A Guide to Writing as an Engineer

Fourth Edition

David Beer • David McMurrey

A GUIDE TO WRITING AS AN ENGINEER

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FOURTH EDITION

David Beer

Department of Electrical and Computer Engineering
University of Texas at Austin

David McMurrey

Formerly of International Business Machines Corporation
Currently, Austin Community College

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Preface

A Guide to Writing as an Engineer, Fourth Edition, like its previous editions is intended for professional engineers, engineering students, and students in other technical disciplines. The book addresses:

- Important writing concepts that apply to communication in these fields.
- Content, organization, format, and style of various kinds of engineering writing such as reports, proposals, specifications, business letters, and email.
- Oral presentations.
- Methods and resources for finding engineering information, both in traditional ways and online.
- Ethics issues in the field of engineering and strategies for resolving them.
- IEEE citation system for ensuring that the sources of all engineering written work and graphics are properly cited.
- Social media: how professional engineers and engineering students can and are using social media to promote themselves, their organizations, products, and services and take an active contributing role in their profession.

WHAT'S NEW IN THIS EDITION

Here is how we have revised *A Guide to Writing as an Engineer*, Fourth Edition:

- Social media: Once viewed as a fad, social media tools and strategies—such as WordPress blogs, LinkedIn, Twitter, and even Google Plus—have become essential tools for many engineering professionals. Jill Brockmann, of Get-Ace.com, provides us with a practical introduction to these tools in Chapter 12 and specific step-by-step instructions on the companion website.

- Tech boxes: Each chapter contains text boxes that briefly describe exciting innovations and advances in the field of engineering: for example, solar panels integrated with roofing shingles, solar paint, insect cyborg spies equipped with piezoelectric generators, graffiti-resistant surfaces based on scorpion exoskeletons, light-producing bacteria, power-producing kites, pavement tiles that produce electricity when walked on, a device that generates electricity from simple human respiration, and many more.
- New examples: Included are examples involving the University of Maryland Watershed building, winner of the 2011 Solar Decathlon; research on batteries for hybrid vehicles; specifications for the University of Minnesota Centaurus II solar vehicle; Maglev space launch systems; a thermal-release ice-cube maker designed by Carnegie Mellon engineering students.
- Engineering design report: Long overdue, Chapter 6 provides discussion and examples of the engineering design report.
- Writing strategies: Chapter 3 adds strategies for explaining the technical to the nontechnical. Chapter 4 adds strategies for writing in tricky situations.
- Companion website: The website companion for *A Guide to Writing as an Engineer*, Fourth Edition, has been resurrected at www.wiley.com/college/beer. It updates URLs, references, and technical content, as necessary. It now includes interactive quizzes, step-by-step procedures for important software tasks, exercises, additional examples, additional tech box items, and other resources.
- Condensed text: To keep the book trim while adding the chapter on social media, we have reduced the word count in each chapter as much as possible but without harming content.

WHO SHOULD USE THIS BOOK

The idea for this book originally grew from our experience in industry and the engineering communication classroom—in particular, from our wish to write a practical rather than theoretical text that devotes *all* its pages to the communication needs of working engineers and those planning to become engineers. Many engineers and engineering students complain that there is no helpful book on writing aimed specifically for them. Most technical writing texts focus, as their titles imply, on the entire field of technical writing. In other words, they aim to provide total information on everything a technical writer in any profession might be called on to do.

Few engineers have the time to become skilled technical writers, yet all engineers need to know how to communicate effectively. They are required to write numerous short documents and also help put together a variety of much longer ones, but few need acquire the skills of an advanced copy editor, graphic artist, or publisher. For most, engineering is their focus, and although advancement to management might bring considerable increase in communication-related work, these will, for the most part, still be focused on engineering and closely related disciplines.

Thus our purpose in this fourth edition is the same as it has been in previous editions: to write a book that stays close to the real concerns engineers and engineering students have in their everyday working lives. Thus, we give little coverage to some topics focused on at length in traditional textbooks and plenty of coverage to topics that a traditional text might ignore. These choices and priorities reflect what we have found to be important to the audience of this book—engineers and students of technical disciplines.

The book can support writing courses for science and engineering majors, or indeed for any student who wants to write about technology. Teachers will find the exercises at the end of each chapter—as well as in the companion website—good starting points for discussion and homework. The book can also function as a reference and guide for writing and research, documenting research, ethical practice in engineering writing, and making effective oral presentations.

