College of Engineering

GE106:Introduction to Engineering Design

An Overview of Engineering Design

By

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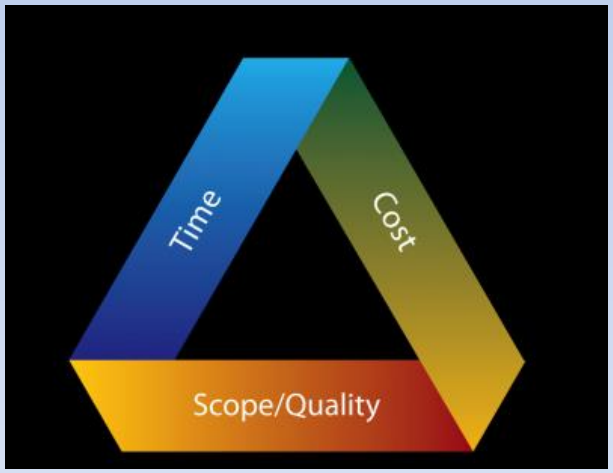
Outline

- What is Engineering Design?
- Importance of Engineering Design
- ABET Engineering Design Requirements
- The Steps Used in the Design Process
  - Problem Statement
  - Brainstorming
  - Search and Research
  - List and Evaluate Alternative Solutions
  - Choose the Best Solution
  - Construction-Create a Prototype or Model
  - Analysis & Testing
  - Final Testing
  - Communication
- Summary

What is Engineering Design?

- Engineering design is the **process** of devising a system, component or process to meet desired needs.
- It is a decision making process in which the , basic sciences, mathematics and engineering are applied to optimally convert resources to meet a stated objective.



- Among the fundamental blocks of this process are: objectives, criteria, synthesis, analysis, construction, testing, and evaluation.
- In addition to these blocks, it is essential to consider realistic **constraints** such as economic factors, safety, reliability, aesthetics, ethics and social factors.

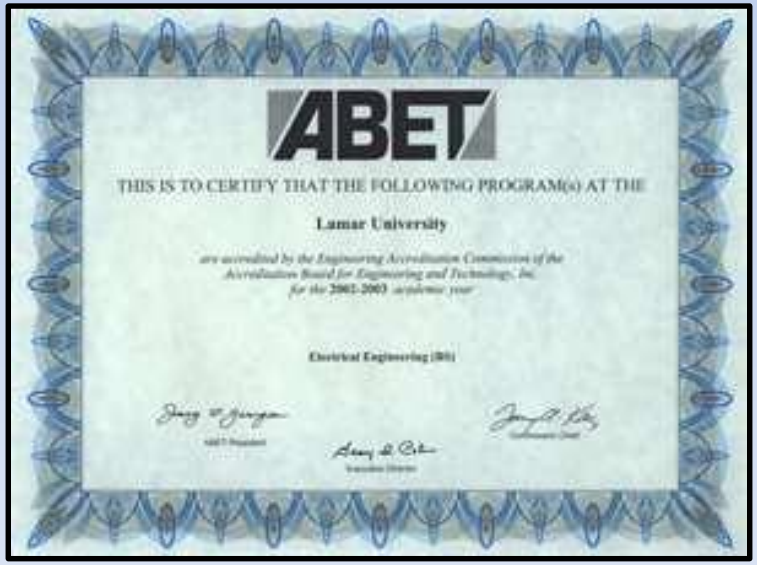
Importance of Engineering Design

- 70% of a product's total cost (design, manufacturing and installation) is determined by its design
- Studies have shown that 50 to 80% of the life cycle costs* of products (maintenance, energy, etc.) are influenced by engineering design

- Costs Include:
  - Material costs
  - Facilities
  - Tooling
  - Labor
  - Other support costs

An ABET Requirement
(Accreditation Board for Engineering and Technology)

- Every Engineering Department must include a major engineering design experience that builds upon the fundamental concepts of: **mathematics, basic sciences, humanities, social sciences, engineering topics, and communication skills.**



