

ENGINEER'S LOG-BOOK

(Adapted from "Design Concepts for Engineers" by Mark N. Horenstein, Prentice Hall, 2002)

DOCUMENTATION: THE KEY TO PROJECT SUCCESS

Engineering design is never performed in isolation. Even the simplest of projects involve a designer and those who will benefit from the finished product. More often, a design effort involves considerably more individuals who worry about many facets of the product. The design of an automobile, for example, encompasses the work of mechanical, electrical, industrial, biomedical, and safety engineers. A consumer products company involved in the production of, say, cellular telephones, will bring together computer, electrical, mechanical, and manufacturing engineers in a multidisciplinary team that may include people from sales and marketing. Complex engineering projects are successful only if everyone on the design team communicates with everyone else at all phases of the design effort.

One way in which engineers communicate with each other is through careful record keeping. Good documentation is essential when engineers work in teams. When you work as a member of a design team, it's your responsibility to maintain a comprehensive collection of design concepts, sketches, detailed drawings, test results, redesigns, reports, and schematics. This *documentation trail* serves as a tool for passing information on to team members who may need to repeat or verify your work, manufacture your product from a prototype, apply for patents based on your inventions, or even take over your job should you be promoted or move to another company. Written records are also a good way to communicate with yourself. Many an engineer has been unable to reproduce design accomplishments or confirm test results due to sloppy record keeping. Indeed, one of the marks of a professional engineer is the discipline needed to keep accurate, neat, up-to-date records. Documentation should never be performed as an afterthought. If a project is dropped by one team member, the state of documentation should *always* be such that another team member can resume the project without delay. As a student of engineering, you should learn the art of record keeping and develop good documentation habits early in your career. Most companies, laboratories, and other technical institutions require their employees to keep records that document the results of their engineering efforts.

Paper Versus Electronic Documentation

Today, just about every piece of engineering documentation, with the exception of the engineer's notebook described in the next section, is produced on a computer. Examples of documents destined for preservation include word processed text, spreadsheets, schematics, drawings, design layouts, and simulated test results. Some engineers prefer to store information on disk so that it can be viewed on screen and printed out only as needed. Others prefer the older method of preserving documentation by printing everything on paper and storing the documents in a physical file cabinet. Whichever method you choose, you should follow these important guidelines:

- *Organize your information:* It's important to store documentation in an organized and logical manner. If the project is small, its documentation should be stored in a single folder (paper or electronic). Larger projects may require a group of folders, each relating to different aspects

of the project. The folders should be labeled and dated with informative titles such as "Propulsion System for XYZ Project" and kept in a place that will be easy to find should another team member need to use it.

- *Back up your information:* It's equally important to store a duplicate copy of all documentation. This guideline applies to written as well as electronic information. Fire, flood, theft, misplacement, and the all-too-common disk crash can lead to the loss of a project's documentation trail. Archival storage of records in a different physical location will help to keep a project on track should one of these catastrophes occur.

The Engineers' Logbook

One important vehicle for record keeping is the *engineers logbook*, sometimes called the *engineer's notebook*. A well-maintained logbook serves as a permanent record that includes all ideas, calculations, innovations, and test results that emerge from the design process. When engineers work in a team, each team member keeps a logbook. When the project is brought to completion, all logbooks of all team members are placed in an archive and remain the property of the company. An engineering notebook thus serves as an archival record of new ideas and engineering research achievements *whether or not they lead to commercial use*. A complete logbook serves as evidence of inventorship and establishes the date of conception and "reduction to practice" of a new idea. It shows that the inventor (you!) has used diligence in advancing the invention to completion. In this respect, the engineer's logbook is more than just a simple lab notebook. It serves as a valuable document that has legal implications. When you work as an engineer, you have a professional responsibility to your employer, your colleagues, and to the integrity of your job to keep a good logbook.

