GE105: Introduction to Engineering Design

An Overview of Engineering Design

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Engineering Design

Importance of Engineering Design

- **70%** of a product's total **cost** is determined by its design

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

- Studies have shown that **50** to **80%** of the life cycle costs of products are influenced by engineering design

Engineering Design

- **Definition**
  - 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** and **mathematics** and **engineering sciences** are applied to convert **resources** optimally to meet a stated **objective**.

- Among the fundamental elements of the design process are the **establishment of the objectives** and **criteria**, **synthesis** and **analysis**, **construction**, **testing** and **evaluation**.

- It is essential to include a variety of realistic **constraints** such as **economic factors**, **safety**, **reliability**, **ethics** and **social factors**.

ABET

Objectives

- Each educational program must include a meaningful major engineering design experience that builds upon the fundamental concepts of mathematics, basic sciences , the humanities and social sciences and engineering topics, and communication skills.

- Design is too broad for a single course.

- 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

ABET: Accreditation Board for Engineering and Technology

Engineering

- What is engineering?
- What is your experience with engineering?
- What does it mean 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

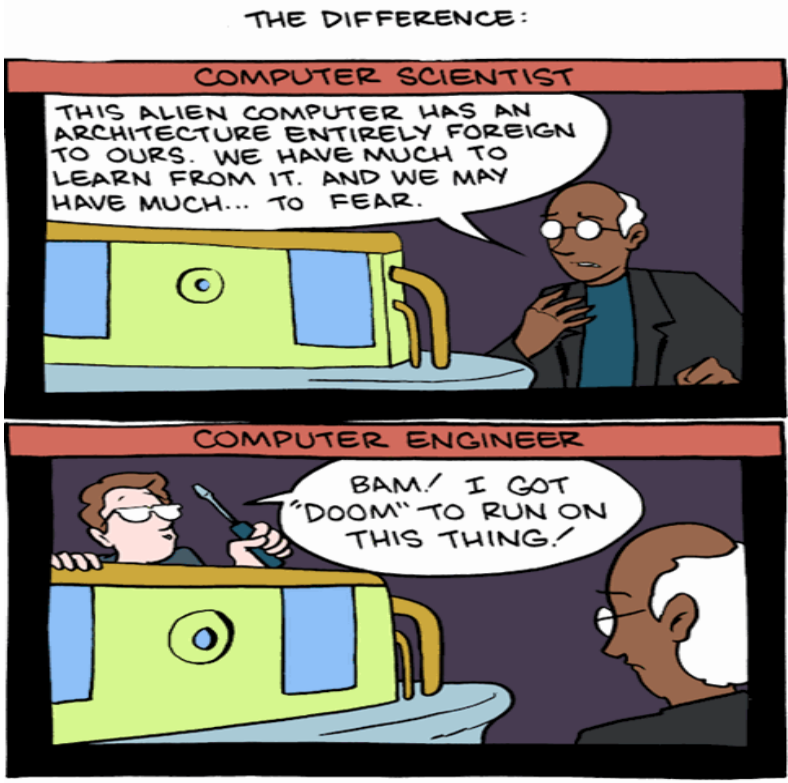
Science versus Engineering

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."

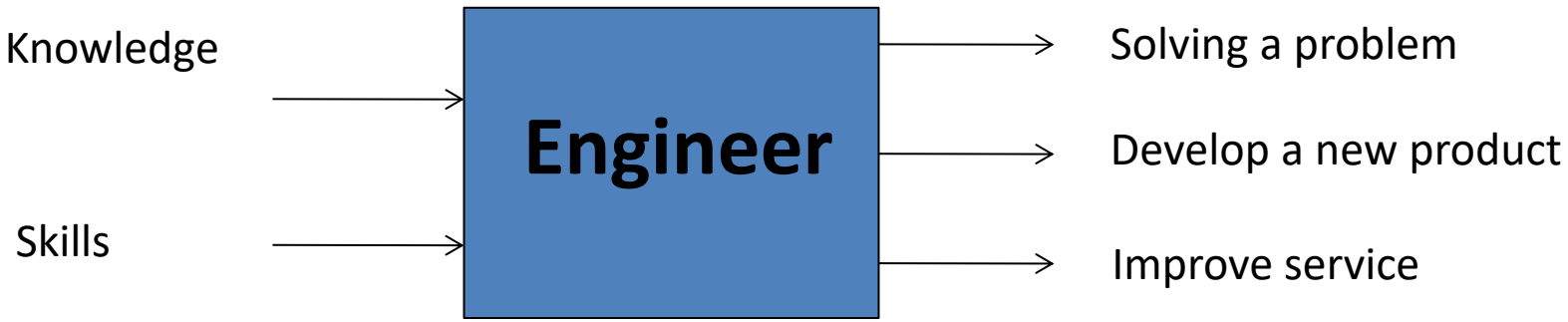
- Theodore Von Karman

Video (Mataf)

Who is the Best Engineer?