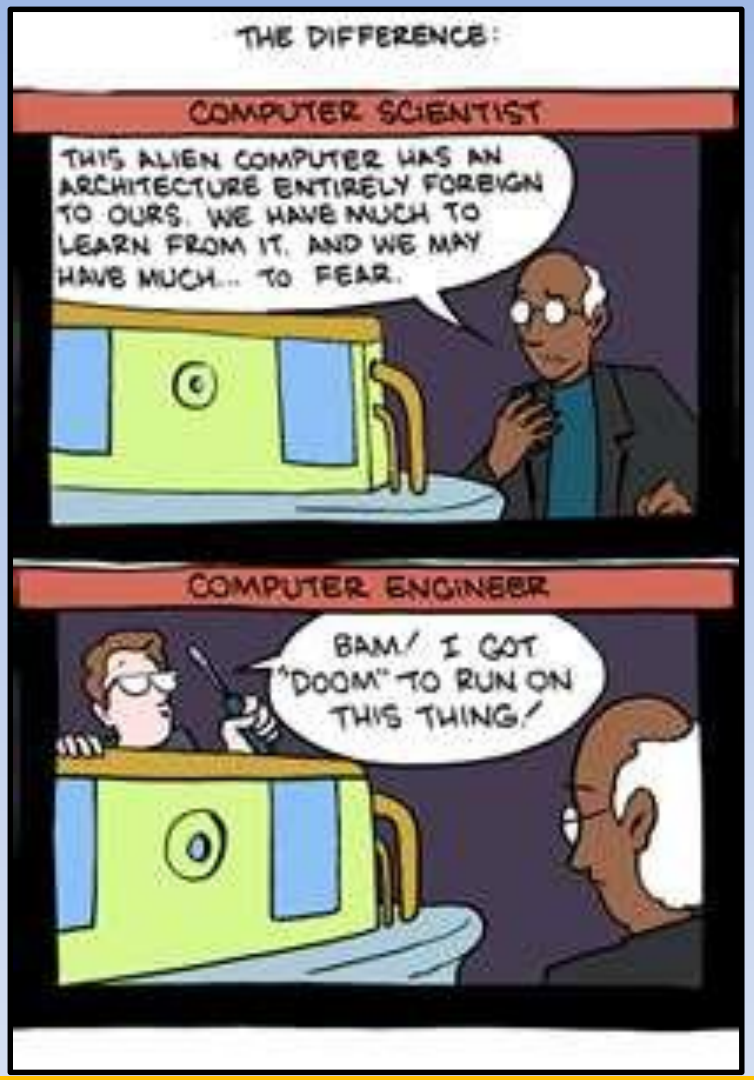
- The scope of the design experience within a program should match the requirements of practice within that discipline.
- All design work should **not** be done in isolation by individual students; team efforts are encouraged where appropriate.
- Many projects at the Junior/Senior level are team oriented.

Engineering

- What is engineering?
- What is your experience with engineering?
- What does it mean to learn to be an engineer in school?
- Can you name one thing in this room that was not developed, produced, or installed by an engineer?
- Can you think of a profession that is affecting your life more pervasively than engineering?
- ***Engineering is the Art of Design***
- ***Starts with a need and end with a product***

Even in the smallest and most remote places on earth, engineering is there shaping life and the environment.