The logbook used in industry, government labs, and research institutions typically has permanently bound and numbered pages, a cardboard cover, and quadrille lines that form a coarse grid pattern. A label fixed to the front cover uniquely identifies the notebook and its contents. The company, laboratory, or project name is printed at the top, and the notebook is assigned a unique number by the user. In some companies and large research labs, a central office assigns notebook numbers to its employees when the notebook is signed out.

The techniques for logbook use differ from those used in some science and introductory engineering classes where instructors encourage students to write things down first on loose scratch paper and then recopy relevant items into a neat notebook. This procedure is bad practice for a design engineer. Although notebooks prepared in this way are easier for instructors to grade, the finished notebook seldom resembles a running record of what actually occurred in the laboratory and is not especially useful for engineering design projects. Design is as much a *process* as it is a final product, and the act of writing down ideas as they emerge and of recording (and commenting on) events as they happen helps engineers to think and be creative. Also, keeping a record of what did *not* work is just as important as recording what did, so that mistakes will not be repeated in the future.

Logbook Format

An engineering logbook should be used as a design tool. Enter everything into your logbook, no

matter how seemingly irrelevant. Write down ideas as you think of them, even if you have no immediate plans to pursue them. Keep an ongoing record of successes and failures. Record the results of every test-mechanical, structural, electrical, system, flight, or performance-even if the results may not be used in the final design. Stop to write things down. This habit will require discipline but will always be worth the trouble. Important information, including some you might otherwise have forgotten, will be in your logbook and at your fingertips when you need it.

Any logbook format that meets your needs and those of your team is suitable, as long as it forms a permanent record of your contributions to the design process. Ban loose paper from the laboratory. It is easily lost, misfiled, or spilled upon. Resist the temptation to reach for loose paper when you need to do a calculation. Instead of grabbing that pad to record information, draw a sketch, or discuss an idea, take the time to open your logbook. You'll be glad you did when these numbers and sketches you need are readily available. Unbound paper used for anything other than doodling has no place in an engineering laboratory.

Using Your Engineer's Logbook

As chief author of your logbook, you have the freedom to set your own objectives for its use. The following guidelines, however, are typical of those used by many engineers and design teams:

1. Each person working on a project should keep a separate logbook specifically for that project. All relevant data should be entered. When the logbook is full, it should be stored in a safe place specifically designated for logbook storage. In that way, everyone will know where to find the logbook when it's needed.
2. All ideas, calculations, experiments, tests, mechanical sketches, flowcharts, circuit diagrams, etc, related to the project should be entered into the logbook. Entries should be dated and written in ink. Pencil has a nasty habit of smudging when pages rub against each other.
3. Relevant computer-generated plots, graphics, schematics, or photos printed on loose paper should be pasted or taped onto bound logbook pages. This procedure will help prevent loss of important data.
4. Logbook entries should outline the problem addressed, tests performed, calculations made, and so forth, but subjective conclusions about the success of the tests (e.g., "I believe...") should be avoided. The facts should speak for themselves. Logbook entries should not be a tape recording of your opinions. The voice of the logbook should speak to a third-party reader. Assume that your logbook will be read by teammates, your boss, or perhaps someone from marketing.
5. In settings where intellectual property is at stake, the concluding page of each session should be dated and, where appropriate, signed. This practice eliminates all ambiguity with regard to dates of invention and disclosure. At least one other person and preferably two should periodically and routinely witness important entries that signify key events in the design process. Witnesses should endorse and date the relevant pages with the words, "witnessed and understood."

6. Logbook pages should not be left blank. If a portion of a page must be left blank, a vertical or slanted line should be drawn through it. Pages should be numbered consecutively and not be torn out. These measures are necessary should your logbook ever become part of a legal proceeding where the integrity of the information comes into question. Do not erase or make changes using correction fluid. Cross out instead and then write the correction above. This precaution will prevent you from creating obscure or questionable entries should your logbook be entered as legal evidence in patent or liability actions.
7. Do not staple, tape or glue anything into the logbook because it could become detached at any time. Instead, write down where the additional information can be found and file the information safely. Also, from a legal standpoint the time something was attached or removed could be questioned.