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

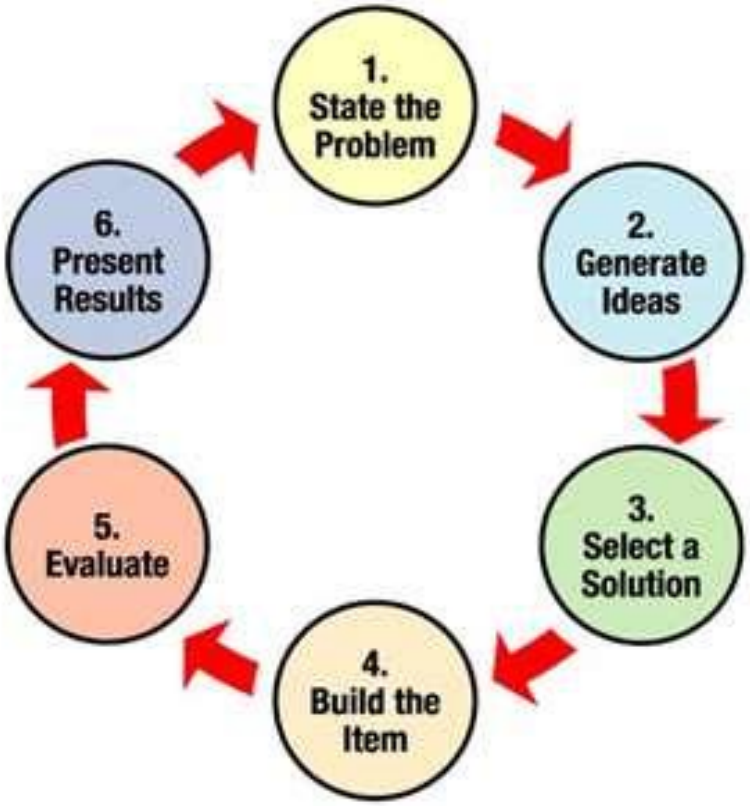
K. Åström



The Design Process

Steps:

1. Problem statement
2. Search and re-search
3. Brainstorm/Generate Creative Ideas
4. Analyze alternative solutions
5. Arrive at an optimum solution
6. Construction, analysis and testing
7. Final Evaluation
8. Communication



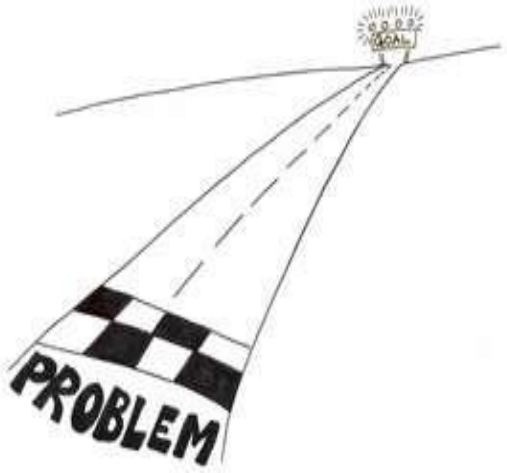
Problem Statement Examples

Step 1 – Problem Statement

Problem Statement
"The current bumper is too easily damaged in low-speed collisions"

Objective
"Design a stronger bumper for our new passenger car"

Better Objective (more general)
"Design an improved bumper"



Step 1 – Problem Statement

Problem Statement
"Childproof pill bottles are too difficult for people with arthritis to open."

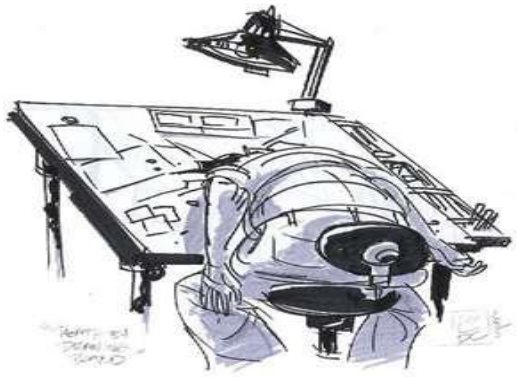
Sample Objectives

1. Design a childproof pill bottle that is easier to open.
2. Design a childproof pill container that is easier to open
3. Design a childproof system for dispensing medication

Remarks:

