7

Effective Communication

Imagine that you have just purchased a new, top-of-the-line computer with the fastest available processor, many megabytes of memory, a huge disk drive, and a large, sophisticated sound card. When you get the computer home from the store, you notice that the model you bought has been shipped without a monitor. In fact, the computer is missing entirely a socket where a monitor can be connected. In all other respects, the computer is state-of-the-art and in perfect condition. What would your reaction be? You probably would take the computer back to the store claiming, of course, that any computer, no matter how fast or powerful, is useless without a means to extract the information it produces. Now imagine a similar scenario in which the computer has a monitor but comes with a very poor modem capable of a maximum data transfer rate of only 300 baud (about thirty printed characters per second). Such a slow modem would indeed limit the efficiency with which your computer could talk to other computers over the Internet. Reading electronic mail (e-mail) would be hopelessly slow, and accessing Web pages would be next to impossible. You probably would take this second computer back to the store also, claiming it to be a powerful machine that is incapable of communicating with others.

SECTIONS

OBJECTIVES

In this chapter, you will learn about:

- Writing effective e-mail messages and memos.
- Preparing for formal and informal presentations.
- Writing long reports and journal papers.
- Preparing an instruction manual.
- Identifying the characteristics of good oral and written communication.
- Studying examples of good and bad writing styles.

People are a little bit like computers in this respect. The smartest person in the world, the fastest thinker, the most prolific scientist or engineer, is severely handicapped without an ability to communicate with others. The famous physicist Dr. Steven Hawking, author of *A Brief History of Time** and other works on cosmology, has been acknowledged as one of the most brilliant minds of modern physics. A debilitating disease known as ALS took away his ability to speak and move his limbs and facial muscles, cutting off all normal means of communication. His thoughts and ideas have come to the world one agonizing word at a time by way of synthesized computer speech. How much more the world would understand about the nature of the universe were Stephen Hawking able to communicate using normal human speech and body language

7.1 THE IMPORTANCE OF GOOD ORAL AND WRITTEN COMMUNICATION

Asked what the most important single skill is for new engineers in the workplace, most every employer will state emphatically: *communication skills!* The best software programmer in the world will do a poor job if the ideas behind the software are not well understood by the user. The most proficient mechanical designer will fail if the structure being designed is set up incorrectly or is used in an improper manner. Communication skills are so important that the Accreditation Board for Engineering and Technology, the national organization responsible for accrediting programs in schools of engineering in the U.S. and Canada, has listed oral and written communication as mandatory elements for all engineering programs regardless of discipline. Listening also is a very important skill for students of all types. Engineering departments have risen to the challenge by teaching these skills in many different ways, from writing workshops and courses taught by English departments to required oral presentations by students in key core courses.

In this chapter, we cover some of the most basic of oral and written communication skills. Although not all inclusive, the scenarios presented in this chapter cover many of the communication situations in which you might find yourself during your engineering career. Topics include preparing for meetings, conferences and presentations, drafting short memos, writing letters and electronic mail, and writing long technical reports and journal papers.

7.2 PREPARING FOR INFORMAL MEETINGS AND CONFERENCES

Whenever you get together to socialize, you are participating in an informal meeting. You also participate in an informal meeting when you meet with your boss or co-workers to discuss the status of your latest project. Are these two events similar? Should you approach both with the same level of preparation? In the first case, you'd feel silly if you prepared beforehand for a social gathering with your friends. The purpose of such a gathering would be to relax and dispense with formalities. In the case of a meeting with your boss, you *should* spend time preparing beforehand because the meeting will reflect upon your work, your competency, and your role and status within the company. The same could be said for a meeting with your professor to discuss your work as a student.

*Stephen W. Hawking, *A Brief History of Time.* Toronto: Bantam Books, 1988.

Figure 7.1. Good communication skills are important to all aspects of engineering.

Preparing for an informal meeting takes only a small amount of forethought and planning, because no long speech or formal presentation is required. On the contrary, you may come across as being phony if your conversation seems contrived or orchestrated. Natural speech and hand gestures are always preferable at an informal meeting. You should, however, take the time to think about the content of the meeting beforehand. What will be the topics of conversation? What are your own opinions or thoughts about those topics? Are you being called upon to provide information? If so, take the time to prepare a list that highlights your important points or gives a summary of recent data. Perhaps a one-page outline of your progress to date would be beneficial. Or maybe a list of future planned tasks would be appropriate. Whatever the setting, a brief, to-the-point, one-page document is always helpful at an informal meeting that isn't a social gathering. The following list gives a few examples of informal meetings of various types along with suggestions for a document that might be passed out to all those present at the meeting.

- Project status review: Prepare a one-page bullet list of accomplishments that you've achieved since the last meeting.
- Report on recent tests: Prepare a one- or two-page table showing test results.
- Discussion on market potential of customers: Compile a list of the ten most important customers from the past five years.
- Product design review: Write a one-page summary of the key features of your design concept for the product under development.
- Changes in company procedure: Draw an outline of your proposed organizational chart.

7.3 PREPARING FOR A FORMAL PRESENTATION

Engineers are called upon frequently to make formal presentations to design teams, management personnel, customers, and other large groups of people. Sometimes, engineers must present formal papers at technical conferences. In contrast with an informal presentation, a formal presentation requires careful preparation. You should organize your talk much like a written document. It should contain an introduction, body, summary, and recommendations or conclusion. The following points will help you to prepare an interesting talk that meets its objectives:

1. Know your audience and plan upon an appropriate level of detail.
2. Assume that the customer is hearing about your topic for the first time.
3. Check out audio-visual equipment before the audience arrives. If you are using a laptop computer to present a slide show, determine *ahead of time* that it interfaces properly with the room's computer projection equipment.
4. Dress in suitable attire.
5. Cite the purpose of the talk within the first few minutes.
6. Tell your audience why it's you who is speaking.
7. Show an outline of your talk at the beginning. Give an initial overview of what the presentation will address. A single anecdote can help put the audience at ease and establish rapport.
8. Keep your talk simple. It's easy to get lost in technical details without addressing the main points of your presentation. Leave discussion of details for audience questions. In that way, you'll be able to spotlight only those technical issues of true interest to the audience.
9. Keep your talk short. If you plan to use between 50 percent and 60 percent of the allotted time, you probably will end on time.
10. Ask your own questions, and then answer them. Prepare visual aids to use as your own cues. Use bullets (•) as thought initiators and breakpoints. Use your visual aides, calling attention to them as your talk progresses. Try to format all slides the same way. Maintain eye contact. Never read! If you've brought along notes, refer to them as infrequently as possible.
11. Do not show the audience equations. The audience has little time to decipher them. This rule can be broken occasionally.
12. End your talk with "thank you, any questions?" or a concluding slide. In this way, the audience will know when your talk is over.
13. Restate postpresentation questions so that the entire audience can hear them. Restating a question also will help to clarify its content and will give you an extra moment to formulate your response.

The following example illustrates the elements of a good oral presentation. The context is a student who is presenting the results of recent mechanical loading tests to a group of engineers, students, and professors. The student has been investigating the use of composite materials as part of a high-tech entry for the Peak-Performance Design Competition.

EXAMPLE 7.1: MECHANICAL LOADING AND TESTING

Dan began with a short introduction that explained the purpose of his talk. "Thank you all for coming to my presentation. In this talk I will summarize test results on samples of materials that are candidates for the chassis frame of our Peak-Performance vehicle. As you all know, we've decided to go with composites—matrices of glass, carbon fiber, and epoxy resin—for the principal structural members of the vehicle. This choice will result in some extra costs, because these materials are more expensive than aluminum, plastic, or steel, but ultimately we'll have a better performing and more competitive vehicle. I've done some initial tests on sample compositions and wish to share them with you." Dan displayed the first of his overhead transparencies:

Loading Tests on L-type Carbon Composites
Daniel Little
Peak-Performance Design Competition
Mechanical Design Lab

His next slide summarized the content of his presentation, providing an overview to the audience:

Summary of Presentation

- Description of Composite Materials
- Selection of Test Samples
- Stress-Strain Properties (Nondestructive Test)
- Maximum Load to Failure (Destructive Test)
- Fatigue Tests (Destructive Test)

"Let me begin by providing a brief review of composites. These materials were invented by the aircraft industry as possible light-weight alternatives to more expensive metals, such as titanium and magnesium. Now they're used in everything from bicycles to sailboat masts. Composites are made from a matrix of carbon or glass threads woven into the desired shape and impregnated with high tensile-strength epoxy resin." Dan passed out several samples of composite materials. They were black in color and felt like plastic. He put up a slide that asked two questions he planned to answer during his talk:

Structural Frame for the Peak-Performance Design Competition

- Should we use composites?
- What composition of fiber and epoxy is best?

"Composition, to remind you, is a measure of the percent weight of carbon fiber to epoxy. The diameter of the fibers is also a factor. Basically, the more fiber there is in the mixture, the more expensive the material will be. The trick is to find the optimal composition while considering strength *and* cost. I have here some data on carbon composition, because carbon fiber is the type we're most likely to choose." Dan displayed an overhead that described the various composites he had tested:

TABLE 7-1 Description of Various Composite Materials

PRODUCT	PERCENT CARBON	APPROXIMATE COST PER POUND
L-8	8	$ 96
L-10	10	$ 102
L-12	12	$ 113
L-16	16	$ 120
L-20	20	$ 136
L-24	24	$ 141

"Above about a 24-percent fill rate, this particular composite has too little epoxy resin to hold together well," explained Dan, "and below 8 percent, too little carbon fiber to retain tensile strength."

