How to Complete an Engineering Project

What is an engineering project?
An engineering project uses design and engineering processes to find a practical solution to a problem that addresses a need that exists.

Engineering Graphic: If you are doing an engineering project, make sure you use the Engineering Design Process diagram to guide your work through completing an engineering project. It is located on page 23.

1. Get an Idea for Your Engineering Project
Like a science project, an engineering project starts with a problem, but the problem is a bit different. In science, you might be asking a “What if?” question, such as “What will happen if I add food coloring to saltwater before I evaporate the water?” Engineering, on the other hand, looks at the real world, sees a problem or a condition that may not be working the best, and tries to solve the problem. In other words, what do you see in the real world that you think you can fix, change, or improve?

There are two categories in the Engineering division of the Science and Engineering Fair.

- ***Engineering Mechanics*** focus on the science and engineering involved in movement or structures. Some engineering fields connected to this category include:
    - aerospace and aeronautical engineering
    - circuit engineering
    - civil engineering
    - ground vehicle system engineering
    - industrial engineering/processing
    - mechanical engineering
    - naval systems engineering
- ***Environmental Engineering*** includes developing a prototype or process that solves an environmental problem. Environmental Engineering covers many careers in the real world, including:
    - bioremediation
    - land reclamation
    - pollution control
    - recycling and waste management
    - water resources management
    - invasive species management

2. Start an Engineer’s Log Book
A detailed engineer’s log book with accurate records allows engineers to describe their design process so others can follow the process. Your log should be a bound notebook (such as a composition book). It should be done fully in ink. That’s because it can be used as a “legal document” to prove your invention is your creation. In the real world, the engineer’s log book is used as proof for

patents and copyright. It can even be used as evidence in lawsuits over who was the first person to come up with a new idea. That's a pretty powerful book!

Don't worry about making mistakes or making a messy drawing. Mistakes are part of the process of learning and discovering. If you make a mistake, just draw one line through the mistake and keep going. Don't tear out pages or scribble out anything. It's possible that a design you thought wouldn't work early in the process turns out to be the solution to your problem.

Setting Up Your Engineer's Log Book: Divide your log book into two sections.

- In the **Daily Work** section, write down all the things you do or think about concerning your project each day. ***Make sure you date every entry.*** Think of it as a blog post each day:
  - What did you do today for your project?
  - Did you write your testing procedure?
  - Did you build your prototype?
  - Did you change your prototype today?
  - What issues did you run into today?
  - Who did you talk to about your project?
  - What did you research? Make sure to add the bibliography information for each source as you come to it.
  - Give details! Each day's entry should show the progress on your project.

- In the **Data** section, make charts **before** you start testing. The Data section of your log book should have all the data and observations from your testing. If you make a mistake, draw a line through it and rewrite it. Do not erase or white out a mistake.
  - Record all **measurements** in ink as you measure them during your testing.
  - Make **observations** during your testing. Observations help the engineer explain the data. For example, on one test cycle, a trial ends up much lower than all the other trials. The engineer observes that the prototype wheel was wobbling on that trial. So, the observation explains the data and both parts are very important. Sometimes, it's the unexpected observation that leads to a new idea for improving the prototype.

3. Complete the Project Approval Form - 2 pages

This form lets your teacher know what you've chosen for your project. It gives an overview of your project with enough detail that anyone who reads it can get a pretty good idea of what you will be doing. Once your teacher approves the project, he/she will give this form back to you. It will have a list of other forms you will need to complete before you begin your project. ***Make sure you keep this signed form and all forms you complete--they are required to be turned in with your project.***

4. Become an Expert in Your Problem

The research phase of your project is very important. This is where you learn everything you can about the topic of your project. If you are trying to solve a problem, you need to understand the problem. Spend some time getting background information. Good research will help you become an expert on your topic. Remember to write down the bibliographic information about each source you read, consulted, or tried to contact. Some ideas of places to go for research are:

- library
- internet--Make sure it is a ***reliable*** source of information (talk to your school media specialist about this).
- experts in the field
- Write to companies involved in your field.

