Engineering Skills (Design)

Chapter 6

Engineering Design

- The word “design” is often used as a generic term that refers to anything that was made by human effort.
- The process of originating and developing a plan for a new object
- *Engineering design (ABET) 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 objectives and criteria, synthesis, analysis, construction, and testing….*
- Engineering design is a process. The process is comprised of **ten** essential steps that engineers follow to help solve design problems.

The Design Process

1.Identify the problem
- Engineers are Problem Solvers
- Understand the scope and the nature of the problem
- Identify the correct issues and background of the problem

2.Define the working criteria/goals
- Establish preliminary goals
- Develop working criteria to compare possible solutions
  - Specifications
  - Constraints

3.Research and gather data
- Stay consistent with working criteria while researching
- Use resources to help research including: Internet, Library, newspaper, etc.
- Keep info found through all steps of the design process and add to it

4.Brainstorm ideas
- Develop as many creative ideas as possible
- Remember: No idea is a bad idea, Document all ideas, Combine ideas to create new ideas, Do not evaluate
- Goal: Long list of ideas!

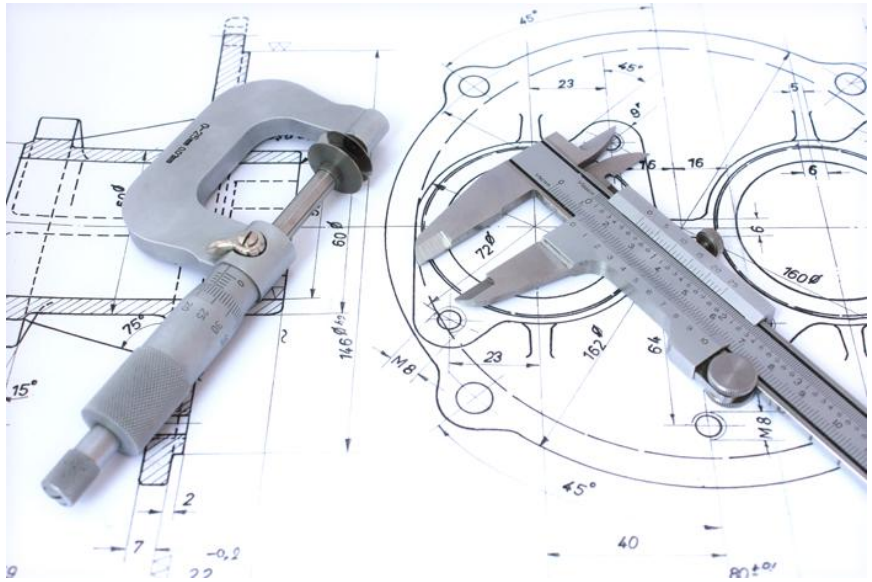
5.Analyze potential solutions
- Eliminate duplicate ideas
- Clarify ideas
- Select ideas to analyze in more detail

The Design Process

6.Develop and test models
- Develop models for the selected solutions
- Types of models: descriptive, functional, mathematical, computer, and scale.
- Test each model against working criteria and goals
- Test for functionality and performance

7.Make decision
- Evaluate the results of testing to determine the solution to use
- If none of the solutions are ideal, return to stage 4 or 5
- Once a solution is selected, continue to stage 8