1. Objectives are function of needs
2. Objectives should be SMART

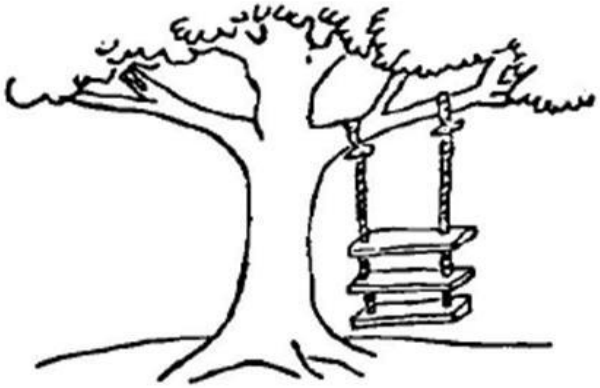
Specific
Measurable
Achievable
Realistic
Timebound



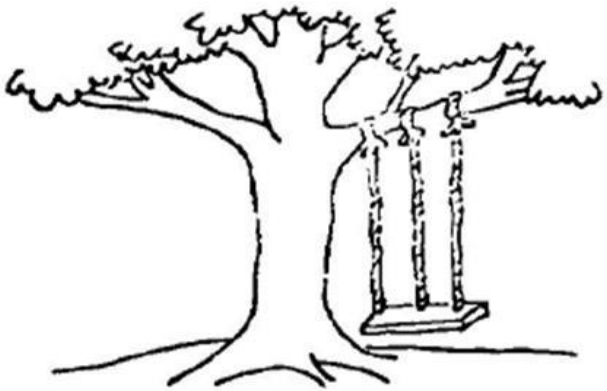
Only when you can specify the problem can you hope to achieve your goal

Loss of efforts and efficiency occurs when trying to solve un-clear problems

Importance of Understanding What the Project is About: of Objectives, Need and Problem Definition



As proposed by the project sponsor



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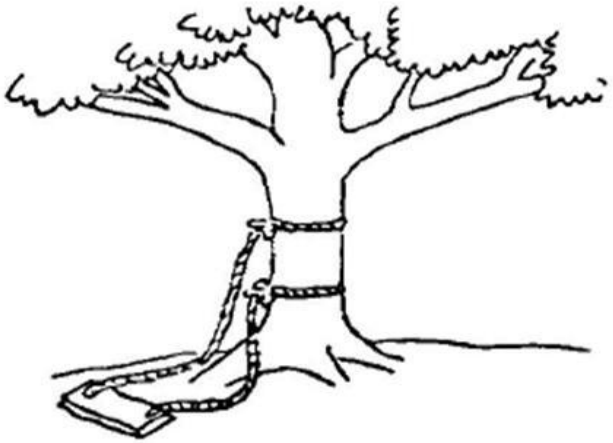
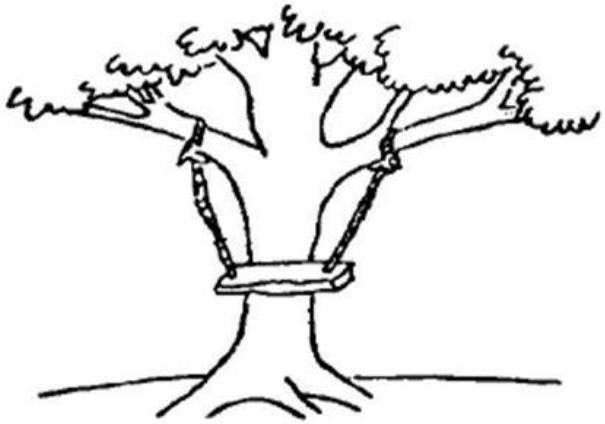
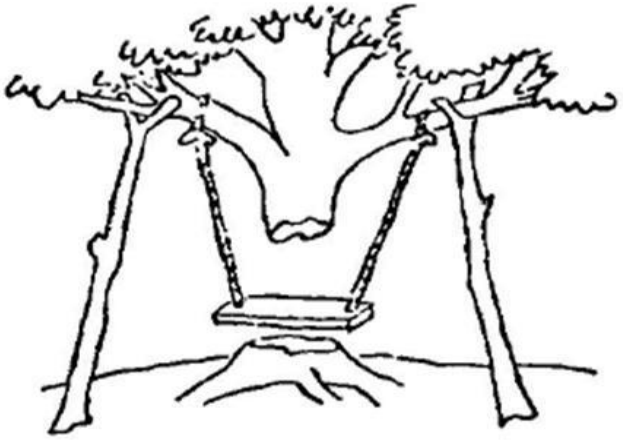