Technical Reports and Memoranda

Logbooks provide but one method by which a team keeps a good documentation trail. Engineers also communicate by writing technical reports at the significant milestones of a design project. A technical report describes a particular accomplishment and perhaps provides some project history or background material before explaining the details of what was achieved. The report may contain theory, data, test results, calculations, design parameters, or fabrication dimensions. Technical reports form the backbone of a company's or laboratory's technical database. Reports are typically stored in archival format, each with its own title and catalog number. Information for technical reports is easily gathered from logbooks that are accurate and up to date. When the time comes to write a journal paper, patent application, or product application note, the technical report becomes an indispensable reference tool. It is wise for engineering students to study techniques for writing technical reports in a clear and concise manner.

A technical report is also an appropriate way to explain why a particular idea did not work or was not attempted. Taking the time to write a technical report about a negative result or design failure can save considerable time should a design concept be revisited by engineers who were not present when the original project was undertaken.

Schematics and Drawings

Documentation does not always appear in the form of text. Graphical records, such as drawings, circuit schematics, photographs, and plots, also become part of the documentation trail. These items typically are created with the help of computer software tools. If the documents are to be stored electronically, then all files related to a particular project should be organized in a logical hierarchy. Some engineers choose to keep all files for a project in a single file folder on the computer. Others prefer to sort files by the applications that produce them (e.g., CAD drawings in one folder, spreadsheet files in another). Other engineers like to transfer all the computer files related to a given project to a single removable disk that can be stored in a physical file cabinet folder. If paper is chosen as the storage medium, then graphical output should be printed on paper and kept in a folder along with other written records. Regardless of which storage method is chosen, the information related to a particular project should be carefully preserved in a format that will prevent loss.

Appendix: EXAMPLE OF AN ENGINEER'S LOGBOOK

The following example illustrates proper use of an engineering logbook. Imagine that the logbook pages shown describe a self-propelled vehicle that you are designing for a student design competition. The first page, Figure 1, shows your preliminary sketch of a basic concept based on a vehicle that has the shape of a moving wedge. The second page, Figure 2, contains some calculations that estimate the battery drain as the vehicle moves up the contest ramp. The entries on the third page, Figure 3, show a list of parts and materials to be purchased at the hardware store. These parts will enable you to build a prototype and test your vehicle's ability to climb the ramp.

DESIGN CONCEPT FOR DEFENSIVE STRATEGY.

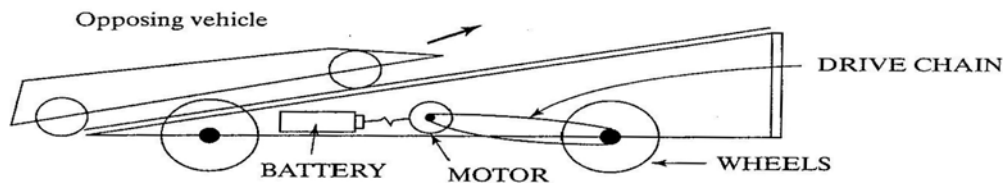


Figure 1: Logbook entry: Moving wedge concept for competition vehicle.

BATTERY POWER REQUIREMENTS

Estimate the weight of the vehicle:

$$0.9 \text{ kg} \times 10 \text{ N/kg} = 9 \text{ Newtons}$$

Compute the stored energy as the vehicle arrives at the top of the ramp:

$$9 \text{ N} \times 3 \text{ ft} \times 12 \text{ in/ft} \times 0.25 \text{ m/in} = 8 \text{ J}$$

Estimate the mechanical power. Assume vehicle takes about 7 sec to travel up the ramp:

$$8 \text{ J} / 7 \text{ sec} = 1.1 \text{ Watts}$$

Estimate the current drain on a 9-V battery (assume $P_{\text{elec}} = P_{\text{mech}}$ -- neglect losses for now):

$$I = P/V = 1.1 \text{ W} / 9\text{V} = 0.12 \text{ A}$$

Figure 2: Logbook entry: Power consumption calculations.

