SCENARIO

It's only your third week on the job, but you decide that a better graphics accelerator on your office computer is critical. You have to write a memo to your boss to justify the request. You don't have much time to write this memo, and you know your boss won't have much time to read it. You could write several paragraphs comparing and contrasting your existing equipment with the graphics accelerator you'd like to have, but you decide it would be a lot easier on your boss if you display the specifications in a simple table. And to emphasize the substantial difference in image quality, you choose two pictorial illustrations that dramatically display the distorted images generated by your existing equipment versus the crisp images that the new graphics accelerator would give you. Side by side on the page, the two pictures build a persuasive case: you could never have said it better.

chapter 12

Using Illustrations

▶ Choosing Illustrations
  Consider Your Purpose
  Consider Your Audience
  Consider Your Audience Again
  Consider Your Purpose Again

▶ Creating Illustrations
  Designing Tables
  Designing Bar and Column Graphs
  Designing Circle Graphs
  Designing Line Graphs

▶ Designing Illustrations Ethically

In communicating technical information, you will often need to use illustrations either in addition to words or instead of words to convey your message. Learning how to create effective tables, graphs, diagrams, and drawings will give you additional tools for helping readers to understand your subject.

As in all technical communication, using illustrations has ethical implications. In every diagram and drawing, every table and graph, you have a moral responsibility to offer a clear and correct impression of your subject.

CHOOSING ILLUSTRATIONS

How do you determine whether illustrations are really desirable? The answer is to consider your rhetorical situation, including both purpose and audience.

Consider Your Purpose

- What do you want to have happen as a result of the document?
- What do you want the reader to do or think after reading your document?
- How will illustrations help you to achieve your objective?

For example, Andrew Crowell, the owner of Crowell Heating & Cooling in Rising Star, New Mexico, is writing a recommendation report regarding the installation of new air conditioning equipment for a local business. He wants the potential client to approve this recommendation quickly, to clinch the sale. Andrew decides that illustrations will dramatize the benefits of the new equipment. He includes a photograph of the same equipment being installed, for a previous client, wanting both to help the prospective client to envision a similar installation and to reinforce Crowell's track record with such installations. And he includes a bar graph spotlighting the high cooling costs with the current system versus the lower costs projected for the new equipment. Andrew believes the two illustrations will focus attention on the persuasive evidence.

Erica Vasquez of Wild Computers has a different challenge. She is writing a set of instructions for customers on how to install additional memory chips in their computers. She wants such installations to proceed without incident, reinforcing the image of Wild Computers as easy to operate and easy to upgrade. She wants people to read the instructions and feel confident that they can perform the installations; she doesn't want users getting stuck in the middle of the procedure, feeling frustrated, and calling Wild for technical support. Erica believes that a flowchart, outlining the steps in the procedure, will give customers a comforting overview. She will also need to include lots of drawings to show users exactly how to open the case, insert the chips, and close the case.

Consider Your Audience

What are the expectations of your readers regarding illustrations? If they expect illustrations, you will need to deliver illustrations or risk disappointing and distracting your audience. If your audience doesn't expect illustrations, you will need to gauge carefully the likely positive or negative impact of including graphics. For example, readers of financial reports expect to see tables of sales figures, profits and losses, stockholders' equity, and long-term debt. If your financial report doesn't display this information in tables, your readers probably will be confused and irritated. On the other hand, World Wide Web users, expect to see illustrations (including animated illustrations). A site that is all paragraphs is considered primitive and uninviting. Readers of résumés, however, still expect words on a page and might interpret illustrations as a distraction to mask a weak set of credentials.

In addition to the expectations of your audience, consider their background, attitude, and environment.

- If your readers have little or no knowledge of your subject, illustrations may create a virtual experience by showing what the subject looks like, summarizing its specifications, highlighting its components, revealing its organization, or displaying its operation.
- If your readers have limited language abilities, illustrations may help them circumvent the difficulties of deciphering words on a page.
- If your readers aren't motivated to read your document, illustrations may encourage them to read by making your document look more inviting and accessible.
- If your audience has little time to read your document, illustrations may assist by capsulizing information in a quick snapshot of your subject.
- If your readers are in a distracting environment, illustrations may focus their attention with a display of information that is eye-catching and engaging.

For example, Andrew Crowell believes the prospective client will be nicely surprised by the two illustrations. In conversations regarding the new cooling equipment, Andrew has noticed that the client is often impatient with long explanations and likes to go straight to the point. Instead of offering a boring, all-prose recommendation report, therefore, Andrew integrates illustrations that focus on key issues and expedite the job of reading.

Similarly, Erica Vasquez knows that most of her readers have never before installed additional memory chips in their computers. She knows that to motivate users to read the instructions and perform this procedure, she must make the job look as easy as possible. And instead of using words and requiring readers to picture objects and actions for themselves, Erica includes a series of drawings that show customers what they need to do and what their computers should look like at every step along the way. For the minority of customers who are experienced in such installations, Erica believes a flowchart outlining the steps will provide sufficient guidance. And for the inexperienced majority, the flowchart will make the whole procedure look coherent and systematic.

Once you decide to use illustrations, how do you decide which illustrations to use? Once more, you will have to consider your rhetorical situation, chiefly your audience and purpose.

Consider Your Audience Again

Is your audience familiar with this kind of illustration? Does your audience have the ability to interpret the illustration? If your audience is unfamiliar with circle graphs, for example, displaying the information in such a manner will be ineffective without considerable verbal explanation. And if considerable explanation of an illustration is necessary, you are probably using the wrong kind

of illustration for your audience. If your audience is international, you must also be sensitive to cultural variations in the interpretation of illustrations. For example, the convention of using bubbles in drawings to depict what people are thinking (see Figure 12-1) will be readily understood in some cultures but can cause confusion in others. International variations in the design of objects such as trash containers, mailboxes, or electrical outlets also can lead to misunderstanding or misinterpretation of pictures displaying such objects. (see Figure 12-2).

Consider Your Purpose Again

- **If the purpose of your document is to summarize information, use a table.**
- **If you wish to exhibit or emphasize information, use a figure.**

Tables are rows and columns of numbers and words. Tables offer readers the details of a subject. If you want your readers to be able to remember or retrieve specific pieces of information, tables will serve your purpose.

For example, Tom Skiludi of National Oil & Gas, headquartered in Pittsburgh, is reporting to the northeast regional supervisor on the year's operations. He knows the supervisor will pass the figures on to the company's chief financial officer. Tom chooses a table as the efficient way to display the information (see Table Exhibit 12-1). Figures come in a wide variety and dramatize different kinds of information (see Table 12-1).

To emphasize or reinforce the meaning of data, start with a table and then use a figure to spotlight the implications of the data. For example, in reporting on the year's operations, Tom considered several possible illustrations, including a line graph to dramatize the company's rising oil production and a pair of circle graphs to highlight the stability in the relative proportions of gas distribution and transmission. He decided, however, on a bar graph because it would readily focus attention on a potentially ominous piece of information: While gas transmission and distribution both increased in 2001, gas production decreased (see Figure 12-3).

Ordinarily, you will use a table to arrange your data for easier analysis and interpretation. Graphics programs will then allow you to select a dramatic way of displaying the data.

Often a variety of illustrations will serve your purpose. Consider, for example, the various tables and figures in the U.S. Environmental Protection Agency's chemical accident investigation report of the Tosco Avon Refinery in Martinez, California. On page v of this 105-page report, the purpose and audience are identified:

A key objective of the EPA chemical accident investigation program is to determine and report to the public the facts, conditions, circumstances, and causes or likely causes of chemical accidents that result, or could have resulted, in a fatality, serious injury, substantial property damage, or serious off-site impacts, including a large scale evacuation of the general public. The ultimate goal of an accident investigation is to determine the root causes in order to reduce the likelihood of recurrence, minimize the consequences associated with accidental releases, and to make chemical production, processing, handling, and storage safer.

The report describes the investigation of an accident in the refinery's hydrocracker (a device that splits the molecules of hydrocarbon oil at high temperature and pressure). A hydrocarbon and hydrogen release and a subsequent fire killed one operator and injured forty-six others. The cause was a rupture of one of the reactor effluent pipes due to excessively high temperature.

Among the illustrations in the report are maps of the refinery and the hydrocracker that show the site of the accident (see Figures 12-4 and 12-5). A flowchart explains the hydrocracking process (see Figure 12-6). A table lists the operating parameters of the reactor (see Table Exhibit 12-2) and two line graphs reveal spiking temperatures in the reactor prior to the explosion (see Figure 12-7). A series of photographs shows the damage to the equipment from the explosion (see Figure 12-8). Three tables summarize the chronology of incidents leading to the tragic accident and the various errors committed by operators at the refinery (see Table Exhibits 12-3, 12-4, and 12-5). Without the illustrations, the EPA investigators could never have achieved their purpose or communicated effectively with their audience.

Notice, however, the absence of pictures of human beings. There are no drawings of people making mistakes in their operation of the hydrocracker unit (human error is relegated to a table) and no photographs of the people killed and injured in the accident. This omission diminishes the importance of the people at this facility, both as contributors to the accident and as its victims. The illustrations focus the viewer's attention on buildings and machines. The impression thus communicated is that the chief cause of the accident was technological—a mechanical failure—and the chief consequence was also technological—a bunch of ruptured pipes. The human dimension of the incident is literally invisible.

As the illustrations in this report demonstrate, you have a variety of ways to help your readers perceive your meaning. In choosing illustrations, always consider your purpose and your audience. Consider illustrations while you are planning your document, but continue to look for ways to visualize your message even as you are writing and revising.

CREATING ILLUSTRATIONS

In deciding when and how to use illustrations, remember the following guidelines:

- **Simplify your illustrations.** Keep your illustrations as simple as possible so that your reader has no difficulty understanding your message. Avoid distracting your reader with unnecessary details or decorative flourishes.
- **Use computer applications critically.** Computer graphics software and clip art allow you to include in your document all manner of illustrations. To ensure the effectiveness of your tables and figures, however, you must impose your judgment on the choices available from the computer. Graphics software, for example, might create artistic but misleading graphs, and clip art might exhibit a pictorial style that isn't quite serious enough or detailed enough to do justice to your subject. It is your job to choose illustrations that display your information clearly and correctly, in a format that can be quickly grasped.
- **Consider size and cost.** Calculate the impact of illustrations on the expected length of your document. Illustrations will often increase the size of a document and add to the cost of production and distribution.
- **Choose illustrations carefully.** Realize that you usually have a choice of illustrations. If a table or figure that you initially consider using does not convey your point quickly and clearly, look for other ways of displaying the information visually.
- **Title your illustrations.** Give each table and figure a title that clearly indicates the content of the display.
- **Number your illustrations.** If you use several illustrations in your report, number them. Number the tables and figures separately (e.g., Table 1, Table 2, Figure 1, Figure 2). Place the number and title above a table and below a figure.
- **Alert your readers.** Always alert your readers to illustrations by referring to them in the text. Every time you refer to the illustration, use the table or figure number.
- **Position your illustrations strategically.** Place each illustration as close to the passage it explains as possible. Announce the table or figure—what it is or shows—then insert the illustration, and add any verbal explanation your reader will need to fully understand the illustration. Don't lead readers through a complicated explanation and only afterward refer to the illustration. Send them to the illustration immediately; then they can shift back and forth between the explanation and the illustration as necessary.
- **Identify your sources.** If you borrow or adapt a table or figure from another source, identify that source below the illustration.

Designing Tables

- Every column in a table should have a heading that identifies the information below it. In a table of numbers, include the unit of measurement, such as "miles per hour." For large numbers, add a designation such as "in thousands" or "in millions" to the column heading (and delete the corresponding zeros from the numeric data). Headings should be brief. If headings need more explanation, include this information in a footnote below the table. Use lowercase letters, numbers, or symbols (e.g., * or +) to indicate footnoted material.
- If possible, box your table to separate it from surrounding paragraphs.
- Keep tables as simple as possible. Include only data relevant to your purpose.
- Consider omitting lines between rows and columns to avoid giving your table a crowded appearance. If possible, use white space to separate rows and columns.

Table Exhibits 12-6–12-8 show three ways of presenting tabular data. The first two examples contain serious design flaws.

Designing Bar and Column Graphs

- Avoid putting excessive information on a bar or column graph and thereby complicating the reader's ability to decipher it. Consider using a separate graph to communicate each point.
- Be sure to label the *x*-axis and the *y*-axis—what each measures and the units in which each is calibrated. Readers can't understand your graph if they don't know what you are measuring or how it is measured.
- For bar graphs, start the *x*-axis at zero and equally space the intervals on the *x*-axis to avoid distorting the length of the bars. For column graphs, start the *y*-axis at zero and equally space the intervals on the *y*-axis to avoid distorting the height of the columns.
- Color can enhance the effect of a graph, but excessive color can reduce comprehension and distort information. Use the same color for all bars or columns that are representing the same items. Avoid using color as simple decoration.
- Make the graph accurate. Computer graphics allow a tremendous range of special effects. However, artistic graphs are not always either effective or accurate. Three-dimensional bars and columns are often deceptive because readers have difficulty visually comparing the relative lengths of the bars and heights of the columns. If you choose three-dimensional bar or column graphs, watch for distortion.
- Try to write captions or labels on or near the bars. Avoid legends (or keys) that slow reader comprehension. When bars are divided into too many divisions, which cannot be interpreted without consulting a legend, the result can be confusion rather than effective communication. However, placing labels on bars can be difficult if you use colored bars. Even black text will often be difficult to read on any colors but very light ones. For that reason,

many graphics software programs offer you the use of legends. In short, legends are fine if you don't have too many segments or bars—more than four—and if the legend is close to the bars.

- For divided bar and column graphs with extensive divisions, use color or shading to distinguish divisions instead of crosshatching patterns. Crosshatching often creates distracting optical illusions.
- Avoid crowding the bars or columns within a graph. Such visual clutter makes a graph look difficult to interpret. Using three-dimensional bars or columns will also reduce the number that will fit in a given space. Effective and inviting graphs leave generous space between the bars or columns.

     See Figures 12-9–12-13 for examples of column and bar graphs.

Designing Circle Graphs

- Restrict the number of segments in a circle graph to seven or eight. There is simply a limit to the number of segments into which a circle can be divided before comprehension of the relative sizes is jeopardized. If necessary, combine several smaller segments and create a second circle graph to display the composition of that combined segment.
- Use shading or color to differentiate segments and make them easier for readers to see.
- Watch for possible distortion when you use three-dimensional circle graphs.
- Clearly label all segments. Whether they are placed inside or outside the circle, labels should be horizontal for easier reading.
- As you segment the graph, begin with the largest section in the upper right-hand quadrant. The remaining segments should be arranged clockwise, in descending order.

     See Figures 12-14–12-16 for examples of circle graphs.

Designing Line Graphs

- Label each axis clearly. Like bar and column graphs, line graphs must have clearly labeled scales to show the variables you are measuring. Ordinarily, the independent variable is placed on the horizontal *x-axis*, and the dependent variables are placed on the vertical *y-axis* and the diagonal *z-axis* (in a three-dimensional graph).
- Choose the scale of each axis to show the appropriate steepness of the slope of the line. Typically, the scales start at zero, with the intervals equally spaced on each axis.
- The major difficulty in designing line graphs lies in choosing the spacing for each axis so that the steepness (slope) of the line accurately measures the actual trend suggested by the data. Computer graphics will allow you to adjust the intervals on the *x-* and the *y-axis,* but your job is to decide whether

the slope of the graph accurately depicts your data or gives a distorted impression.

- Avoid using more than three data lines on one graph unless they are spaced apart and do not overlap. Graphs with several intersecting data lines are usually difficult for readers to interpret.
- Keep the data lines on your graph distinctive by using different colors or styles for each line.
- If possible, label each data line. Avoid legends (or keys) that slow reader comprehension.

See Figures 12-17–12-20 for example of line graphs.

DESIGNING ILLUSTRATIONS ETHICALLY

Displaying information ethically requires that you make careful choices about the design of your illustrations.

For example, the scale of the *x*- and *y*-axes on a line graph has a significant impact on the data display. In designing a graph, you ordinarily start the *x*- and *y*-axes at 0. Exceptions are possible if beginning at some other point ("suppressing the zero") will not distort information. If several line graphs are to be compared and contrasted, it would be unethical to suppress the zero on some of the graphs but not on others: readers might focus only on the data lines and overlook the difference in the starting points of the *x*- and *y*-axes (see Figures 12-21 to 12-25).

Pictographs (graphs using pictorial images) can be deceptive if the pictures are likely to distract the viewer or allow the graphic information to be misinterpreted (see Figures 12-26).

Using distorted graphs, however, isn't the only error that will result in the creation of unethical illustrations. It is unethical to create a drawing that makes a product look bigger or somehow better than it actually is. It is unethical to design a flowchart that disguises a procedure's complexity by making things look relatively simple. It is unethical to stage or doctor a photograph to create a positive or negative impression of your subject that isn't fully justified.

In addition, if you illustrate information regarding people, you must strive to be sensitive to their humanity. For example, to use a circle graph to depict the human beings killed in various kinds of automobile accidents genuinely diminishes the dignity of the victims, reducing real people to objects in a statistical display. To illustrate this information ethically, you might superimpose the circle graph on a photograph of a victim, thus offering a vivid reminder of the tragic impact on human beings of your subject. In certain cases, however, it is desirable to avoid illustrations altogether, conveying delicate information with

words only. If you believe human life is unique or special, choose unique or special ways to illustrate it (see Figure 12-27).

The use of unethical illustrations damages your credibility and hinders your audience's understanding of your subject. (You may want to refer frequently to Chapter 6, Writing Ethically, to help you remain aware of issues that pertain to the ethical presentation of technical information.)

PLANNING AND REVISION CHECKLISTS

Planning Illustrations

- How important are illustrations to your presentation?
- How complex are your illustrations likely to be?
- How expert is your audience in reading illustrations?
- What kinds of illustrations is your audience familiar with?
- Are you working with any concepts that can be presented visually or in a combination of words and graphics?
- Do you have any definitions that should be presented visually in whole or in part?
- Do you have any processes or algorithms that could be depicted visually in a flowchart?
- Will you be presenting information on trends or relationships? Should some of this information be presented in tables and graphs?
- Do you have masses of statistics that could be summarized in tables?
- Do you need to depict objects? If so, what do you need to display about the objects? Do you need to focus attention on specific aspects of the objects? Do you require the realism of photographs?
- What are the design conventions of your illustrations?
- How much prose explanation of your illustrations are you likely to need?

Revising Illustrations

- Are your illustrations suited to your purpose and audience?
- Do your illustrations communicate information ethically?
- Are your illustrations effectively located and easy to find?
- Are your illustrations numbered and labeled?
- Do your verbal and visual elements complement each other?
- Are your illustrations genuinely informative instead of simply decorative?
- When necessary, have you helped your readers to interpret your illustrations with commentary or annotations?
- Will your readers easily understand the processes you have displayed visually?
- Have you included necessary units of measure in your tables and graphs?

- Are your tables simple, clear, and logical? Are the numbers in your tables aligned correctly (whole numbers on right-hand digits and fractional numbers on the decimal points)?
- Do your graphs need a grid for more accurate interpretation? Have you avoided the use of keys or at least kept them simple? Have you plotted your graphs according to the conventions: independent variable horizontally, dependent variable vertically? If you have used a suppressed zero, will it be obvious to your readers?
- Have you acknowledged the sources for borrowed or adapted tables and figures?

EXERCISES

1. Analyze the effectiveness of Figures 12-28 (a) and (b). How would you revise the figures to clarify the visual display of information?
2. Analyze the ethics of Figure 12-29. How would you revise this display to minimize the possibility of deception?
3. Examine several technical publications (e.g., brochures, manuals, pamphlets) in your field of study. Choose examples of four effective or ineffective illustrations. Write a report for majors in your field that analyzes the effectiveness or ineffectiveness of each illustration. Develop conclusions and recommendations on the use of illustrations in your field. Be sure to integrate a copy of each illustration with your analysis of it.
4. Examine the various kinds of illustration used in several of the professional journals in your major field of study. Which types of illustration do you ordinarily find? Which types don't you find? Which occur most often? Which occur least often? Reproduce sample tables and figures to demonstrate the conventions for illustrations in your field. Give an oral presentation to your class in which you report your findings.
5. You are the director of marketing for Howell & Field, Inc., which raises turkeys in Texas, Oklahoma, Nebraska, and Kansas. You receive a call from Juanita Elizondo, Howell & Field's vice president of operations, who wants you to give an oral sales report to the company's board of directors. Your presentation should take approximately 10 minutes. Prepare several illustrations to explain Howell & Field's sales figures for 1996–2000.

   Sales (Thousand of pounds)

	1996	1997	1998	1999	2000
Texas	90.4	98.6	99.8	104.6	97.6
Oklahoma	60.3	62.4	60.6	58.4	54.8
Nebraska	58.4	60.6	65.6	67.8	72.4
Kansas	40.8	48.5	52.5	56.3	58.9

6. After your sales presentation, Elizondo asks you to write a report for a group of prospective investors from Australia. She specifically wants you to

make projections for 2001–2005 based on the 1996–2000 figures. Design the illustrations that you will include in your written report.

7. Aeschylus Corporation, which designs 3-D computer games, is looking for new employees, especially individuals able to conceive and design state-of-the-art computer software products. It has been a small private corporation for five years and hopes to achieve a major expansion. The president of Aeschylus, Robin Pierce, has asked your organization, Creative Consultants, to develop a brochure for prospective new employees, incorporating appropriate illustrations. You've interviewed Pierce and have gathered quite a bit of information on the company that you believe will be pertinent:

History	Founded in 1996, in Kansas City, Missouri, by Robin Pierce, B.S. in Computer Science, 1992, University of St. Louis; MBA, 1994, Missouri University
Sales	1996: $200,000; 1997: $750,000; 1998: $2 million; 1999: $7 million; 2000: $16 million
Employees	with specialists in design (3), graphics and animation (4), programming (5), video and movie editing (3), production (2), quality assurance (1), documentation (1), sound (1), and music (1)
Products	6 current products, looking to diversify, especially in action–adventure, newest product: Street Maniac (driving game); biggest seller: Trojan War (fantasy role-playing)
Facilities	State-of-the-art computer equipment, serves both PC and Macintosh systems
Location	1224 Howard Avenue, Kansas City: new building, spacious offices
Salary and benefits	Competitive with industry; excellent medical coverage, 4 weeks vacation each year

Design a brochure for Aeschylus Corporation that incorporates as wide a variety of illustrations as possible.

8. In designing your brochure for Aeschylus Corporation, you are surprised by a moral dilemma. Robin Pierce is willing to hire people with disabilities and would like you to include that information in the brochure. At this time, Aeschylus has no permanently disabled employees. However, programmer Jacqueline Brown, who injured her back in a skiing accident, is temporarily restricted to a wheelchair. In a meeting with your design group, Pierce suggests including a photograph of all the Aeschylus employees (with

Brown in the wheelchair) to show prospective employees that people with disabilities are welcome. You mention the idea to your staff photographer, Kishor Mitra, but he objects, claiming such a picture would be deceptive and thus unethical. As project leader, you have to determine which side should prevail and then write one of two memos: either to convince Pierce, your client, that such a photograph would be wrong, or to persuade Mitra, your employee, to set up the photograph.

FIGURE 12-1 • Depiction of Thinking
This drawing is from a research report prepared by the federal Department of Justice. Aimed at American audiences, the drawing communicates effectively by using a readily understood convention of bubbles to depict that the school administrator is considering different security techniques. For a person unfamiliar with the practice of using bubbles to imply thought, however, the drawing is almost impossible to decipher.
Source: National Institute of Justice. The Appropriate and Effective Use of Security Technologies in U.S. Schools: A Guide for Schools and Law Enforcement Agencies. NCJ178265. (Washington, DC: GPO, 1999), 2.

FIGURE 12-2 • Variations in Electrical Outlets in Five Nations
Electrical outlets differ from one nation to the next. With no universal standard for representing this common feature of schematic illustrations, you must adapt drawings and diagrams of electrical outlets according to the national origins of your audience.

FIGURE 12-3 • Bar Graph
Notice that though the 2001 bars exceed the 2000 bars for both Transportation and Distribution, the reverse is the case for Production, which is located prominently at the top of the figure. In addition, the vertical grid lines make it easier to decipher the approximate numerical values depicted by each bar.

FIGURE 12-4 • Map of Refinery
In this map of the refinery facility, notice the clear labeling of each building. The labels occur inside the buildings whenever possible and are usually horizontal for easier reading. A directional arrow is given to indicate the geographical orientation of the map. A note below the arrow specifies that the map is a pictorial approximation of the relative positions of the buildings instead of a precise scale drawing.
Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 4.

FIGURE 12-5 • Map of Hydrocracker Unit
In this map of the hydrocracker unit, only the objects necessary to understanding the accident have been identified. The unidentified graphic elements serve to

clarify the relative positions of crucial objects. Notice that the labeling is almost always horizontal for easier reading.
Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 12.

FIGURE 12-6 • Flowchart of Hydrocracking Process
This flowchart of the hydrocracking process, though it claims to be simplified, might be unclear to a nonspecialist audience because of its several crisscrossing lines and arrows. For example, it is difficult to decipher where the process starts and stops. This figure seems to be designed for readers with a specialized education or experience. Before including such a figure in your report, you would have be certain that your audience could interpret it.
Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 7.

FIGURE 12-7 • Line Graphs of Reactor Temperatures
These two line graphs are a fairly dramatic display of the spiking temperatures in the reactor. The four data lines on each graph are quite crowded and the different shapes for each line are almost indistinguishable, but the basic message of both graphs is still clear: The operation was proceeding normally but abruptly changed at roughly 7:38:40.
Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 20.

FIGURE 12-8 • Photographs of Damaged Equipment
This series of photographs reveals the exterior of the hydrocracker unit in full color, offering viewers a vivid and realistic depiction—a "you are there" experience that helps them to visualize exactly what happened. No drawings of the unit would have quite the dramatic impact that the photographs do. Notice the careful labeling of objects in each photograph that serves to direct and focus the viewer's attention.
Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 24–26.

FIGURE 12-9 • Bar Graph
This bar graph displays the population of Russian men and women of various ages in the year 2000, making it easy for viewers to compare and contrast among the different groups. It is readily apparent, for example, that men and

women start off roughly equal in number and remain so until about age 40; at that point and continuing thereafter, the number of women exceeds the number of men. The simple design of the graph, including the use of the same color for every bar for both men and women, eliminates all potential distractions.
Source: U.S. Census Bureau, International Data Base. Population Pyramids for Russia. http://www.census.gov/cgi-bin/ipc/idbpyry.pl. April 15, 1999.

FIGURE 12-10 • Column Graph
This column graph would be better designed as a bar graph (i.e., with horizontal bars instead of vertical columns). The series of vertical columns aligned on the x-axis from left to right might be initially perceived as a chronological progression—the same subject displayed at consecutive points in time. In fact, the figure displays different subjects at the same points in time—1996 and 2006. Displaying the information as a bar graph would avoid any initial misunderstanding and speed the viewer's access to the information. Otherwise, the figure is quite effective in displaying the number of jobs for scientists and engineers. The two-dimensional columns keep the display simple, and the color-coding of the columns makes it easy to compare and contrast across the different occupations and time periods.
Source: National Science Board, *Science & Engineering Indicators*—1998. (Arlington, VA: National Science Foundation, 1998), 3-22.

FIGURE 12-11 • Column Graph
This column graph is clean and concise. The blue columns are in clear contrast to the white background, and the horizontal gridlines aid the viewer's eye in determining the quantity depicted by each column. In the report from which this graphic comes, however, none of the 18 tables and figures are numbered, making it difficult to refer to specific illustrations without the nuisance of using their full title.
Source: U.S. Government Working Group on Electronic Commerce. Toward Digital eQuality. Second Annual Report. (Washington DC: GPO, 1999), iii.

FIGURE 12-12 • Multiple-Column Graph
This is a multiple-column graph depicting the year-to-year changes in spending by industry on various kinds of equipment. The columns are displayed in two dimensions with visibly distinct shadings. The six groups of columns, however, are so close together that it is difficult to differentiate among the groups; because the same amount of space is used for the column width and the width of the space between columns, the spaces themselves look like additional columns. Inserting more space between the groups would make the graph easier to decipher. In addition, the purpose of this figure is to emphasize spending on information technology (IT) equipment, but it is the black columns of transportation equipment that receive visual emphasis and thus the viewer's initial attention. Using the black shading for the IT columns would better suit the purpose of the graph. The legend to the right could also be improved by

consistent style: the word "equipment" is abbreviated differently three times and omitted for the last item.
Source: U.S. Department of Commerce, The Emerging Digital Economy II. (Washington, DC: GPO, 1999), 22. *Source:* U.S. Government Working Group on Electronic Commerce. Toward Digital eQuality. Second Annual Report. (Washington DC: GPO, 1999), iii.

FIGURE 12-13 • Divided Column Graph
This divided column graph does a good job of emphasizing its key points but could be better designed nevertheless. It is readily apparent, for example, that the number of scrap tires going to landfills has decreased dramatically from 1990 to 1996, while the number being used for fuel has increased substantially and the number being processed has roughly doubled. The divisions that have seen the most obvious changes are also the divisions of highest contrast: The viewer notices them immediately. In addition, the numbers in each division give viewers access to specific information, essentially merging the details of a table with the emphasis of a figure. The cross-hatching for the exported spare tires division, however, makes it difficult to read the numbers and is inconsistent with the shading of the other divisions. A lighter shading or no shading would avoid this distraction. And instead of the legend, arrows pointing from the labels to the divisions in the 1996 column would be easier for viewers to interpret.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Statistics, Annual Report 1998: Long Distance Travel and Freight. BTS98-S-01. (Washington, DC: GRO, 1998), 126.

FIGURE 12-14 • Circle Graphs
These paired circle graphs compare and contrast the occurrence of pesticide residues on domestic and imported foods. Both graphs are designed with the largest segment starting in the upper right quadrant, followed systematically by the smaller and smallest segments. Together the two graphs emphasize that the difference in residues on domestic versus imported foods is insignificant: that is, the two circles look almost identical, and the numbers that identify the relative size of each segment reinforce that message. The graphs might be easier to read if the segments were fully labeled, but the legend is clear and concise. And while nothing is gained by making the graphs three-dimensional, nothing is distorted here either.
Source: U.S. Food and Drug Administration. Food and Drug Administration Pesticide Program: Residue Monitoring 1997. (Washington, DC: GPO, 1997), 15.

FIGURE 12-15 • Two or More Circle Graphs
These circle graphs compare and contrast the number of searches on a World Wide Web site before and after changes to the design of the site. The pair communicate the intended point effectively while violating conventions of the circle graph. If the largest segment started in the upper right quadrant as convention stipulates, the smaller segments would all be relegated to the upper left quadrant—a position of lesser emphasis. Proceeding from the largest

segment to the smallest segment would also be ineffective. It is the identical positioning and sequencing of the segments that makes the differences between the two graphs more obvious: Viewers will readily notice that the yellow segment almost doubles in size. In the graphs, color is used effectively to differentiate the six segments. Nevertheless, the graphs would be easier to read if the segments were fully labeled: With six segments to identify, the legends are fairly complicated and require more time for reading and interpreting.

Source: Naomi, Miller, Improving the NLM Home Page: From Logs to Links. Poster presented at the annual meeting, of the Medical Library Association, May 26–27, 1997. U.S. National Library of Medicine. http://www.nlm.nih.gov/psd/web poster/web poster.html. February 11, 1999.

FIGURE 12-16 • A Distracting Circle Graph

While this circle graph is nicely labeled, the sections offer a distracting array of shadings and crosshatchings, from diagonal dashes to horizontal lines to dots to two levels of gray. Inexplicably, black is used twice. Moreover, instead of starting with the largest segment in the upper right quadrant and progressing to the smallest segment, the graph displays a seemingly arbitrary order of segments and leaves it to the viewer to sort by size. Visually and logically, the graph is considerably more complicated than it needs to be.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics. Transportation Statistics Annual Report 1998: Long Distance Travel and Freight. BTS98-S-01. (Washington, DC: GPO, 1998), 109.

FIGURE 12-17 • Line Graph

This is a simple, clean line graph. Both scales are readily interpreted, and the single data line is plainly visible. Notice that the break in the y-axis (jumping from 0 to 2.35) is clearly identified with diagonal slashes.

Source: Steven Payson, R&D as a Percent of GDP Is Highest in Six Years. Data Brief. National Science Foundation, Division of Science Resource Studies. NSF 99-302. October 16, 1998, p. 1.

FIGURE 12-18 • A Bad Multiple Line Graph

This is a fairly confusing line graph. The excessively numerous data lines are inadequately differentiated by the black circles, diamonds, and triangles. The five lines also crisscross several times, creating a visual tangle that is difficult for viewers to decipher. Each data line is labeled, but three of the lines are assigned abbreviations (two of which are likely unfamiliar to viewers); because a definition key is necessary, quick understanding of the graph is once again hindered.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics. Transportation Statistics Annual Report 1998: Long Distance Travel and Freight. BTS98-S-01. (Washington, DC: GPO, 1993), 113.

FIGURE 12-19 • A Better Multiple Line Graph

In this line graph, the multiple data lines are readily distinguishable, simplifying visual interpretation of the figure. The data lines, however, are labeled with

undefined abbreviations, yet again hindering quick understanding. Viewers of this line graph would have to search through the accompanying text for explanations of the abbreviations. If abbreviations in a graph cannot be avoided, a definition key is essential.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics. Transportation Statistics Annual Report 1998: Long Distance Travel and Freight. BTS98-S-01. (Washington, DC, GPO, 1998), 118.

FIGURE 12-20 • Line Graph Variant

In this line graph, the multiple data lines never intersect, making it possible to color in the space between the data lines for additional emphasis. (Such a figure is often called a surface graph, but it is essentially a design variation of the line graph). A simple legend is used to identify the different subjects.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics. Transportation Statistics Annual Report 1998: Long Distance Travel and Freight. BTS98-S-01. (Washington, DC: GPO, 1998), 110.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics. Transportation Statistics Annual Report 1998: Long Distance Travel and Freight. BTS98-S-01. (Washington, DC: GPO, 1998), 110.

FIGURE 12-21 • Deceptive Paired Column Charts

Positioned side by side, the two graphs create a distorted impression. All the columns in the debts graph are smaller than the corresponding columns in the assets graph, giving the incorrect impression that throughout the year, debts were smaller than assets. The assets graph starts the y-axis at 0, but the debts graph suppresses the zero, and the percentages on the y-axis of the assets graph are given in increments of 20, whereas the debts graph uses increments of 10. Readers will be deceived unless they notice these differences in the two scales. The three-dimensional columns are distracting and hinder a clear comparison of the two graphs.

FIGURE 12-22 • Deceptive Column Graphs

It is also possible to distort graphic information by stretching one axis and shrinking the other, thereby making the differences among the data points either more or less apparent. Tall and narrow columns exaggerate differences in the data, while short and wide columns disguise such differences.

FIGURE 12-23 • Deceptive Line Graph

If readers look quickly at this graph of sales figures, they might come away with the impression that sales are rising. They might not notice that the time line on the x-axis is reversed; that is, instead of the earlier date on the left and the later date on the right as one would ordinarily expect, the horizontal scale starts with 2000 and proceeds backward in time to 1996. Sales, in fact, are falling. The extra-thick data line and
the small labels on the x-axis contribute to the deception, as does the color. The

green, in particular, would suggest money to American audiences. In addition, the graduated shading
of the background (darker at the bottom and lighter at the top) lifts the reader's eye and reinforces the misperception of rising sales.

FIGURE 12-24 • More Deceptive Line Graphs
It is also possible to distort graphic information by stretching one axis and shrinking the other, thereby making the data line either more vertical (depicting a rapid and dramatic change) or more horizontal (depicting a slow and moderate change).

FIGURE 12-25 • Deceptive vs Clear Circle Graphs
The first circle graph (a) is quite deceptive: Even though the labeling of each section is correct, the visual impression is that the Humanities major is the smallest group instead of the second smallest group (i.e., Engineering is the smallest). The light coloring of the Humanities major section versus the dark coloring of the other sections distorts the relative size of the light section: the blue, brown and green sections essentially collapse so that the reader perceives a large dark section versus a small light section. Also disrupting the reader's understanding of the relative size of each section are the slight elevation of the circle graph and the three-dimensional perspective as well as the arbitrary ordering of the sections. The second circle graph (b), on the other hand, offers a clear and unambiguous display of information because of its two-dimensional view with a systematic ordering of the sections (largest to smallest) and a systematic coloring (from darkest to lightest).

FIGURE 12-26 • Deceptive vs Clear Pictographs
The first pictograph (a) is potentially deceptive. Even though the numerical information is clearly specified in words, the visual impression is distorted. The picture for the 6-cylinder category is both three times wider and three times taller than the picture for the 8-cylinder category, making it nine times larger instead of only three times larger. Similarly, the picture for the 4-cylinder category is twice as wide and twice as tall as the picture for the 8-cylinder category, making it four times larger. The visual message, as a consequence, contradicts the verbal message. Since the visual message (bright red automobiles) is more conspicuous than the verbal message (in small, light type), the reader could easily misunderstand this illustration. To avoid such confusion, design the visual message to reinforce the verbal message by using one picture for a specific number (e.g., 1000) and duplicating that picture (or portions of it) to depict multiples of that number, as shown in the second example (b).

FIGURE 12-27 • Unethical Circle Graph
This is a circle graph of dubious ethics, cruelly depicting the loss of 380 human lives as you might the loss of 380 fish. While the text accompanying this graphic specifies such tragic accidents as "being pulled overboard by a hook caught in one's clothing" or "being caught in winches and other machinery," the visual display conveys none of this horror. The drownings, hypothermia, electrocutions, impalements, and eviscerations that plague the fishing industry—the genuine

dangers to human beings engaged in this occupation—are nowhere illustrated. To depict this loss of human lives with a conventional circle graph (and to label it with the euphemism "fatal events") shows a considerable insensitivity to the victims and their survivors.

Source: Persons Overboard/Sunk Vessels: Fishing Jobs Continue to Take Deadly Toll, *Issues in Labor Statistics,* June 1998, p. 1.

Source: U.S. Census Bureau, *Highlights from the Preliminary Report on Manufacturers' Shipments, Inventories, and Orders.* http://www.census.gov/indicator/www/m3/index.htm, February 9, 1999.

Source: U.S. Census Bureau, *Highlights from the Preliminary Report on Manufacturers' Shipments, Inventories, and Orders.* http://www.census.gov/indicator/www/m3/bench/bch98no.gif, February 9, 1999.

FIGURE 12-28 • Graphs for Exercise 12-1

FIGURE 12-29 • Graphs for Exercise 12-2
Source: U.S. Department of Transportation, Bureau of Transportation Statistics. Transportation Statistics Annual Report 1998: Long Distance Travel and Freight. BTS98-S-01. (Washington, DC: 1998, GPO), 84.

TABLE EXHIBIT 12-1 • Sample Table
This is a simple and clean table, offering specific numerical information. Notice that the words are left aligned while the numbers are right aligned. White space is used (instead of thin rules) to separate the rows and columns of information.

TABLE EXHIBIT 12-2 • Critical Operating Limits
This is a simple table and poorly designed. Notice that the headings are displayed in the same plain type as the information in each cell of the table. The heavy lines separating the cells are unnecessary. Notice also that the temperatures are left-aligned instead of right-aligned, as numerical information typically is. Nevertheless, the table serves to organize the information so that it is easy to access and easy to understand.
Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 19.

TABLE EXHIBIT 12-3 • Time Line of Key Events Preceding the Day of the Accident
This is a simple table that serves to summarize the sequence of events leading to the accident. Notice that the dates are displayed in bold, thus emphasizing the chronological organization of this information. The heavy lines separating the

cells, especially the lines separating times within a single day, are an unnecessary distraction.

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 27.

TABLE EXHIBIT 12-4 • Time Line of Key Events the Day of the Accident

This is essentially a continuation of the preceding table, organizing the sequence of events on the day of the accident. The heavy lines separating the cells again are unnecessary.

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 28.

TABLE EXHIBIT 12-5 • Human Errors Contributing to Accident

This is a simple table and poorly designed. Notice that the headings are displayed in the same plain type as the information in each cell of the table. The heavy lines separating the cells also are unnecessary. Nevertheless, the table does a good job of summarizing important information and making that summary readily accessible.

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA Chemical Accident Investigation Report: Tosco Avon Refinery, Martinez, California. EPA 550-R-98-009. (Washington, DC: GPO, 1998), 31.

TABLE EXHIBIT 12-6 • Web Sites Collecting Personal Information by Sample and Company Size

This table summarizes information according to two categories. The table has a clear and concise label. Notice that the headings in the first column and the top row are displayed in bold to distinguish them from the information in the remaining cells of the table. Subheadings are displayed in a smaller size of type, and heavier lines separate the heading cells from the information cells. Numerical information, however, is centered in each cell instead of being aligned on the right. Statistical details are effectively displayed in a smaller size of type. If no information in a particular category is available, a dash is used to indicate the absence of information. Footnotes offer important explanations that clarify or qualify the information displayed.

Source: Federal Trade Commission. Privacy Online: A Report to Congress. (Washington, DC: GPO, 1998), D-3.

TABLE EXHIBIT 12-7 • Percent of Web Sites Collecting Various Types of Personal Information

This table is difficult to read. The title is long, complicated, and partially parenthetical. The headings in the top row are displayed vertically instead of

horizontally. Numerical information is centered in each cell instead of aligned on the right. In addition, because every number in every cell is a percentage, the use of a percent sign in every cell of the table body is unnecessary, creating a cluttered, hard-to-read display.
Source: Federal Trade Commission. Privacy Online: A Report to Congress. (Washington, DC: GPO, 1992), D-5.

TABLE EXHIBIT 12-8 • Of Those Web Sites That Collect Personal Information, Percent with an Information Practice Disclosure
This table is designed effectively with distinctive headings, though the numerical information is centered instead of right aligned. Making the table look difficult, however, are other design features: the long and complicated label and the excessive footnoting. The definition of "Information Practice Disclosure," in particular, might easily be shifted to accompanying paragraphs of text instead of displayed as a footnote to this table.
Source: Federal Trade Commission. Privacy Online: A Report to Congress. (Washington, DC: GPO, 1998), D-3.