Science versus Engineering



- **Science :** The study of nature and natural processes
- **Engineering:** The use of knowledge of nature and natural processes to solve problems

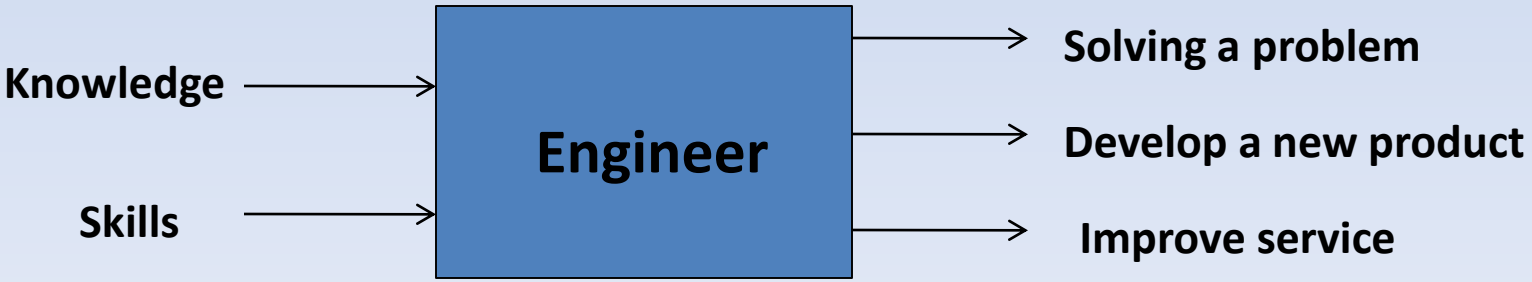
"Scientists discover the world that exists; engineers create the world that never was."

- Theodore Von Karman

Who is the Best Engineer?

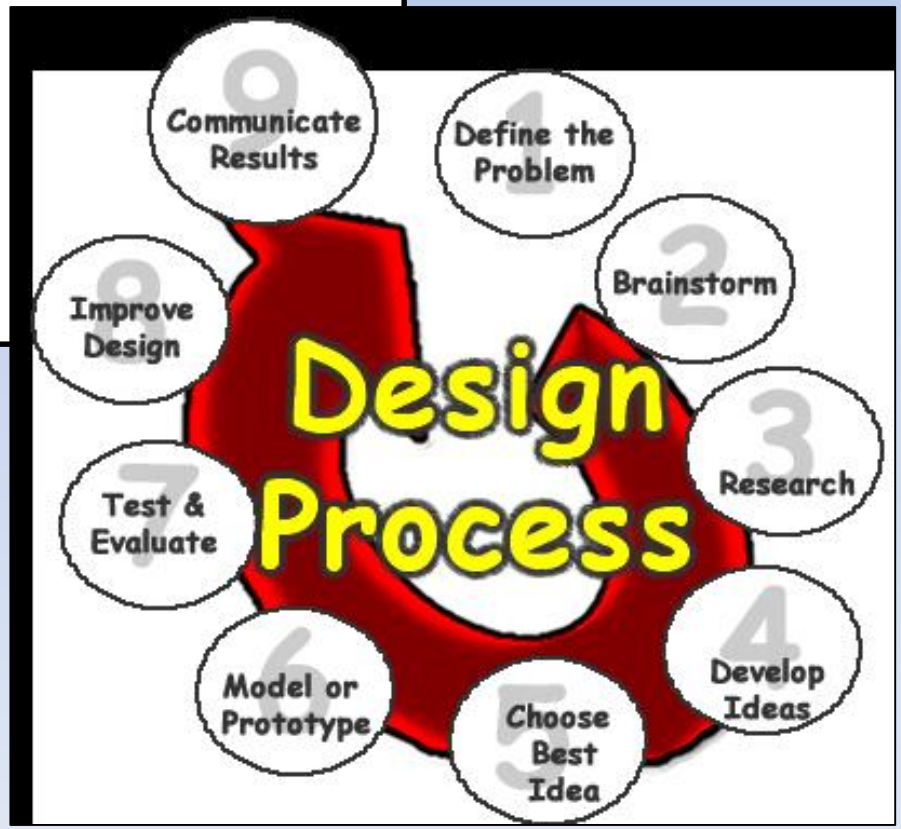
- **"The best engineer is the person who can provide the simplest and more effective solution to solve a problem"**

