Engineering Science Fair Packet

Engineering Design

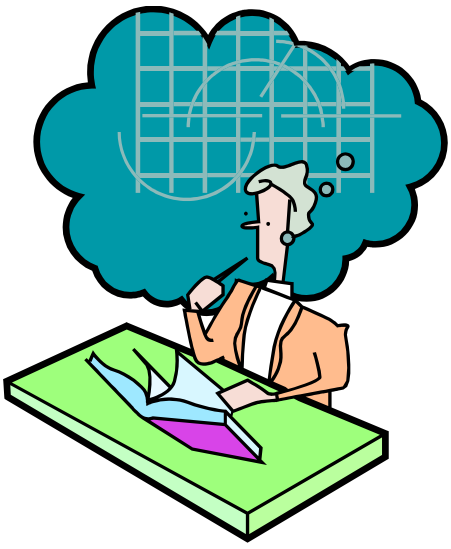
Engineering is the designing, building, and testing of a made-at-home product. This is the invention category of the science fair. The student builds a prototype based on the requirements that the he or she established. After the prototype is built, it needs to be tested to see if it works. Data is recorded during the testing and is then analyzed. This is compared to the design requirements. If it doesn't perform according to the design requirements, the student needs to go back and redesign the prototype on paper, then on the prototype which is then retested.

This process of redesigning and making adjustments continues until the prototype works according to the design requirements. The product results should be useful and it should have real world applications. **The prototype cannot be made from a kit.**

The Engineering Design Process

Here are the steps of the Engineering Design Process. These are all required and need to be followed in the order shown. The student needs to record every step as they move through the process in their log book.

- **Define a Need**
- **Research**
- **Design Requirements**
- **Preliminary and Final Designs**
- **Materials Needed**
- **Step-by-step Procedure**
- **Build and Test the Prototype**
  - **Build the Prototype**
  - **Test the Prototype**
  - **Record the Data**
  - **Analyze the Data**
- **Redesign and Retest if Necessary**
- **Conclusion**



The Engineering Design Procedure

The purpose of an engineering project is to understand the process of designing something and building a prototype (model of the product). This should be a novice idea. It cannot be a purchased kit. The materials are to be materials found around the house and/or purchased at a store.

Students who want to build a prototype for the science fair are required to follow the engineering design process described below. They must complete and submit a Safety Assessment form prior to beginning this process. As students follow the engineering design process, they must write about each of the following steps in their log book.

1. Define a Need:

Begin by writing a need for the thing you want to construct and explain its purpose. This could be for a problem that needs to be solved or a situation that needs improvement. Write clearly so the need is easily understood. The goal of an engineering project is to design and construct a prototype for someone to use to perform a useful task. Example: "The goal of this project is to design, build, and test a way to create a step stool that folds out of a cabinet."

2. Research:

You need to make sure that your invention does not already exist. Research your topic using internet sites, magazines, textbooks, experts, and other available and reliable sources. **At least three sources must be used for the research.** On the last page of this packet you will find a sample research page. It is suggested that you make three copies of this page and use them in your science log book. A fairly lengthy paragraph should be written about each source telling what you learned. On this page you must record the information about the source of the information.

3. Design Requirements:

Next, you need to establish the requirements needed for the development of the prototype to decide how it will be built. Typical requirements relate to shape, size, weight, appearance, physical features, performance, use, cost, time and money. Another part of the design requirements is to describe what you expect the prototype to do and how it will be tested to meet the desired expectations.

4. Preliminary and Final Designs:

- **Beginning designs**

Draw the beginning designs of the prototype and be sure to label all parts. These designs can be brainstorming designs. You should show two or three ideas.

- **Final designs**

You need to select one type of design. Record all of the changes that had to be made to the design so that it can meet the requirements and expectations of the prototype. The changing designs should show progress from design to design.

- **List of materials**

All the materials and equipment you will use for building the prototype should be listed. It is suggested that you use descriptive words to describe your materials and equipment. Any materials that are measured should be measured in metric units.

- **Step-by-step procedure**

Write a step-by-step procedure you will follow to build the prototype. Write it in the order you want to follow. Be very descriptive in your writing.

5. Build, Test and Record, and Analyze the Results of the Prototype

- **Building the prototype**

Based on your design requirements, drawn designs, list of supplies and equipment, and by following the step-by-step procedure build your design. Write about your experience of building the prototype in your log book.

- **Testing and data recording**

After your prototype is built you need to test it to see if it works according to the testing procedure stated in the design requirements. You need to write down everything that happens during the testing. You should be as descriptive as possible. You must test your prototype three times. This helps you to get accurate test data.