5. Complete Ethics Agreement and Risk Analysis and Designated Supervisor Form

By signing the *Ethics Agreement*, you are saying that you won't copy someone else's work. You can refer to someone else's work, but you have to cite it in your log book and on the bibliography. Copy-and-pasting images, words, etc., from the internet is considered plagiarism. If you identify *where* you got each part of what you copied (cite the source), you have done your job.

The *Risk Analysis and Designated Supervisor Form* is used to state all the risks in your project. Risks might include:

- the tools and materials you are using. How can you stay safe when you use them?
- the location you are testing in. Is it close to a road or body of water?
- the science safety tools you will be using.

In this handbook, the Risk Assessment and Safety Considerations section will help you complete this form.

6. State the Problem in a Question Form

Your problem is what you are trying to fix with your prototype. The problem should be a practical need. Are you building a completely new item or are you modifying (changing) an existing item to make it work better in certain conditions? Whatever it is you are trying to do, your final prototype should be a solution to the problem you identified. Your problem should also be very specific. For instance, if you want to design a tool that can collect litter, be very specific about where the tool would be used (on the beach, in the water, on grass?). Also ask yourself, "What is the real-world application for my prototype?"

7. Research

Engineers need to get a full picture of the problem they are addressing before they start building their prototypes. That's where research comes in. If you are building a bridge, find out about different bridge designs and the uses, strengths, and weaknesses of each design. If you are designing a tool to solve an environmental issue, become an expert on the issue and on what other people have done to try to solve the problem. You don't want to duplicate something that has already been done; you want to come up with an original design. Research helps you to fully understand the problem and possible solutions before you start your design.

For the Science and Engineering Fair, at least ***3 sources*** are required for the research phase. These sources must be documented in both the engineer's log and on a bibliography. Interviewing an engineer or other expert in the field of your project is an acceptable source.

8. Brainstorm Ideas

Your initial design should start as a brainstorm of several designs. Don't stop at just one. Brainstorm alternative designs that might solve the problem. All of your designs should be in your log book, with detailed labels, materials needed, and measurements. Another engineer should be able to take your diagram and make an exact replica of your prototype, based only on your diagrams.

9. Choose Your Engineering Goal

Once you have multiple designs to choose from, select the one that you think best fits the specifics of your project. In science, we call this part the "hypothesis." In engineering, it is called the engineering goal. The engineering goal is a written description of the design you choose to build, test, and modify. Make sure you document in your log your rationale for choosing that design. At judging time, you might be asked about different ideas you brainstormed and why you thought your design was the best design.

10. Design the Testing Procedure

Your testing Procedure should mirror the real-world conditions, as much as possible, that the prototype will face. If you aren't able to test your prototype in the real world (due to safety considerations), come up with an "analogous" or simulated situation. For example, if your prototype is meant to be used in the Indian River Lagoon, but Science and Engineering Fair rules don't allow you to test in the actual Indian River Lagoon, where else could you set up a safe testing environment? Perhap a bathtub, child's pool, or other area would provide a suitable place. If your project is addressing the collection of invasive species, could you test it on toys instead? These not-quite-real-world conditions are used to simulate the real world and can be used for data collection.

Your testing Procedure should be very specific, as it describes the steps to be followed every time you test your prototype. It should include how you will measure the effectiveness of the prototype. Think about all necessary safety precautions and include them in the Procedure.

Testing your prototype should also include repeated trials. If you only test your prototype once in each cycle, your results may not be reliable.

11. Build a Prototype of Your Initial Design

As you build a prototype of your initial design, make sure you are following the design plan in your log. If you find you have to change the design as you build it, make sure to show that in your log.

Changing a prototype is called "modifying," and it is extremely important to document all modifications in engineering. ***Any project with no evidence of modifications will not be entered in the Regional Science and Engineering Fair.*** As you finish your prototype, it might be helpful to take a photo of it for documentation. However, photos are NOT a substitute for detailed diagrams in the log. Remember, another engineer should be able to build the same prototype out of just your diagram.