  K. Åström



The Steps Used in the Design Process

1. Define the Problem (Problem Statement)
2. Brainstorm for creative ideas
3. Search and *re*search
4. Develop Ideas
5. Analyze alternative solutions and choose the best one
6. Model or prototype
7. Test and Evaluate
8. Improve if needed
9. Communicate results



Step 1: Problem Statement

Problem Statement:

"The current box is easily damaged during transportation"

Objective:

"Design a stronger box for our new product"

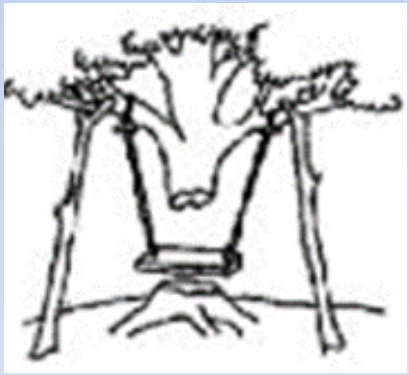
Better Objective (a broader objective):

"Design an improved box*"

Importance of Accurate Objective and Statement **

Problem Definition

Design



Installation

Customer Need

Problem Statement

- This is the single most important step in the design process.
- Only when you can specify the problem can you hope to achieve your goal.
- Loss of efforts and efficiency occurs when trying to solve unclear problems.
- If this step is done incorrectly or incompletely it results in a failure of the design.
- It is important to define the *true problem* one is solving, not just the symptoms of the problem or the perceived problem.

Objectives

- Objectives are a function of needs.
- Objectives should be ***SMART*** ***i.e.,***

  Specific – Exact, precise, detailed, definite, unambiguous.

  Measurable – Quantifiable, computable, calculable, determinate.

  Achievable – feasible, possible, doable, attainable.

  Realistic – sensible, practical, pragmatic reasonable, rational.

  Time-bounded – time-constrained, of a spcecified duration.

Step 2: Brainstorming

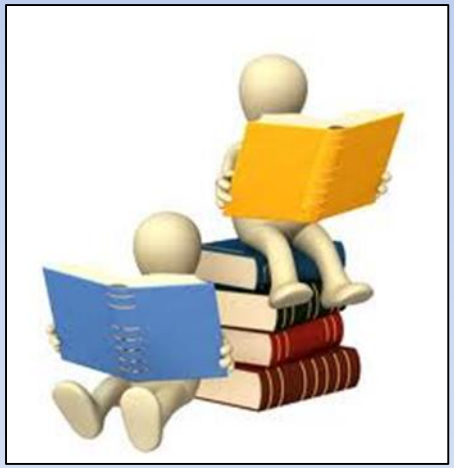
- Think "outside the box".
- Generate creative ideas.
- Explore other members' ideas.
- Avoid criticism/judgment.

*Do not criticize during brainstorming!

*Criticism will be applied at a later stage

Step 3: Search and Research

- **Search** for: finding a product or checking the price of an item.
- **Research***: finding the answers to more complicated questions or looking at multiple aspects of an issue.
- **Possible resources**: Publications, Internet, Market, Patent listings, Sales catalogs, Experts



Creativity

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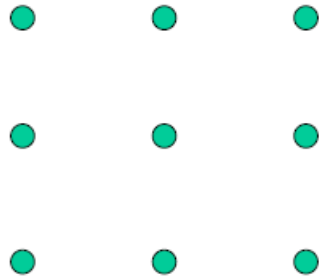
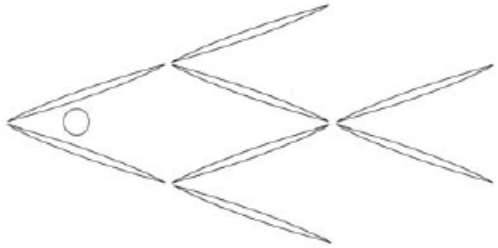
Creativity - Lateral Thinking

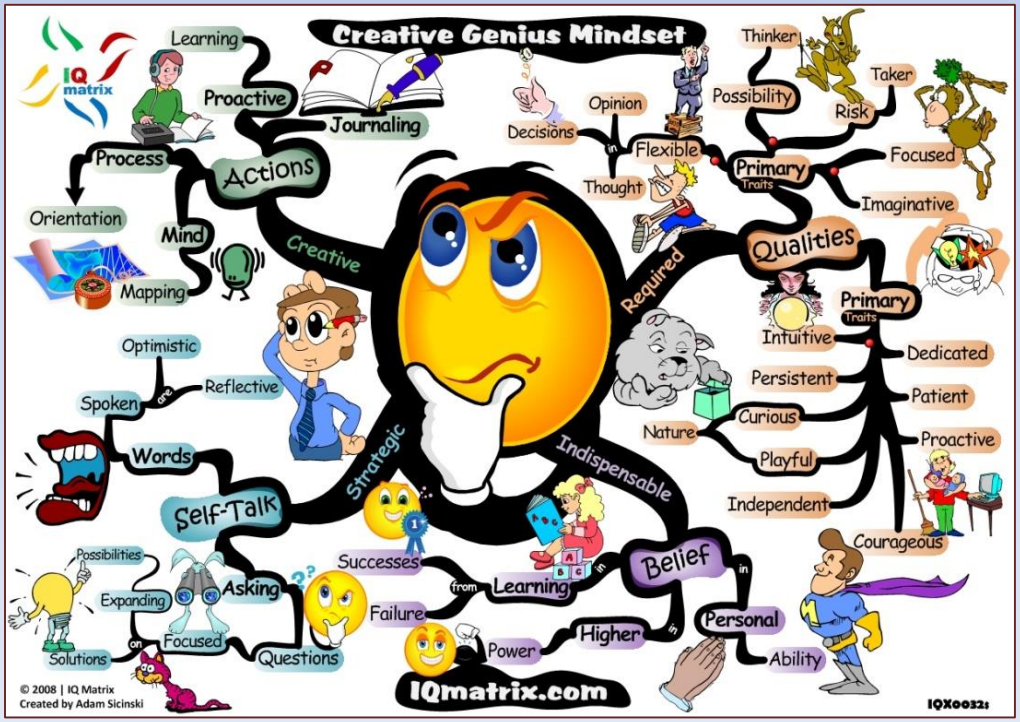
Connect all 9 points with only 4 straight lines



Creativity - Lateral Thinking

Move three toothpicks and only one coin so that the fish swims in the opposite direction





Creativity can lead to all kind-of ideas

Creative people usually have busy thoughts…

Step 4: List and Evaluate Alternative Solutions

One possible solution!!

- Be critical
- Edison: ”It is easy to obtain 100 patents if you also have 5000 unsuccessful inventions*”

Step 5: Choose the Best Solution

	Weight	Rate for Design 1	Rate for Design 2	Rate for Design 3
1. Cost				
2. Production difficulty				
3. Size, weight, strength				
4. Appearance				
5. Convenience				
6. Safety				
7. Legal issues				
8. Reliability/durability				
9. Customer appeal				
TOTAL points	100	points=rate*weight		

