Awesome Engineering Projects…Step-by-Step

"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. In any case, it is what engineering is all about – using knowledge and know-how to achieve a desired outcome."

-Lee Harrisberger

Engineersmanship…The Doing of Engineering Design

Engineering projects involve ***creative problem solving***, but they are not hypothesis testing. Each engineering design project should have a ***goal*** which can fit the following ***model statement***:

"The design and construction of an (engineered product) for (target user) to do (some useful function)."

Where can you get project ideas?

You may get suggestions from teachers, advisors, or mentors. Be sure to use the web to find assistance (http://stemed.unm.edu; www.sciencebuddies.com, www.societyforscience.org, www.madsci.org). Quality entries from previous fairs are good sources of ideas and best practices. Some high school technology curricula address the engineering design process (www.engineering-ed.org, www.gears-id.org) and many college and professional engineering societies have on-line resources.

You will use the ***engineering design process*** to create your project. This process is typical of those used by practicing engineers: the definition of terms and the number of steps may vary, but these are the "essential steps." ***Your very first step is to start a project notebook in which you will record every step of your process and the results of your design efforts.*** The process is iterative, meaning the designer will often repeat steps until he or she is confident the design will meet the identified needs. ***NOTE: the terms product, invention, project, design, and solution are often used interchangeably in fair guidelines, rules, etc.***

The Engineering Design Process:

1) Identify a need; express as a goal
2) Establish design criteria/ constraints
3) Evaluate alternative designs
4) Build a prototype of best design
5) Test and evaluate the prototype using the design criteria
6) Analyze test results, make design changes, and retest
7) Communicate the design

Identify a Need

The need *(also called the problem you are solving or the engineering goal)* is frequently identified by customers – the users of the product. The customer could be a retail consumer or the next team in a product development. Customers may express needs by describing a product ("I need a car.") or as a functional requirement ("I need a way to get to school."). The need should be described in a simple statement that includes what you are designing (the product), who it is for (customer), what need it satisfies (problem to solve), and how it improves upon previous designs (easier to use, less expensive, more efficient, safer, etc.).

Establish Design Criteria & Constraints

Design criteria are requirements you specify that will be used to make decisions about how to build and evaluate the product. Criteria are derived from needs expressed by customers. Criteria define the product's physical and functional characteristics. Some examples of criteria are shape, size, weight, speed, ruggedness, and ease of manufacture.

Constraints are factors that limit the engineer's flexibility. Some typical constraints are cost, time, and knowledge; legal issues; natural factors such as topography, climate, raw materials; and where the product will be used. Good designs will meet important design criteria within the limits fixed by the constraints. Good designs are also economical to make and use because ***cost is always a design constraint***!

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Evaluate Alternative Designs

Your research into possible solutions will reveal what has been done to satisfy similar needs. You'll discover where knowledge and science limit your solutions, how previous solutions may be improved, and what different approaches may meet design objectives. You should consider at least two or three alternative designs and consider using available technology, modifying current designs, or inventing new solutions. Superior work will demonstrate tradeoff analyses such as comparing the strength vs. cost of various bridge building materials. It's important to document in your project notebook how you chose and evaluated alternative designs. Can you defend your choices to the judges?

STOP! You must obtain approval from your teacher before you build the prototype. Many engineering design projects will require PRIOR APPROVAL FROM THE SCIENTIFIC REVIEW COMMITTEE (SRC), particularly if you will involve humans in particular types of product testing that involve more than minimal risk to the product testers.

Build a Prototype of Best Design

Use your alternative analyses to choose the design that best meets criteria considering the constraints, then build a prototype. A prototype is the "first full scale and usually functional form of a new type or design." – Webster's Dictionary

Test and Evaluate the Prototype Against Important Design Criteria to Show How Well the Product Meets the Need

You should develop a test plan describing what you will test, how you will test, and how you'll perform analysis. You must test your prototype under actual or simulated operating conditions. Customers are usually involved in product testing so be sure you have SRC approval if people are involved.

Analyze Test Results, Make Design Changes, and Retest

Testing will disclose some deficiencies in your design. Sometimes the testing fails completely and sends the designer "back to the drawing board." Make corrections and retest OR prepare an analysis of what went wrong and how you will fix it. As always, document your analyses, fixes, and retests in your notebook.

Communicate the Design

The designer's real product is the description of a design from which others will build the product. Use your notebook and the fair/expo exhibit to communicate the design to your customer and the judges. Your product description will be conveyed in drawings, photos, materials lists, assembly instructions, test plans, and results. Consider listing lessons learned so future designers need not repeat any of your "frustrations." You'll have clear instructions on how to produce your design, along with production cost estimates.

Prepare Your Project Exhibit

Be sure you are familiar with the ISEF Display and Safety Rules for the current fair year. Your local, regional, and state fairs/expos may have additional rules with which you need to be familiar as well.

Prepare and Bring Your Abstracts

Remember to bring 10-15 copies of your abstract with you to have on your display. Judges like to take copies of student abstracts as they are reviewing and evaluating projects to be scored. Members of the public are also sometimes interested in picking up copies of your abstract as they come through during Public Open Houses.

Scientific Process	Engineering Process
State your question.	Define a need.
Do background research.	Do background research
Formulate your hypothesis. Identify variables.	Establish design criteria.
Design experiment. Establish procedures.	Prepare preliminary designs.
Test your hypothesis by doing an experiment.	Test and redesign as necessary.
Present results.	Present results.