12. Testing, Analysis, and Modification

The Engineering Process is a loop of repeated testing (according to your Procedure), analysis of the results of the testing, then modification of the prototype, based on the analysis. The analysis should include the following questions:

- What on the prototype worked well?
- What parts of the prototype didn't work as well as expected?
- What parts of the prototype failed? It's okay if a part failed--that shows a part that definitely needs modification.

During testing, it's critical to record not just the measurement data, but also observations made as the prototype was performing. You might observe something that is causing the prototype to underperform. An example:

- You are testing your prototype for distance, but your prototype doesn't go as far as you expected (measurement). You observe that one gear is not spinning as well as the others (observation). That one gear could be a starting point for modifications.

Once you've analyzed your test results, it's time to modify your prototype to address the issues identified in testing. Document your changes with a new detailed and labeled sketch for each testing, analysis, modification cycle. Also, give a rationale for each change to your design, basing it on your testing and analysis. **You should be modifying your Initial Design, not starting over with a new design each time.**

The ***Testing - Analysis - Modification*** cycle of the Engineering Process should continue until you have a prototype that completely solves the problem you identified for your project.

A note about "perfect prototypes": If your prototype works perfectly the first time, consider if you have made the test requirement too lenient. In other words, did you account for ***all*** the different factors in the process? Engineers test their products and processes "to failure." How can you tell how much stress your device can take if you don't keep going until it fails? Once you know where it fails, you know the limits of your device. Then you can also engineer ways to increase what your device can do.

13. Final Prototype

Once you have a prototype that solves the problem, you are ready for your final prototype. Your rationale (conclusion) for this being your final prototype should be supported by your data and analysis. You should also have a detailed diagram of your final prototype. Remember to include:

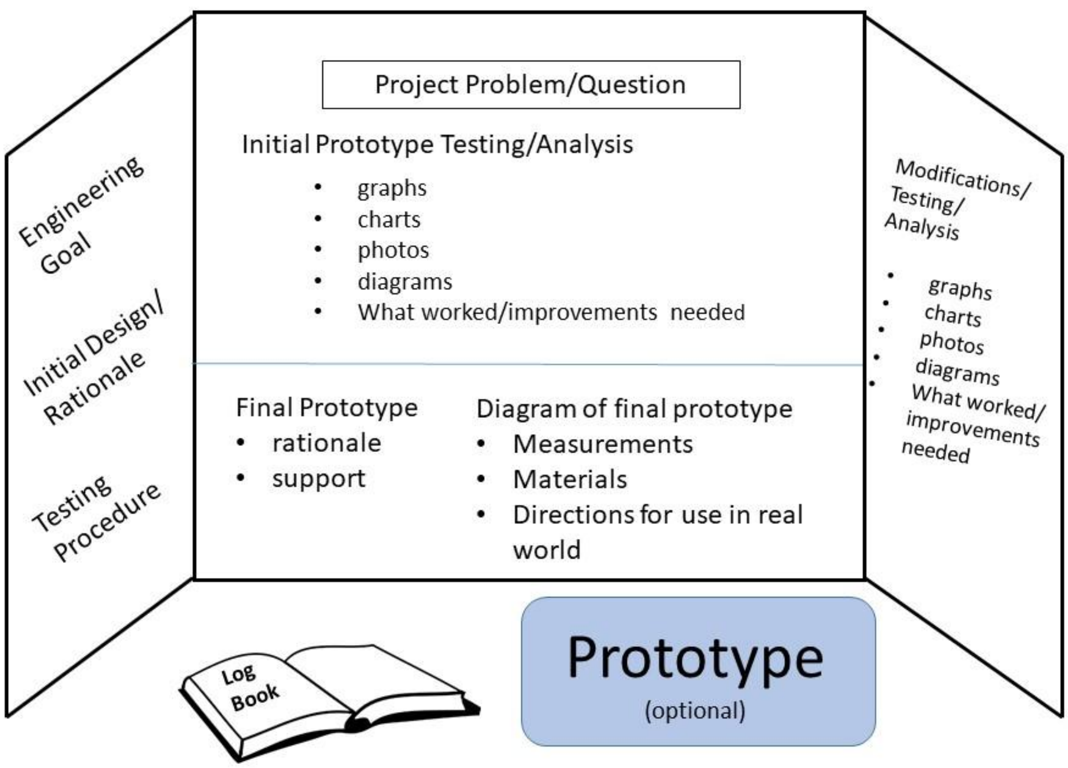
- measurements
- specific materials used
- specific directions for the use of your prototype in the real world

14. Communicate Your Results/Construct a Display

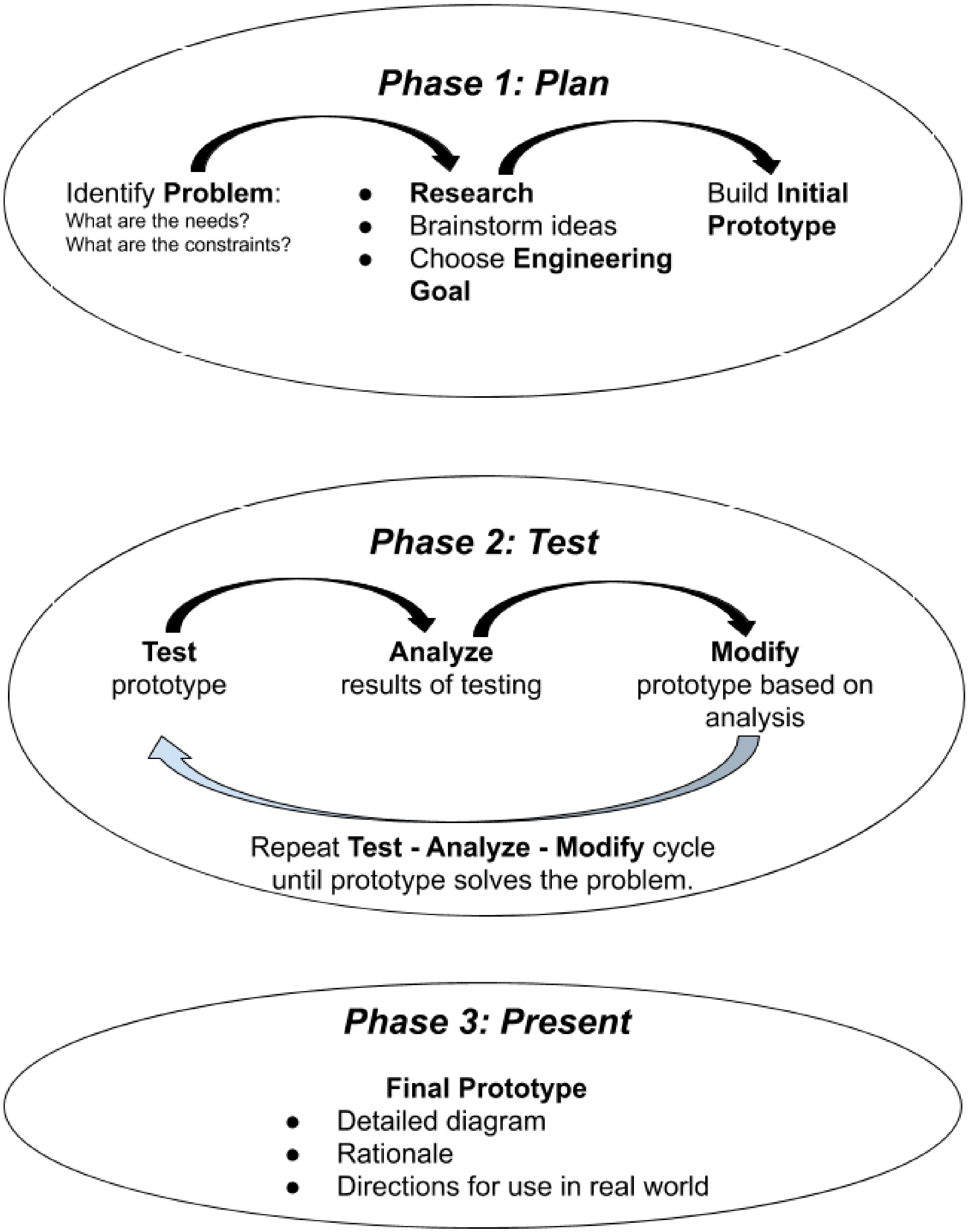
Engineers share their findings with others. If your prototype solves a problem, it is good to let others know about it! You should be able to fully explain all parts of your project:

- engineering goal
- initial design ideas
- testing procedure
- modifications made
- final reflection

On the next page is a sample of an Engineering Project Display Board. Your board does not have to match this exactly, but it MUST have your problem and tell the story of your project.



