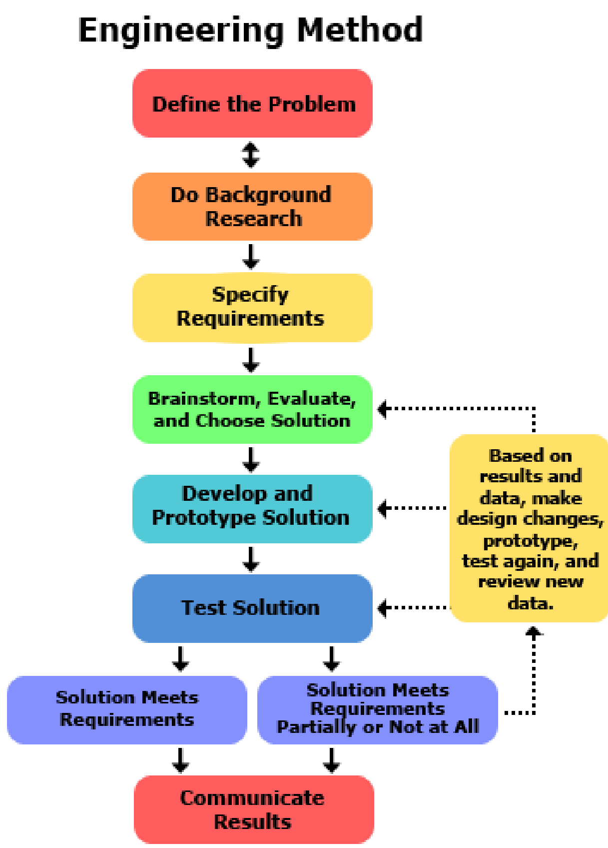
Engineering Design Project Guide

(This information was found on the wonderful website: sciencebuddies.org)

Invention/Engineering Design

In this project type, students should identify a scientific problem and attempt to address this problem with an invention or model. An invention is the building or creation of a device, machine or other creation designed to address this problem. Use the Engineering Method when designing an invention or model. It is important for you to identify the problem, research and plan your ideas, and develop and test your invention.



Suggested Steps

Here are some suggestions on the steps you can take to work on your engineering design project. These are only some of the ideas and ways you can approach it:

Step 1: Find an Idea or Problem you want to solve

Think about what type of question you are going to answer OR type of problem you are going to solve. This is your objective, purpose or problem.   This process of uncovering a problem, or identifying the need for change or improvement to an existing solution, is called need finding.

One really great way to start the need-finding process is to make a "bug list." Think about all of the things that bug you or bug other people around you. Write them down. They may seem like small and silly problems, but they can spark ideas for a project or lead to larger problems that you may not have noticed otherwise.

They don't all have to be things that bother you; think about other people and the problems that they face as well. You will be surprised at the number of bugs you can identify in the world around you. Start this list in your design notebook, and spend a few days recording your ideas.

Step 2: Define the Problem

Engineers solve problems by creating new products, systems, or environments. Before creating something, it is very important to define the problem. Otherwise, you might build something only to find that it does not meet the original goal!

To define your problem, answer each of these questions:

- What is the problem or need?
- Who has the problem or need?
- Why is it important to solve?

The answers to these three questions are the what, who, and why of your problem.

Your problem statement should incorporate the answers as follows:

[*Who*] need(s) [*what*] because [*why*].

The problem statement for any good engineering design project should be able to follow the format shown. If you are improving an existing solution for your project, keep in mind that the improvements will be part of your problem statement. Making something better, faster, or cheaper should be part of your statement—either in the "what" portion and/or the "why" portion. For example, if you are improving a car radio, your problem statement might be:

People need cheaper and better-performing car radios, because current radios are expensive and poor at picking up weak radio signals.

Step 3: Do Background Research

Background research is especially important for engineering design projects, because you can learn from the experience of others rather than blunder around and repeat their mistakes. To make a **background research plan**— a roadmap of the research questions you need to answer -- follow these steps:

1. Identify questions to ask about your **target user** or customer.
2. Identify questions to ask about the products that already exist to solve the problem you defined or a problem that is very similar.
3. Plan to research how your product will work and how to make it.
4. Network with other people with more experience than yourself: your mentors, parents, and teachers. Ask them: "What should I study to better understand my engineering project?" and "What area of science covers my project?" Better yet, ask even more specific questions.

This information and more is available at:
https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/background-research-plan#makingabackgroundresearchplan

Step 4: Specify Requirements

Design requirements state the important characteristics that your solution must meet to be successful.

For example, imagine that your problem statement relates to grocery store bags. You want to design a better grocery store bag--one that uses less expensive material than the paper and plastic bags that already exist. Your design requirements are the important characteristics that your bag must meet to be successful. Based on your problem statement, a successful bag would use less expensive material than existing bags and function properly as a grocery bag. Examples of some of your design requirements might be that the bag needs to:

- Have handles so that shoppers can carry multiple bags of groceries.
- Hold up to five pounds of food without breaking.
- Cost less than five cents to make.
- Collapse so that it can be stored in large quantities at grocery stores.

Effective design requirements are:

- *Needed* to solve your design problem. If it is not needed, leave it out. You'll have enough other things to work on!
- Feasible. A good design requirement is not just a wish. Ask if you have the time, money, materials, tools, and knowledge to make it happen.
- Subject to change as you do more research and design. Always ask yourself, is this requirement needed and feasible? If your answers to those questions change, it is OK to change the requirement.

This information and more is available at:
https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-requirements#designrequirements

Step 5: Develop Multiple Prototypes

When solving a design problem, there are always many possible good solutions. If you focus on just one before looking at the alternatives, it is almost certain that you are overlooking a better solution. Good designers try to generate as many possible solutions as they can before choosing one that they feel is the best. Even "wild and crazy" design ideas that you end up rejecting might have some pieces that can make other designs better.

This information and more is available at:
https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/alternative-solutions#howtocreatemultiplesolutions

Step 6: Pick the Best Solution and Develop It

First, look at whether each possible solution met your design requirements. Consider solutions that did a much better job than others, and reject those that did not meet the requirements.

This information and more is available at:
https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/best-solution#howtochoose

Step 7: Pick the Best Solution and Develop It

- **Development** involves the refinement and improvement of a solution.
- The goals of development work are to:
    - Make it work!

    - Reduce risk.
    - Optimize success.
- **Methods** of development work include:
    - Drawings
    - Modeling
    - Prototyping
    - Storyboards
    - Analysis

This information and more is available at:
https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/best-solution#howtochoose

Step 8: Build a Prototype

- A **prototype** is an operating version of a solution. It is often made with different materials (cheaper and easier to work with) than the final version.
- Prototypes allow you to test how your solution will work and even show the solution to users for feedback.
- Creating prototypes may involve using readily available materials, construction kits, storyboards, or other techniques that help you to create your solution quickly and with little cost. Keep in mind that these are mockups of your final solution, not the real thing!

Prototyping Physical Structures, Objects, and Mechanical Designs

Readily Available Materials

Cardboard, paper, poster board, mat board, and Foam-core™ are excellent modeling materials for prototypes. You can cut them easily with the proper knife, and you can assemble them with a variety of tapes and glues. You can find these materials at an art supply store. Plastic sheet and wood are also good modeling materials.
Found objects like plastic bottles, straws, aluminum cans, and other things lying around the house can often fill a need in your prototyping.

Construction Kits

There are a number of construction kits that are excellent for prototyping. Don't think of these as kids' toys; even professional engineers use them for prototyping simple devices!

- Lego™, Lego Mindstorms™, and Lego Technic™. Pieces are easy to assemble, but also come apart easily.
- Fishertechnik™. This system is more sophisticated than Lego, and it is less likely to fall apart.
- Meccano™. Meccano has been around a very long time. Parts are metal, not plastic, and they are bolted together.