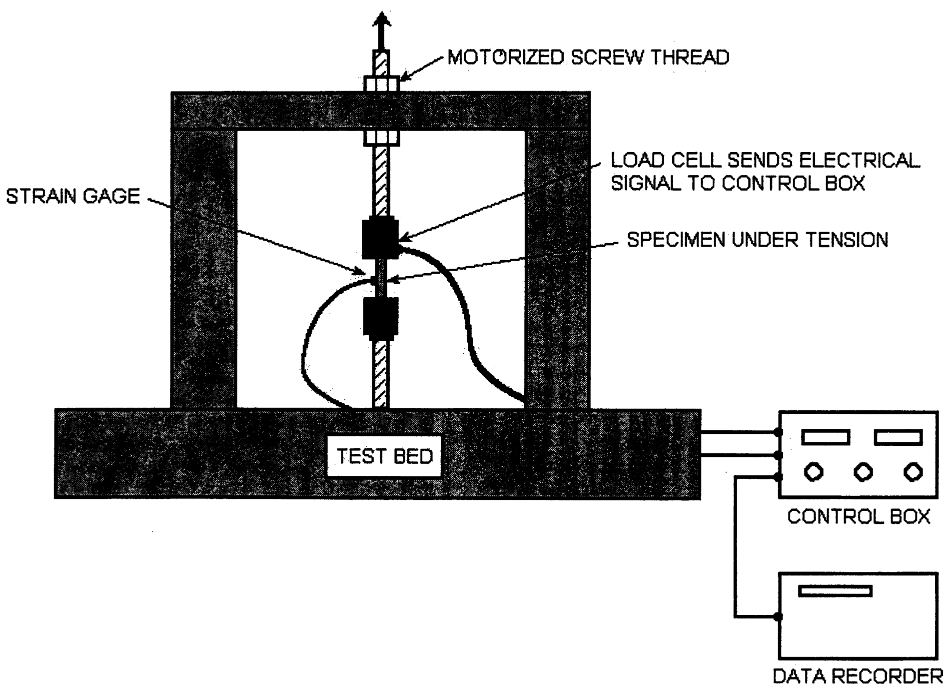
Dan next described the first of the tests performed on the samples. "The first test consisted of determining the stress–strain relationship for each of the materials in the sample list for a number of different fiber diameters. As a review, let me remind you that *stress* is a fancy word for applied force, and *strain* is another term for the amount by which the material stretches (or compresses) in response to the applied force. In a *linear* material, the strain, or stretch, is directly proportional to the applied stress. Double the stress, and you've doubled the strain. If too much strain occurs due to too much applied stress, the material will go into its nonlinear region in which added stress produces almost no additional strain.

"Now let me explain the tests I've performed. The first involves measuring the stress–strain, or force–displacement, properties of the material using the following setup." Dan put up the overhead shown in Figure 7.2.

"The sample to be tested is first machined into a round bar of 4-mm cross section. It's then installed in a tensile test machine that can apply a stretching force to the bar. The applied force is measured by a load cell that produces a voltage in proportion to the applied force. A strain gage is used to measure the strain. It's actually a thin-film resistor that's glued right onto the side of the test sample. Its resistance changes in proportion to how much the sample has been stretched from its rest length. Here's a typical plot of data taken on one sample, in this case L-8." Daniel put up the slide shown in Figure 7.3.

"The slope of the linear portion of this curve will be equal to the reciprocal of the material's elastic constant. The breakpoint in the curve defines the elastic limit. For our application, we'd like an elastic constant of about 6 kN/mm and an elastic limit of at

Figure 7.2. Instron™ test bed and computerized data recorder. The tensile test specimen is inside.



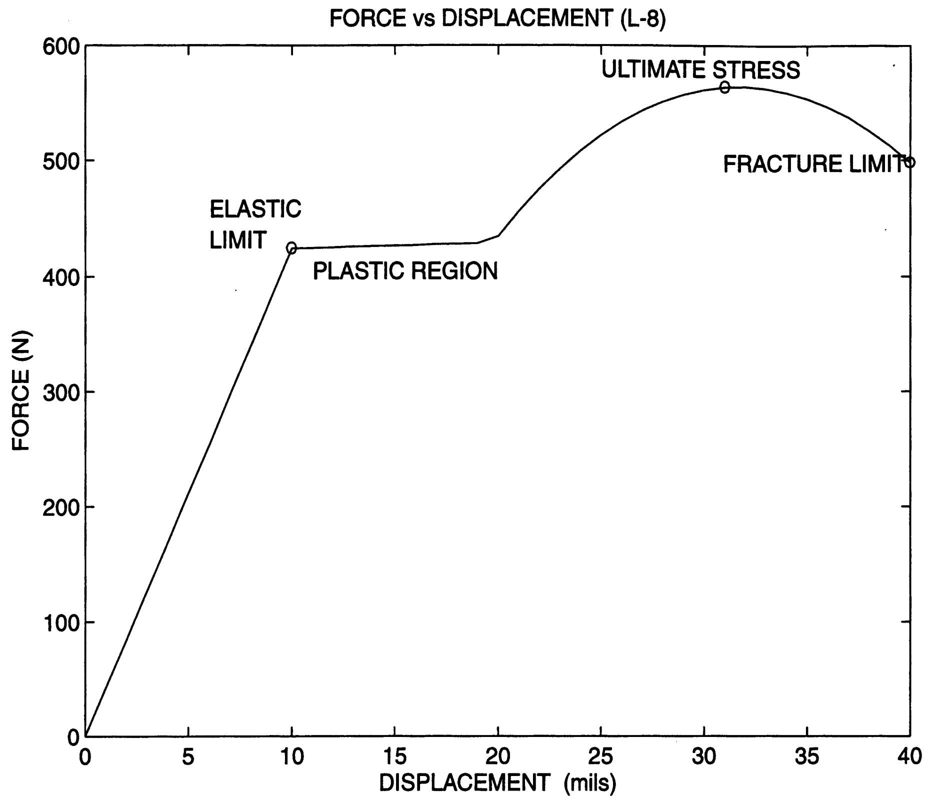


Figure 7.3. Force-displacement curve showing linear region and elastic limit.

least 400 N to ensure an adequate safety margin of about five times the largest force we realistically expect on the components.

"Let me show you the results of measurements obtained from one of my test matrices*." Dan put Table 7.2 up on the screen. He'd copied it from a page in his engineer's logbook, which served as a written record of the data.

"The entries in this first test matrix table indicate the measured elastic constant of each sample in kilonewtons per millimeter of displacement. This next table gives the elastic limit of each sample in kilonewtons." Dan then presented a slide showing Table 7.3.

TABLE 7-2 Measured Elastic Constant (kN/mm) under Tensile Force for 4-mm Diameter Carbon Composite Test Samples

	CARBON FIBER DIAMETER (MILS)				
SAMPLE	**3**	**4**	**5**	**6**	**PERCENT CARBON**
L-8	8.4	7.1	6.5	6.0	8
L-10	9.0	7.6	6.6	6.2	10
L-12	9.5	8.2	6.9	6.5	12
L-16	9.7	8.8	7.2	6.8	16
L-20	9.9	9.2	7.5	7.1	20
L-24	10.1	9.7	7.8	7.4	24

*A *test matrix* consists of a table of methodically performed tests in which one variable changes on the vertical axis and one along the horizontal axis.

TABLE 7-3 Measured Elastic Limit (kN) Under Tensile Force for 4-mm Diameter Carbon Composite Test Samples

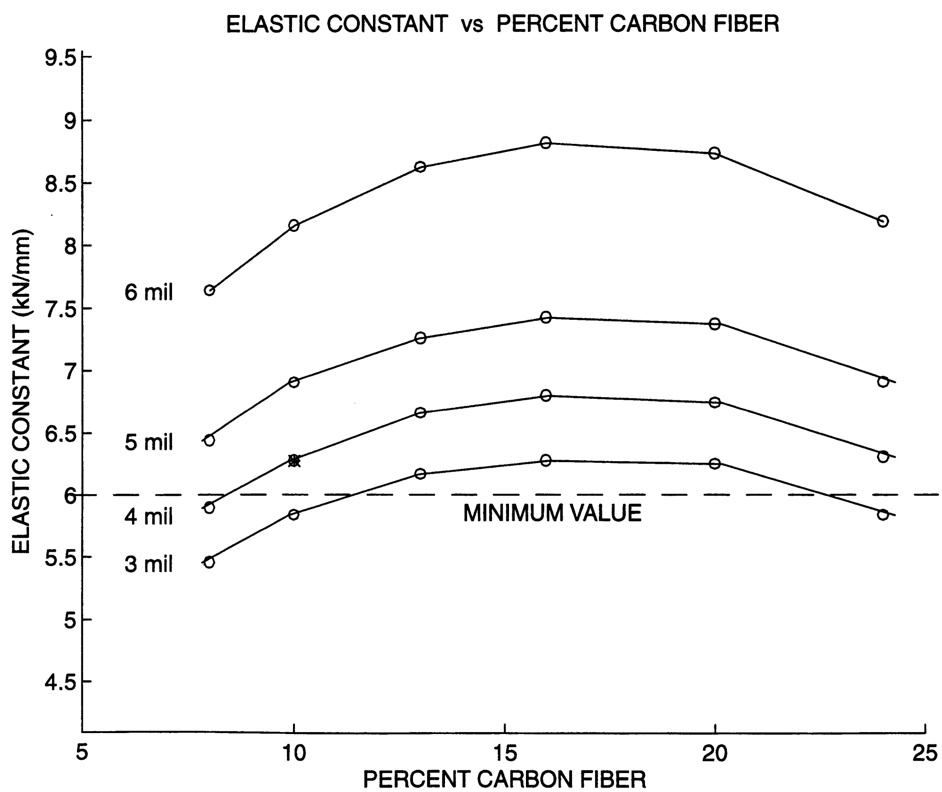
	CARBON FIBER DIAMETER (MILS)				
SAMPLE	**3**	**4**	**5**	**6**	**PERCENT CARBON**
L-8	0.28	0.33	0.41	0.52	8
L-10	0.29	0.34	0.42	0.53	10
L-12	0.30	0.36	0.43	0.56	12
L-16	0.32	0.38	0.46	0.58	16
L-20	0.30	0.36	0.44	0.56	20
L-24	0.29	0.34	0.42	0.53	24