Engineering Design Process



SEF Student Checklist

Engineering Division

Student Name____

check each box	Congratulations on completing your project! Use your SEF Student Handbook and this checklist to be sure you have completed all of the required parts and that you stayed within the rules for your project. ***In order to be safe and fair, if you don't follow the rules, your project will not be permitted in the Regional Science and Engineering Fair.***
☐	Check the box if you have completed and signed all of the ***necessary forms*** for your project. Look on page 2 of your Project Approval Form for what you need.
☐	Check the box if your ***problem/question*** is on the board or in your log.
☐	Check the box if your ***engineering goal*** is on the board or in your log.
☐	Check the box if your ***initial prototype design/rationale*** is on the board or in your log.
☐	Check the box if your ***testing procedure*** is on the board or in your log.
☐	Check the box if you have evidence of testing, analysis and modification to your initial prototype on the board. ***Any project with no evidence of modifications will not be entered in the Regional Science and Engineering Fair.***
☐	Check the box if your ***bibliography*** is complete, with at least ***three sources,*** and with your project.
☐	Check the box if you have a detailed diagram of your ***final prototype*** with directions for how to build it and how to use it in the real world.
☐	A ***log book*** is required for each student engineer (team projects require a log book for each student). Check the box if ***your log book is complete and with your project***.
☐	You can use ***photographs,*** (even ones that show your face), but you have to tell who took the photos. If the same person took them all, just put one label that says, "All photos taken by _______." But only use first names. You can also say, "Scientist's mom took this photo," or "Photo taken by scientist." Check the box if you have labeled your photographs.
☐	Items used from the ***Internet*** (articles, graphs, charts, pictures, etc.) need to have labels to cite the source. For example, "This chart was from (URL of website)" Check the box if you've labeled your Internet sources (if this applies to you).
☐	Check the box if your display board is able to ***fold and lay flat*** and does not contain prohibited objects (such as lighting, soil, rocks, liquids, living or dead organisms, blood, sharp objects, plastic bottles, etc.).
☐	Check the box if your project ***meets all of the rules and requirements*** outlined in the *SEF Student Handbook*.

Judging Criteria: *Engineering Division*

________________________/____

Project Number *Category*

Project Problem____

	Superior	Very Good	Good	Poor	Notes
Research Problem ● clear and focused ● description of practical need or problem to be solved ● real-world application	10	8	4	2	
Design and Methodology ● well-designed plan for prototype and testing ● explanation of limitations ● explanation of alternatives	15	10	5	2	
Testing/Modifications ● systematic data collection ● evidence of testing, analysis, and modification of prototype ● rationale for modifications ● final design is supported by data	15	10	5	2	
Representation of Data/Design ● accurate application of mathematics for analysis ● clarity of graphs/charts/diagrams ● appropriate representation of graphs/charts	10	8	4	2	
Log Book ● detailed observations/entries ● sketches/diagrams ● dated entries ● evidence of research ● bibliography (at least 3 sources)	15	10	5	2	
Interview ● clear, concise response to questions ● understanding of science concepts ● understanding of design process ● degree of independence ● lessons learned ● ideas for future research ● If team, both members demonstrate significant contribution to project	15	10	5	2	
Display ● logical organization of project content ● tells story of project ● displays student learning	10	8	4	2	
Creativity ● project demonstrates imagination and inventiveness ● project opens up new possibilities or new alternatives	10	8	4	2	

**Form to be printed in blue for the Regional Science and Engineering Fair.

Total ____________