- **Data is analyzed if redesigning is necessary**

Analyze the data. See if the results match the design requirements. If not, you need to redesign and rebuild your prototype. Repeat testing just as stated above.

6. Redesign, Retest, Record, and Analyze As Necessary

- After the first tests you may need to make adjustments by redesigning parts of the prototype that need adjusting. You need to show the adjustments with diagrams and labeling. Keeping accurate notes of the changes is very important in this part of the engineering project.
- Retesting is always necessary after redesigning has occurred. When you are retesting be sure to test three times and write down data as to what is happening.
- Analyze the data. See if the results match the design requirements. If not, redesigning is necessary. The redesigning and retesting of your prototype is a major part of the project. Keeping notes of the changes and the results are very important. You should be able to see at a glance what changes have been made and what happened when these changes are retested. You need to be able to recall the changes and results if needed.

- When you feel that the prototype has reached its greatest efficiency according to the design requirements, you can then go on to the conclusion. If you feel that more designing and testing is needed, then you need to continue to redesign and retest, writing down the data until you feel the prototype is finished. Each time you retest be sure to conduct three tests. The prototype needs to work and meet the design requirements.

7. Conclusion:

- When writing your conclusion you need to show evidences of what was learned. The conclusion summarizes the learning by answering some of these questions:

- How do the results validate what was expected to happen?

- What was learned from building the prototype?

- In what way is this prototype important?

- Is there more that could be done to improve the prototype?

- How does this prototype help people understand the world better?

- How can this information be applied to real life?

- What new insights were discovered?

- What knowledge was gained by designing and building to prototype?

- The conclusion needs to show the value of the project and the prototype and how it can apply to life and/or the real world. Write about the final prototype by looking at its merits, originality, and usefulness.

Please note: Any other project that is done by testing a product that does not involve the Engineering Design process should be done by using the Scientific Method.

The Engineering Design Log Book

All students must have a log book. It contains four main parts.

- **Title page**
- **Engineering Design pages**
- **Abstract**
- **Bibliography page**

1. Title Page

The title page consists of the project title, student name, and teacher name.

2. The Engineering Design

In this section you will write what you did or discovered by following each part of the Engineering Design process. There should be a page for each one of the following:

- Define a Need
- Research
- Design Requirements
- Project Designs
  - Beginning Designs
  - Final Design
- List of Materials
- Step-by-Step Procedure
- Building Prototype
- Testing and Recording Prototype
- Analysis
- Redesign
- Retest and Record Prototype
- Analysis
- Conclusion

3. Abstract

This is a one page summary including your need, design requirements, designs, procedure, your data analysis, and your conclusion. Also included is your bibliography. This abstract must be placed in the lower left corner of the display board. (Look for the abstract outline on page 9 in this packet.)

4. Bibliography

Write a list of the three or more sources you used for your research by telling the type of source, title, and page numbers if text was used.

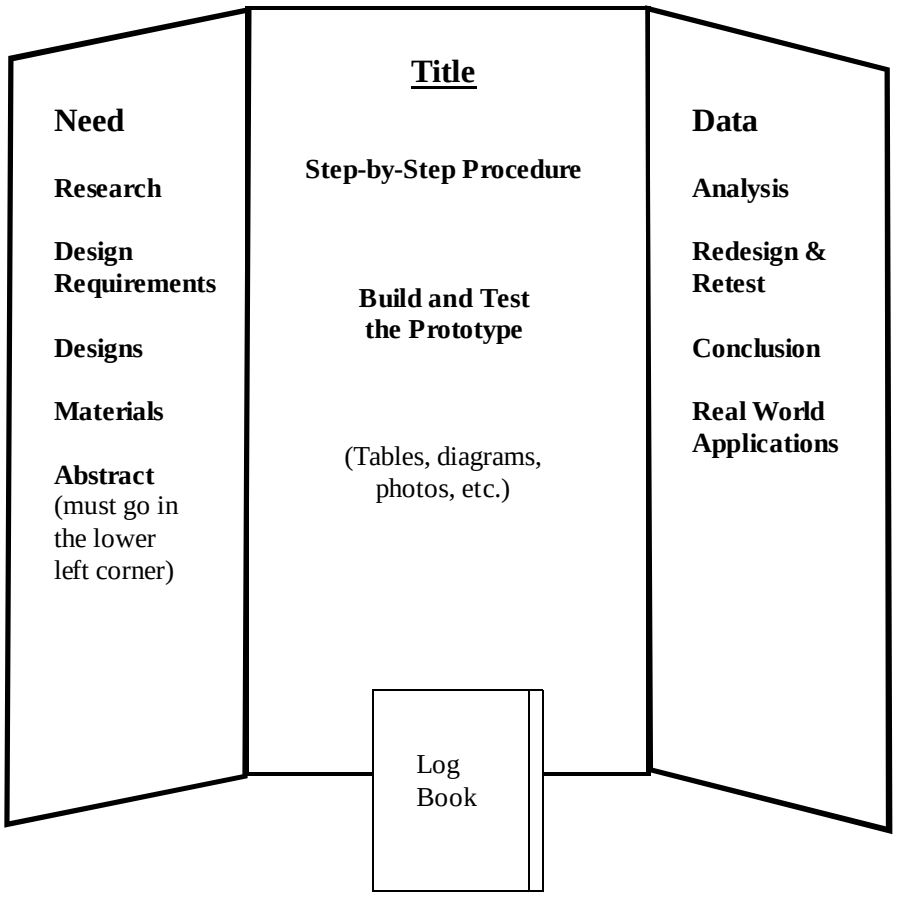
The Engineering Design "Display Board"