In the following figure, I've plotted the most important parameter, the elastic constant, versus percent carbon using fiber diameter as the third parametric variable." Daniel put up the plot shown in Figure 7.4.

"In my next overhead, I've plotted the elastic limit versus percent carbon, again using fiber diameter as the parametric variable." Dan put up the second plot of Figure 7.5.

"Because we need an elastic limit of at least 0.4 kN, we're limited to fiber diameters of 5 mils or more. Similarly, the smallest elastic constants occur for 6-mil fiber, but the 5-mil fiber has adequate properties. Based on my tests, I'm recommending that we go with 16 percent carbon composite with 5-mil fiber for our Peak-Performance vehicle. Thank you for your attention. Are there any questions?"

Figure 7.4. Force-displacement ratio versus percent carbon.



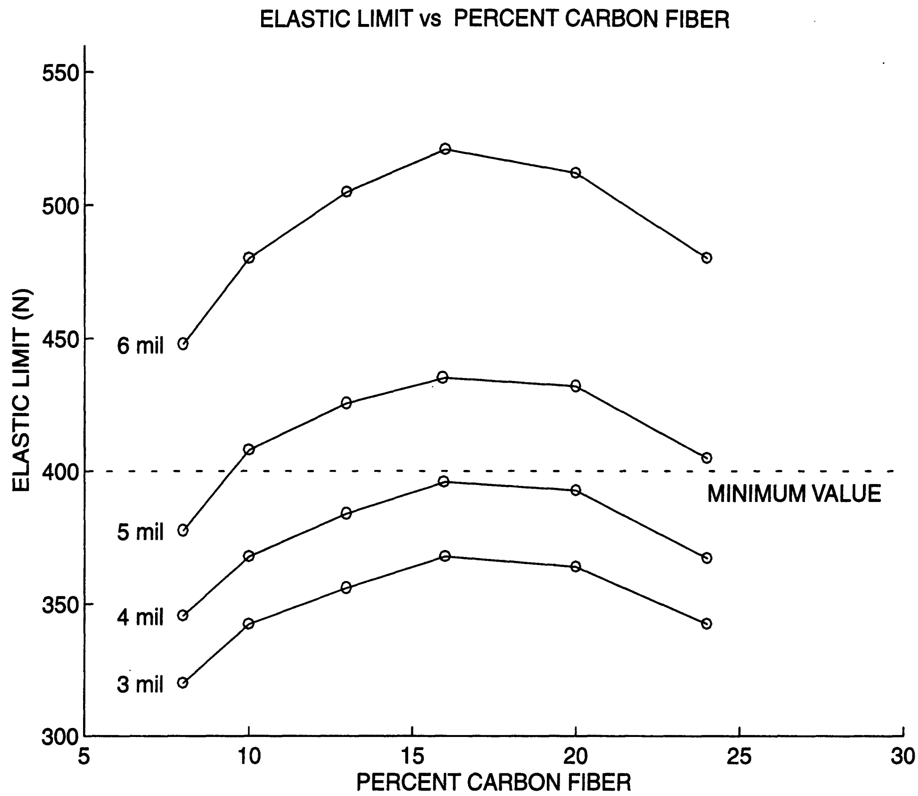


Figure 7.5. Elastic limit versus percent carbon.

7.4 WRITING ELECTRONIC MAIL, LETTERS, AND MEMORANDA

As an engineer, you'll often need to compose short memoranda, faxes, e-mail messages, and notes to fellow engineers, supervisors, employees, or customers. Whether sent on paper or electronically, a memo must convey its message clearly and concisely. It must leave no room for ambiguity or misinterpretation, and it must be written in proper grammatical style. When you engage in a face-to-face conversation, you can modify your communication approach on the spot, depending on the person's reaction. But you will not have the benefit of witnessing the reaction of a person who has received a memo. A written memo must be carefully crafted to elicit the desired reaction on the first reading.

Writing Electronic Mail Messages

Electronic mail, or e-mail, has become the communication tool of choice for countless individuals worldwide. Engineers certainly are included in this group of e-mail participants. E-mail has become an indispensable part of an engineer's work environment as well as an integral part of the design process. E-mail has many uses, but its most common use is as a replacement for hard-copy memoranda. Before electronic mail, communication between employees was conveyed by distributing paper to each recipient. The method was slow and labor intensive.

Electronic mail has made distribution an instantaneous and incidental event. The act of composing an e-mail message, rightfully so, now takes up the largest fraction a sender's time. In the age of electronic mail, the sender has more time to *think* about the what is being written, because almost no time is needed to copy and distribute the document. One of the most common mistakes in e-mail writing, however, is to assume that messages sent electronically do not have to be prepared with the same care as other written documents. An e-mail message that is sloppy and poorly written will not be taken as seriously as one that is carefully written in a professional manner. The wise writer sets a proper tone by preparing e-mail messages with the same care as paper memos. The recipient of an e-mail message will read it in private, just like a written memo, and may treat it with the same formality as a memo received on paper. In addition, an e-mail memo can be copied to large numbers of additional recipients instantly, spawning multiple exposures. Some people print out received e-mail messages, thereby further blurring the distinction between paper and electronic memos.

The formula for writing a competent and effective electronic mail message is easy to learn. A good message should include the following three items:

- A *header* that indicates the recipient, sender, subject, and date,
- A *first sentence* that states the purpose of the message,
- A *body* that delivers the key points of the message.

Header

In our information-abundant world, document organization has become a critical component in business, commerce, and all engineering disciplines. A header that announces the *recipient, sender, subject,* and *date* of the e-mail helps both the sender and receiver to categorize the message and properly file it for future reference. Identifying the subject of the message in the header will also set its tone and prepare the reader for the message to follow. Has the memo been sent to a general distribution list? Is it intended for one person's eyes only? Will the message to follow be formal, informal, alarming, or humorous? A properly designed header will set the tone for the message and prepare the reader to receive it. The header of a memo should look something like this:

To: Karin Peterson
From: Frederick Unlu
Subject: Test Data for Peak-Performance Motor Evaluation
Date: April 12, 1999

An alternative form suitable for a message sent to a group of people might look like this:

To: Distribution
From: Tina Oulette, Team Leader
RE: Next Team Meeting
April 12, 1999

Note that many electronic mail systems include automatic prompts for header entries, and most all include a date stamp on the message regardless of whether the sender inserts one on his or her own. Nevertheless, it's a good idea to specifically include a header similar to one of the foregoing examples, because the Internet system often adds network routing information between the automated header and the body of the text.

First Sentence

A good message will clearly state its purpose in the first, or possibly the second, sentence. A sentence that begins with, "I am writing this message to inform you . . ." will help the reader unambiguously understand why you have written the message. Stating the purpose of the message right at the beginning will help formulate its tone and state its objectives. Will your message provide information, request a response, ask for permission, or give instructions? The structure of the first sentence will determine the way in which the body is received. It will also ensure that the reader does not misinterpret your reason for writing.

EXAMPLE 7.2: THE TRIP REQUEST

As an example of the power of the first sentence, consider the following memo which was sent by an employee of an engineering company. The engineer was writing to his boss to ask for permission to attend a conference of the American Society of Mechanical Engineers.

> To: Roscoe Varquin
>
> From: Harry Coates
>
> Subject: Upcoming ASME Conference
>
> Date: January 14, 1998
>
> Roscoe,
>
> As you may know, the American Society of Mechanical Engineers is holding a conference on lightweight composites in Dayton, Ohio, at the end of June. I think that someone from our company should attend this meeting. Over the past several years, composites have shown promise as a viable alternative to steel or aluminum. They combine the strength of the former with the light weight of the latter. It's time that we learned more about these important materials.
>
> The conference will be held at the Dayton Buena Vista. I've spoken with our travel agent and found that flights will cost about $300 for a round trip. Hotel will be $82 per day, and the conference registration fee is $180. Please let me know what you think.

