

Design

Engineering and Design

In the 1982 Annual Report of ABET (Accrediting Board for Engineering and Technology), the definition of engineering is given as:

"Engineering is the profession in which a knowledge of mathematics and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind."

A very brief, concise definition of engineering design!

Engineering Design

Many textbooks and papers have been written on the subject of engineering design. A former professor of mechanical engineering at Alabama (Lee Harrisberger) has published several books on the subject. A short excerpt from one of his publications is given below.

“The crux of the design process is creating a satisfactory solution to a need. The need may be to improve an existing situation or to eliminate a problem. Or, the need may be to develop a use for a new discovery or concept. In any case, it is what engineering is all about—using knowledge and know-how to achieve a desired outcome. Designing is problem solving. It is *creative* problem solving. A change has to be created. Something different will be produced, and someone will have to decide what to do with the result.”

“Engineers are applications specialists. They apply the principles, discoveries, experiences, techniques, and methods derived from ages of research, experimentation, trial and error, and invention. It really takes some doing to determine which elements of this vast storehouse of knowledge apply to the situation at hand. Developing the best combination of principles and procedures into a highly desirable plan and/or product is an engineer's business and it's tough work. The design process is not just a matter of dreaming up clever ideas and schemes. It is a long process of imaginative planning, detailed analysis, computational prognostication, experimentation, detailed sizing, specifications for every piece and part, development of tools and manufacturing procedures, selection of materials, and detailed planning for assembly, maintenance, repair, safety, durability, sales appeal, etc. And, superimposed on all of this activity is the continuous and necessary attention to cost. The design process is an integration of technical knowledge drawn from the research laboratory and applied to the market place and customer use. It converts information into decisions and ideas into useful hardware.”

from Lee Harrisberger, "Engineersmanship ... The Doing of Engineering Design," 2nd Ed, Brooks/Cole Engineering Division, Monterey CA, 1982.

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Another definition of engineering design comes from a well-know freshman engineering textbook:

"The end result of an engineering effort - generally referred to as design - is a device, structure, or process which satisfies a need. A successful design is achieved when a logical procedure is followed to meet a specific need. The procedure, called the design process, is similar to the scientific method with respect to a step-by-step routine, but it differs in objectives and end results. The design process encompasses the following activities, all of which must be completed.

1. Identification
2. Definition
3. Search
4. Establishment of criteria and constraints
5. Consideration of alternatives
6. Analysis
7. Decision
8. Specification
9. Communication

from Eide, A., R. Jenison, L. Mashaw, and L. Northup , "Engineering Fundamentals and Problem Solving," 2nd Ed., McGraw-Hill, New York, 1986.

Note that any discussion of engineering design very quickly mentions a design process. Each author has a slightly different view of the engineering design process and will describe it with different words. Some will have a four step process, others a five step, some have as many as nine (or more). There is really no substantial disagreement over the actual process, but in how the various steps are described. Note the similarities between the design process description given above, and the one given on the next page. Which of the steps described by Eide, et al, have been combined in Harrisberger's description?

As you review the engineering design process, many of you will recognize that you have done things very much like this throughout your life. For example, if you are a carpenter, how do you go about building an addition to a house, a deck for example? You first look at the house and find out what the owner wants (*clearly define the problem*). Any special situations are particularly noted, for example, the customer wants to build around the large hickory tree (*identify physical constraints*). Next, the materials are ordered and purchased, tools are gathered, and you show up at the site ready to work (*gather necessary information*). If everything has been done correctly prior to this point, the actual building of the deck is relatively straightforward (*find a solution*). The final test of your solution comes when the customer looks at the deck, bounces up and down on it a few times, then pronounces it "OK," and pays the bill (*test or evaluate the solution*).

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A Final Definition of Design

Although all design engineers have their own styles, they all end up doing the following (one way or another).

1) **Defining the problem**

2) **Information retrieval**

3) **Seeking alternatives: The creative process**

- generate a unique, custom-made solution "from scratch,"
- find an "off-the-shelf" solution that someone else has used to solve a similar problem, or
- find a bunch of existing stuff, combine it, and adapt it.

A good design engineer will explore all three and show the clients what they would get and what it would cost to go with each of these three.

4) **Development/synthesis/analysis/detail**

5) **Cost/benefit analysis**

- will it do what I need done?
- can I afford to do it?

The clients can live with all sorts of exotic engineering alternatives if they get appropriate answers. The bottom line for them is *being able to justify the money spent*.

6) **Reporting to the clients**

There are some imperative objectives that must be met in reporting any design solution to the clients:

- credibility.
- explanation.
- thoroughness.
- a clear answer.

From: Lee Harrisberger, "Engineersmanship ... The Doing of Engineering Design," 2nd Ed, Brooks/Cole Engineering Division, Monterey CA, 1982