Create a display board so your findings can be shown at the science fair. It is a summary of your project and reflects your journal. This is your showcase. Make it creative and colorful. Below are ideas for a good display board.

- The board must be able to stand by itself.
- Title of your project should be at the top
- Show all the steps of the Engineering Design Process with a brief explanation of each: the need, research, design criteria, preliminary and final designs, building, testing results and the analysis, redesigning and retesting results and the analysis as needed, and the conclusion.
- Well-organized and easy to follow from one idea to the next
- Neat, edited, and without scribbles and misspelled words
- Creative, pleasing to look at, colorful, with different font sizes to show emphasis
- Photos of the developing design process; Your photos should only be of the prototype and the testing, not of people.

You may bring in your prototype and display it with your science fair board and log book. Your display board should look like this one.

PHYSICAL DISPLAY



<u>This is a suggestion for the placement of information on the display board</u>.

The abstract must go in the lower left corner. Put that on first then go to the top of that column and fit in the sections that you can. Then have the rest flow over onto the middle of the board in order.

Your display should be clear and easy to follow.

Here is an outline for the abstract. It should be done just as described below.

ABSTRACT

TITLE (ALL IN CAPITAL LETTERS)

Student Name

First paragraph includes the need and design requirements.

Second paragraph discusses the design/s and the step-by-step procedure, do not number.

Third paragraph discusses the data analysis and the conclusion.

Bibliography:

The bibliography should contain at least three (3) sources.

The abstract must be placed in the bottom left corner on the front of the display board.

What an Engineering Design Science Fair Project Is and Is Not

A Science Fair Project using the Engineering Design is Not:

- Just building a product
- A report about an engineering design
- A simulation or demonstration to show how something works
- A survey of what people think or feel about something
- A design that shows common knowledge that everyone knows
- A design that is copied from of a book or off the Internet

A Science Fair Project using the Engineering Design is:

- Thinking of a problem to solve by means of the building a prototype using the Engineering Design process
- Planning a design to construct a prototype to solve the problem
- Follow through with constructing something that works
- Testing the prototype and analyzing data to reach a goal
- Using the knowledge learned to make a connection to higher-level ideas and to understand those new ideas to see how to apply them to the real world.

Judging Criteria for Engineering Projects

I. Research Problem (10 pts)
___ description of a practical need or problem to be solved
___ definition of process for proposed solution

II. Design and Methodology (20 pts)
___ exploration of alternatives to answer need or problem
___identification of a solution
___ background research is diverse with multiple sources
___ procedure is sequential and describes the investigation clearly
III. Execution: Construction, Testing, and Results (25 pts)
___ prototype demonstrates intended design
___ prototype has been tested in multiple conditions/trials
___ prototype demonstrates engineering skill and completeness
___quantitative, metric data collected and displayed appropriately
___conclusion based on success in regards to the problem being solved and suggestions for further efforts or practical applications

IV. Creativity (10 pts)
___ project demonstrates significant creativity in one or more of the above criteria
___ project demonstrates imagination and inventiveness that offer different perspectives to new possibilities or new alternatives

V. Presentation (35 pts)
a. Poster (10 pts)
___logical organization of material with supporting documentation displayed
___clarity of graphics and legends

b. Interview (25 pts)
___ clear, concise, thoughtful responses to questions
___ understanding of basic science relevant to project
___ understanding interpretation and limitations of results and conclusions
___degree of independence in conducting project
___ recognition of potential impact in science, society and/or economics and quality of ideas for further research

Scoring Rubrics

Judges use the scoring rubrics below when evaluating projects. All questions assessing the project itself are scored using the Project Display Rubric. All questions requiring a student response are scored using the Student Response Rubric.