Critique Harry began his message by explaining the upcoming conference and proceeded to present his data about how much it would cost him to make the trip. Despite what seemed like a clear explanation, however, Harry never got to go to the conference, even though Roscoe was convinced of its value to the company. Harry presented his data and did his research but never stated explicitly in his first sentence that it was *he* who wanted to attend the conference. The message brought the matter to Roscoe's attention, and it was Roscoe himself who wound up going to the conference! The confusion resulted because Harry failed to clearly state the purpose of his memo. His e-mail message would have been *much* more effective had it begun with the simple sentence, "I would like permission to attend the upcoming ASME conference in June." Harry learned, much after the fact, that it's important to state the purpose of a memo in its first sentence. Had he talked to Roscoe in person, he might have detected the confusion by witnessing his boss's reaction on the spot, but his chosen method of communication omitted the link of personal contact.

Body

When composing the body of an e-mail message, follow basic rules of style and grammar. Each idea or concept should have its own paragraph, and paragraphs should never consist of a single sentence only. Each paragraph should follow logically from its predecessor so that the flow of ideas makes sense to the reader. When you compose a message, think about the sequence of ideas so that your message has structure and flows logically. Use the full-screen edit feature of your software, rather than the one-line-at-a-time mode available on some e-mail systems. In this way, you will be able to go back and revise or restructure the body of the message before sending it.

EXAMPLE 7.3: VISIT TO THE CUSTOMER'S WORKPLACE

One quality of a good e-mail message is its ability to convey correctly all the subtleties of a given subject. Without personal contact to enhance communication, an e-mail message must be precise and readily comprehended on the first reading. Consider the following not-so-well written message that describes the visit of a software engineer to the client's workplace. Try to identify the deficiencies in the memo. Its subject concerns a program called the Universal Information System. The task involved rewriting an original UNIX version of the program to run under Microsoft Windows98. The software program is used by the client to keep track of customer charge card records. The software engineer in charge was writing a memo to her boss summarizing the results of a recent exploratory visit to the client.

> To: Roscoe Varquin
> From: L. Berkin
> Subject: Universal Information System
> February 26, 1999
>
> On the 25th of February, my group met with the customer. We were allowed to use a user's ID in order to bring up his account record on the UIS. The customer crossed out the user's name on the sheet containing his information, but it turned out that the UIS listed his account with both his name and social security number. My group made a record of how the system was set up in order for us to have the same heading in our program.
>
> I learned some of the commands that are used on the UIS Galaxy system. The command TR14 finds the user's in-question account and displays it on the monitor. The TR33 command displays all transactions which the user made since the specified date. Last, but not least, the TR35 command displays all payments made since the given date. It turned out that this command was a recent one designed and implemented by one of our fellow employees who recently left the company. In our program, we will assume that this command will be used by the customer, even though there is doubt that no one would keep it up to date except for the fellow employee who's stay there is not guaranteed.
>
> Meeting with the customer at her office made it clearer what they expect of the product. They want the product easy to use. They want the account summary sheet to highlight all the transactions not yet paid for. In all, I learned several commands and got some exposure to the UIS system. This was a profitable meeting.

Critique Despite its poor grammar and flow of ideas, the body of the message does contain the following key points:

- Opportunity to see demonstration of UIS system
- Customer erroneously allowed us to see the identity of a sample account holder.
- Program within UIS system is called Galaxy

- UIS system includes several commands:
  -TR14: Customer account
  -TR33: Transactions display
  -TR35: Payment history
- TR35 command designed by previous employee of company
- Meeting was useful.
- Customer wants unpaid transactions highlighted.

Regardless of its content, however, the body is deficient, because the order in which the information is presented is entirely random. The message lacks logical progression, contains no preamble, and includes no added comments to aide in interpretation. Each fact is presented with no accompanying explanation of how it fits into the overall context of the memo. Additionally, the information contained in the first paragraph is irrelevant to the writer's boss who would not care that the customer made a mistake while attempting to access the system. The writer seems to have had a list of facts in her head and proceeded to regurgitate them on paper in whatever order they came to mind. The message also omits critical information. The author of the memo does not mention the identity of the customer or who the person was that gave the tour and demonstration. There is no mention of what the letters "UIS" stand for, and the term "Galaxy" is used without explanation. It's highly likely that this memo underwent very little onscreen editing or rewriting and probably was poorly received.

Now consider the following version of the message which was written and revised using proper grammar, construction, and form prior to being sent.

To: Roscoe Varquin
From: L. Berkin
Subject: Summary of customer meeting at Boulton Industries
February 26, 1999

Roscoe,

This memo summarizes what we learned during our visit to Boulton Industries on February 25, 1999. Our project team met with Boulton's representative, Ms. Connie Donaldson, at their Weston office. The meeting provided us with an overview of the customer's existing Universal Information System (UIS) and introduced us to the procedures commonly used in Ms. Donaldson's office. We worked with her on the UIS system using actual account records.

The UIS system contains an application program called Galaxy that allows the customer to view account records. The record of an account holder is accessed by entering an ID number into the Galaxy system at the menu prompt. The account data can then be viewed in a variety of formats useful to the customer.

Several user programs, called Transaction (TR) screens, reside within Galaxy and help the user to display account information. These TR screens are used routinely by Boulton employees for processing monthly bills and servicing customer call-in inquiries. During our meeting, we recorded the display headings of each important TR screen so that we can create the same headings on our PC-based Windows98 version of the UIS system.

As part of our tour, Ms. Donaldson demonstrated some of the commonly used TR screens. One command, for example, is called TR14. It retrieves a specified account record and displays it as a standard mailing form on the monitor. A second command, called TR33, displays all transactions that have occurred since a date specified by the user. A third command, called TR35, displays the history of all payments made since the user-specified date. This last command was written previously for Boulton by one of our employees. When writing our new version of the program, we should assume that this command again will be used by Boulton to process records and should plan to integrate the feature into the Windows version of the program.

I feel that we learned enough from our meeting to enable us to proceed with the Boulton UIS project. If necessary, we can return to Ms. Donaldson's office at a later date to obtain more information.

Sincerely yours,

Laura Berkin
Software Division

Writing Formal Memos and Letters

The informality of an e-mail message in not appropriate for all communication. At times, the added formality of a written, hard-copy letter is preferable. Formality suggests importance. Applying for a job or sending a follow-up thank-you letter, for example, are situations that call for a formal written letter. Likewise, if your information has archival quality, or if your message may have legal implications, then you should send your memo in paper format. Besides carrying more social weight than an e-mail message, a paper letter can bear a binding signature.

The rules for composing and sending a written letter are almost identical to those for sending electronic mail. One key difference is that a formal letter normally does not contain a To and From header, but instead begins with the recipient's address letter and a formal salutation. A letter should be well presented on good paper or letterhead and be printed in an attractive format. The following example illustrates some of the finer points of writing an effective formal letter. The first version shows the letter as originally written, and the second shows the results of a much needed revision.

EXAMPLE 7.4: SUMMARY OF TESTS RESULTS

The following letter was written by an engineer who wished to summarize the results of mechanical loading tests for a client. The letter is based on the following points, listed here in the order in which the author wrote them down in his logbook:

- Initial loading tests are completed
- Test samples were composites of carbon and epoxy
- Control samples were steel
- Same shape chosen for each; steel was machined, composites were molded
- Samples were composites and steel
- Initial difficulties fitting samples into test machine
- Made a holding jig to allow testing
- We should go with composites at slightly increased diameter
- Numerical data from test results:

Diameter	**Composite**	**Steel**
0.25 in	245 lbf	321 lbf
0.375 in	1644 lbf	1790 lbf
0.50 in	3021 lbf	3229 lbf

The letter as written by the engineer reads as follows:

Apex Systems
Structural Testing Laboratory
730 Commonwealth Ave., West Roxbury, MA 02132

Helen Brickland
Access Engineering
44 Cummington St.
Boston, MA 02215
January 18, 1999

Dear Ms. Brickland:

We've completed the initial loading tests on the samples made from composites and steel. The samples had the same shape, and the steel was machined and the composites molded. We had some initial difficulties fitting the samples into the test machine but finally made a holding jig to allow testing. I think that we should go with composites at slightly increased diameter.

Here are the pieces of data:
0.25 in. diameter: composite 245 lbf, steel 321 lbf
0.375 in. diameter: composite 1644 lbf, steel 1790 lbf
0.50 in. diameter: composite 3021 lbf, steel 3229 lbf

Sincerely yours,

Ed Garber
Mechanical Engineer

Critique This letter is correctly formed and includes all needed information, but the writer would have done a better job of stating his objectives if the first sentence had cited the real purpose of the letter, which was to make a recommendation to Ms. Brickland that composites be used instead of steel. A better opening might have been the following:

Dear Ms. Brickland:
For the past month, Apex Systems has been performing loadings tests on samples of composites and steel for Access Engineering. Based on our test results, I'd like to recommend that we choose composites for this project.

The original letter has other problems beyond those of its first sentence. Its body, for example, is completely disorganized. Although the author has followed almost verbatim the ordering of ideas as recorded in his logbook, those ideas were not particularly well ordered to begin with. The letter reads disjointly, as if it's been poorly edited. The sentences are choppy and do not flow from one to another. The numerical data should have been presented in more concise, tabular form. Finally, the author failed to describe the purpose of the tests, didn't go into detail about how they were performed, and didn't describe the test samples other than to say that they were a mix of composites and steel. He should have provided the dimensions of the samples, the composition mix of the composites, and how many of each type of sample were tested.

A revised version of the letter that corrects for these deficiencies might look something like the following:

Apex Systems
Structural Testing Laboratory
730 Commonwealth Ave., West Roxbury, MA 02132

Helen Brickland
Access Engineering
44 Cummington St.
Boston, MA 02215
January 18, 1999

Dear Ms. Brickland:

The mechanical group working on the Delta vehicle project with Access Engineering has just completed tests on samples of the composite and steel materials that we are evaluating for the main structural members of the frame. Based on our test results, our group recommends that we choose composites of slightly enlarged diameter for the structural materials. The details of the tests are described below.

Samples of machined steel and molded composites were fabricated in the shape of standard tensile test specimen bars having a variety of diameters in the range 0.25 in. to 0.625 in. (ASME specification 246). These samples were stressed to the breaking point in our lab's Instron test machine. Although we had some initial difficulties in fitting the samples of diameter other than 0.5 in. into the test machine, we were able to make a holding jig to accommodate testing of all samples. The numerical data from our tests results are summarized in the following table:

BREAKING FORCE UNDER TENSION				
Diameter (in):	0.250	0.375	0.500	0.625
Composite (lbf):	845	1644	3021	4229
Steel:	1421	2790	4310	5541

As you can see, our minimum targeted breaking strength of 4000 lbf can be met with either a composite rod of 5/8-in (0.625″) diameter or a steel rod of 1/2-in (0.500″) diameter. Given the much lighter weight of the composite material, however, its strength-to-weight ratio is much higher than that of steel. I recommend that your company go with composites for this project.

Sincerely yours,

Ed Garber
Mechanical Engineer

This second version is much improved over the original. The author has articulated the purpose of the letter in the second sentence, rather than in the first, but it works well here because the letter still reads and flows nicely. The first sentence serves as a preamble to the real purpose of the letter which is revealed in the sentence that begins, "Based on our test results . . ."

The data are also well presented in the table contained within the letter. Instead of putting the units next to each entry, Ed has written them just once next to the category titles on the left-hand side. This format makes for a much neater display of data. Ed also has elaborated on the details of the tests. When Ms. Brickland reads the letter, the context in which the tests were taken will immediately be clear. This point is an important one. Ed might falsely conclude that Ms. Brickland will understand its context, because his primary work assignment over the past month has been the taking of data and the testing of the materials. But Helen, as a manager, is likely to be juggling dozens of projects and details, and she will welcome a letter that first refreshes her memory about its context and background. In addition, she may find herself reading the letter at some future time when the background details of the test procedures have faded from memory. Or she might forward the letter to someone else who is unfamiliar with the details that Ed has correctly provided.

PROFESSIONAL SUCCESS: PREPARING A PRESENTATION FOR A NON-TECHNICAL AUDIENCE

At times an engineer must make a presentation to a non-technical audience. You also may encounter this challenge while you are a student. Perhaps you'll be invited to speak at your old high school. Maybe you'll be asked to explain the activities of a research laboratory to visiting parents and prospective students. Or maybe you'll receive a class assignment to prepare a talk on a technical subject for a general audience. In these and similar situations, the following few basic principles can guide you:

- Assume the audience knows nothing about your topic.
- Explain background material without using jargon words. (You'd be surprised at how many seemingly common words are really part of the engineer's private lexicon.)
- Start at the beginning to provide the big picture.
- Pretend that you're speaking to a group of fourth graders.
- Never show equations to a non-technical audience. (You'll probably pique their math anxiety

7.5 WRITING TECHNICAL REPORTS, PROPOSALS, AND JOURNAL ARTICLES

Technical reports, proposals, and journal articles are the engineer's equivalent of term papers. As an engineer, you are likely to face the task of writing one of these documents at some point in your career. Unlike short e-mail messages, memos, and letters, which are usually only a few paragraphs long, longer technical documents require considerable thought and preparation and usually cannot be finished in one sitting. The sections that follow highlight some of the key elements of these longer documents.

Technical Report

A technical report is used to convey important findings or test results to a controlled audience. Technical reports seldom undergo peer review, and distribution of the report is done at the discretion of the author or employer.

The typical technical report is between two and twenty pages long. In content and form, it's not unlike a lab report you might prepare in some of your college courses. Although the format may vary somewhat, most technical reports contain the following elements: Introduction (or Background), Experimental Setup (if applicable), Theory, Data, Analysis, and Conclusion.

The introduction serves as a preamble to the document and states its reason for having been written. Unlike the first sentence of a simple memo, the introduction of a technical report can occupy a paragraph, a page, or sometimes many pages. A person pressed for time will merely skim the introduction, so it, along with the conclusion, should provide a self- contained overview of the entire report.

If the document describes the results of an experiment, an experiment section should be included that describes the physical setup. This section should provide enough detail that a reasonably competent person could completely reconstruct the experimental apparatus and obtain similar results. It should describe instruments, apparatus, mechanical techniques, dimensions, and other key parameters.

The data section includes the results of any experiments or tests that were performed. It should explain why each set of data is presented, how it was obtained, and what bearing it has on the main purpose of the document. A report or journal paper is likely to be used later as a reference source, so it's important to present data completely and accurately. The presentation should be easily digested by someone not intimately familiar with the details of the project.

The analysis section is where the data are evaluated, interpreted, and used to support any claims made in the report. Mathematical calculations belong in this section, as do plots and charts derived from the data. In some cases, particularly in reports that deal with design work, the analysis and data sections appear in reverse order. First the analysis of the device is presented, followed by data on tests that show whether the device meets the expectations or predictions of the analysis.

Finally, the conclusion is used to summarize the claims, results, and observations included in the report. Some individuals may not have time to read the whole report, but need to be familiar with its content. The conclusion section should be written to serve the needs of a person who only has time to browse or skim the report. The conclusion should be a stand-alone section that summarizes all the key points of the report.

Journal Paper

Journal papers provide a way in which engineers disseminate information of interest to other engineers. They also provide a public forum in which engineers and scientists can announce "first to invent" status of a new technology or discovery. Most journal papers, particularly those sponsored by professional organizations, must undergo peer review before publication. This procedure helps insure their quality and accuracy. Although the standard format—introduction, theory, experiment, data, analysis, and conclusion—is appropriate for journal papers, many publications specify their own format in which a journal paper must be submitted.

Proposal

A proposal differs from a report or journal paper in that is its primary objective is usually to secure *money*. A proposal attempts to convince a client or funding source that your organization can best handle a research or design job, or perhaps that your product will be best for a particular application. In addition to the various sections of a technical report, a proposal often includes additional sections on objective, budget, company background, and personnel.

7.6 PREPARING AN INSTRUCTION MANUAL

One of the most common documents written by engineers is the instruction manual. An instruction manual introduces the user to your product and provides information regarding its setup, operation, and use. A well-written instruction manual also includes sections on safety information, troubleshooting, repair, and theory of operation, if applicable. While not all engineered devices require an instruction manual (the operation of a snow shovel, for example, should be self explanatory), those that involve detailed operating procedures should be accompanied by instructions. Indeed, user perception of many products is derived directly from the quality of the instruction manual.

The sections of a typical instruction manual are outlined below. If the manual is long, a table of contents with page numbers should be included. Obviously, the need for each of the sections suggested below will depend on the specific product described by the manual.

Introduction

The introduction should provide an overview of the product. It should explain the purpose of the product, its usefulness to the user, its special features, and proper use of the manual itself. Various titles for the introductory section include "Getting Started," "Welcome to Product X," "Before Using Your Device," etc.

Setup

The setup section should outline the procedures that the user must follow before the product is ready for use. This section should appear at the front of the manual, where it will be easy to find. It should guide the user through the setup procedure step by step, and it should use illustrations liberally.

Operation

The operation section of the instruction manual is its most important part. A first-time user will use this section to learn how to operate the product and will refer to it thereafter to clarify points of operation. Because of its likely use as a reference source, the operation section should be carefully laid out and organized so that the user can extract information without having to read the entire manual from the beginning.

Safety

Safety is a very important aspect of engineering design, and any such information relevant to the well-being of the user must be included in the instruction manual. If the product has dangerous moving parts or high voltages, includes safety panels or guards that must not be removed, or has the potential to emit flying objects or capture loose clothing, then appropriate warnings should be included. In our overly litigious society, where personal injury lawyers advertise freely on the radio and TV, safety warnings have become pervasive. Some safety warnings may seem overly cautious or even ridiculous (e.g., don't put your fingers in the moving blades or you might get hurt), but safety warnings have become a necessary part of engineering.

Troubleshooting

Expect your product to break down, regardless of how well it is made. If it should happen not to malfunction over its lifetime, consider yourself lucky. Designs do fail, and the troubleshooting section should guide the user through a simple set of tests that can help identify the source of any malfunction and get the system running again. The section should outline simple repairs that the user can try before taking the more drastic step of returning the product. If appropriate, include a section that explains how to get in touch with the manufacturer (you) in case difficulties cannot be resolved by the user.