Prototyping Electrical and Electronic Devices

Solderless breadboards are ideal for prototyping simple electrical circuits. You can learn how to use a breadboard in the Science Buddies reference How to Use a Breadboard.
You can also purchase commercial prototyping boards and development systems that can be quite sophisticated.

Prototyping Experiences and Environments

Storyboards are useful for prototyping experiences (like a theme park ride or an interactive museum exhibit).

This information and more is available at:
https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-prototypes#prototyping

Step 9: Test and Redesign as Necessary

The design process involves multiple loops and circles around your final solution. You will likely test your solution—find problems and make changes—test your new solution—find new problems and make changes—and so on, before settling on a final design.

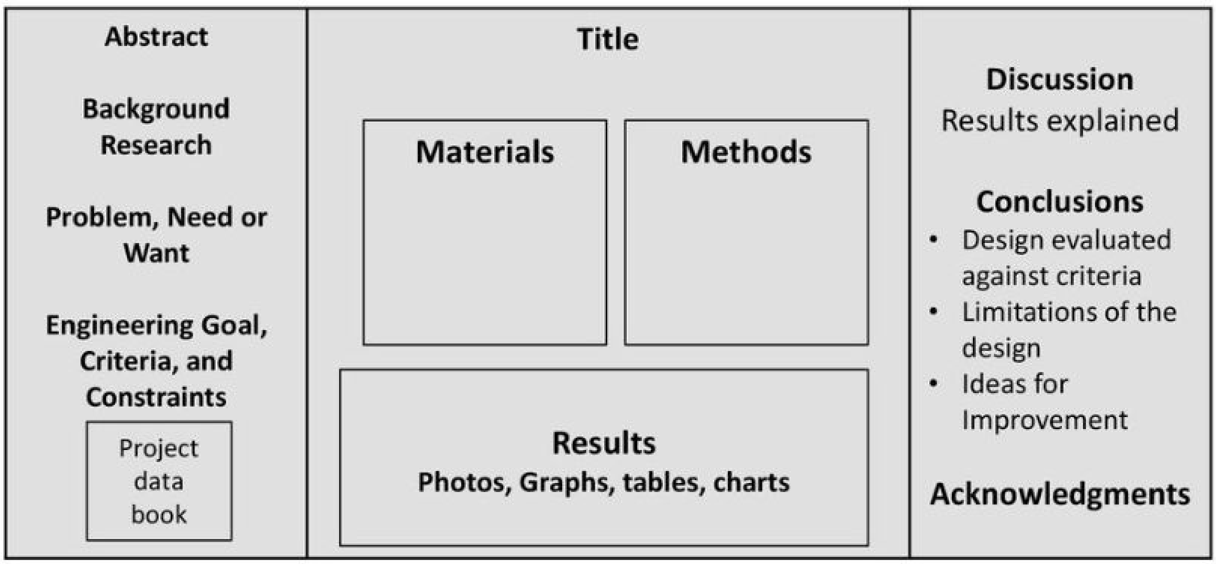
At this point, you have created prototypes of your alternative solutions, tested those prototypes, and chosen your final design. So you're probably thinking that your project is finished! But in fact, you have yet to complete the final and most important phase of the engineering design process—test and redesign.

Test and redesign requires you to go out and test your final design with your users. Based on their feedback and their interaction with your solution, you will redesign your solution to make it better. Repeat this process of testing, determining issues, fixing the issues, and then retesting multiple times until your solution is as successful as possible. Keep in mind that minor changes this late in the design process could make or break your solution, so be sure to be thorough in your testing.

This information and more is available at:
https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/testing-redesign#usertest

Tri-fold Board Suggestions

Engineering Design Display Board



The overall display can be enhanced with physical prototypes, video recordings of the design in action, etc. The project data book can sit on the display table.

ENG DES- This is a suggested layout. Your board should flow in the same fashion but may be modified to fit your project. Boards are due ________