WHAT'S IN THIS BOOK

To keep our book focused squarely on the world of engineering, we have organized the chapters in the following way:

Chapter 1, ''Engineers and Writing.'' Study this chapter if you need to be convinced that writing is important for professional engineers and to find out what they write about.

Chapter 2, ''Eliminating Sporadic Noise in Engineering Writing.'' Study this chapter to learn about and avoid communication problems that distract busy readers, causing momentary annoyances, confusion, distrust, or misunderstanding.

Chapter 3, ''Guidelines for Writing Noise-Free Engineering Documents.'' Use this chapter to learn how to produce effective engineering documents that enable readers to access your information with clarity and ease.

Chapter 4, ''Letters, Memoranda, Email, and Other Media for Engineers.'' Learn format, style, and strategies for office memoranda, business letters, and email. (The survey of alternatives to email such as forums, blogs, and social-networking applications has been moved to the new Chapter 12.)

Chapter 5, ''Writing Common Engineering Documents.'' Study the content, format, and style recommendations for such common engineering documents as inspection and trip reports, laboratory reports, specifications, progress reports, proposals, instructions, and recommendation reports.

Chapter 6, ''Writing Research and Design Reports.'' See a standard format for an engineering report, with special emphasis on content and style for its components. Read guidelines on generating PDFs. New to this book is the discussion and examples of the engineering design report.

Chapter 7, ''Constructing Engineering Tables and Graphics.'' Learn strategies for planning graphics for your reports. Techniques for incorporating illustrations and tables into your technical documents have been moved to the companion website.

Chapter 8, ''Accessing Engineering Information.'' Review strategies on how to plan an information search in traditional libraries as well as in their contemporary online counterparts. See the special section on finding resources available on the Internet.

Chapter 9, ''Engineering Your Speaking.'' Read about strategies for preparing and delivering presentations, either solo or as a team.

Chapter 10, ''Writing to Get an Engineering Job.'' Review strategies for developing application letters and résumés—two of the main tools for getting engineering job. The chapter includes suggestions for engineers just beginning their careers. Information on using social media (such as LinkedIn) for the job search has been moved to the new Chapter 12 on social media.

Chapter 11, ''Ethics and Documentation in Engineering Writing.'' Explore the ethical problems you may encounter and how to resolve them. Use one of the two codes of ethics provided to substantiate your position. Read about plagiarism and review the IEEE system for documenting borrowed information. Sample formats of citations and references are provided.

Chapter 12, ''Engineering Your Online Reputation.'' Design and implement a social media strategy for building an online reputation for yourself, your company or your organization using such tools as WordPress, Facebook, Twitter, LinkedIn, and Google+. Learn how to build a community and curate its contributed information so that that information reliably provides online support for products or services. Put what you learn into practice by using these tools to accomplish one or both of these goals, preferably for a business, organization, product, or service.

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Also deserving of our gratitude are those professors who assisted us in reviewing the manuscript of earlier editions of this text. Such people include Professor W. Mack Grady, ECE Department, UT Austin; Thomas Ferrara, California State University, Chico; Jon A. Leydens, Colorado School of Mines; Jeanne Lindsell, San Jose State University; Scott Mason, University of Arkansas; Geraldine Milano, New Jersey Institute of Technology; Heather Sheardown, McMaster University; and Marie Zener, Arizona State University.

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Contents

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Engineers and Writing

Poor communication skill is the Achilles' heel of many engineers, both young and experienced—and it can even be a career showstopper. In fact, poor communication skills have probably claimed more casualties than corporate downsizing.

H. T. Roman, ''Be a Leader—Mentor Young Engineers,'' *IEEE-USA Today's Engineer*, November 2002.

It is nearly impossible to overstate the benefits of being able to write well. The importance of the written word in storing, sharing, and communicating ideas at all levels of all organizations makes a poor facility with the mechanics of writing a severely career-limiting fault.

John E. West, *The Only Trait of a Leader: A Field Guide to Success for New Engineers, Scientists, and Technologists*, 2008.

Like a lot of other professionals, many engineers and engineering students dislike writing. After all, don't you go into engineering because you want to work with machines, instruments, and numbers rather than words? Didn't you leave writing behind when you finished English 101? You may have hoped so, but the fact remains—as the above quotes so bluntly indicate—that to be a successful engineer you must be able to write (and speak) effectively. Even if you could set up your own lab in a vacuum and avoid communication with all others, what good would your ideas and discoveries be if they never got beyond your own mind?

If you don't feel you have mastered writing skills, the fault probably is not entirely yours. Few engineering colleges offer adequate (if any) 3 courses in engineering communication, and many students find what writing skills they did possess are badly rusted from lack of use by the time they graduate with an engineering degree.

Ironically, most engineering programs devote less than 5% of their curriculum to communication skills—the very skills that many engineers will use some 20% to 40% of their working time. Even this percentage usually increases with promotion, which is why many young engineers eventually find themselves wishing they had taken more writing courses.

But rather than dwell on the negative, look at the needs and opportunities that exist in engineering writing, and then see how you can best remove barriers to becoming an efficient and effective writer. You'll soon find that the skills you need to write well are no harder to acquire than many of the technical skills you have already mastered as an engineer or engineering student. First, here are four factors to consider:

- Engineers write a lot.
- Engineers write many kinds of documents.
- Successful engineering careers require strong writing skills.
- Engineers can learn to write well.

Instant learning?

Researchers at Boston University and ATR Computational Neuroscience Laboratories in Kyoto, Japan, think that by using decoded neurofeedback, people's brain activity can be trained to match that of someone who possesses a certain skill (for example, writing or piano playing). Don't we wish!

For details, see the Preface for the URL.

ENGINEERS WRITE A LOT

Many engineers spend over 40% of their work time writing, and usually find the percentage increases as they move up the corporate ladder. It doesn't matter that most of this writing is now sent through email; the need for clear and efficient prose is the same whether it appears on a computer or sheet of paper.

An engineer told us some years ago that while working on the B-1b bomber, he and his colleagues calculated that all the proposals, regulations, manuals, procedures, and memos that the project generated weighed almost as much as the bomber itself. Most large ships carry several tons of maintenance and operations manuals. Two trucks were needed to carry the proposals from Texas to Washington for the ill-fated supercollider project. John Naisbitt estimated in his book *Megatrends* over 25 years ago that some 6,000 to 7,000 scientific articles were being written every day, and even then the amount of recorded scientific and technical information in the world was doubling every five and a half years. Jumping to the present, look what John Bringardner has to say in his short article entitled ''Winning the Lawsuit'':

> *Way back in the 20th century, when Ford Motor Company was sued over a faulty ignition switch, its lawyers would gird for the discovery process: a labor-intensive ordeal that involved disgorging thousands of pages of company records. These*

days, the number of pages commonly involved in commercial litigation discovery has ballooned into the billions. Attorneys on the hunt for a smoking gun now want to see not just the final engineering plans but the emails, drafts, personal data files, and everything else ever produced in the lead-up to the finished product.

Wired Magazine, July 2008, p. 112.

Who generates and transmits—in print, online, graphically, or orally—all this material, together with countless memos, reports, proposals, manuals, and other technical information? Engineers. Perhaps they get some help from a technical editor if their company employs one, and secretaries may play a part in some cases. Nevertheless, the vast body of technical information available in the world today has its genesis in the writing and speaking of engineers, whether they work alone or in teams. Figure 1-1 shows just one response we got when we randomly asked an engineer friend, who works as a software deployment specialist for a large international company, to outline a typical day at his job (our italics indicate where communication skills are called for).

Friday's Schedule
2/15/08

7:30	Arrive, *read and reply to several overnight emails.*
8:00	Work on project.
10:30	*Meet with* project manager to *write answer to* department head request.
11:00	*Write up a request* to obtain needed technical support.
11:30	Lunch.
12:00	*Meet with* server group about *submitted application* to fix process problems.
12:20	*Reply to* emails from Sales about prospective customers' *technical questions*.
12:30	*Write to* software vendor about how our product works with their plans.
1:00	*Give presentation to* server hosting group *to explain* what my group is doing.
2:00	*Join* the team *to write up* weekly *progress report*.
2:30	*Write emails to* update customers on the status of solving their problems.
2:45	*Write email reply to* question about *knowledge base article I wrote*.
3:00	*Meet with* group *to discuss project goals* for next four months.
3:30	*Meet with* group to *create presentation of findings* to project management.
4:00	Work on project.
5:00	Leave for day.

Figure 1-1 The working day of a typical engineer calls for plenty of communication skills.

The ability to write effectively is not just a ''nice-to-have''; it translates into significant dollars. If the average starting salary for engineers in 2011 is $60,000 and those engineers spend 40% of their time writing, that means they are being paid $24,000 a year to write!

ENGINEERS WRITE MANY KINDS OF DOCUMENTS

As mentioned above, few engineers work in a vacuum. Throughout your career you will interact with a variety of other engineering and non-engineering colleagues, officials, and members of the public. Even if you don't do the actual engineering work, you may have to explain how something was done, should be done, needs to be changed, must be investigated, and so on. The list of all possible engineering situations and contexts in which communication skills are needed is unending. Figure 1-2 identifies just some of the documents you might be involved in producing during your engineering career. (Not all companies label reports by the same name or put them in the same categories as we have.)

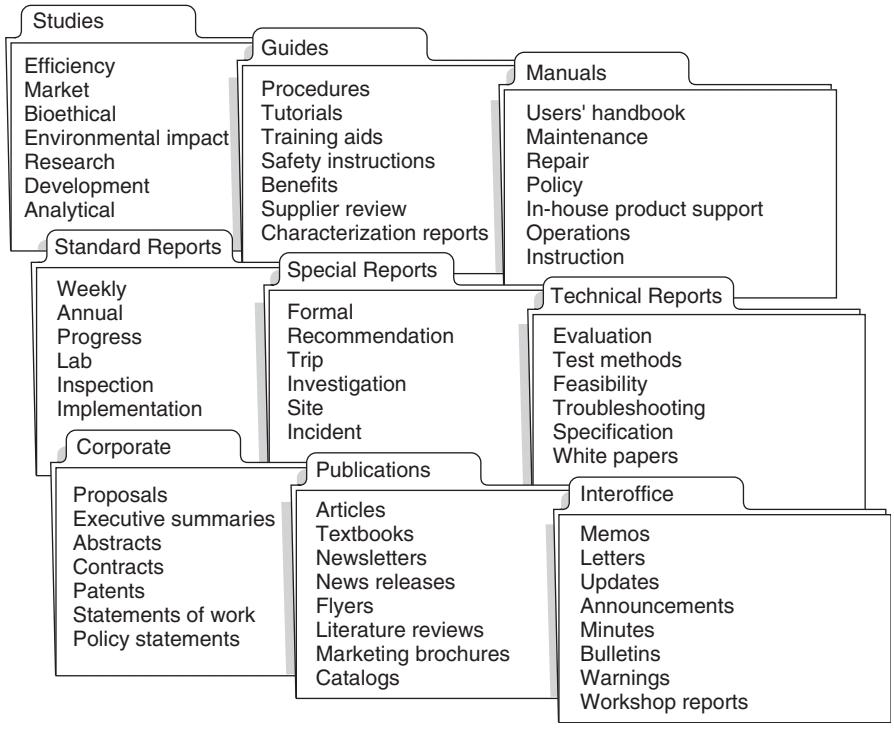

Figure 1-2 Throughout their careers, engineers write many kinds of documents in various contexts and with different purposes and audiences.

Moving further into the twenty-first century, electronic communication is rapidly replacing much hard copy. Used for anything from quick pithy notes and memos to complete multivolume documents, email has perhaps become the most popular form of written communication. Yet this fact does not in any way change the need for clarity and organization in engineering writing, and whatever the future holds, solid skills in clear and efficient writing, and the ability to adapt to many different document specifications, will probably be necessary for as long as humans communicate with each other.

SUCCESSFUL ENGINEERING CAREERS REQUIRE STRONG WRITING SKILLS

In the engineering field, you are rarely judged solely by the quality of your technical expertise or work. People also form opinions of you by what you say and write—and how you say and write it. When you write email or reports, talk to members of a group, deal with vendors on the phone, or attend meetings, the image others get of you is largely formed by how well you communicate. Even if you work for a large company and don't see a lot of high-level managers, those same managers can still gain an impression of you by the quality of your written reports as well as by what your immediate supervisor tells them. Thus Robert W. Lucky, former Executive Director of AT&T Laboratories and head of research at Telcordia Technologies, and an accomplished writer himself, points out:

> *It is unquestionably true that writing and speaking abilities are essential to the successful engineer. Nearly every engineer who has been unsuccessful in my division had poor communication skills. That does not necessarily mean that they failed because of the lack of these skills, but it does provide strong contributory evidence of the need for good communication. On the contrary, I have seen many quite average engineers be successful because of above-average communication skills.*
>
> rlucky@telcordia.com Accessed August 20, 2008

Moreover, two relatively recent trends are now making communication skills even more vital to the engineering profession. These are *specialization* and *accountability*. Due to the advancement and specialization of technology, engineers are finding it increasingly difficult to communicate with one another. Almost daily, engineering fields once considered unified become progressively fragmented, and it's quite possible for two engineers with similar academic degrees to have large knowledge gaps when it comes to each other's work. In practical terms, this means that a fellow engineer may have only a little more understanding of what you are working on than does a layperson. These gaps in knowledge often have to be bridged, but they can't be unless specialists have the skills to communicate clearly and effectively with each other. (Chapter 3 presents ''translation'' techniques that can help with these gaps as well.)

In addition, because engineers and their companies are now held much more accountable by the public, engineers must also be able to communicate with government, news media, and the general public. As the Director of the Center for Engineering Professionalism at Texas Tech University puts it,

> *The expansiveness of technology is such that now, more than ever, society is holding engineering professionals accountable for decisions that affect a full range of daily life activities. Engineers are now responsible for saying: ''Can we do it, should we do it, if we do it, can we control it, and are we willing to be accountable for it?'' There have been too many ''headline type'' instances of technology gone astray for it to be otherwise . . . Pinto automobiles that burn when hit from the rear, DC-10s that crash when cargo doors don't hold, bridges that collapse, Hyatt Regency walkways that fall, space shuttles that explode on national TV, gas leaks that kill thousands, nuclear plant accidents, computer viruses, oil tanker spills, and on and on.*
>
> Engineering Ethics Module, Murdough Center for Engineering Professionalism, Texas Tech University, Lubbock, Texas. www.murdough.ttu.edu/EthicsModule/EthicsModule.htm. Accessed December 13, 2011.

People do want to know *why* a space shuttle crashed (after all, their taxes paid for the mission). They want to know if it really is safe to live near a nuclear reactor or high-power lines. The public—often through the press—wants to know if a plant is environmentally sound or if a project is likely to be worth the tax dollars. Moreover, there is no shortage of lawyers ready to hold engineering firms and projects accountable for their actions. All this means that engineers are being called upon to explain themselves in numerous ways and must now communicate with an increasing variety of people—many of whom are not engineers.

ENGINEERS CAN LEARN TO WRITE WELL

Here are the words of Norman Augustine, former chairman and CEO of Martin Marietta Corporation and also chair of the National Academy of Engineering:

> *Living in a ''sound bite'' world, engineers must learn to communicate effectively. In my judgment, this remains the greatest shortcoming of most engineers today—particularly insofar as written communication is concerned. It is not sensible to continue to place our candle under a bushel as we too often have in the past. If we put our trust solely in the primacy of logic and technical skills, we will*

lose the contest for the public's attention—and in the end, both the public and the engineer will be the loser.

Norman R. Augustine, in *The Bridge*, The National Academy of Engineering, *24*(3), Fall 1994, p. 13.

Writing is not easy for most of us; it takes practice just like programming, woodworking, or playing the bagpipes, for example. A lot of truth lies in the adage that no one can be a good writer—only a good *re*writer. If you look at the early drafts of the most famous authors' works, you will see scribbling, additions, deletions, rewordings, and corrections where they have edited their text. So don't expect to produce a masterpiece of writing on your first try. Every initial draft of a document, whether it's a one-page memo or a fifty-page set of procedures, needs to be worked on and improved before being sent to its readers.

As an engineer you have been trained to think logically. In the laboratory or workshop, you are concerned with precision and accuracy. From elementary and secondary school, you already possess the skills needed for basic written communication, and every day you are exposed to clear writing in newspapers, weekly news magazines, and popular journal articles. Thus you are already in a good position to become an effective writer partly by emulating what you've already been exposed to. All you need is some instruction and practice. This book will give you plenty of the former, and your engineering career will give you many opportunities for the latter.

NOISE AND THE COMMUNICATION PROCESS

Have you ever been annoyed by someone talking loudly on a cell phone while you were trying to study or talk to a friend? Or maybe you couldn't enjoy your favorite TV show because someone was using the vacuum cleaner in the next room or the stereo was booming.

In each case, what you were experiencing was noise interfering with the transmission of information—specifically, *environmental* noise. In written communication, we are primarily concerned with *syntactic* (grammar), *semantic* (word meanings), and *organizational* noise.

Whenever a message is sent, someone is sending it and someone else is trying to receive it. In communication theory, the sender is the *encoder*, and the receiver is the *decoder*. The message, or *signal*, is sent through a channel, usually speech, writing, or some other conventional set of signs. Anything that prevents the signal from flowing clearly through the channel from the encoder to the decoder is *noise*. Figure 1-3 illustrates this concept. Note how all our actions involving communication are ''overshadowed'' by the possibility of noise.

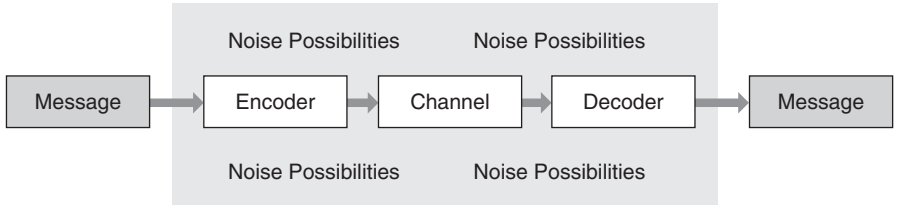

Figure 1-3 In noise-free technical communication, the signal flows from the encoder (writer, speaker) to the decoder (reader, listener) without distortion or ambiguity. When this occurs, the received message is a reliable version of the sent one.

Apply this concept to engineering writing: anything causing a reader to hesitate—whether in uncertainty, frustration, or even unintended amusement—is noise. Chapter 2 will provide more detail, but for now the following box shows just a few simple samples of written noise.

Noisy sentences

When they bought the machine they werent aware of it's shortcomings.

They were under the allusion that the project could be completed in six weeks.

There was not a sufficient enough number of samples to validate the data.

Our intention is to implement the verification of the reliability of the system in the near future.

In the first sentence, two apostrophe problems cause noise. A reader might be distracted momentarily from the sentence's message (or at least waste time wondering about the writer). The same might be said for the confusion between *allusion* and *illusion* in the second sentence. The third sentence is noisy because of the wordiness it contains. Wouldn't you rather just read *There weren't enough samples to validate the data*? The final example is a monument to verbosity. With the noise removed, it simply says: *We want to verify the system's reliability soon*.

It's relatively easy to identify and remove simple noise like this. More challenging is the kind of noise that results from fuzzy and disorganized thinking. Here's a notice posted on a professor's door describing his office hours:

More noise

I open most days about 9 or 9:30, occasionally as early as 8, but some days as late as 10 or 10:30. I close about 4 or 4:30, occasionally around 3:30, but sometimes as late as 6 or 6:30. Sometimes in the mornings or afternoons, I'm not here at all, but lately I've been here just about all the time except when I'm somewhere else, but I should be here then, too.

Academic humor, maybe, but it's not hard to find writing in the engineering world that is equally difficult to interpret, as this excerpt from industrial procedures shows:

Noisy procedure

If containment is not increasing or it is increasing but MG Press is not trending down and PZR level is not decreasing, the Loss of Offsite Power procedure shall be implemented, starting with step 15, unless NAN-S01 and NAN-S02 are de-energized in which case the Reactor Trip procedure shall be performed. But if the containment THRSP is increasing the Excess Steam Demand procedure shall be implemented when MG Press is trending down and the LIOC procedure shall be implemented when the PZR level is decreasing.

Noise in a written document can cause anything from momentary confusion to a complete inability to understand a message. However, noise inevitably costs money—or to put it graphically,

NOISE = $$$$

According to engineer Bill Brennan, a senior member of the technical staff at Advanced Micro Devices (AMD) in Austin, Texas, it costs a minimum of $200 to produce one page of an internal technical report and at least five times that much for one page of a technical conference report. Thus, as you learn to reduce noise in your writing, you will become an increasingly valuable asset to your company.

Noise can also occur in spoken communication, of course, as you will see in Chapter 9. For now, recall how often you've been distracted by a speaker's monotonous tone, nervous cough, clumsy use of notes, or indecipherable graphics—while you just sat there, a captive audience.

The following chapters contain advice, illustrations, and strategies to help you learn to avoid noise in your communication. Try to keep this concept of noise in mind when you write or edit, whether you are working on a five-sentence memo or a 500-page technical manual. Throughout your school years you may have been reprimanded for "poor writing," "mistakes," "errors," "choppy style," and so on. However, as an engineer, think of these problems in terms of *noise to be eliminated from the signal*. For efficient and effective communication to take place, the signal-to-noise ratio must be as high as possible. To put it another way, filter as much noise out of your communication as you can.

CONTROLLING THE WRITING SYSTEM

Engineers frequently design, build, and manage systems made up of interconnected parts. Controls have to be built into such systems to guarantee that they function correctly and reliably and that they produce the desired result. If the ATM chews up your card and spits it back out to you in place of the $200 you had hoped for, you'd claim the system is not working right—or that it is out of control. The system is only functioning reliably if the input (your ATM card) produces the desired output (your $200).