Never assume that the user will understand something that is not clearly specified. The following troubleshooting entries may seem silly, but many instruction manuals contain similar versions:

> Symptom: No lights or displays of any kind are lit; unit appears to be dead.
> Possible Cause: Unit is unplugged or has blown fuse.
> Remedy: Plug cord into proper outlet. Replace fuse.
>
> Symptom: No sound coming out of speaker.
> Possible Cause: Volume control is turned all the way down.
> Remedy: Turn volume knob clockwise.
>
> Symptom: Drive shaft does not turn.
> Possible Cause: Clutch is not engaged.
> Remedy: Engage clutch by moving lever to on position.
>
> Symptom: No flame from burner.
> Possible Cause: Pilot light extinguished.
> Remedy: Relight pilot. (See Section 2.1: Lighting the Pilot Light.)
>
> Symptom: Pilot light cannot be lit.
> Possible Cause: No gas supply.
> Remedy: Open main gas valve; replace propane tank.

Appendices

Information likely to be of interest only to a special readership should be included in appendices. Examples include circuit schematics, exploded assembly diagrams, theory of operation, and lists of part numbers.

Repetition

One of the subtle features of a good instruction manual is its ability to engage the reader regardless of where he or she begins reading it. This attribute can be achieved by repeating informative details at several junction points throughout the document. As you write the manual, imagine the viewpoint of a reader who has begun to read it somewhere in the middle of the document. Restate key information at topical transitions and major section headings, rather than referring to previous sections. Do not assume that the reader remembers details covered previously if they are relevant to the present section.

EXAMPLE 7.5: THE ATM SIMULATOR

The following example contains (slightly edited) excerpts from an instruction manual written by senior project students in the Department of Electrical and Computer Engineering at Boston University*. It includes many of the elements mentioned above and illustrates the overall features of a good instruction manual. The manual explains the operation of a simulator for a bank automatic teller machine designed to teach banking procedures to elementary school and special needs students.

* "G. DeBernardi, R. DeMayo, M. Givens, M. Magne, E. McMorrow, and S. Tansi, *Automated Teller Machine Simulator Instruction Manual.* Terriers Technologies of Boston, 1992

Automated Teller Machine Simulator
Instruction Manual
Terrier Technologies of Boston

WELCOME TO THE TTB ATM SIMULATOR

The Terrier Technologies of Boston Automated Teller Machine simulator has been designed to help you teach students the important aspects of banking skills. The unit has been designed for simplicity and ease of use. It should provide you with many years of trouble-free operation.

HOW TO USE THIS MANUAL

The TTB ATM users' manual is divided into five sections and an appendix. The first two sections provide a general overview of setup and system start up, respectively. The third section explores the inside of the ATM simulator and discusses its various modules. The remaining two sections deal with care and troubleshooting of the equipment. The appendix contains wiring diagrams and computer software codes.

OVERVIEW OF OPERATION

The TTB ATM simulator is a self-contained product. Each of its modules simulates the operation of a real bank ATM machine. Account information is stored in the computer connected to the ATM panel. A banking session begins by prompting the user to insert a card into the card slot. Once the card has been properly inserted, the user is asked for a password to be entered via the keypad. After entering the correct password, the user is asked to choose from the following list of transactions:

1. Deposit
2. Withdrawal
3. Fast Cash
4. Account Balances

Once the type of transaction has been chosen, the simulator asks the user to choose between a savings and a checking account. The user can withdraw facsimile money from the cash dispenser or place an envelope in the deposit slot. Immediately following the transaction, a receipt of the session is printed out and the user's account is updated inside the computer.

The system operator has additional choices not shown on the main user menu. These additional choices include: `Modify Parameters`, `Troubleshooting`, and `Print Account Information`. The `Modify Parameters` command enables the system operator to update user accounts. The `Troubleshooting` command tests the individual modules of the ATM simulator. `Print Account Information` makes a printout of all user names and account balances. The ATM simulator is also equipped with two flip-up panels. The top panel exposes the main keyboard used by the system operator to initiate and update accounts. The bottom panel provides access for paper replacement for the receipt printer and provides access to the cash dispenser.

INITIAL START-UP (SYSTEM OPERATOR)

The power switch is located on the rear of the unit. Plug in the power cord and move the power switch to the ON position. You should hear a whirring sound as the internal disk drive is activated. To begin the session for entering or updating user accounts, first access the keyboard by raising its hinged cover. The screen display will give instructions on how to proceed.

SETTING UP OR CHANGING AN ACCOUNT

To set up a new account or change a previous account, access `Modify Parameters` from the `Main Menu`. Once this selection has been made, the following set of selections will appear on the screen:

1. ID Number
2. Password Savings
3. Checking
4. Account Balances

Choose your selection by pressing the appropriate number on the numeric keypad. Using the arrow keys, move the cursor to the entry for the user account to be edited. The following set of commands can be used to enter and edit field data:

`Enter:` Access the field that needs to be added or edited.

`Ins:` Add information to a user field

`Del:` Delete information from a user field

`Esc:` Return to the Main Menu

All fields must be filled if the system is to access properly each user account. Once all account information has been entered, a full printout can be made by choosing `Print Account Information` from the `Main Menu`.

BEGINNING A BANKING SESSION

When all user accounts have been entered, the unit is ready for simulated banking sessions. From the `Main Menu`, select `Begin Session` to begin a simulation. The screens will guide the user through the entire process in a manner very similar to a real automated teller machine.

INSIDE THE ATM SIMULATOR

An IBM 8088 computer is used to control all aspects of operation for the simulator. The system operator controls the account balances and all other program functions via the keyboard. The display consists of a 13-inch monochrome monitor. The screen guides the user through the entire process and provides help whenever necessary. Display screens are similar to those found on real ATM bank machines. Additional screens take the system operator through the account information sequences.

KEYPAD

The TTB ATM keypad is identical to that found on real Diebold ATM machines. It consists of fifteen keys (11 blue and 4 white.) The 0 through 9 blue digits and decimal-point keys are used for selecting dollar amounts, and the four white keys, labeled A, B, C, and D, are used for making transaction decisions. Pressing the CANCEL key will terminate the session at any given time.

CARD SLOT

After the system operator has set up user accounts, the simulator will wait for the insertion of a bank card. The card must be placed into the machine in the proper direction shown on the diagram on the ATM front panel. The card will be pulled into the slot by the TTB ATM and will remain in place unless the card is inserted in the wrong direction, the transaction is terminated by the user, or the system is shut down or loses power.

MONEY DISPENSER
The user may ask the ATM for a withdrawal in increments of ten dollars. If the user asks for cash in other increments, the simulator will inform the user that the transaction is not allowed and will suggest trying again. Once an amount has been specified for withdrawal, the cash dispenser will drop facsimile ten-dollar bills into the money bin. The system operator can reload the machine with money when needed.

RELOADING
When bills need to be reloaded, the operator should access the cash dispenser from the back of the TTB ATM by pushing down on the springs and placing a neatly packed stack of facsimile bills into the unit. Be sure that the bills can roll out freely by manually turning the dispensing wheels until the bills can move easily.

DEPOSIT SLOT
As in most ATM machines, money or checks can be deposited by placing a deposit envelope into the deposit slot. After the simulator has informed the user that it is ready to receive a deposit, it awaits the insertion of an envelope. The deposit slot module will pull the envelope inside the unit. Deposit envelopes may be collected later by the system operator from the deposit bin. An indicator light located on the back panel of the TTB ATM will inform the system operator if a deposit envelope has been received. Once the envelope has been securely received by the ATM, the user's account will be updated automatically.

PRINTER
After a transaction has been completed, the simulator will produce a copy of the transaction and balance information. The printer is mounted on the side of the unit for easy access. The paper is the same type used in adding machines. Its roll should be placed on the bar so that it can be fed into the printer. When the paper roll runs out, it can be easily replaced by sliding a new roll on the bar. The printer is connected to the computer via a standard Centronics printer interface cable.

EQUIPMENT MAINTENANCE
The main unit may be cleaned with a damp (not wet), lint-free cloth. Aerosol sprays or other cleaning solvents are not recommended for cleaning. If the screen gets dirty, use a clean cloth or paper towel to wipe the screen.

The unit contains no user serviceable internal parts. Repairs should be performed only by a qualified TTB technician. Moving or tampering with any of the components of the TTB ATM may adversely affect the operation of the overall system.

SAFETY PRECAUTIONS
Even though the TTB ATM unit is designed to be as safe as possible, a few circumstances can lead to hazard conditions. For your own safety, and that of your equipment, always take the following precautions. Disconnect the power plug if . . .

- the power cord or plug becomes damaged.
- any piece of clothing gets caught in the bank card, printer, envelope, or money dispensing slots.
- any liquid is spilled on the unit.
- the ATM simulator is dropped.

TROUBLESHOOTING
Problem: No lights or displays of any kind are lit; unit appears to be dead.
Possible Cause: Unit unplugged or has a blown fuse.

Problem: Keys are stuck.
Possible Cause: Keys may begin to stick due to temperature or excessive use. Try to loosen stuck keys by gently pulling them up. WARNING: Do not pull too hard or the keys may break off.

Problem: No response from keypad.
Possible Cause: The TTB ATM may not be in transaction simulation mode.

Problem: Envelope is not being pulled into the deposit slot.
Possible Cause: The wheel of the drive motor may be stuck. Pull up on the traction wheel or remove the envelope and push it manually through the slot.

Problem: Bills are not being dispensed from the machine.
Possible Cause: The money dispenser may be empty.

SERVICE AND SUPPORT
Service for the ATM simulator is available through our local field service network. Please contact:

Terrier Technologies of Boston
ECE Department, Boston University
8 Saint Mary's St.
Boston, MA 02215
617-353-9052

7.7 STRATEGY FOR PRODUCING GOOD TECHNICAL DOCUMENTS

With the possible exceptions of the short memo and e-mail message, writing good documents takes preparation, time, and effort. Whether your writing task consists of an instruction manual, technical report, journal paper, annual summary, or an entire book, it will stand a better chance of accomplishing its objectives if it is well written. As with any other skill, learning to write well requires practice, patience, and attention to detail. In this section, we review several time-tested techniques for improving your writing abilities. Although different writers develop individual styles, most follow the same basic rules outlined below.

Plan the Writing Task

Before sitting down to write, gather all pertinent information. Assemble the results of design calculations, tests, experiments, user specifications, and all other available material. If it's pertinent to the writing task, make sure your engineering logbook is by your side. Gather reference citations, figures, and graphics, if applicable. Have everything in your disposal before you begin the writing task.

Find a Place to Work

One of the most important lessons to learn about writing long documents is that you must devote an uninterrupted block of time to the job. It's simply not possible to write well if you are distracted by phones, e-mail, television, or people coming to talk to you. Writing a complex document takes a long time, sometimes hours or days. When you face a writing task, persistent concentration over an extended period of time will help get you into a creative writing mode. Your mind must sort ideas, arrange their flow, and commit them to well-written and enticing prose. Choosing precise words is an art form similar to painting, sculpting, or composing music. Your writing will flow more smoothly if you find a secluded spot where you'll have absolutely no interruptions. The telephone, your e-mail terminal, or other people stopping by will almost certainly break your concentration during writing and interrupt the creative process. In an ideal world, writers would be able to post "Writing in Progress: Do Not Disturb" signs over office doorways or cubicle portholes. In the real world, such sequestered spots are not always available. Go wherever you can find privacy. A library, cafeteria (during off hours), lab bench, or even the corner donut shop provide mental seclusion, despite their public nature, because they provide uninterrupted time for writing.

Define the Reader

Decide who will be reading your document. Some readers will know more about your subject than you do. Others will know nothing at all. It's important to know the technical level of your reader so that you can set the *tone* of the document. Suppose, for example, that you are reporting on Peak-Performance loading tests for a group of nonengineering students. In such a case, you probably wouldn't include material on spring constants, test methods, or Young's modulus of elasticity. If the report were for engineering students or professors, you might want to include these items.

Regardless of the technical level of your readers, you should decide how much detail the reader will need about the topic. Also be aware of what the reader will do with the document. Will it be redistributed? Will someone else read it? Answering these questions will help you set the tone of the document.

Make Notes

Professional writers always seem to get their documents to read just right. You, too, can produce well organized, easy-to-read documents by mastering one valuable method used by the professionals. Before you begin writing the actual document, make random, stream-of consciousness notes—one line reminders—of *anything* that might need to go into the document. At this stage, give no particular attention to order or emphasis. Include the obvious essentials, as well as the possibly needless trivia. Many writers find it more effective to perform this step with traditional paper and pencil rather than on a computer, because the act of keyboard typing is known to occupy a sizable fraction of brain activity, leaving less mental power for creative and organizational activities. Regardless of which method you choose for recording your ideas, the key at this stage is not to worry about the order in which you write things down on your list. Commit all your ideas to paper now. You'll scrutinize them at a later step in the writing process.

Create Topic Headings

Your next step should be to form the overall structure of the document. To accomplish this task, you should write down the topic headings that will need to go into the finished work. Again, you should write these items down in random order, paying no attention at this stage to how they will be structured. Each of these topical headings will eventually become a paragraph or sequence of paragraphs in the finished document. When you're done with your list, examine each topic heading to see if additional headings come to mind. Delete irrelevant headings and group remaining headings into the main topic areas of the document.

When your list of topic headings is complete, arrange them in a suitable order. Decide which order of presentation is the most interesting, logical, and easiest to understand. It's at this point that the main structural framework of the document begins to take shape.

Take a Break

Before you begin to write the actual document, take a break. Clear your mind before beginning the writing process.

Write the First Draft

If you've done a good job of preparing your list of one line notes, you'll be ready to begin the writing process. Find an interruption-free spot to work, and start to write. Don't worry about writing in perfect form at this stage. Expect to revise your document many times before it's completed. The important thing during the first draft stage is to get your words down on paper. Use a word processor or write by hand and type later, whichever method suits you. As previously mentioned, using a keyboard detracts from the creative energy of writing for some people, so don't feel that you must compose the first draft on a word processor. A word processor is an indispensable tool for writing, of course, but it's main advantage comes in the revision process. On the other hand, if you *can* learn to compose the first draft directly on a word processor, you'll save a lot of time otherwise spent in transcribing handwritten pages.

At this point in the writing process, don't be too concerned about spelling or exact phrasing. These aspects of the document will be corrected and modified later, in the revision phase.

If the work is short, write the first draft in one work session. If the document is long, divide the work into medium-length work sessions. At the end of each work session, rapidly scan the draft and make only *obvious* changes. Do not do major revisions at this time. When the draft is finished, again take a break to clear your mind. If time permits, set aside the document for another day so that you can approach it with a fresh perspective.

Read the Draft

After your break, when you are no longer intently focused on the document, reread it as if you are seeing it for the first time. Check your writing style for clarity. Are there vague, confusing, or ambiguous passages? Are the sentences in the correct order? Is there a logical flow within each paragraph and between successive paragraphs? Check for correct tone. Is the writing style suitable for both the subject matter and the reader?

Try not to read the draft solely from your computer screen. A document always looks different when it's been printed out on paper, because the reader is able to absorb more text at once and get a better feeling for how the entire document is structured.

Revise the Draft

A document seldom is ready for distribution after the writing of its first draft. After you write the first draft, take the time to review your work. Revise words, reword sentences, rearrange paragraphs, and reorganize sections to further refine and clarify meaning. As you revise, mercilessly slash unnecessary words and sentences. Weigh each word and phrase, and keep only those words and phrases that carry important meaning. Technical writing should be direct and to the point. Keep each paragraph relevant. Replace complicated phrases with simple words, and limit superlatives. As you reread your document, give it at least one pass in which you ignore content and look at words, sentences, and paragraphs in their grammatical context only. Remove "fat," unnecessary words, and details that have low information content. You should also recheck factual statements, formulas, numbers, and calculations for accuracy. Be careful to proofread material cited from other documents. Most all word processors include a spelling checker. Get into the habit of using one before sending out a document of any kind.

Revise, Revise, and Revise Again

After you've made your first revision, revise, revise, and revise again. Most good writers devote three or more, and sometimes dozens, of rewrites to get a document to read just right. Each chapter of the book you are reading now was revised at least six times before being sent to the editor for publication.

Review the Final Draft

When you feel that your document is finished, put it aside and come back to it, preferably on another day when you will not be prejudiced by the intensity of the writing process. As you read your document, evaluate it as an outside reader would. Keep an open mind and ask yourself the question, "How would *I* react to what I have written? Will it produce the intended reaction or response from the reader?" If the answer is "yes," your document is ready for the outside world.

Common Writing Errors

Errors in usage and grammar are common in work prepared by student writers. Learning to write well takes practice, discipline, and the careful advice of a good teacher. Despite this observation, it is possible to learn some elements of good writing from a text such as this one. In particular, understanding and avoiding common writing errors will help you immensely as you try to develop good writing habits. The writing errors listed in the following sections are typical of those found in written assignments submitted by engineering students. Review them so that you can avoid making similar mistakes in your own work. Additional examples of correct and incorrect usages can be found in references such as Strunk and White (1979).*

Parallelism. Sentences that include multiple items or ideas should follow parallel construction.
Correct: "Our module will provide data communication, consume minimal power, and satisfy the customer's needs." (All three sentence endings begin with a verb.)
Incorrect: "Our module will provide data communication, minimal power will be consumed by it, and it will satisfy the customer's needs." (The three sentence endings don't have the same construction.)

Commas. Use a comma to separate the second part of a sentence only when the second half could stand on its own as a complete sentence.
Correct (do use a comma): "We will supply five commands to the robot, and we will power the robot with batteries." (The second half of the sentence, "We will power the robot with batteries," is a complete sentence.)
Incorrect (don't use a comma): "We will supply five commands to the robot, and power it with batteries." (The second half of the sentence, "and power it with batteries," cannot stand on its own as a separate sentence. The comma after the word "robot" should be omitted.)

*W. Strunk and E.B. White, *The Elements of Style*. New York: MacMillan, 1979.

Past, Present, and Future Tense. Maintain consistent tense (past, present, or future) as your writing progresses, or at least within a given paragraph.
Correct: "The routes will be difficult to change once they have been programmed into memory. This drawback also will apply to future versions of the robot." (future, future)
Incorrect: "The routes will be difficult to change once they have been programmed into memory. This drawback also applies to future versions of the robot." (future, present)

Use of the Word This. For clarity the word "this" is best used as an adjective, not a noun or pronoun. It should be accompanied by an object of reference.
Correct: "This problem will be solved by designing a new system."
Incorrect: "This will be solved by designing a new system." (i.e., this . . . what?)

Use of the Words Input and Output. "Input" and "output" are best used as nouns. Their use as verbs is often awkward and unprofessional.
Correct: "The input to the mixing circuit consisted of three microphone voltage signals. The output was fed to the amplifier in the form of a voltage summation."
Incorrect: "The microphone signals were inputted to the mixer. Their combined sum was outputted to the amplifier."

Punctuation Around Parentheses. When words are set aside by parentheses, place periods *before* the trailing parenthesis if the parenthetical thought is a major part of the sentence.
Correct: "Our design project was completed on time. (We had been given a week to complete it.)
Incorrect: "Our design project was completed on time. (We had been given a week to complete it).

Infinitives ("To" Verbs). Never split an infinitive. If you use the word "to" followed by a verb, do not put words in between.
Correct: "The purpose of this section is also to help you with your homework."
Incorrect: "The purpose of this section is to also help you with your homework."

KEY TERMS

E-mail
Memorandum
Presentation
Report
Instruction manual

Problems

1. Write a report that outlines your vehicle design process for the Peak-Performance Design Competition introduced in Chapter 2.
2. The following document relates to the Peak-Performance Design Competition introduced in Chapter 2. It outlines the approach to be taken in the design of a system for paging contest participants over a three-minute time interval. It is an example of very poor writing.

Rewrite the proposal, taking into account the writing principles and suggestions outlined in this chapter.

> The three minute pager receiver will be based on a simple bandpass filter that is tuned to a distinct RF band for each receiver. Additionally, each receiver will tune into a general public announcement band which will broadcast voice messages or tones. The cost will be held very small by constructing our own receiver circuits.
>
> Power consumption is minimized by sleep mode. In sleep mode, the receiver's PA band amplifier will be disconnected from its power source via a relay or power monitor switch. Detection of a wakeup signal on the wakeup band will close the circuit between the PA band's amplifier and the speaker.
>
> In addition, preliminary cost research shows that a three-minute countdown circuit and LCD screen can be constructed for under nine dollars in quantities of 100. A speaker and blinking LED can also be provided at minimal cost.
>
> The countdown itself would also be initiated by reception of the wakeup signal. The end of the internal countdown would power down the PA band amplifier, or a second detection on the wakeup band would toggle the power off.
>
> The unit itself could be wearable and styled after a pager or smartcard. We have scheduled a meeting for Tuesday, January 21, at 11 am.

3. The following memo was written by an engineer responsible for designing a parts counting device. The writing style is very poor. Rewrite the memo using the guidelines discussed in this chapter.

> During our first conversation with the customer, we came to an initial design for the project and have scheduled a meeting with the clients on Tuesday. For the design, first thing come across is a detector to physically count the parts falling through the sorting mechanism and we generally prefer to use a photosensor. For the counting mechanism, two methods are proposed and yet remain undecided. One of them is to program a PLA whose reprogramming process could be too complicated for the end user. However, it's advantage is that the design would be simple and cheap. Another approach is to use a microprocessor to do the counting. However, since our team don't have any experience on this subject before, we are still seeking advice and reference. Finally, when the designated no. of parts are counted, the counter will activate a visual and audio signal which prompts the user that parts are ready for packaging. Then the user can put a plastic bag underneath the container and push a button which opens up the bottom of the container.

The above would conclude our initial idea and we will come up with more details and specifications after the meeting.

4. Write a memo to your fictitious boss asking permission to attend a technical conference.
5. Write a short instruction manual that explains how to operate your VCR.
6. Write a memo to all students using your laboratory addressing the importance of safety procedures and protocol.
7. Write a memo that summarizes the following information relating to data communication protocol:

> Data Protocol:
>
> *DCE = Data Communication Equipment (female connector)
>
> Computer, processor, host: receives data, decodes, establishes communications
>
> *DTE = Data Terminal Equipment (male connector)
>
> Terminal, printer, data board - Sends data and displays output
>
> Parallel Data: 8 or 16 bits of data sent simultaneously with a DR (Data Ready) strobe from the DTE to the DCE and a CTS (Clear to Send) signal from the DCE from the DCE
>
> Serial Data: 1 start bit; 8 data bits; 2 stop bits, 14,400 baud (bits audio); no parity
>
> Synchronous data - a clock line must be established between DCE and DTE

Asynchronous data - relies on nearly precise timing and start/stop bits
RS-232 standard (receive-send asynchronous data)
Positive and negative voltages (MARK = 1 = NEG; ZERO = 0 = POS
Held in MARK state when not in use
DB-25 Connector: pin 1 - shield
pin 2: transmit data to DCE
pin 3: receive data at DTE
pin 5: clear to send (CTS) from DCE to DTE
pin 7: signal ground
Note: The DTE sends data on pin 2

8. Write a proposal to your student governing body asking for money to start an on-campus amateur radio club.
9. The following memo was handed in by the employee of a small company specializing in adaptive aides for physically challenged individuals. The memo is not written particularly well. Rewrite the memo using the principles and guidelines outlined in this chapter.

   To: Xebec Management

   From: H. Chew

   This project is to work with a 47-year-old individual who has no speech capability and limited physical abilities. The subject groans and grunts to indicate discomfort, displeasure, requesting, and refusing. During dinner, our customer would like us to provide the subject with a means to indicate "I want more", "I want something else", and "I want a drink," etc.

   To solve this problem, we had called the customer for more information, and she would give us a video tape that is talking about the older person. We also had a team meeting to discuss the project. At the end of the meeting, we considered that we would design a box which consists of an interface panel and a data control unit. The interface panel would consist of four 2.5″ buttons. Each button represents a prerecorded phrase. The sets of outputs from the buttons will correspond to the mode selected. The data control unit consists of the power supply, speech memory, speech synthesizer, and audio amplifier.
10. The following entries were collected by a design team working on a major software project. These notes are to be used by the team to write a summary report to the project manager indicating the features that the finished product must have. The software is to be a voice synthesizer system that will enable individuals with impaired speech capability and limited motor skills to communicate by way of a simple computer mouse. Using the rough notes provided by the design team, write the finished report to the project manager.
    - Topics covered include the alarm, requests, and greetings portions of the user interface.
    - The requests frame should be configured to allow the user to express common requests.
    - The greetings frame must have the most common greetings and be designed for easy access.
    - All frames should give the user the option to reconfigure them in any order desired.
    - The alarm frame will consist of five buttons for use in an emergency only.
    - Alarm messages include help, pain, fire, police, and ambulance.
    - Requests include drink, food, bathroom, book, pen, television, radio, and music.
    - Greetings include hello, goodbye, good morning, good evening, and good night.
11. Compose the text of an e-mail message that announces a meeting of your design team for the Peak Performance Design Competition.
12. Compose the text of an e-mail message in which you request a meeting with your boss to discuss a possible raise in salary.

13. Compose the text of an e-mail message in which you request a meeting with your professor to discuss a possible change in your course grade.
14. Compose the text of an e-mail message in which you ask a semiconductor manufacturer to send you a free sample of a microprocessor chip.
15. Compose the text of an e-mail message in which you inform a client about your travel plans for an upcoming technical review meeting.
16. Compose the text of an e-mail message in which you provide arrival information for a government contractor who is coming to your laboratory to review your work.
17. Compose the text of an e-mail message in which you ask for volunteers for a committee to review company safety standards.
18. Compose the text of an e-mail message in which you solicit volunteers to participate in the annual company blood drive for a local hospital.
19. Compose the text of an e-mail message in which you ask your boss for permission to attend the annual conference of the control and automation group of the Institute of Electrical and Electronic Engineers (IEEE).
20. Compose the text of an e-mail message in which you reassure a nervous customer that your prototype for a manufacturing system will be shipped on time.
21. Prepare a set of overhead slides in which you outline your design approach for the Peak Performance design competition described Chapter 2.
22. Prepare a set of overhead slides in which you describe the results of combustion tests on a new aircraft engine.
23. Prepare a set of overhead slides in which you outline plans for a proposed new light-rail transportation system in a metropolitan area.
24. Prepare a set of overhead slides in which you describe the benefits of a proposed new graphical user interface for a record-keeping system for a real estate company.
25. Prepare a set of overhead slides in which you describe the important features of a professional quality mountain bicycle.
26. Prepare a set of overhead slides in which you report the results of tests on a high speed data link for transferring cell phone routing information from site to site.
27. Write a letter to the human resources director of Alpha Corporation in which you reply to a classified advertisement seeking software engineers.
28. Write a letter to the human resources director of Beta Corporation in which you reply to a classified advertisement seeking entry-level mechanical design engineers.
29. Write a letter to the human resources director of Gamma Corporation in which you reply to a classified advertisement seeking biomedical engineers for synthetic drug development.
30. Write a letter to the human resources director of Delta Corporation in which you reply to a classified advertisement seeking mechanical engineers to work on developing jet engines.
31. Write a letter to the human resources director of XYZ Corporation in which you reply to a classified advertisement seeking industrial engineers to design manufacturing systems.
32. Write a letter to the human resources director of Omega State Highway Department in which you reply to a classified advertisement seeking civil engineers for highway construction.
33. Write a letter to the graduate admissions director of State University in which you request information about possible financial aid for Master's degree study.
34. Write a letter to the CEO of your company in which you highlight the details of an unethical practice that you have uncovered within the company.
35. Write a letter to the sales manager of your company in which you detail the virtues of the new pencil that your engineering division has designed.