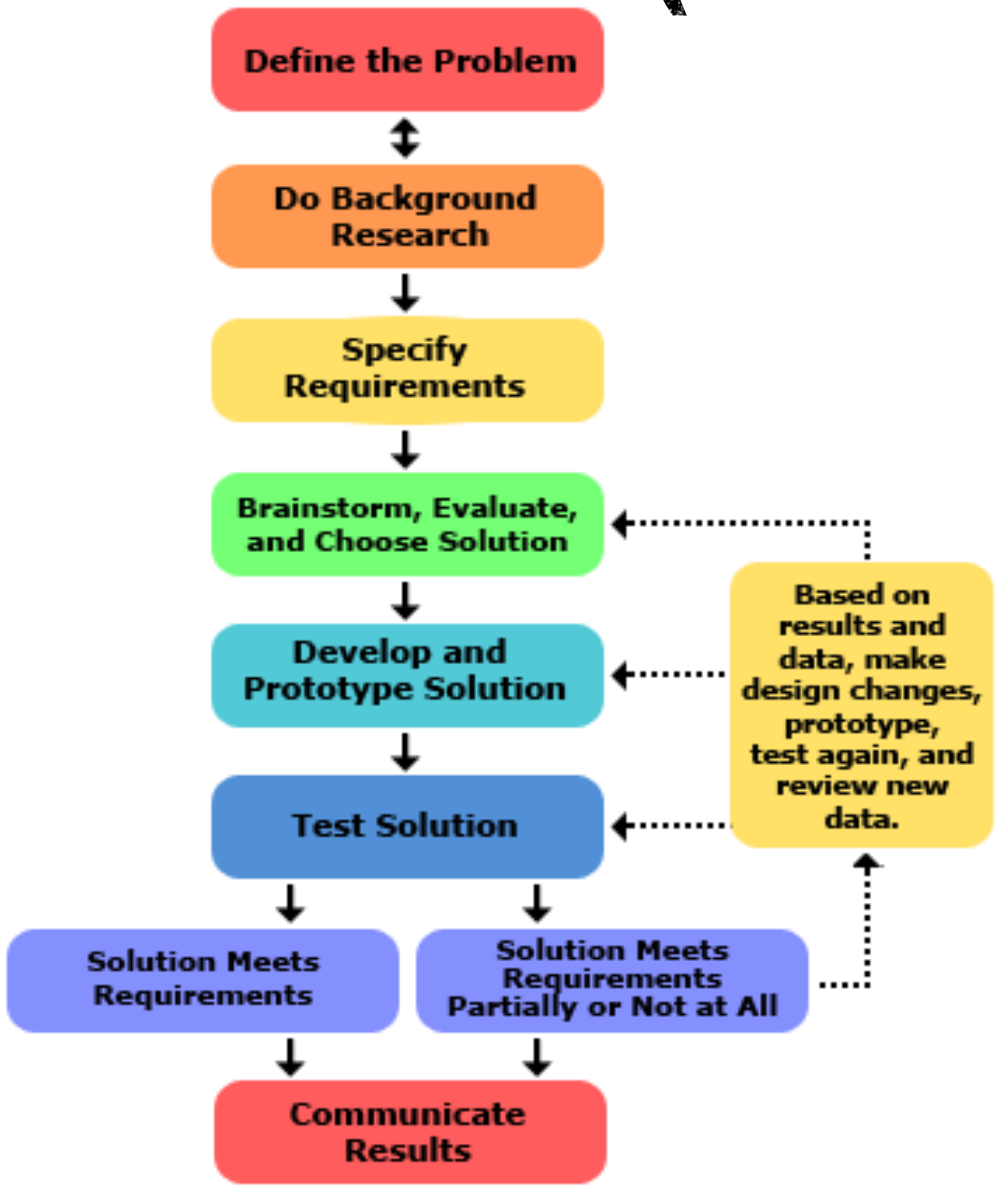
8.Communicate decision
- Document the design's specifications and measurements and communicate to all groups
- Communication between groups is especially important in this stage
  - Meetings
  - Presentations
  - Reports
  - Drawings



9.Implement and commercialize decision
- Final design revisions
- All groups should agree on the proposed project, including: Management, Technical, Business, and legal support representatives
- Production