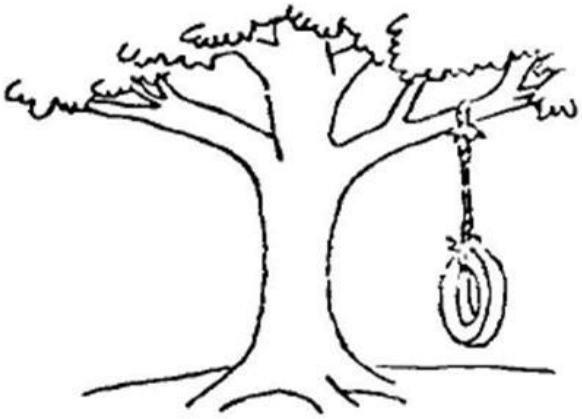
As designed by the senior designer



As produced by manufacturing



As installed at the user's site



What the user wanted

Other Steps

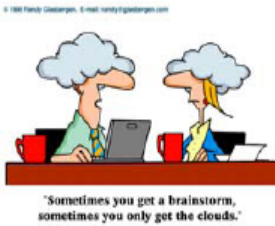
Step 2 – Search and Research

Available Resources include:

- ✓ Libraries
- ✓ Professional associations (technical and non-technical)
- ✓ Trade journals and publications
- ✓ Market assessment surveys
- ✓ Government publications
- ✓ Patent searches and listings
- ✓ Technical salespersons and their reference catalogs
- ✓ Professional experts including engineers, professors and other scientists
- ✓ Competition's product (How do they construct it? disassemble their product and study it.)

Search for alien life on other planets!

Step 3 – Brainstorm



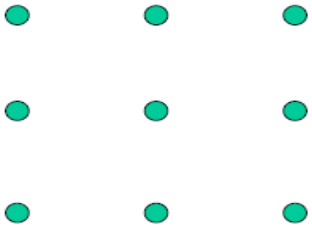
Goal of the Step

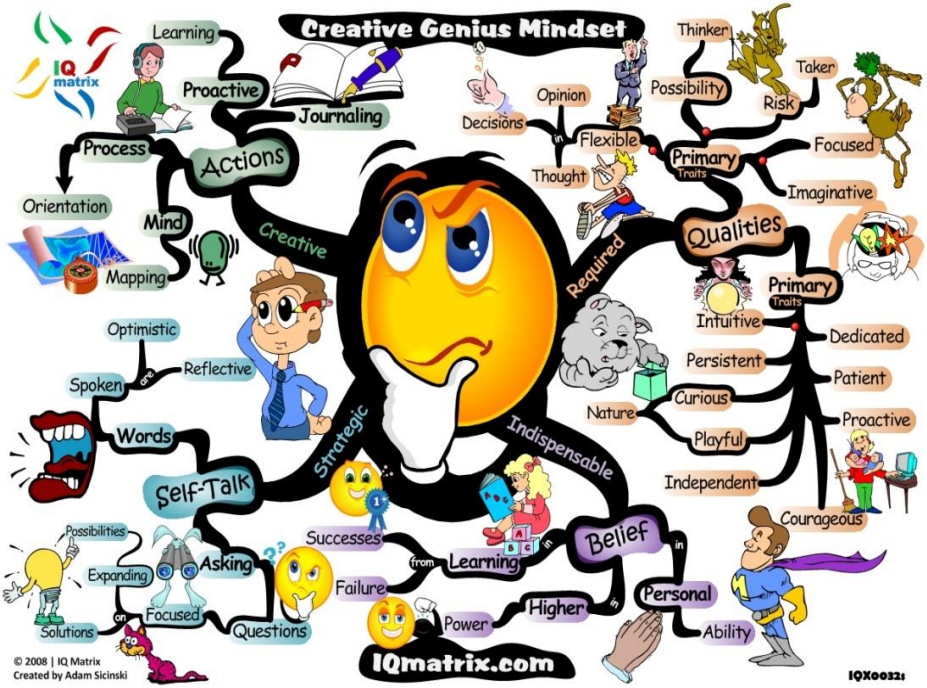
- Generate creative alternatives
- Think outside the box
- Feed from other team members ideas
- Don't be critical (initially)

Creativity

Creativity - Lateral Thinking

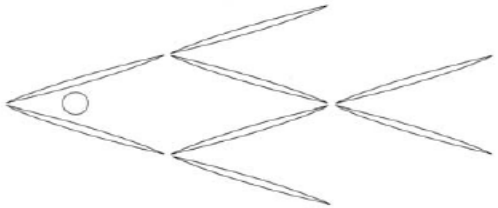
Connect all 9 points with only 4 straight lines





