Capstone Design

Engineering Design

What is Engineering Design and why is it important?

Definition (Web Example)

• "Engineering Design: is the creative, iterative and often open-ended process of conceiving and developing components, systems and processes. Design requires the integration of engineering, basic and mathematical sciences. A designer works under constraints, taking into account economic, health and safety, social and environmental factors, codes of practice and applicable laws. [1]"

1. "Engineering Council of South Africa Standards and Procedures System," Jan. 2003; www.ee.wits.ac.za/~ecsa/gen/g-04.htm.

Definition (ABET)

- Engineering design is the process of devising a system, component, or process to meet desired needs.
  - It is a decision-making process (often iterative), in which the basic science 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, testing and evaluation
- Taken (and edited) from http://en.wikipedia.org

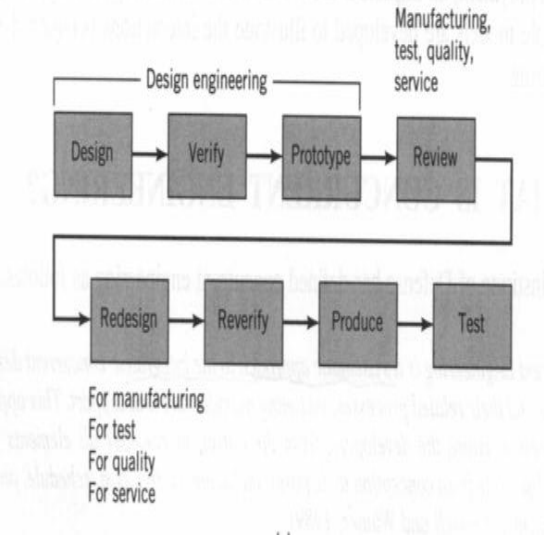
ABET Design Component Features

- The engineering design component of a curriculum must include most of the following features:
  - Development of student creativity
  - Use of open-ended problems
  - Development and use of modern design theory and methodology
  - Formulation of design problem statements and specification
  - Consideration of alternative solutions
  - Feasibility considerations
  - Production processes
  - Concurrent engineering design and
  - Detailed system description
- Further it is essential to include a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics and social impact

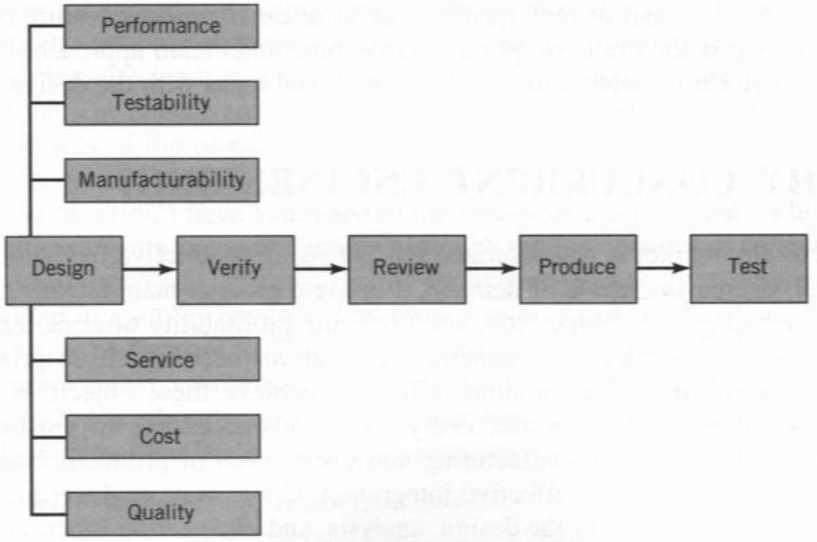
Concurrent Engineering?

- Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers from the outset, to consider all elements of the product life cycle from conception to disposal, including quality, cost, schedule, and user requirements

Serial or sequential engineering



Concurrent engineering



Engineering Design Steps (ABET)

• This process can be divided up into a ten-step process, which includes:

1. Identifying a need
2. Defining the problem
3. Conducting research
4. Narrowing the research
5. Analyzing set criteria
6. Finding alternative solutions
7. Analyzing possible solutions
8. Making a decision
9. Presenting the product
10. Communicating and selling the product

Identifying a Need

- The first step of this process is the identification of a need
- Engineers themselves often do not do this step of the process, but rather society discovers a need and then presents that need to the engineering firm/community
- The term “need” is fairly vague, but often refers to desire or shortage of a good
- This “need” can sometimes be considered a necessity to some people but a luxury for others

Identifying a Need -- Examples

- Dealing with _____ is almost impossible. I wish there was a _____ to help.
- I need a _____ to get _____ done.
- What is the scope of "***need***"?
  - Personal
  - Local
  - Global

Defining the Problem

- The second step of the engineering design process is defining the problem

- Engineers must appropriately define the problem first in order to find an acceptable solution to it or improve it

- Question
  - What is the first step in "***defining a problem***"?

Defining the Problem (continued)

- Identify client (or customer)
- Confer extensively with the client about the problem
  - Put yourself in the client's shoes; try to learn as much as you can about the business, process, people, … whatever it is that is experiencing the problem
  - This will help you to fully define the problem
- The key is to listen
  - You may know more about technology than the client, but they know much more about the problem
- Don't be afraid to go back and ask the client questions
  - The better you understand the problem the better your solution will be
  - When you think you fully understand the problem, write a statement describing the client's problem in detail and get him or her to review the statement and agree

Conducting Research

- The third step in the design process is research
- Most of a productive engineer's time will be spent locating, applying, and transferring information
- In order for an engineer to solve a problem, they first must be well acquainted with as much information possible, which in turn produce a better solution

Conducting Research (continued)

- First we have to look at the types of information available
- Here the engineer asks many questions, such as:
  - What has been written about it?
  - Is something already on the market that may solve the problem?
  - What is wrong with the way it is being done?
  - What is right with the way it is being done?
  - Who manufactures the current 'solution'?
  - How much does it cost?
  - Will people pay for a better one if it cost more?
  - How much will they pay (or how bad is the problem)?"
- All these questions help us get a better grasp on the problem

Conducting Research (continued)

- Another major part of this research step is determining the source of information
  - It is the engineers' job to sift through all of the gathered research and decide what is relevant
  - One source available is an already existing solution
- Reverse engineering is an effective learning technique if other "solutions" are available on the market
  - Is this ethical?
- Effective sources of information include:
  - the Internet, local libraries, government documents, personal organizations, trade journals, vendor catalogs and individual experts
- It is very important to record these findings in a bibliography so that it is easy to find the information at a later date

Narrowing the Research

- The next step, step four, is to put limitations or constraints on the research
- Up until now, the problem research and definition has been kept broad to allow for a large amount of possible solutions
- Constraints are necessary because they eliminate any extreme solutions that would be inefficient, costly, and physically impossible to create

Analyzing Set Criteria

- Step five is to analyze the criteria, or "characteristics of the solution that are established from experience, research, market studies, and customer preferences" that are desired by the consumer
- In this step, solutions are compared on a qualitative basis such as appearance, durability, and cost
- The importance of each characteristic must be agreed upon the team of engineers in order to find the top reasonable solutions to the problem