Step 6 – Construction, Analysis and Testing

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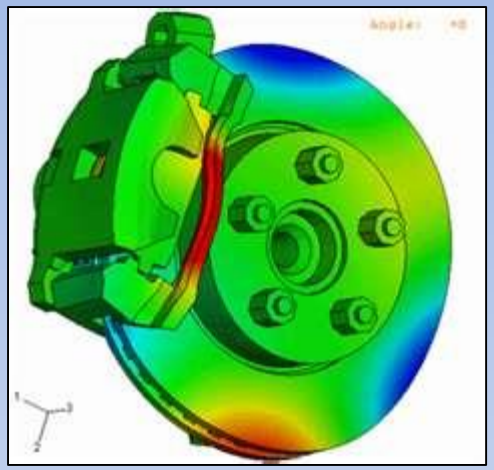
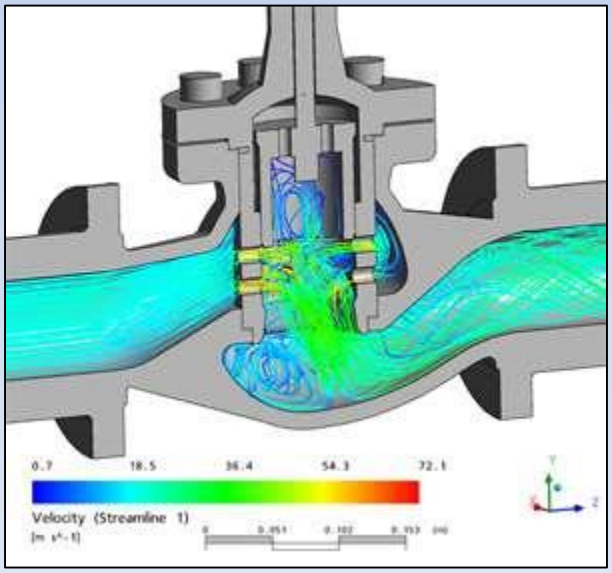
Motor Prototype Testing



Break Squeal FEA Analyses

Toyota RAV4 Prototype Testing



Valve Flow CFD Analyses

Construction, Analysis and Testing (Contd.)

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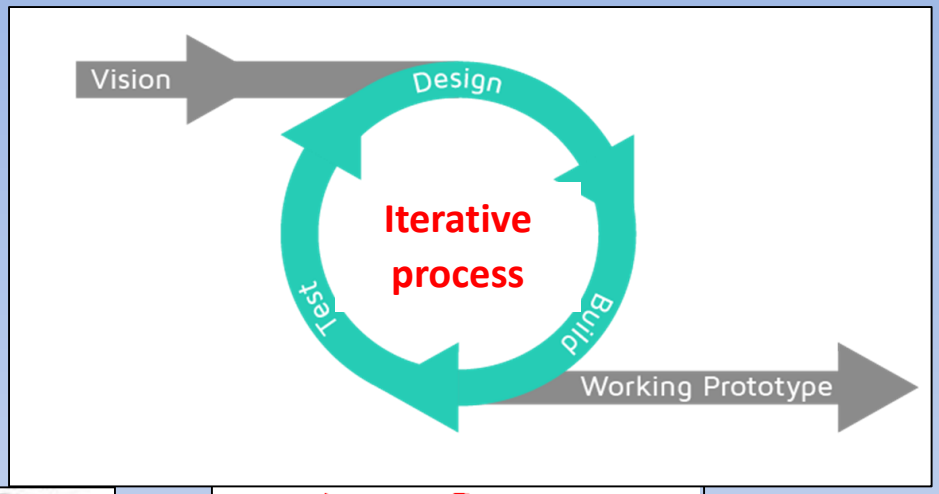

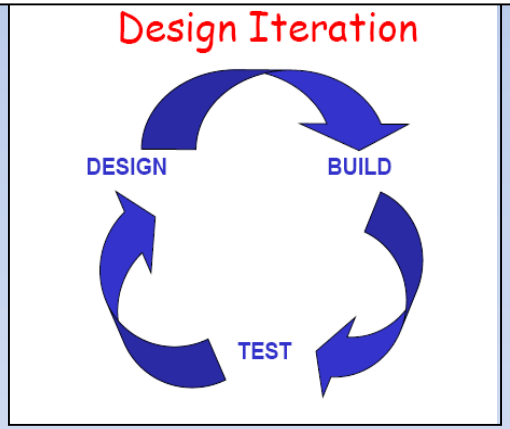

Step 8: Final Evaluation & Improvements

Develop the best design

Step 8: Communicate The Results

Communicate and report on all the final details of the design through:

- **Engineering Notebook (logbook)**
- **Written reports**
- **Technical presentation**
- **Training material, catalogue, manuals***

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