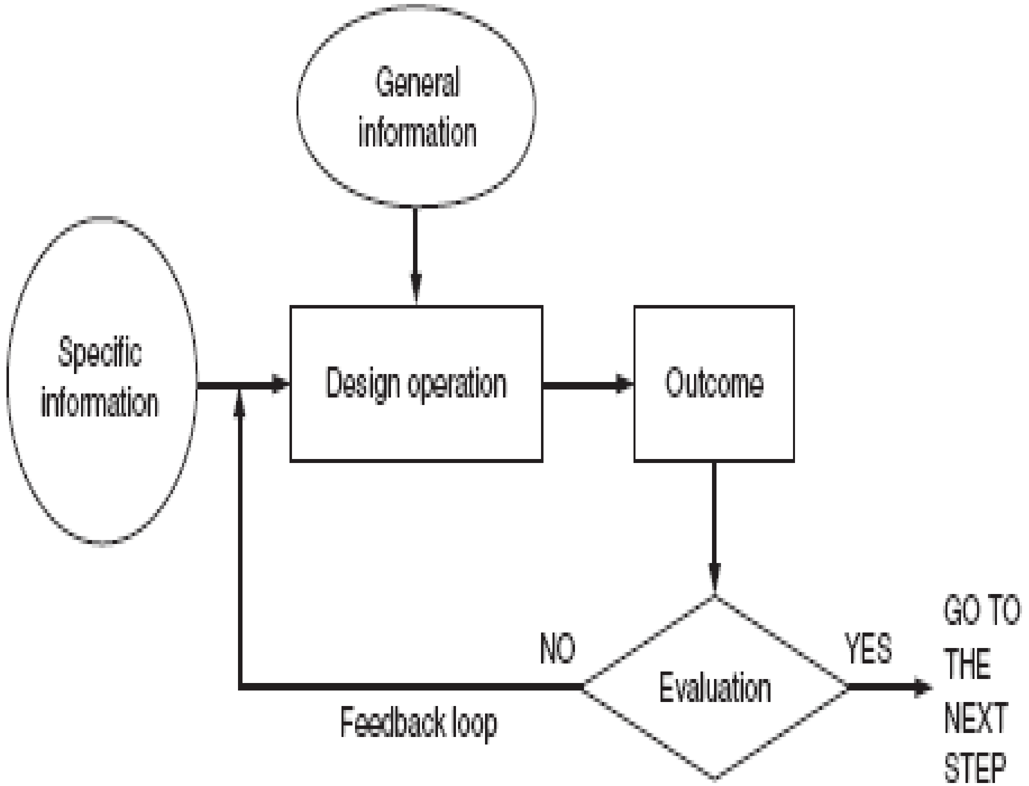
Design as a System

A system may be

- An electric power distribution network for a region of the nation,
- A complex piece of machinery like an aircraft jet engine, or a
- Combination of production steps to produce automobile parts.

A large system usually is divided into *subsystems* , which in turn are made up of *components* or *parts* .

Design as a Simplified Iteration Model



- As per Morris Asimow, design process consists of the elements as shown in figure
- Examples of the operations might be,
  - Exploring the alternative concepts that could satisfy the specified need.
  - Formulating a mathematical model of the best system concept.
  - Specifying specific parts to construct a subsystem.
  - Selecting a material from which to manufacture a part.
- The iterative nature of design provides an opportunity to improve the design on the basis of a preceding outcome.
- That, in turn, leads to the search for the best possible technical condition—for example, maximum performance at minimum weight (or cost). – (Motive for R & D)

3. Design as a Problem-Solving Methodology

- Design is a problem-solving methodology that is useful in design consists of the following steps.
  - Definition of the problem:
    - The formulation of the problem should start by writing down a problem statement.
    - Problem definition often is called *needs analysis.*
    - It is important to identify the needs clearly at the beginning of a design process.
  - Gathering of information: The following are some of the questions concerned with obtaining information:
    - What do I need to find out?
    - Where can I find it and how can I get it?
    - How credible and accurate is the information?
    - How should the information be interpreted for my specific need?
    - When do I have enough information?
    - What decisions result from the information?
  - Generation of alternative solutions:

    It involves
    - The use of creativity stimulation methods.
    - The application of physical principles and qualitative reasoning.
    - The ability to find and use information.
    - Experience helps greatly in this task.

Design as a Problem-Solving Methodology

- Evaluation of Alternatives and Decision Making:
  - It involves systematic methods for selecting the best among several concepts, often in the face of incomplete information.
  - Engineering analysis procedures provide the basis for making decisions about service performance. e.g. Design for manufacturing analyses & and cost estimation.

- Communication of the Results:
  - It must always be kept in mind that the purpose of the design is to satisfy the needs of a customer or client.
  - The communication is usually by oral presentation to the sponsor as well as by a written design report.
  - Detailed engineering drawings, computer programs, 3-D computer models, and working models are frequently among the “deliverables” to the customer.

Considerations of A Good Design

Considerations of A Good Design

- Considerations of good design classified into three categories:

  1. *Achievement of performance requirements:*
     - Performance measures both the function and the behavior of the design, that is, how well the device does what it is designed to do.
     - Performance requirements can be divided into primary performance requirements and complementary performance requirements.

     E.g. Design may be required to grasp an object of a certain mass and move it 50 feet in one minute, then

     Functional requirements are usually expressed in capacity measures such as forces, strength, deflection, or energy

     Complementary performance requirements are concerns such as the useful life of the design, its robustness to factors occurring in the service environment, its reliability, ease, economy, and safety of maintenance or power output or consumption.

