The Design Process

What is it?

The engineering design process can be defined as:

- A decision-making process using these elements
  - Basic sciences (chemistry, physics, biology)
  - Mathematics (algebra, geometry, calculus)
  - And the engineering sciences (aerospace, biomedical, chemical, civil, computer, electrical, manufacturing, mechanical)
- To enable available resources (material and people)
- To meet a desired, measurable goal (usually resulting in a product or system).

What are some of the steps in the process?

1. Define the problem. Identify shortcomings in current methods and what is needed in new solutions.
2. Explore. Research existing technologies and methods that could be adapted to the design.
3. Constraints. Define the target values of the requirements.
4. Design and analysis. Design alternative solutions and analyze each to determine its fit within the requirements.
5. Evaluation.* Carefully compare the results of each design analysis to the project’s requirements and select the one that meets them.
6. Delegation. Assign tasks for the design, management, and production of the product.
8. Test. Identify developmental testing procedures as well as qualification and acceptance tests.

* During evaluation, it may be decided to terminate the project. This may be due to immature technology or lack of anticipated market demand. Many good ideas must wait for their time in the marketplace. For example, the music CD was designed 50 years before a cost-effective technology for manufacturing it was developed.

Design changes. Why do they happen?

Part of the fun of engineering is that it’s an exploratory, creative process, which demands its engineers adjust their thinking to meet a project’s changing requirements. Here are few reasons why:
The basic technology is leading-edge and is not fully understood, so engineers discover new things during the design process.

The initial goals or objectives were unclear and are clarified as the design progresses.

The objectives are in conflict. For example, an engineer is charged to "make it quickly, make it cheaply, and make it reliable." However, making it reliable may require additional testing costs or time, so the target values need to be adjusted. For this reason, it’s sometimes best to set attainable targets rather than ideal ones.

If the design takes a long time, the expectations of the market may change before the design is completed.

Because engineering design is as much art as science, there can be an infinite number of possible solutions, or possible variations of one solution. The good engineer is always open to new approaches.

**How does changing a design affect its cost?**

Changes can be made more easily and less expensively earlier in the process rather than later. For example, if a change occurs during the concept phase, little time or money has been spent. However, as additional materials and manpower are needed with each succeeding step, there is a corresponding increase in cost and effort. The following table gives a typical example of the cost of design changes with each stage of development.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept</td>
<td>X</td>
</tr>
<tr>
<td>Design</td>
<td>10X</td>
</tr>
<tr>
<td>Tooling</td>
<td>100X</td>
</tr>
<tr>
<td>Testing</td>
<td>1,000X</td>
</tr>
<tr>
<td>Release</td>
<td>10,000X</td>
</tr>
</tbody>
</table>

What product attributes must an engineer consider in a design?

Depending on which engineering discipline is being considered, any or all of the following factors must be evaluated as part of the engineer’s design solution.

- **Power.** The amount the product produces or consumes.
- **Speed.** How fast does it operate? How long will it take to manufacture?
- **Cost.** The price to the consumer to purchase, the cost to the company to manufacture, and the cost its implementation will have on society in general.
- **Reliability.** How well does it operate? How long will it last? Is it a quality product?
• Safety. Are there any health risks?
• Functionality. Does it perform the desired tasks effectively?
• Ease of use. Can the customer operate it easily and intuitively?
• Aesthetics. Is it pleasing to see, feel, touch, or hear.
• Ethics and social impact. Will it benefit or harm people and the social or physical environments in which they live?
• Maintainability. How easily and cost-effectively can it be kept in good working order?
• Testability. How easily and effectively can it be tested by the manufacturer prior to volume production for the market?
• Manufacturability. What issues must be addressed in the manufacture of the product?

Prototypes (early versions of the design or its computer models) help the learning curve, identify missing requirements, evaluate design targets and product attributes, and get potential customer feedback.