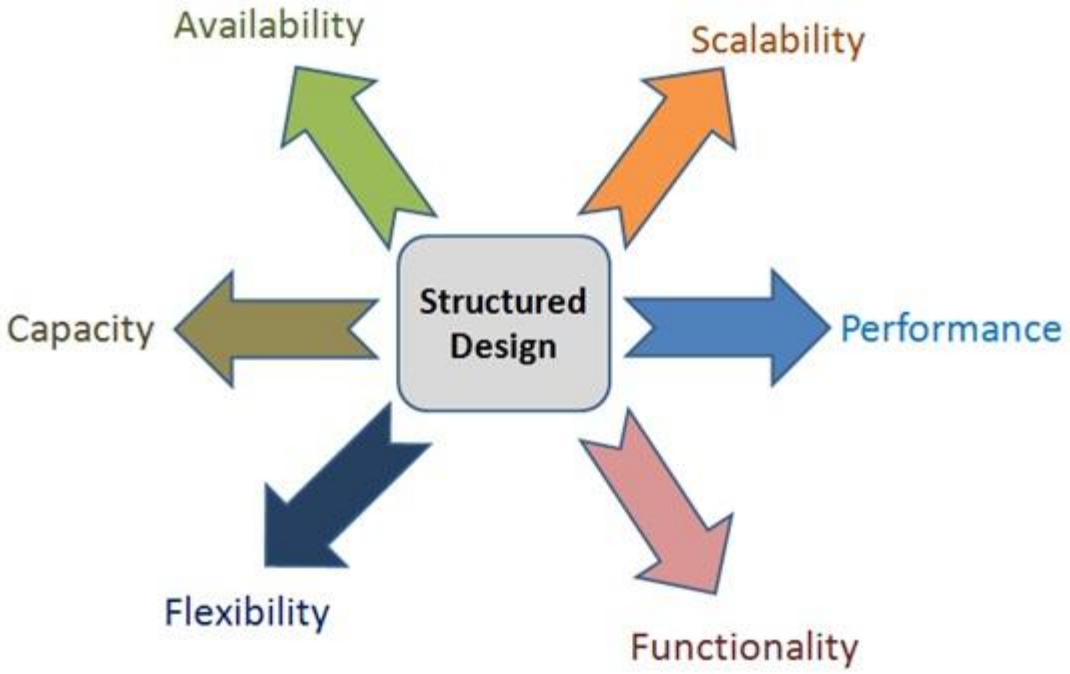
10.Perform post-implementation review
- Review the product's performance
- Assess the product's strength and weaknesses and document
- Make suggestions for future improvements

The Design Process (Classroom)



Design Considerations

1) **WORST CASE DESIGN**
   - Component variation
   - Environmental conditions
2) **RELIABILITY**
   - mechanical parts fail first
   - design redundancy into system
   - simple system = more reliable
3) **SAFETY**
   - identify failure modes
   - provide protection
4) **TEST**
   - design for ease of test
5) **PRODUCTION/MANUFACTURING**
   - consider ease of assembly
   - consider cost



Design Issues

- Conceptual design is generating a concept, identifying problems, establishing function structures, and searching for possible solutions.
- Build a prototype: Prototype - an operating version of a solution. It is often made with different materials (cheaper and easier to work with) than the final version. They allow you to test your solution and supply feedback. Push yourself and the group for creativity, imagination, and excellence in design.

Invention

A device or process *originated* after study and experiment

Innovation

A new improvement to an *existing* device or process

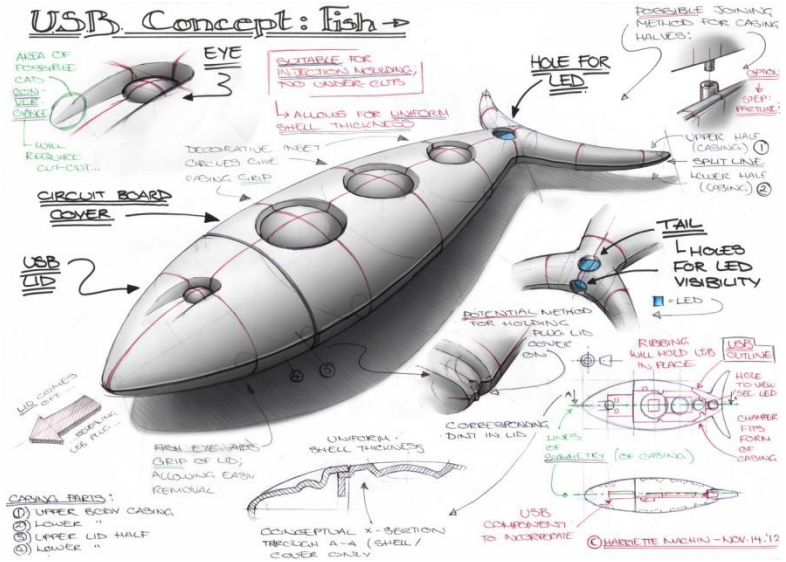
- Analytical design takes a concept and puts it through testing and redesign to find the best possible solution. Analytical design takes into consideration cost, life expectancy, durability, and marketability in the initial design stages.
- Product design – the process of defining all of the concerns product characteristics

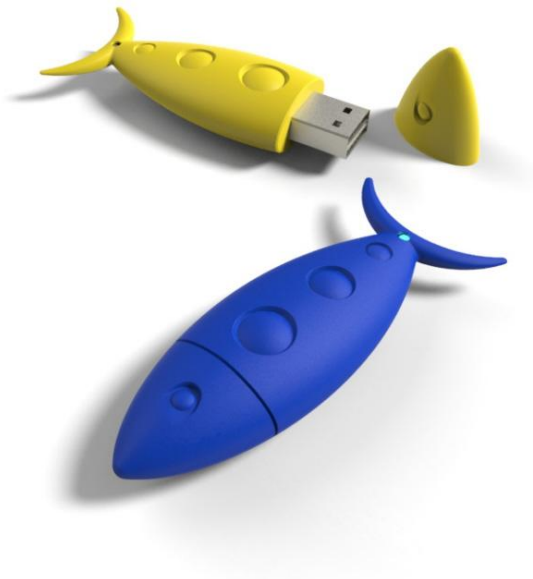
Product design defines a product's characteristics of:

- Functionality (inputs, outputs, operating modes)
- Appearance,
- Physical (size, weight, temperature, materials)
- Reliability, durability, security
- Power (voltage levels, battery life)
- Performance (speed, resolution)
- Ease of use
- Conformance to applicable standards
- Compatibility with existing product(s)
- Cost

Design Issues

- Must **Design for Manufacturing – DFM**
- **Guidelines to produce a product easily and profitably**
  - **Simplification - Minimize parts**
  - **Standardization**
    - **Design parts for multiply applications**
  - **Use modular design**
  - **Simplify operations**
- Uses components of old products in the production of new ones and has:
  - Environmental benefits
  - Cost benefits

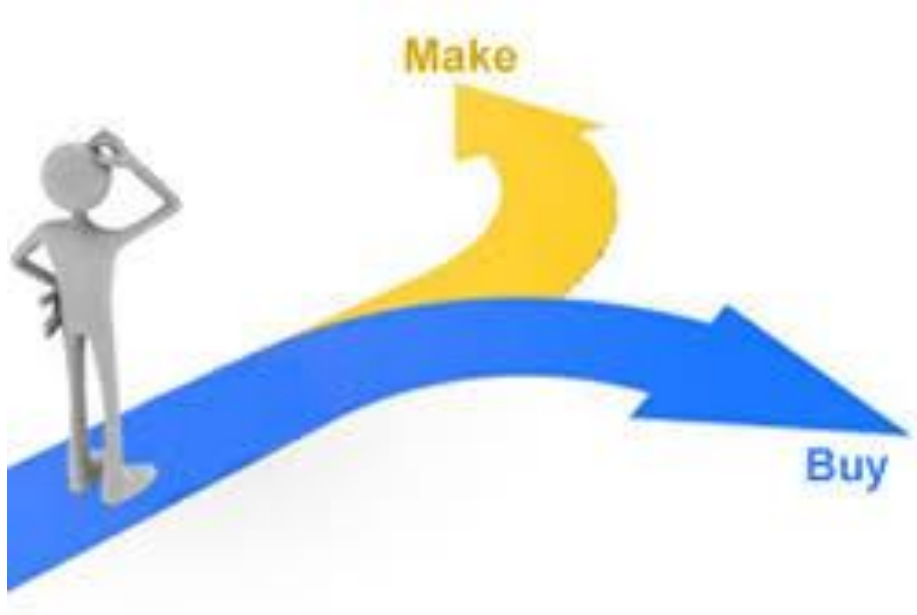




Make or Buy

A firm's *Make-or-Buy* choices should be based on the following considerations:

- Available capacity
- Expertise
- Quality considerations
- Speed
- Cost



Make or Buy

Decision of Make

Advantages

- High degree of control over inputs
- Visibility of overall process
- Can respond to customer better use

Disadvantages

- High Volume required
- High investment needed
- Problems with supply chain

Decision to Buy

Advantages

- Greater flexibility
- Lower investment risk
- Lower potential labor costs

Disadvantages

- Possibility of choosing wrong supplier
- Loss of control over process
- dependency may increase over years

Design Methodologies

- Top-Down:
  - **Also called “functional decomposition“**
  - **implementation details considered only at the lowest level**
  - **top-down design, is not so clean and linear in practice**
- Bottom-up:
  - **Opposite of top-down**
  - **Start at the bottom with detail design**
  - **To do this, you must have some idea of where you are going.**
- Reverse engineering:
  - **Find an existing design**
  - **Model your process on that**
  - **Modify as required**
  - **Detailed and least global aspects of the design are explored and redesigned, if necessary, first**

Break-Even Analysis

Computes the quantity of goods company needs to sell to cover its costs

Q_{BE} = F/ (SP - VC)

- Q_{BE} – Break even quantity
- F – Fixed costs
- SP – selling price/unit
- VC – Variable cost

Break-even analysis also includes calculating

- Total cost – sum of fixed and variable cost

Total cost = F + (VC)*Q

- Revenue – amount of money brought in from sales

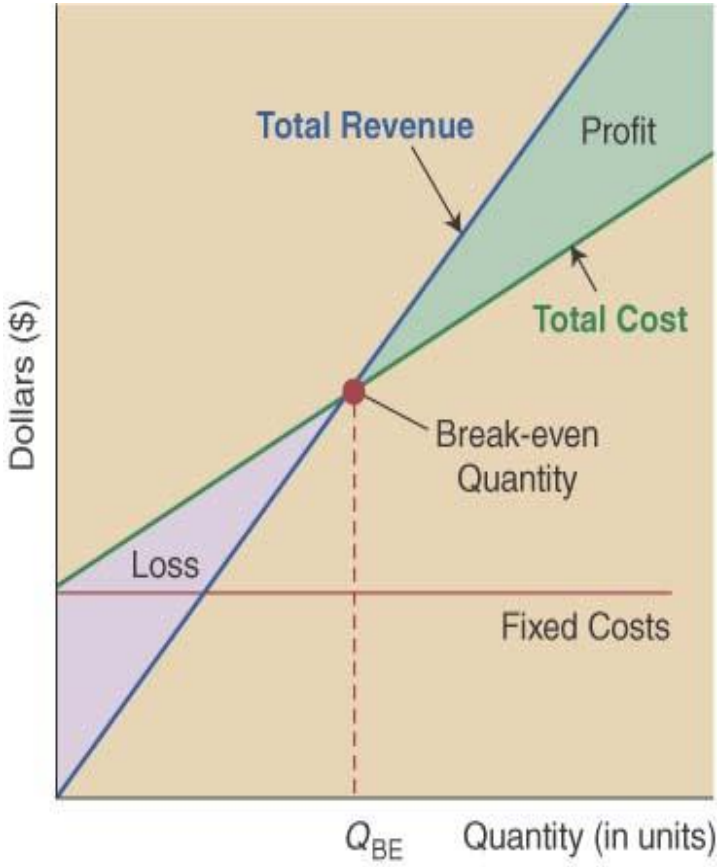
Revenue = (SP) * Q

- Q = number of units sold

Break-Even Analysis: Graphical Approach

Compute quantity of goods that must be sold to break-even

- Compute total revenue at an assumed selling price
- Compute fixed cost and variable cost for several quantities
- Plot the total revenue line and the total cost line
- Intersection is break-even



Break-Even Example:

A company is planning to establish a chain of movie theaters. It estimates that each new theater will cost approximately $1 Million. The theaters will hold 500 people and will have 4 showings each day with average ticket prices at $8. They estimate that refreshment stand sales will average $2 per customer. The variable costs in labor and material are estimated to be $6 per customer. They will be open 300 days each year. What must average occupancy be to break-even?

- **Break-Even Point**

  Total revenues = Total costs @ break-even point Q

  Selling price*Q = Fixed cost + variable cost*Q

  ($8+$2)Q= $1,000,000 + $6*Q

  Q = **250,000 customers (42% occupancy)**

- **What is the gross profit if they sell 300,000 tickets**

  Profit = Total Revenue – Total Costs

  P = $10*300,000 – (1,000,000 + $6*300,000)

  P = **$200,000**

- **If refreshment stand only average $.50/customer, what is break-even Q now?**

  ($8.50)Q = 1,000,000 - $6*Q

  Q = **400,000 customers (67% occupancy)**

Microsoft Word Topics

- How to use Styles to format documents
- How to create a Table of Contents
- How to create and deal with Multilevel Lists
- How to use captions and cross-reference to link figures and tables
- How to Insert Breaks to manage the document format and create a landscape page
- How to use EndNote to organize references