Considerations of A Good Design

1. *Achievement of performance requirements…..*
   - The service conditions under which the product must operate
     (temperature, humidity, corrosive conditions, dirt, vibration, and noise)
   - Fulfilling the environmental requirements
     (maintaining a safe and clean environment, that is, green design.)
   - Aesthetic requirements refer to "the sense of the beautiful."
     (how the product is perceived by a customer because of its shape, color, surface texture etc.)
   - *Human factors:* which uses the sciences of biomechanics, ergonomics, and engineering psychology to assure that the design can be operated efficiently by humans.
   - The final major design requirement is cost.

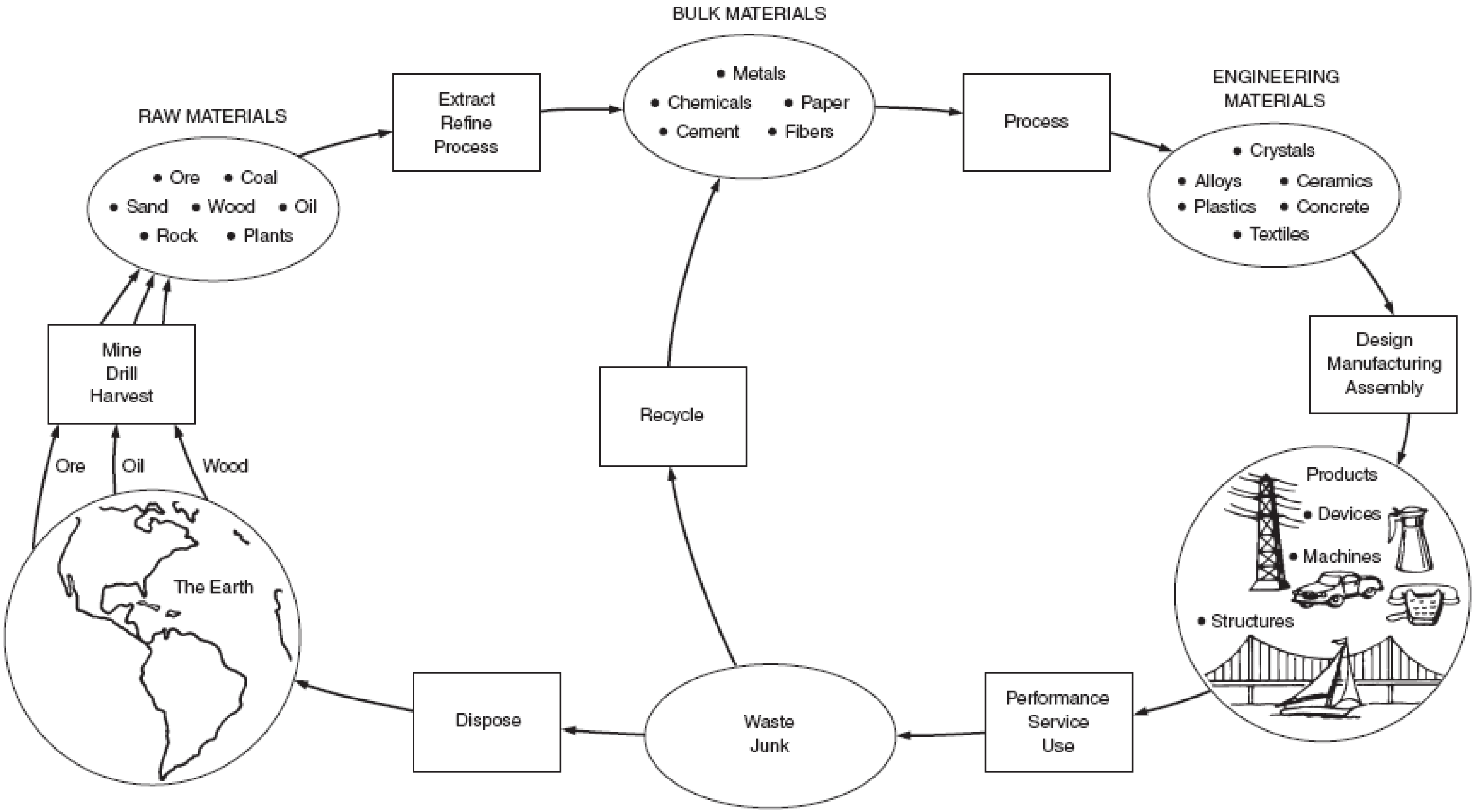
Considerations of A Good Design

2. *Life-cycle issues*

- The total life cycle of a part starts with the conception of a need and ends with the retirement and disposal of the product.

- Material selection is a key element in shaping the total life cycle.

- There is an inherent connection between design and material selection and the manufacturing processes.



Considerations of A Good Design

3. *Regulatory and Social Issues:*

- The standards produced by such societies as ASTM and ASME represent voluntary agreement among many elements (users and producers) of industry.
- Good design requires more than that, it may be necessary to develop your own company or agency standards.
- The codes of ethics of all professional engineering societies require the engineer to protect public health and safety.

Questions

1. In your opinion what is Design?

2. How can we say that the design is a multidisciplinary task?

3. If you consider a product or a system, what are the parameters on which you can say that it is a good design?

4. What is the role of innovation and research in design?

5. What are the required qualities of a Design Engineer?