PEAK PERFORMANCE DESIGN COMPETITION

2/7/99

PARTS LIST (to be purchased at hardware store)

Nuts and bolts (#8 $\times$ 1/2" with washers)

Wood screws (#6 $\times$ 3/4" long)

L-brackets (4):

Super Glue

Electrical tape

Solder (small cheap soldering iron? Or borrow?)

Switch (may have to go to electronic parts store)

Long threaded rod #10 thread size (will they have one?)

#10 thread wing nut

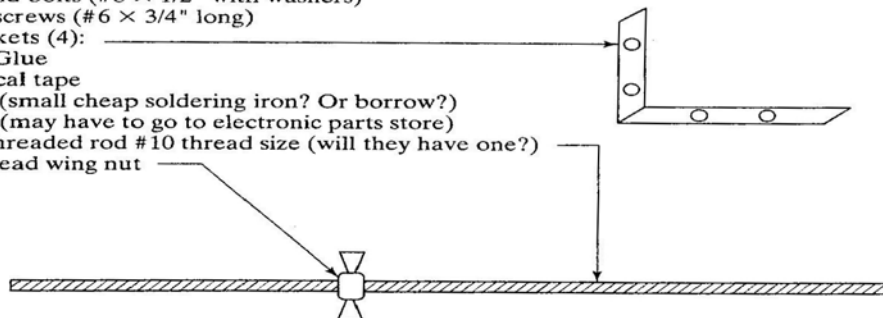


Figure 3: Logbook entry: List of parts to be purchased at the hardware store.

Software Documentation and the Role of the Engineering Notebook

Of all design endeavors, the writing of software is the one most prone to poor documentation. The revision loop of a software design cycle can be extremely rapid, because the typical software development tool enables a programmer to make small changes and test their effects immediately. This rapid-fire method of development invites poor documentation habits. Seldom does the software engineer find a good time to stop and document the flow of a program, because most pauses are short and change is frequent. As a result, the documentation for many software programs is added after the fact, if at all.

If you find yourself writing software, get into the habit of including documentation in your program as you go along. All software development tools provide a means for adding comment lines right inside the program code. Add them frequently to explain why you've taken a certain approach or written a particular section of program code. Explain the meaning of object names and program variables. Your in-program documentation should enable other engineers on your team to completely understand and take over the writing of your sections of the program simply by reading the comment lines. Good in-program documentation also will be invaluable to you should you need to modify your program at a later time. It's amazing how quickly a programmer can forget the internal logic of a program after setting it aside for only a short time.

If your program is destined for commercial sale, then good internal documentation and truly helpful "help" files are essential. Documentation included inside the program on a regular basis will easily translate into help files and an instruction manual when the need arises. One trick used by top-notch software developers is to write the help and instruction files as the program code is developed, rather than as an afterthought. Changes to the instruction manual can be made at the same time that changes are made in the program code. The abundance of commercial software packages with pathetic or poorly written help files or instruction manuals is testimony to generations of software engineers who have perpetuated a tendency toward poor documentation habits. If you master the skill of documenting software, your software products will be better utilized and more successful than those with poor documentation.

Although the keeping of engineering logbooks is less relevant to software development than to other types of engineering, logbooks still can play a special role. On the pages of your notebook, you can outline the overall flow of the program and the interconnections between its various modules. You can try out sketches for graphical user interfaces without first having to write actual computer code. You can draw plots of relational databases and make lists of the variables to be used in the software.

If you want to keep a good documentation trail, get into the habit of carrying your logbook with you wherever you go. In that way, it will be available whenever you have a thought or idea that needs recording. Buy a medium-size notebook that can fit easily into your backpack. Clip a pen right inside the front cover. Be sure to write your name and contact information on the front cover in case you misplace your logbook! A tiny, 3" x 5" bound notebook will do nicely. Although writing space will be limited because of the smaller size, you'll be more likely to carry it if it's not overly large.