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…

Evaluations

Step 4 – List and Evaluate Alternative Solutions

Goal of the Step

- Be more critical
- Edison - "It's easy to obtain 100 patents if you also have 5000 unsuccessful inventions"

Alternative Energy Solutions

Step 5 – Select an Optimal Solution

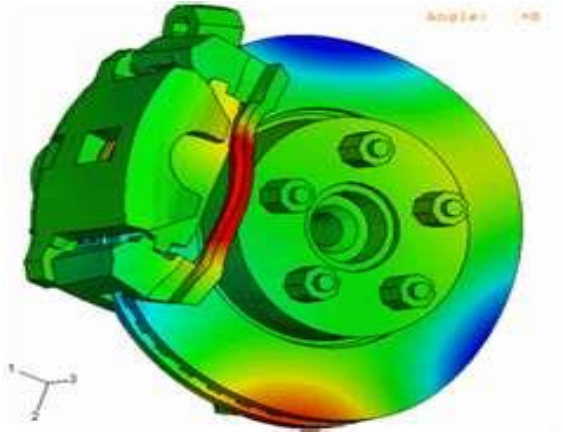
Working Criteria	Points Available	Design 1	Design 2	Design 3
Cost				
Production Difficulty				
Size, Weight, Strength				
Appearance				
Convenient to use				
Safety				
Legal issues				
Reliability /Durability				
Customer Appeal				
Total	100			

One possible solution!!

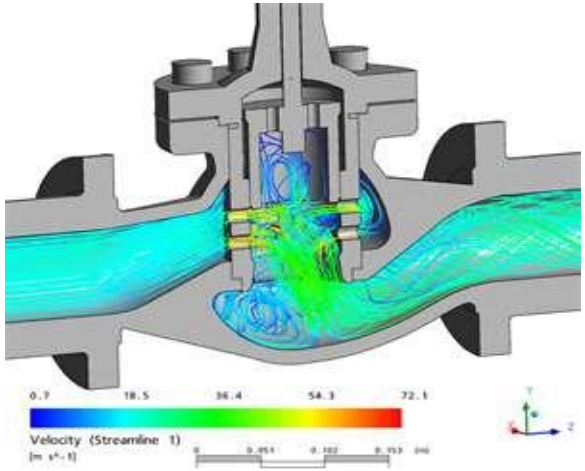
Step 6 – Construction, Analysis and Test

Motor Prototype Testing

Toyota RAV4 Prototype Testing



Break Squeal FEA* Analyses

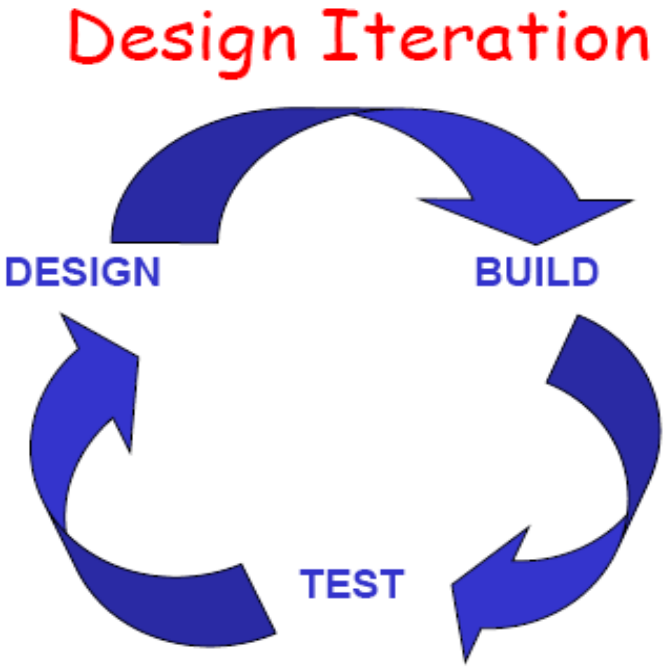


Valve Flow CFD** Analyses

*FEA: Finite Element Analyses

**CFD: Computational Flow Dynamics

The Iterative Design Process



Final Steps

Step 7 – Final Evaluation

Goal - Develop the best design

Step 8 – Communication

Communication crucial throughout the design process

- ✓ Engineering Notebook
- ✓ Written reports
- ✓ Technical presentations
- ✓ E-mail
- ✓ Create training materials, operating manuals, etc.

The final product from such a design process is usually a nice, sleek, powerful and efficient product

The Design Process

"The formulation of a problem is far more essential than its solution."

- Albert Einstein