	Project Display Rubric	**Student Response Rubric**
0	No evidence or incorrect	Student has no understanding or is unable to respond or section is missing.
1	A weak attempt made/ many errors or major flaws	Student has little knowledge or flawed understanding.
2	Partial evidence/ some flaws or omissions	Student has some knowledge but lacks complete understanding.
3	Missing some evidence/few minor flaws or omissions	Student has good knowledge but lacks complete understanding.
4	Clear evidence/minor flaws or omissions	Student is able to articulate an adequate understanding.
5	Clear evidence/no flaws	Student able to articulate a clear understanding.

Proposed Schedule

Week 1
Student becomes familiar with the Engineering Design process. Student gets the science fair log book ready. Student comes up with a need for his/her science project design and writes it in the log book.

Week 2
Student researches the topic by finding at least three sources and reading about them. He/she writes detailed paragraphs about what was learned on the research pages that get put into the log book.

Week 3
Student writes his/her design requirements in the log book. Student begins the preliminary designs and narrows it down to the design desired. Student creates a list of the materials needed.

Week 4
Student writes up the final step-by-step procedure for the prototype in the log book. Student acquires the materials needed to build the prototype.

Weeks 5-6
Student builds the prototype according to the design requirements and sets up a plan on how to test it. Student tests the prototype three times. He/she gathers data and writes the data in the log book. Student analyzes the data and determines if it worked or not according to the design requirements.

Week 7
If the prototype doesn't work according to the design requirements, then redesigning and retesting is necessary. Data is gathered and analyzed again. Once it meets the design requirement a conclusion is written up.

Week 8
Student makes a creative display board using colors, decorative paper, different font size, pictures, and designs. The board displays all parts of the engineering design (except the research). Student writes a brief explanation under each design step on the board.

What Parents Can Do and What Students Need To Do

It is very important that a student do as much as he/she can when doing a science fair project. This is how the student learns first-hand what is involved in the planning, the experimenting, and the writing of a science fair project. A rule of thumb is if the student can do it, the student should do it.

Parents can act as a coach, but they shouldn't be in the "game" playing. In other words, the student should do all the work that is part of the project. Parents can brainstorm, share ideas, and help bring out the knowledge learned by the student. Parents can help build things that are hard for the student. After the parent help, final decisions should rest with the student.

Parents can help by sharing ideas on how to set up a log book. They can help with brainstorming questions or problems for an engineering design project. They can brainstorm with the student about which books, encyclopedias, Internet sites, and people for interviews, etc. to use for the research. The parent and student could read the research together if needed. After the reading, parents can help bring out the information of the research so the student can understand it.

Parents can help with brainstorming ways to design the prototype. They can make sure the design is safe and the student is following all the science fair rules. Parents can help with the purchase of supplies needed for the project. They can coach and assist the student in building things.

Parents can teach the student computer techniques to make charts, graphs, and downloading pictures off the computer. They can help the student understand what the gathered data means. Parents can help bring out the ideas as to what was learned in the testing process so the student can come up with a conclusion. They can help with brainstorming ways to put together an effective display board, such as, ideas of what to put on the display board and where to effectively place the important information.

What the Student Needs to Do Mostly By Themselves With Some Parent Guidance

- The student should do all the writing in the log book.
- The student should come up with the final decisions for 1) the need of the engineering project, 2) the design requirements, 3) and the prototype design.
- If items need to be purchased for the project, the student should mostly be with the parents during the purchase of the supplies.
- When it is time to build the prototype and tools are needed, parents should let the student help as much as possible at the discretion of the parents for the sake of safety for the student. The student should help with measuring, sanding, gluing, building, and anything else the student is able to do. The student shouldn't leave the project for the parent to finish.
- During the prototype testing, the student should be there the whole time measuring and writing down the data in the log book. The parent should oversee the testing for the sake of safety.
- The student should have the final say for the analysis and conclusion writing.
- The student should mostly come up with the final decisions as to how the display board should look.
- The student should mostly do all the computer work that is going on the display board.
- The student should mostly do all the pasting of the words and pictures on the display board.

RESEARCH YOUR TOPIC

You should find out as much as you can about your topic. You must use at least 3 sources that could include teachers, professionals, librarians, books, encyclopedias, magazines, newspapers, videos, etc. **Take notes by writing down the most important facts. You need 3 copies of this page or you can make you own research pages. These pages should be included in your log book.**

Source of Information: Be sure to record the title of the article or book, the author, the page numbers and the year it was published. If you interviewed someone be sure to record their name, title and the date and time. This will be the information you will need to put in your bibliography as part of your abstract.

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Important Facts: