Graphics

One of the nice things about technical writing courses is that most of the papers have graphics in them—or at least they should. A lot of professional, technical writing contains graphics—drawings, diagrams, photographs, illustrations of all sorts, tables, pie charts, bar charts, line graphs, flow charts, and so on. Once you get the hang of putting graphics like these into your writing, you should consider yourself obligated to use graphics whenever the situation naturally would call for them.

Unlike what you might fear, producing graphics is not such a terrible task—in fact, it's fun. You don't have to be a professional graphics artist or technical draftsperson to get graphics into your technical writing. The Internet has advanced our sources for graphics immensely. And, if you are still living the 1970s, you can produce professional-looking graphics with tape, scissors, white-out, and a decent photocopying machine.

Graphics—An Overview

Before getting into details on creating, formatting, and incorporating graphics, consider the types and their functions. You can use graphics to represent the following elements in your technical writing:

- **Objects**—If you're describing a fuel-injection system, you'll probably need a drawing or diagram of the thing. If you are explaining how to graft a fruit tree, you'll need some illustrations of how that task is done. Photographs, drawings, diagrams, and schematics are the types of graphics that show objects.
- **Numbers**—If you're discussing the rising cost of housing in Austin, you could use a table with the columns marking off five-year periods since 1970; the rows could be for different types of housing. You could show the same data in the form of bar charts, pie charts, or line graphs. Tables, bar charts, pie charts, and line graphs are some of the principal ways to show numerical data.
- **Concepts**—If you want to show how your company is organized, the relationships of the different departments and officials, you could set up an organization chart—boxes and circles connected with lines that show how everything is hierarchically arranged and related. A concept graphic shows nonphysical, conceptual things and their relationships. In the figure to the right, see how Apple Computer illustrated the difference between 32-bit processors and 64-bit processors (these days, these are called infographics).
- **Words**—And finally graphics are used to depict words. You've probably noticed how textbooks put key definitions in a box, maybe with a different color. The same can be done with key points or extended examples. Not the sexiest form of graphics, but it still qualifies, and it's good to keep in mind as a useful technique. (A graphic for words is best done with tables.)

**Drawings, Diagrams, Photos**

To depict objects, place, people and relationships between them, you can use photos, drawings, diagrams, and schematics.

**Uses of illustrations and photos**

In the realm of illustrations and photographs, the types run from minimal detail to maximal. A simple line drawing of how to graft a fruit tree reduces the detail to simple lines representing the hands, the tools, the graft stock, and graft. Diagrams are a more abstract, schematic view of things, for example, a wiring diagram of a clock radio; it hardly
resembles the actual physical thing at all. And of course photographs provide the most detail of all. These graphics, supplying gradations of detail as they do, have their varying uses. Here are some examples:

- In instructions, simple drawings (often called line drawings) are the most common. They simplify the situation and the objects so that the reader can focus on the key details. In the examples below, you can see a fully detailed photograph and a simplified, labeled diagram. Which would you prefer?

![Diagram of microprocessor and socket](image)

- In descriptions, you would want to use drawings, but in this case drawings with more detail, such as shading and depth perspectives.
- In feasibility, recommendation, and evaluation reports, photographs are often used. For example, if you are recommending a photocopier, you might want to include photos of the leading contenders.

**Formatting requirements**

When you use an illustration in a report, there are several requirements to keep in mind (most of these are shown in this illustration):
For an accessible version of the illustration above, click here: Formatting Requirements

- **Labels**—Just about any illustration should contain labels—words and phrases—with pointers to the parts of the things being depicted.
- **Keys**—If the illustration has certain shadings, colors, line styles, or other such details that have a special meaning in the illustration, these should be indicated in a key—an area in an unused corner of the illustration that deciphers their meaning.
- **Titles**—Except in special cases, illustrations should have titles, and these titles should be numbered (Figure 1, Figure 2, and so on). The exceptions are these: if you have lots of illustrations (for example, in certain instructions, there are illustrations practically after every paragraph) and if there is no benefit from the titles; if you only have one or two illustrations and they are not cross-referenced; and/or if you do not cross-reference your illustrations. In some of these cases, you might want to keep the title but discard the word "Figure" and the number following it.
- **Cross-references**—Almost all illustrations should be referred to from the relevant point in the discussion. And, do more than just tossing in a "(See Figure 2)"; discuss the illustration a bit—focus readers’ attention on the key details of the illustration.
- **Location within the report**—Ideally, you place illustrations just after the point where they are needed. However, sometimes because of the pagination (the way the text falls on the pages) and the size of the illustrations, this close placement is not possible. No problem—just put the illustration at the top of the next page; that is what the figure-numbering system is for.
- **Size of illustrations**—Again, ideally, you want illustrations to be between one-half to one-quarter of the vertical size of the page. You want them to fit on the page with other text. In fact, that's what you really want—to interperse text and graphics in a report. What you do not want is to append the illustration to the back of the report! When you have a large illustration, use your software or a photocopier to reduce it.
- **Placement within margins**—Make sure that your illustrations fit neatly and comfortably within standard margins. You don't want the illustration spilling over into the right or left margins. You want to allow the equivalent of at least one blank line above and below the illustration.
- **Level of technical detail**—And, rather obviously, you want illustrations to be at the right technical level for your readers. No chip circuitry diagrams for computer beginners!

### Producing illustrations

Now for the question we're all waiting to ask—how to create graphics? There are several options: scanning, photocopying, using computer graphics, and hand-drawing. In all of these production methods, don't forget that you must indicate the source of the borrowed graphic.

- Scanning is the best way to pull graphics into your document files. Scanners are quite affordable now, especially those that include printing and faxing capabilities. Universities and colleges usually make scanners available to students and faculty. Print shops will scan for a fee. You copy your graphics to graphic-format files.
(such as .jpg or .png) then copy them into your document files.

Note: When you scan a graphic, trim off the title (caption) and other material from the original. Replace this material with words of your own.

- Photocopying used to be the method. You photocopied graphics from print sources, trimmed them, left room for them as you typed text (yes, with a typewriter), taped in the photocopies, and photocopied the whole document. Done well, the result could look almost professional.
- Using computer graphics With a little practice, you can create graphics like the ones show in the figure here in OpenOffice Writer or Microsoft Word (and of course GIMP and Illustrator). With a computer-graphics drawing like the keylock mechanism to the right, you are at the very edge of what OpenOffice Writer or Microsoft Word can do.
- Hand-drawing may not be as out of the question as you might think. Take a blank sheet of paper and start sketching lightly with a soft-leaded pencil. Keep working until you have the drawing the way you like. Then use a black marker to ink in the lines that you want, and erase the stray pencil markings. Now, scan this drawing and follow the method described above.

### Documenting Graphics—Indicating Sources

As mentioned earlier, it's perfectly legal to borrow graphics—to trace, photocopy, scan, or extract subsets of data from them. But you're obligated to cite your sources for graphics just as you are for the words you borrow. Normally, this is done in the figure title of the graphics.

### Guidelines for Graphics—A review

The preceding sections state a number of common guidelines that need to be stated all in one place. These are important!

- Use graphics *whenever* they would normally be necessary—don’t wimp out because it seems like too much trouble! But at the same time, don’t get hung up about creating perfect graphics (scans and photocopies work just fine for our purposes as long as you cite your source). This course is a writing course, not a graphic-arts course.
- Always discuss graphics in nearby text preceding the graphic. Don’t just throw a graphic out there unexplained. Orient readers to the graphic; explain its basic meaning.
- If a certain graphic is difficult to produce, discuss the problem with your instructor (you might be able to leave a blank with a descriptive note in the middle).
- Make sure your graphics are appropriate to your audience, subject matter, and purpose—don’t zap beginners with advanced, highly technical graphics they can’t understand.
- Intersperse graphics and text on the same page. Don’t put graphics on pages by themselves; don’t attach them to the end of documents.
- Use figure titles for graphics (see the exceptions to this rule in the preceding).
- Indicate the source of any graphic you have borrowed—this includes tables, illustrations, charts, and graphs. Whenever you borrow a graphic from some other source, document that fact in the figure title.
- Include identifying detail such as illustration labels, axis labels, keys, and so on. For labels, use text boxes and turn off the borders.
- Make sure graphics fit within normal margins—if they don’t, enlarge or reduce the copies. Leave at least one blank line above and below graphics.
- This guideline is for folks still operating in the 1970s. When you tape graphics in to your report, photocopy your *entire* report, not just the pages on which the tape-ins occur. Hand in the entire photocopied document, *not* the original and *not* a mixture of original and photocopied pages. Don’t manually add color or other detail on the pages of the final copy that you intend to submit—in other words, don’t draw on the final copy. Any details like these should be added before photocopying. If you must have color, use color photocopying equipment.
• Place graphics as near to the point in the text where they are relevant as is reasonable. However, if a graphic does not fit properly on one page, put it at the top of the next, and continue with regular text on the preceding page. Don't leave half a page blank just to keep a graphic near the text it is associated with.
• Cross-reference all graphics from the appropriate text. In the cross-reference, give the figure number (if one is used), indicate the subject matter of the graphic, and provide explanatory information as necessary.
Help Desk: Creating an Index

In long technical documents, an index, or a list of almost everything in the document, is found at the end of the document. The index is a helpful tool for quickly locating information, and many readers expect it. There are several techniques for creating an index, but the most efficient and up to date is right at your fingertips.

Microsoft Word allows you to create an index for a single word, a phrase, or even a symbol. You can also create an index item for a topic that covers several pages or paragraphs, or one that refers to another entry, such as "Chihuahua. See Dogs."

After you have completed your document, consider what you think needs to be referenced in the index so the reader can find it quickly. You may need to brainstorm to make some decisions here, especially as to how detailed you want the index to be.

Then, get started! Open the References tab on your Word toolbar (see below).

In your text, go to the first word you want to go into the index and highlight it. Then, go to the Index tool in the References tab and click on "Mark Entry." The dialog box below will pop up, with your highlighted word in the main entry field. You may then choose to insert a subentry and then click "Mark" if you just want only this reference to the term listed, or "Mark All" if you want every instance the term appears in your document listed in your index.

After you mark all the index entries you want, you can choose an index design and build the finished index. Word collects the index entries for you, sorts them in alphabetical order, lists page numbers, finds and removes duplicate entries, and puts the index in the document.

Don't panic when your document begins to look strange. When you select text and mark it for an index entry, Microsoft Word adds a special XE (Index Entry) field that includes the marked main entry and any cross-reference information that you choose to include. The example below is from Support.Office.com.

When you are satisfied that you've gotten all the important stuff (and you can even include topic headings and illustrations in the index) it's time to create the actual index!

Back to the Indexing tool ...

Click where you want to add the index to your document. Now, click on "Insert Index." You will see a dialogue box like the one below. Unfortunately, it won't show your index in the preview page, but you can get an idea of how it works.

The preview will scroll so you can see how the whole thing will look, and under Formats just below the preview screen, you can choose from 4 different styles. You can also create your own style by selecting "From template" and choosing "Modify" in the bottom right corner of the box.

Click okay. Don't worry...you can always go back and update or edit if you need to by going to the Update Index button in the Index tool. If your document still has all the crazy looking markups, just go to to the Paragraph tool in the Home tab and click on the little show/hide icon (¶) in the upper right hand corner.
Writing Process

The writing process takes you from the very beginning of a writing project—finding topics and analyzing audience and purpose—all the way to the end—writing and revising the rough draft. The following chapters focus on some of the key phases of that process:

Strategies for team-writing
Audience Analysis
Brainstorming and invention
Narrowing
Outlining
Note-taking
Libraries, Documentation, Cross-Referencing
Strategies for Peer-Reviewing
Power-Revision Techniques

Find Report Topics

As a writer in a technical writing course, you may need some strategies for finding topics for writing projects, which are provided in this section.

By definition, technical-writing courses are opportunities to focus on practical uses of your writing skills. In the ideal technical-writing course, you would have a work-related writing project every two to three weeks: for example, instructions for that pesky fax machine down the hall or recommendations on home alarm systems. However, technical-writing courses are also great opportunities for exploring science and technology: latest advances in nanotechnology, latest theories about the origin of the universe, latest methods for hydroponic gardening. If your instructor encourages you to find your own topics, take a look at the following suggestions.

Cutting-Edge Technologies
How ambitious and daring are you? The link below takes you to some amazing, crazy inventions and discoveries.
Gizmag.com clippings

Volunteer Opportunities
Find a service-learning opportunity that involves some writing!
Read about Service Learning. In particular, take a look at the volunteer opportunities

Topic Ideas for Technical-Writing Courses
Peruse these topics—see if any possibilities for projects come to mind.

<table>
<thead>
<tr>
<th>Wormholes</th>
<th>Superstrings</th>
<th>3D printing</th>
<th>High-definition TV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropocene era</td>
<td>Unmanned avionics (drones)</td>
<td>Green roofs</td>
<td>WiFi</td>
</tr>
<tr>
<td>Global warming</td>
<td>Deforestation</td>
<td>Acid rain</td>
<td>Ozone depletion</td>
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<tr>
<td>Rain forests</td>
<td>Continental drift</td>
<td>Greenhouse effect</td>
<td>Endangered species</td>
</tr>
<tr>
<td>Industrial waste disposal</td>
<td>Mount St. Helens eruption</td>
<td>Solar energy devices</td>
<td>Nuclear power</td>
</tr>
<tr>
<td>Plate tectonics</td>
<td>Solar automobiles</td>
<td>Petroleum-based energy</td>
<td>Thermal power</td>
</tr>
<tr>
<td>Wind energy</td>
<td>Freon</td>
<td>Mass transportation</td>
<td>Nuclear fusion</td>
</tr>
<tr>
<td>Microwave technologies</td>
<td>Bomb detection methods</td>
<td>High-tech weaponry</td>
<td>Advances in automotives</td>
</tr>
<tr>
<td>Xeriscaping</td>
<td>Soil analysis</td>
<td>Hybridization techniques</td>
<td>Hydroponics</td>
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<tr>
<td>Genetic engineering</td>
<td>World Wide Web</td>
<td>Computer video</td>
<td>Multimedia</td>
</tr>
<tr>
<td>Computer memory</td>
<td>Computer animation</td>
<td>Fiber optics</td>
<td>Computer audio</td>
</tr>
<tr>
<td>Virtual reality</td>
<td>Artificial intelligence</td>
<td>Telecomputing</td>
<td>Telecommuting</td>
</tr>
<tr>
<td>Advanced compact disks</td>
<td>Cellular telephones</td>
<td>Personal digital assistants</td>
<td>Videoconferencing</td>
</tr>
<tr>
<td>Digital interactive TV</td>
<td>UFOs</td>
<td>Satellite TV</td>
<td>Object-oriented programming</td>
</tr>
<tr>
<td>Digital imaging</td>
<td>Cable TV</td>
<td>Computer-aided education</td>
<td>Neural networks</td>
</tr>
<tr>
<td>Teleconferencing</td>
<td>Advances in telephony</td>
<td>CD-ROM technology</td>
<td>Computer graphics</td>
</tr>
<tr>
<td>Distance education</td>
<td>Computer crime</td>
<td>DVD technology</td>
<td>Robotics</td>
</tr>
<tr>
<td>Tech Prep</td>
<td>Virtual classroom</td>
<td>Expert systems</td>
<td>Devices for diabetics</td>
</tr>
<tr>
<td>Advanced prostheses</td>
<td>Artificial heart</td>
<td>Diabetes</td>
<td>Artificial limbs</td>
</tr>
<tr>
<td>Kidney transplants</td>
<td>Alzheimer's disease</td>
<td>Hypoglycemia</td>
<td>AIDS</td>
</tr>
<tr>
<td>Ebola</td>
<td>Encephalitis</td>
<td>Knee/hip replacements</td>
<td>Carcinogens</td>
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<tr>
<td>Hyperkinetic behavior</td>
<td>Caffeine</td>
<td>Saccharine</td>
<td>Psychosomatic disorders</td>
</tr>
<tr>
<td>Nicotine</td>
<td>Genetic engineering</td>
<td>Vitamin therapies</td>
<td>Magnetic resonance imaging</td>
</tr>
<tr>
<td>Recombinant DNA</td>
<td>Gulf War Syndrome</td>
<td>Ultrasound</td>
<td>Sickle cell anemia</td>
</tr>
<tr>
<td>Agent Orange</td>
<td>Inflation</td>
<td>Recession</td>
<td>Capital-punishment methods</td>
</tr>
<tr>
<td>Dream research</td>
<td>Balanced budget</td>
<td>Abortion methods</td>
<td>Handwriting analysis</td>
</tr>
<tr>
<td>Dyslexia</td>
<td>Biorhythms</td>
<td>Pheromones</td>
<td>Wellness programs</td>
</tr>
<tr>
<td>Acupuncture</td>
<td>Big Bang Theory</td>
<td>Life on Mars</td>
<td>Saturn expedition</td>
</tr>
<tr>
<td>Extraterrestrial intelligence</td>
<td>Gout</td>
<td>Supernova</td>
<td>Mars expedition</td>
</tr>
<tr>
<td>Halley's Comet</td>
<td>Universe</td>
<td>Space shuttles</td>
<td>Uranus expedition</td>
</tr>
<tr>
<td>Black holes</td>
<td>The Moon</td>
<td>Volcanoes</td>
<td>Sink holes</td>
</tr>
<tr>
<td>Venus</td>
<td>Tornadoes</td>
<td>Hurricanes</td>
<td>Earthquakes</td>
</tr>
<tr>
<td>Monsoons</td>
<td>Droughts</td>
<td>Whales</td>
<td>Boa constrictors</td>
</tr>
<tr>
<td>Rattlesnakes</td>
<td>Sharks</td>
<td>Geckoes</td>
<td>Panda bears</td>
</tr>
<tr>
<td>Black widows</td>
<td>Iguanas</td>
<td>Wolves</td>
<td>Eagles</td>
</tr>
<tr>
<td>Dolphins</td>
<td>Scorpions</td>
<td>Coyotes</td>
<td>Dinosaurs</td>
</tr>
<tr>
<td>Influenza</td>
<td>Panic attacks</td>
<td>Heart attacks</td>
<td>Breast cancer</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>Bioengineered foods</td>
<td>Migraines</td>
<td>Nanotechnology</td>
</tr>
</tbody>
</table>

**Ideas for Audiences**

See if the following list of audiences brings to mind technical-writing projects.

http://distanceed.hss.kennesaw.edu/technicalcommunication/chapters/5_1WritingProcess/5_1WritingProcess_print.html
<table>
<thead>
<tr>
<th>City council members</th>
<th>Parent-teacher association</th>
<th>Downtown renovation commission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neighborhood association</td>
<td>City transportation board</td>
<td>Rural utilities cooperative</td>
</tr>
<tr>
<td>Recycling special interest group</td>
<td>Student parking action group</td>
<td>Student housing board</td>
</tr>
<tr>
<td>City mass transportation agency</td>
<td>Business secretary association</td>
<td>Pet owners society</td>
</tr>
<tr>
<td>Save-our-trees action group</td>
<td>Citizens antipornography league</td>
<td>City beautification commission</td>
</tr>
<tr>
<td>Alternative energy-resource investors</td>
<td>Friends of sidewalk artists</td>
<td>Housing for the homeless society</td>
</tr>
<tr>
<td>Computer animators society</td>
<td>Alternative-transportation action group</td>
<td>College solar-automobile club</td>
</tr>
<tr>
<td>High-school science teachers association</td>
<td>City busriders support group</td>
<td>Drug-rehab center board</td>
</tr>
<tr>
<td>Citizens-against-crime league</td>
<td>Computer-game design society</td>
<td>Your local government representative</td>
</tr>
<tr>
<td>City mayor</td>
<td>County commissioners</td>
<td>Home-brewers and microbrewers club</td>
</tr>
<tr>
<td>Organic foods cooperative</td>
<td>Student housing cooperative</td>
<td>Local wine makers society</td>
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<tr>
<td>Student services director</td>
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</tr>
</tbody>
</table>

### Academic and Workplace-Oriented Majors

**Consider interesting courses or projects related to your major or any of the following.**

<table>
<thead>
<tr>
<th>Accounting</th>
<th>Air conditioning technology</th>
<th>Aerospace technology</th>
<th>Refrigeration technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy</td>
<td>Automotive technology</td>
<td>Biology</td>
<td>Biotechnology</td>
</tr>
<tr>
<td>Engineering</td>
<td>Chemistry</td>
<td>Child development</td>
<td>Computer science</td>
</tr>
<tr>
<td>Culinary arts</td>
<td>Diagnostic medical imaging</td>
<td>Electronics</td>
<td>Building construction technology</td>
</tr>
<tr>
<td>Emergency medical service technology</td>
<td>Engineering design graphics</td>
<td>Information records management</td>
<td>Physical fitness technology</td>
</tr>
<tr>
<td>Geomatics (land surveying technology)</td>
<td>Fire protection technology</td>
<td>Medical lab technology</td>
<td>Meteorology</td>
</tr>
<tr>
<td>Molecular genetics</td>
<td>Urban studies</td>
<td>Engineering</td>
<td>Marine biology</td>
</tr>
<tr>
<td>Molecular biology</td>
<td>Biochemistry</td>
<td>Petroleum engineering</td>
<td>Geosystems engineering</td>
</tr>
<tr>
<td>Neurobiology</td>
<td>Mechanical engineering</td>
<td>Electrical engineering</td>
<td>Biomedical engineering</td>
</tr>
<tr>
<td>Military science</td>
<td>Civil engineering</td>
<td>Chemical engineering</td>
<td>Nursing</td>
</tr>
<tr>
<td>Occupational therapy</td>
<td>Office systems technology</td>
<td>Pharmacy technology</td>
<td>Photography</td>
</tr>
<tr>
<td>Geology</td>
<td>Physics</td>
<td>Printing technology</td>
<td>Quality assurance</td>
</tr>
<tr>
<td>Surgical technology</td>
<td>Technical communication</td>
<td>Welding technology</td>
<td>X-ray operations</td>
</tr>
</tbody>
</table>

### Interesting Magazines and Journals

**Go to your local library or newsstand and flip through some of the following.**

<table>
<thead>
<tr>
<th>Flying</th>
<th>Mother Earth News Magazine</th>
<th>Popular Photography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issues in Medical Ethics</td>
<td>Wood Magazine</td>
<td>4 Wheel &amp; Off Road magazine</td>
</tr>
<tr>
<td>Air &amp; Space Magazine</td>
<td>Audio Magazine</td>
<td>Smithsonian</td>
</tr>
<tr>
<td>Home Improver Magazine</td>
<td>Family Business Magazine</td>
<td>PC Magazine</td>
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<tr>
<td>Byte Magazine</td>
<td>Family</td>
<td>Handyman Magazine</td>
</tr>
<tr>
<td>Anthropological Linguistics</td>
<td>Nature</td>
<td>Astronomy Magazine</td>
</tr>
<tr>
<td>Scientific American</td>
<td>National Geographic</td>
<td>Cogeneration</td>
</tr>
<tr>
<td>Energy Research News</td>
<td>Lab Animal</td>
<td>Molecular Vision</td>
</tr>
<tr>
<td>Neuron</td>
<td>Petroleum Equipment &amp; Technology</td>
<td>BBC News: Science and Technology</td>
</tr>
<tr>
<td>Electronic Journal of Biotechnology</td>
<td>American Naturalist</td>
<td>Nuclear Plant Journal</td>
</tr>
<tr>
<td>Garden and Forest</td>
<td>Water, Air, and Soil Pollution</td>
<td>Forest Ecology and Management</td>
</tr>
<tr>
<td>Issues in Science and Technology</td>
<td>Technology &amp; Culture</td>
<td>Electric Vehicle World</td>
</tr>
<tr>
<td>Discover Magazine</td>
<td>Distant Star</td>
<td>GEO Magazine</td>
</tr>
<tr>
<td>Gene Therapy Weekly</td>
<td>Home Power Magazine</td>
<td>Physics World</td>
</tr>
<tr>
<td>Robot Science &amp; Technology</td>
<td>UFO Digest</td>
<td>Sea Technology</td>
</tr>
<tr>
<td>UFO Magazine</td>
<td>NanoTechnology Magazine</td>
<td>Popular Mechanics</td>
</tr>
<tr>
<td>Popular Science</td>
<td>Technology Review</td>
<td>Cyberspace Today</td>
</tr>
<tr>
<td>Wired</td>
<td>Space Business International</td>
<td>Amateur Astronomy Magazine</td>
</tr>
<tr>
<td>Sky &amp; Telescope</td>
<td>CNN: Sci-Tech</td>
<td>Brain &amp; Mind</td>
</tr>
<tr>
<td>Journal of Prisoners on Prisons</td>
<td>Electronic House Online</td>
<td>Home Energy</td>
</tr>
<tr>
<td>Popular Home Automation</td>
<td>Hazardous Materials Management Magazine</td>
<td>Professional Boatbuilder Magazine</td>
</tr>
<tr>
<td>Practical Hydroponics &amp; Greenhouses</td>
<td>Progressive Farmer Today</td>
<td>Potato Grower</td>
</tr>
<tr>
<td>Pest Control Technology (PCT)</td>
<td>Goat Farmer Magazine</td>
<td>Disaster Recovery Journal</td>
</tr>
<tr>
<td>Upholster Magazine</td>
<td>CleanRooms</td>
<td>Worm Digest</td>
</tr>
<tr>
<td>Recycling Today Magazine</td>
<td>American Waste Digest</td>
<td>American Small Farm Magazine</td>
</tr>
<tr>
<td>Pacific Fishing</td>
<td>Urban Transportation Monitor</td>
<td>Advanced Rescue Technology</td>
</tr>
<tr>
<td>Pit and Quarry Magazine</td>
<td>Corrections Technology &amp; Management Magazine</td>
<td>Wireless Access Technologies</td>
</tr>
<tr>
<td>Journal of Emergency Medical Services</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Interesting Websites

**Browse some these websites for ideas.**

- **Artificial Intelligence and Robotics.** Provided by the Georgia Tech Mobile Robot Lab: [www.cc.gatech.edu/ai/robot-lab/mrl-jump-points.html](http://www.cc.gatech.edu/ai/robot-lab/mrl-jump-points.html)
- **Humanoid Project.** From Waseda University (Japan), its project to develop a humanoid robot: [www.shirai.info.waseda.ac.jp/humanoid](http://www.shirai.info.waseda.ac.jp/humanoid)
- **Robotics.** From the Seattle Robotics Society: [www.seattlerobotics.org/websites.html](http://www.seattlerobotics.org/websites.html)
- **Virtual Reality Society.** News, software, links, introductory information about virtual reality: [www.vrs.org.uk](http://www.vrs.org.uk)
- **Solar Car Page.** Lots of information about and links to solar-powered cars: [www.lips.ece.utexas.edu/~delayman/solar.html](http://www.lips.ece.utexas.edu/~delayman/solar.html)
- **National UFO Reporting Center.** For the collection and distribution of objective UFO data: [nwlink.com/~ufocntr/index.html](http://nwlink.com/~ufocntr/index.html)
<table>
<thead>
<tr>
<th>Writing Process</th>
<th>Writing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Artificial Intelligence. Developed by Tim Dunn, Adam Dyess, and Bil Snitzer: tqd.advanced.org/2705</td>
<td>Fractalzone. Provided by Philippe Wautelet, a good introduction to fractals and links to related sites: fractalzone.home.ml.org</td>
</tr>
<tr>
<td>Virtual Worlds Project. MIT Artificial Intelligence Laboratory's advanced distributed interactive simulation (DIS) systems for science, engineering, medicine, commerce, and industry: <a href="http://www.ai.mit.edu/projects/vworlds/">www.ai.mit.edu/projects/vworlds/</a> vworlds.html</td>
<td>Human Powered Transportation Committee. From the American Society of Civil Engineers, a group dedicated to incorporating human-powered transportation (walking and bicycling) into transportation systems: ourworld.compuserve.com/homepages/ kbarrett/asec-hpt.htm</td>
</tr>
<tr>
<td>Photovoltaic Power Resource Site. Information on photovoltaic (converting solar to electrical energy) history, resources, applications, projects, and employment: <a href="http://www.pvpower.com">www.pvpower.com</a></td>
<td>American Association for Wind Engineering. An organization for promoting the research and professional practice of as well as for distributing information on wind engineering: liberty.uc.wlu.edu/~aaew</td>
</tr>
<tr>
<td>U.S. Fusion Energy Sciences Program. A knowledge base for an economically and environmentally attractive fusion energy source: wwwwofe.er.doe.gov</td>
<td>Cold Fusion Times. Journal on the scientific aspects of loading isotopic fuels into materials as well as related topics: world.std.com/~mica/cft.html</td>
</tr>
<tr>
<td>Food for Our Future. Provides understandable explanations of the benefits that biotechnology could bring to our food supply and addresses people's concerns about the new technology: <a href="http://www.foodfuture.org.uk/index2.htm">www.foodfuture.org.uk/index2.htm</a></td>
<td>Ethanol Vehicle Challenge. From the College of Engineering, Center for Environmental Research and Technology at University of California, Riverside: helium.ucr.edu/~teamcert/ethanol</td>
</tr>
<tr>
<td>Greener Cars. Toyota's website presenting its efforts to make automobiles &quot;greener&quot;: <a href="http://www.toyota.co.jp/el/green">www.toyota.co.jp/el/green</a></td>
<td>Veggie Van. A small motorhome powered by a clean-burning fuel made from used and new vegetable oil. <a href="http://www.veggievan.org/Veggie">www.veggievan.org/Veggie</a> Van</td>
</tr>
<tr>
<td>Biomedical Visualization. University of Illinois at Chicago website: <a href="http://www.bvis.uic.edu/Biomedical">www.bvis.uic.edu/Biomedical</a> Visualization</td>
<td>Artificial Heart Program. From the University of Pittsburgh, its research and clinical program for the treatment of end-stage heart failure: info.pitt.edu/~gwb1/UPMC</td>
</tr>
<tr>
<td>American Cryonics Society. Preserving the whole body, head, or brain, of persons recently declared legally dead, in the hope of revival at some time in the future: <a href="http://www.jps.net/cryonics">www.jps.net/cryonics</a></td>
<td>The Visible Human Project. MRI cross-sections of the human body with explanations: <a href="http://www.nlm.nih.gov/research/visible/">www.nlm.nih.gov/research/visible/</a> visible_human.html</td>
</tr>
<tr>
<td>Manufacturing at the molecular level! Information and links to articles and websites about nanotechnology provided by Ralph C. Merkle: nano.xerox.com/nano/Nanotechnology</td>
<td>SETI Institute. Search for Extraterrestrial Intelligence Institute, an organization devoted to scientific and educational projects relating to life in the universe: <a href="http://www.seti-inst.edu">www.seti-inst.edu</a></td>
</tr>
</tbody>
</table>
### Writing Process

<table>
<thead>
<tr>
<th>International Space Station. NASA's website for this project: station.nasa.gov/core.html</th>
<th>Project Skylab. NASA's Skylab Project: <a href="http://www.ksc.nasa.gov/history/skylab/skylab.html">www.ksc.nasa.gov/history/skylab/skylab.html</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Companion Object&quot; Near Hale-Bopp Comet? Links concerning the comet, possible UFOs, cover-ups, and other X-File-ish things: 205.243.132.23/comet-1.html</td>
<td>Time Travel. Possibilities of time travel: freespace.virgin.net/steve.preston/Time.html</td>
</tr>
<tr>
<td>Human Genome Organisation. Human Genome Organisation (HUGO), the international organization with the global initiative to map and sequence the human genome: hugo.gdb.org</td>
<td>DOE Human Genome Program Home Page. Department of Energy's website on the human genome project: ww.er.doe.gov/production/ober/hug_top.html</td>
</tr>
<tr>
<td>Human Cloning and Genetic Engineering. Provided by Arthur Kerschen of the University of Arizona, discussion and links related to genetic engineering—human cloning, in particular: <a href="http://www.u.arizona.edu/~ahk/cloning/index.html">www.u.arizona.edu/~ahk/cloning/index.html</a></td>
<td>How to Clone a Human. Also provided by Arthur Kerschen of the University of Arizona: <a href="http://www.u.arizona.edu/~ahk/cloning/human.html">www.u.arizona.edu/~ahk/cloning/human.html</a></td>
</tr>
</tbody>
</table>

### Work Place: Ideas for Technical-Writing Projects

**What's going on at work? Are the projects there, just waiting for you? Browse some of these ideas:**

<table>
<thead>
<tr>
<th>Does the office need a new photocopy machine?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you considering a fax machine? a CD writer? a digital camera?</td>
<td></td>
</tr>
<tr>
<td>Is the staff expected to use a new software application for which there is no user guide?</td>
<td></td>
</tr>
<tr>
<td>Are you and other employees interested in telecommuting (using electronic and computer methods to work at home)?</td>
<td></td>
</tr>
<tr>
<td>Is management considering putting all operating procedures and other administrative materials online?</td>
<td></td>
</tr>
<tr>
<td>Has your agency been challenged to go &quot;paperless&quot;—to get all files stored and searchable electronically?</td>
<td></td>
</tr>
<tr>
<td>Have you been tasked with recommending a personal digital assistant, cell phone, or notebook computer for all employees in your company?</td>
<td></td>
</tr>
</tbody>
</table>

### Problems, Problems, Problems . . .

**A good source for volunteer projects is Idealist at www.idealista.org, a site run by Action Without Borders, a non-profit foundation. It lists 10,000 Web sites for non-profit organizations, information on volunteering, jobs, and projects.**

<table>
<thead>
<tr>
<th>Inadequate public transportation</th>
<th>Lack of parking</th>
<th>Overflowing land fills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smog and otherwise dirty air</td>
<td>Crowded streets and highways</td>
<td>Crime, vandalism</td>
</tr>
<tr>
<td>Homeless people</td>
<td>Lack of daycare facilities</td>
<td>Unemployment</td>
</tr>
<tr>
<td>Lack of low-cost housing</td>
<td>Dwindling water supplies</td>
<td>Expensive electricity</td>
</tr>
<tr>
<td>Natural areas threatened by urban development</td>
<td>Lack of parks and recreational facilities</td>
<td>Lack of facilities for the elderly</td>
</tr>
<tr>
<td>Rodent infestations</td>
<td>Mosquitoes</td>
<td>Lack of vegetation (trees, shrubbery, etc.)</td>
</tr>
<tr>
<td>Projects for nonprofits</td>
<td>Lack of facilities for young people</td>
<td>Expensive water</td>
</tr>
</tbody>
</table>
Brainstorm Topics for Writing Projects

If you have a topic for your writing project (if not, see topics), the next step is to think about subtopics related to it. During this stage, the “invention” or “brainstorming” stage, use the following suggestions to explore your writing project topic:

- Let the subject of your writing project itself suggest subtopics; for example:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Possible topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sun</td>
<td>its temperature</td>
</tr>
<tr>
<td></td>
<td>its composition</td>
</tr>
<tr>
<td></td>
<td>its unusual phenomenon</td>
</tr>
<tr>
<td></td>
<td>its relative size</td>
</tr>
<tr>
<td>Ultrasound in medicine</td>
<td>its physical properties</td>
</tr>
<tr>
<td></td>
<td>equipment used</td>
</tr>
<tr>
<td></td>
<td>medical uses</td>
</tr>
<tr>
<td></td>
<td>advantages</td>
</tr>
</tbody>
</table>

- Use an invention checklist like the following. If you ask yourself the questions listed below, you'll be less apt to overlook important subtopics; and, with use, these questions eventually become almost automatic.

A Checklist of Invention Questions

<table>
<thead>
<tr>
<th>Problems or needs</th>
<th>Does your writing project concern itself with a problem or a need?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solutions and answers</td>
<td>Should your writing project discuss potential solutions or answers to the problems or questions presented in the project?</td>
</tr>
<tr>
<td>Historical events and natural phenomena</td>
<td>Does your writing project concern itself with some historical event or natural (or mechanical) phenomenon?</td>
</tr>
<tr>
<td>Causes and effects</td>
<td>Should your writing project discuss the causes, effects, or both related to the phenomenon, historical event, or problem you are discussing?</td>
</tr>
<tr>
<td>Descriptions</td>
<td>Which aspects of your writing project require description?</td>
</tr>
<tr>
<td>Processes</td>
<td>Does your writing project involve processes, procedures, routines, or repetitive events that must be discussed in steps?</td>
</tr>
<tr>
<td>Classes</td>
<td>Can the main topic or any subtopic within your writing project be divided into classes or types?</td>
</tr>
<tr>
<td>Comparisons to similar or familiar things</td>
<td>Can similar things in your writing project be compared to each other? Can you compare something complex in your writing project to something familiar or common?</td>
</tr>
<tr>
<td>Illustrative examples</td>
<td>Will a discussion of examples related to your writing project be effective?</td>
</tr>
<tr>
<td>Theoretical background (definitions)</td>
<td>Are there unfamiliar terms in your writing project? Should you include them in your project and define them?</td>
</tr>
<tr>
<td>Applications</td>
<td>Can you discuss the applications related to your writing project?</td>
</tr>
<tr>
<td>Advantages and benefits</td>
<td>Should you discuss the advantages or benefits related to your subject?</td>
</tr>
<tr>
<td>Disadvantages and limitations</td>
<td>Are certain disadvantages, problems, limitations, or drawbacks associated with your subject?</td>
</tr>
<tr>
<td>Warnings, cautions, and guidelines</td>
<td>Does your writing project need cautionary or guideline statements?</td>
</tr>
<tr>
<td>Economics or financial considerations</td>
<td>Should you discuss cost factors, purchase expenses, maintenance and operation costs, production or output costs, or savings?</td>
</tr>
<tr>
<td>Importance of the topic</td>
<td>Should you discuss the importance of your subject, why people should concerned about it or interested in it?</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Historical background and important names</strong></td>
<td>Is there some important historical background—events and names—that should be discussed in your project?</td>
</tr>
<tr>
<td><strong>Future developments</strong></td>
<td>Should your writing project speculate about future developments or possibilities related to the subject?</td>
</tr>
<tr>
<td><strong>Social, political, legal, or ethical implications</strong></td>
<td>Does the topic of your writing project raise certain social or ethical questions—as, for example, certain medical technologies do?</td>
</tr>
<tr>
<td><strong>Reasons for or against</strong></td>
<td>In your writing project, should you try to convince readers to take certain actions or think a certain way concerning your topic?</td>
</tr>
<tr>
<td><strong>Conclusions</strong></td>
<td>Should your writing project draw certain conclusions about what it discusses?</td>
</tr>
<tr>
<td><strong>Recommendations</strong></td>
<td>Should your writing project make certain recommendations to its readers?</td>
</tr>
<tr>
<td><strong>Alternatives or choices</strong></td>
<td>Should your writing project discuss several alternatives or choices related to your subject matter?</td>
</tr>
<tr>
<td><strong>Criteria, requirements</strong></td>
<td>Will your writing project use certain criteria to draw its conclusions or to make its recommendations?</td>
</tr>
<tr>
<td><strong>Tests and methods used</strong></td>
<td>Should you have a section on the tests you perform, the methods or theories you use, or the procedures and equipment you use?</td>
</tr>
<tr>
<td><strong>Statistical presentations and analyses</strong></td>
<td>Should you include a section that summarizes and analyzes the data you collect in your project?</td>
</tr>
<tr>
<td><strong>Legal and administrative demands</strong></td>
<td>Should your writing project discuss which agencies to apply to, which forms to fill out, or which steps to take in order to accomplish the purpose of your project?</td>
</tr>
<tr>
<td><strong>Business or professional contexts</strong></td>
<td>Should you describe the specific business or professional situation, for example, a supervisor's orders, that generates the need for your project? (This applies if you invent a writing situation also.)</td>
</tr>
</tbody>
</table>

Here is an excerpt of a brainstorming session in which these questions were used:

**Example of a topic list developed with the invention checklist**

How does a wind-powered electrical system (WPES) work? what are the steps in its operation? Savings: discuss the amount of money that can be saved using WPES. Relationship between average windspeeds and electrical output: what happens when there's no wind, only very light breezes? too much wind? Basic parts: rotor, generator, tail assembly, tower Different manufacturers of WPES: how to get a good system and avoid being ripped off. Dimensions, materials, construction of common models of WPES; sensitivity to low winds speeds Historical background on WPES: the time when more WPES were being used, just before rural electrification in the 1930s; who were the first developers? when has interest in WPES reappeared? why? Two general class of wind machines: lift and drag machines Lightning protection of WPES Aerodynamic principles as they apply to WPES Understanding weather patterns and seasonal and geographical factors affecting wind Principles of electricity: circuits, generators, types of current, meanings of terminology Local, state, federal tax credits and research support in wind systems research and WPES purchase by consumers
Narrow That Report Topic

For a writing project in a technical-writing course, the ideal starting place is a workplace problem requiring some writing as part or all of the solution. With such a project, the audience and problem are there to help you narrow the topic. However, if you begin with a topic, it's harder to narrow. You are likely to end up trying to write a ten-pound textbook on automotive plastics, residential solar energy in the home, or La Niña. Narrow the topic and do some careful research—the result will be a practical, useful document that doesn't go on forever.

Narrowing means selecting a portion of a larger topic: for example, selecting a specific time period, event, place, people, type, component, use or application, cause or effect, and so on. Narrowing also means deciding on the amount of detail to use in discussing those topics.

Note: In the following example of the narrowing process, you may wonder how all those subtopics seem to come to mind so effortlessly. If that's not the way it is for you, try some brainstorming and invention first.

Following the Narrowing Process

Let's walk through a typical narrowing exercise to see how it works. This particular example works "backward" from a topic to a realistic audience and purpose. In a "real world" situation, you'd begin with a workplace situation.

1. Imagine that you want to write something about gardening. You have a backyard vegetable garden that you grow as a hobby, and of course for the vegetables it produces:

   gardening >>

2. What can you do with a topic like gardening? You know you want to focus on vegetable gardening, but that's only a first timid step at narrowing. There are still dozens and dozens of topics related to vegetable gardening:

   gardening >> vegetable gardening

3. What are the possibilities related to vegetable gardening? Obviously, there are topics like planting techniques, pest control, fertilization and irrigation topics, perhaps even special-focus reports on individual vegetables—tomatoes, onions, butter beans, peppers. Among these, you lean more to gardening methods or techniques—such as drip irrigation, raised-bed gardening, organic pest control, and so on:

   gardening >> vegetable gardening >> special gardening techniques

4. Now you are getting somewhere! But you can't write on all those techniques—pick one! Recently, you were reading about how NASA's plans for the human exploration of Mars includes growing food there on the planet—specifically by using hydroponic methods. This sparks your curiosity; it's the right topic for a technical document of some kind:

   gardening >> vegetable gardening >> special gardening techniques >> hydroponic gardening

5. You're all done with narrowing, right? Sorry, you're barely half-way there. Hydroponics, the science and craft of growing plants without soil, is a big topic in its own right. What specifically interests you about hydroponics: Interested in setting up a hydroponics system in your garage? Curious whether the claims about hydroponically grown foods are true? Wondering what it takes to run a hydroponics system? Interested in finding a commercially available hydroponic system that meets your needs and price range? Yes—something about practical realities of hydroponics! Your real interest here is the feasibility of hydroponic gardening, recommendations, or both:

   gardening >> vegetable gardening >> special gardening techniques >> hydroponic gardening >> feasibility/recommendations relating to hydroponic gardening
6. Now you have a choice: (a) focus on the feasibility of hydroponics or (b) focus on commercially available systems to determine which is best and which will fit in your garage. At this stage, you are not ready to pick a system; instead, you must convince yourself that the whole concept is practical. Therefore, let's focus on the general feasibility:

7. Another chapter in this book presents several kinds of feasibility: practical feasibility, whether it works; economic feasibility, whether it's too expensive and whether it pays for itself or offers economic advantages; implementation feasibility, whether it's too much trouble, whether you have to remodel your entire garage; and feasibility in terms of the yield and quality—whether hydroponically grown vegetables are any good.

8. So what's it going to be? You know that you want answers to these questions: does hydroponic gardening work? what's the yield? is it any good? how much of a hassle is it? how expensive and how difficult is it to build your own system? and what do you need—in general terms—to build a system? Is this too much for a semester report in a technical-writing course?

9. You've come a long way from "gardening," but you may still need to keep going. Actually, you've done one other narrowing operation without noticing: the focus is small-time, hobbyist, or "home" hydroponic gardening—not commercial hydroponic gardening. In any case, you have four main questions: (a) how does it work, (b) how well does it work, (c) how much work is it, and (d) and what are the costs? These translate into the subtopics you see at the very bottom of this flow chart:
1. To this point, you've been operating in a vacuum, not considering audience and situation, focusing instead on your interests in this topic. Now it's time to get real—to define a real or realistic audience and situation. Who wants this document? Who would hire you (hydroponics expert) to write it? How would people obtain this document? Imagine that a hydroponics association, club, or special-interest group sends out a request for proposals (RFP). Its members want a technical writer to develop an overview guide on hydroponics: not a how-to, not a parts list—just an introduction answering people's questions and concerns. The organization will ship your overview to anybody who inquires about the topic—and the organization will pay you for all of this great work.

2. Are we there yet? Not quite. Narrowing means two things: zooming in on progressively smaller and smaller subtopics; but also deciding on level and amount of detail. In this hydroponics overview, must you cover the four subtopics in excruciating detail? No, at most you'll want to cover practicality in moderate detail: readers need enough detail to see that the method actually works. Use the same amount of detail for yield, perhaps citing some comparative studies. But use only light detail for management and costs. You must keep this overview relatively brief and readable. Notice that these four main topics are not in the best sequence; we'll get to that in the outlining phase:

**Home hydroponics system: topics**

http://distanceed.hss.kennesaw.edu/technicalcommunication/chapters/5_1WritingProcess/5_1WritingProcess_print.html
Costs—how expensive to build and run a system? | light detail
---|---
Practicality—do they really work? | moderate detail
Management—how much hassle? | light detail
Yield—how much and how good is the produce? | moderate detail

## Finishing the Process

In the end, try to produce something that is integrated with a real or realistic situation like this:

<table>
<thead>
<tr>
<th>What does the RFP that you are responding to request?</th>
<th>An avid association of US hydroponic gardeners wants to spur interest in this method by being able to distribute some sort guide regarding the method.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the organization or individual making the request.</td>
<td>American Home Hydroponics Association is an advocacy group seeking to spur interest in this gardening method and to support current membership with techniques and troubleshooting advice.</td>
</tr>
<tr>
<td>How will the organization or individual use the requested document?</td>
<td>The AHHA will advertise this guide in gardening magazines and send hardcopy to people who are interested but without Internet connection. Also, it will post links to the PDF guide on its website.</td>
</tr>
<tr>
<td>If the requesting organization will make the document available to others, who are those people and how will they get the document?</td>
<td>The requested guide will be aimed at an audience of gardeners but assume nothing about their knowledge of hydroponics. It will seek to spur their interest.</td>
</tr>
<tr>
<td>What kind of document is requested? What is the purpose of the document?</td>
<td>It will be a guide enabling people to get interested in hydroponics and see how to get started.</td>
</tr>
<tr>
<td>What are the characteristics of the target readers of the document (knowledge, background, experience)?</td>
<td>The requested guide will be aimed at an audience of gardeners but assume nothing about their knowledge of hydroponics. It will seek to spur their interest.</td>
</tr>
</tbody>
</table>

**Outlining-Generating Items and Sequencing Them**
When you write a technical report, not only must you think of the right information to include (or exclude); you must also find a good way to arrange it. This is a two-part chapter: this part focuses on generating outline items and sequencing them; the second part focuses on turning a rough outline into a good, polished outline.

Outlines for technical reports are usually hard to handle solely in your mind; it's a little like trying to add a list of large numbers mentally. You must get report outlines in print in order to think about the arrangement of the topics within them. A good working outline serves you in at least four important ways:

- It shows you which areas of information to investigate and gather information on.
- It shows you which areas you can safely ignore (thus saving you plenty of time).
- It enables you to schedule your work into manageable units of time.
- It gives you a "global" view of your report project, an overall sense of the contents, parts and organization of the report.

### Generating Outline Elements

If you go through a brainstorming process, you have generated a rough list of topics that you can start working with. The topic list below concerns cocombustion, which is the incineration of municipal solid waste (MSW) with conventional fuels to reduce conventional fuel consumption costs and related MSW disposal problems. Imagine that you had developed a topic list on this subject and then had narrowed the list to these topics:

- Advantages of cocombustion
- Steps in cocombusting MSW
- Disadvantages of cocombustion
- Historical background on cocombustion
- Economics of cocombustion
- Special components for cocombustion
- Composition of MSW
- Cocombustion power plant construction costs
- Cocombustion power plant operating costs
- Economic advantages of cocombustion
- Environmental advantages of cocombustion
- Characteristics of municipal solid waste (MSW)
- Environmental disadvantages of cocombustion
- Methods of MSW disposal

### Grouping, Combining, and Subordinating Outline Elements

You can tell that the list above needs serious help:

- You can see that a number of topics involve advantages and disadvantages; these might be combined in a more general outline called Advantages and Disadvantages of Cocombustion. The specific related topics would be *subordinated* beneath this more general topic: Advantages and Disadvantages of Cocombustion
  - Advantages of cocombustion
  - Disadvantages of cocombustion
- But wait a minute! One of the advantages has to do with economics. So we could create another group: Economics of cocombustion
  - Economic advantages of cocombustion
  - Cocombustion power plant construction costs
  - Cocombustion power plant operating costs
- So what do we do with Environmental advantages of cocombustion and Environmental disadvantages of cocombustion? It might be best to create a higher-level heading Environmental aspects of cocombustion and subordinate those other two beneath it. And so that means we no longer need Advantages and Disadvantages of Cocombustion. It has been split into an economics group and an environment group.
- Looking further at the rough list of topics, you can probably see that Steps in cocombusting MSW, Special components for cocombustion, Composition of MSW, Characteristics of municipal solid waste (MSW) are related to each other and should exist in their own area of the outline.

So this is how the business of generating, grouping, combining and subordinating works early in the outlining process. Outlining is a messy process so you'll probably come back to this phase again.
Sequencing Outline Elements

The next step in outlining is to sequence the items appropriately. There are so many different patterns of sequencing that only most common ones can be reviewed here. And, frankly, these are all pretty obvious. If they are obvious to you, skip to Elaborating the rough outline.

- **Chronological sequencing.** One of the most common patterns in outlining is the chronological one. In a historical background section of an outline, the chronological approach is just about the only one you can use. Here is an outline excerpt concerning the historical background of nuclear research:

  II. Historical background of nuclear research
  A. Becquerel's theory of radition in uranium (1896)
  B. The work of the Curies (far C. The work of Rutherford past)
  1. Demonstration of the internal structure of the atom (1911)
  2. Transmutation of atoms (1919)
  D. Development of technology to study atomic structure
  1. Cascade transformer (1928)
  2. Linear accelerator (1931)
  3. Cyclotron (1932)
  4. Betatron (1940)
  E. Hahn-Strassmann discovery of uranium fission (1938)
  F. Oppenheimer work on nuclear chain reactions (near (1940s) past)
  G. Explosion of the first atomic bomb (1945)

  In some outlines, however, you almost don't notice the chronological pattern. For example, effects come after causes; solutions, after problems; or findings, after research method. The chronological pattern is most important in a research proposal outline:

  I. Introduction
  A. Historical background on caffeine studies
  B. Objectives of the study
  C. Limitations of the study
  D. Plan of development
  II. Review of the literature on caffeine
  III. Experimental method to be used
  IV. Results of the tests
  V. Discussion of the results
  VI. Summary and conclusions
  VII. Implications for further research

  Chronologically, the researcher first defines the problem, the reviews the literature on the problem, plans a research method, conducts the research and gathers data, analyzes the data and draws conclusions from it. Afterward, she may consider areas for further research on the problem.

- **At-rest to in-motion sequence.** Another common outlining pattern is to start with an object at rest, motionless as if in a photograph, and then to move to a discussion of it in operation, in action as if in a motion picture.

  II. Basic Components of Wind-Powered Electrical Systems
  A. Rotor (motionless)
  B. Generator
  C. Tower
  III. Basic Operation of Wind-Powered Electrical Systems
  A. Wind energy into mechanical energy
  B. Mechanical energy into electrical (in motion)
  C. Stabilization of electrical energy
  D. Conversion to household current

- **Specific to general sequence.** Some outlines move from a specific, close-up focus to a more general, panoramic focus. They seem to start with a microscope, examining the minute details of a subject, and end with a telescope, considering the subject from a distance in relation to other things. (This pattern can also be reversed.)

  I. Introduction
  II. Characteristics of municipal solid waste (MSW)
  III. Methods of disposal of MSW
  IV. Processing municipal solid waste
  V. Plant modifications for cocombustion
  VI. Advantages of cocombusting MSW
  A. Environmental advantages
  B. Economic advantages
  VII. Case studies of three cocombustion plants

  In this next outline, the focus broadens after part III, changing to aspects related to computerized voice recognition technology:

  I. Introduction
  II. Human voice production
  A. The generation of sound
  B. Factors affecting the human voice
  III. Methods of disposal of MSW
  IV. Processing municipal solid waste
  V. Plant modifications for cocombustion
  VI. Advantages of cocombusting MSW
  A. Environmental advantages
  B. Economic advantages
  VII. Case studies of three cocombustion plants
• Rhetorical sequence. Elements in outlines can also be arranged rhetorically, in other words, according to what is most effective for the reader. Here are some examples of rhetorical patterns:
  - Simple to complex
  - Least important to most important (or vice versa)
  - Least controversial to most controversial
  - Most convincing to least convincing (or vice versa)
  - Most interesting to least interesting

This list is by no means complete: but you can see that elements in it are arranged according to impact on the reader—that is, the impact the writer would like to have. Here are some excerpts of outlines where these patterns are used.

If you have ever studied computer programming, you know that commands like PRINT are simple; variable assignment commands (like LET A = 30), less simple; and FOR-NEXT loop statements, rather complex. If you were outlining a report on fundamental BASIC commands for the beginner, you'd probably start with the simple ones and work your way to the complex:

**Simple-to-complex order**

III. USEFUL BASIC COMMANDS
   A. PRINT
   B. LET
   C. IF-THEN
   D. FOR-NEXT
   E. DIM

If you were writing a report on cocombustion of municipal solid waste (MSW) for a city concerned about skyrocketing coal costs, you could arrange your advantages section two ways: (a) save the "reduction of coal consumption" for last in order to build up to a climax, or (b) introduce it right away to grab the citizens' attention:

**Climax order**

Attention-getting order (least-most important) (most-least important)
   A. Recovery of revenue from A. Reduction of coal use and recyclable MSW and related costs B. Reduction of landfill B. Reduction of landfill use, costs, and other re-use, costs, and other related problems C. Reduction of coal use C. Recovery of revenue from and related costs recyclable MSW

• An obvious outlining principle is to avoid creating interruptions within an outline sequence. Here's an example:

**Outline excerpt with interruption**


**Revised outline excerpt**


In the problem version, the municipal solid waste discussion is interrupted by the MSW-processing discussion. A better arrangement would be to discuss MSW fully before going on to the discussion of how it is processed. Use these common arrangement principles to get your topic list into an initial rough order. The rearranged version of the topic list shown previously might look this way:

I. Historical background A. Rising energy, utility costs B. Search for alternatives (review) II. Composition of MSW III. Special components of the cocombustion plant IV. Steps in the cocombustion of MSW V. Economics A. Cost to build or convert B. Cost to operate C. Cost of produced electricity VI. Advantages A. Less coal used B. Reduction of utility rates C. Less landfill used D. Reduction of landfill costs and needs VII. Disadvantages A.
Expense of converting existing facilities  
B. Handling MSW  
C. Increased emissions

## Adjusting Items in an Outline

You should also make sure that items in your outline are on the right level. Here is an example of this problem and a revision:

<table>
<thead>
<tr>
<th>Unadjusted outline</th>
<th>Revised outline</th>
</tr>
</thead>
</table>
| A. Plant Modifications for Coc-  
  Plant modifications for Co- combustion  
  1. Storage areas  
  2. Conveyor lines  
  3. Boiler modifications  
  4. Air control equipment  
  B. Economic Benefits  
  C. Environmental Benefits  
| A. Plant modifications for Coc- combustion  
  1. Storage areas  
  2. Conveyor lines  
  3. Boiler modifications  
  4. Air control equipment  
  B. Economic Benefits  
  C. Environmental Benefits  |

In this revision, the problem was solved by adding a more general item (Benefits of Cocombustion) and downshifting the original "B" and "C" items. Now, here's another example:

<table>
<thead>
<tr>
<th>Unadjusted outline</th>
<th>Revised outline</th>
</tr>
</thead>
</table>
| B. Environmental Benefits  
  C. Reduction of Landfill Needs  
  1. Reduction of landfill  
  2. Economic Benefit needs  
  C. Economic benefits  
| B. Environmental benefits  
  C. Reduction of Landfill Needs  
  1. Reduction of Coal Consumption  
  C. Economic benefits  |

Here, Reduction of Landfill Needs is really a subdivision of Environmental Benefits. Downshifting it to a "1" creates a single-item entry, however. Therefore, we might add a second item like Reduction of Coal Consumption.

Sexy Technical Communication Home

## Note-Taking Methods

### Electronic Note-Taking Methods

As of 2015, the writing-teaching world—at least at the college level and in terms of textbooks—is seriously behind in terms of what it knows and what it teaches about note-taking for major writing projects. Strangely, the very best writing resource on the Internet, the Purdue OWL, has nothing on note-taking. Read the following section Traditional Note-Taking Methods for a review of just what good any note-taking system is.

Until we get our act together, consider how the traditional note-taking system is implemented in software applications.

A number of software applications are available that support note-taking and related tasks: Evernote, EasyBib, NoodleTools, and more. Their basic functions are similar so let's use NoodleTools. It has a nice set of YouTube videos that walk you through the main phases of its use:

**How do I create a new project?** This video takes you from the very start!

**How do I create a notecard for my citation?** In this video, you see how to create a single notecard. In one panel of that view, you can paste the direct quotation; in another, your understanding, paraphrase, or summary of it; in still another, you can jot down ideas and questions; and in another, you can enter the URL or the traditional bibliographical source of the information plus search tags. The video concludes with a demonstration of moving the new notecard to the "tabletop," grouping notecards, and using them to create an outline.

**NoodleTools—Creating Outlines.** If you've created good notecards, creating the outline from them is terrific, as this video shows.

**Noodle Tools Works Cited.** If you've created good notecards, creating the bibliography from them is also terrific.
Traditional Note-Taking Methods

When you've located the right sources of information for your report, it's time to start gathering the right information from them and developing it into a report. In other words, it's time to start reading, summarizing, paraphrasing, interviewing, measuring, calculating, and developing information any other way your report project requires. The technical report may be one of the largest writing projects that you've ever tackled: you may wonder how you are going to do all that reading and remember all that information. Concerning the reading, here are several suggestions:

- Develop as specific an outline as you can: it shows you what information you must gather and, as importantly, what information you can ignore.
- Use the indexes, tables of contents, and headings within chapters to read books selectively for just the information you need.
- Divide your work into manageable, hour-long chunks (make progress rather than relying on big blocks of weekend or vacation time).

As for remembering the information you gather for your report, the most practical suggestion is to use some form of note-taking. Note-taking refers to any system for collecting and storing information until you can use it in the report. Note-taking involves the skills of summarizing, paraphrasing, or quoting. A good system of note-taking is one that enables you to gather a large amount of information over a long period of time and to be able to use that information without having forgotten it or lost it in the meantime.

Traditional Note-Taking Process: An Overview

In the traditional system of taking notes for a long report, you:

1. Develop a rough outline.
2. Do any preliminary reading necessary to construct a rough outline.
3. Locate your information sources, and make bibliography cards for each source.
4. Take the actual notes on index cards.
5. Label each notecard according to its place in the outline.
6. Provide bibliographic information on each notecard.
7. Change or add extra detail to the outline as the note-taking process continues.
8. Check off the areas of the outline for which sufficient notes have been taken.

When you have taken sufficient notes to cover all parts of an outline, you transcribe the information from the notecards into a rough draft, filling in details, adding transitions, and providing your own acquired understanding of the subject as you write. Naturally, you may discover gaps in your notes and have to go back and take more notes.

Developing the rough outline

As the section on outlining emphasizes, you must have a working outline before you begin gathering information. The rough outline shows you which specific topics to gather information on and which ones to ignore. Think of the outline as a series of questions:

<table>
<thead>
<tr>
<th>Rough outline for a report Questions generated light water nuclear reactors by the outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pressurized Water Reactors</td>
</tr>
<tr>
<td>What are the main differences? A. Major Components</td>
</tr>
<tr>
<td>components? what are the materials? design? dimensions? how many are in operation? where? who designed them?</td>
</tr>
<tr>
<td>II. Boiling Water Reactors How does it differ from PWRs? A. Major Components What are the main components? B. Basic Operation What are the materials? design? dimensions? designers? where used? how many?</td>
</tr>
<tr>
<td>III. Safety Measures What are the chief dangers? A. Pressurized Water Reactor What are the dangers and safety measures associated with PWRs? B. Boiling Water Reactors What are the dangers and safety measures associated with BWRs? C. Role of the Nuclear Regulator How</td>
</tr>
</tbody>
</table>

http://distanceed.hss.kennesaw.edu/technicalcommunication/chapters/5_1WritingProcess/5_1WritingProcess_print.html
IV. Economic Aspects of Light Water Reactors

What are the construction, operation, maintenance, and fuel costs? What about the availability of fuel? How do these costs compare to output? How do the PWR and the BWR compare in terms of costs and output?

C. Operating Capacity

How much electricity can a LWR generate at full capacity?

Figure 1. Viewing an outline as a series of questions

If you don't have a good, specific outline, the sky is the limit on how many notes you can take. Think of the outline as a set of boxes that you fill up with the information you collect as you do your research for the report:

Figure 2. Gathering information and taking notes: you continue gathering information from the various sources until all the boxes are filled.

Information on the bibliography cards

On the bibliography cards you should record information that enables you or your readers to locate the books, articles, reports, and other sources. Remember that you'll use this information to create the bibliography or list of references for your report. See the examples of bibliography cards for books, magazine articles, encyclopedias, and government documents; the section on documentation shows you details on the information to record on many different types of sources, but remember these general guidelines:

- For books, record the “facts of publication”: the city of publication, the publisher, and the date of publication.
- For magazines, record the title of the magazine, the date of issue of the specific magazine, and the beginning and ending page numbers of the article.
- For encyclopedia articles, record the edition number and date of the encyclopedia, and look up the authors' initials.
- For government documents, disregard the authors' names, use the department, administration, or agency name as the author, and copy the cataloguing number.
- For any private sources of information you use, for example, interviews or letters, record the date of the communication, the source's full name, title, and organization with which he or she is affiliated.

Information on the notecards

In the traditional note-taking system, a notecard typically looks like this:

BWR—fuel rod (III,A,1,b) fuel rod material—Zircaloy (same as PWR fuel rod) 148 in. long X 0.493 in. diam. slightly longer > PWR fuel rod 16 D, 749

Figure 3. A typical notecard

This notecard has the following features:
A word, phrase, or number that indicates where it fits into the outline (the "locator"). Bibliographic information: that is, an abbreviation for the source of the note (book, article, etc.) and a page number. The note itself, the information that will go into the report. A number that indicates the notecard's place in the final arrangement of all the notecards.

**Locator.** The "locator" phrase or number tells you where the note fits into the outline, that is, when and where you'll use this information in the report. Locaters must be updated regularly. As you read, take notes, and learn more about your subject, you can flesh out, or "elaborate," your outline more and more, subdividing it into third, fourth, and even fifth levels. This process is illustrated in the section on updating the outline.

Bibliographic information. Each notecard must also contain bibliographic information, those details about the source of the note: the author, title, page number, and so on. Rather than write all such information on each notecard, use abbreviations: assign a letter to each source, and keep track of the sources on bibliography cards, as shown above.

**Methods of recording information on notecards**

The actual information that you record on the index card is rather small: a few statistics or a sentence or two, and not much else. You take such small bits of information to make it easier to "shuffle" your notecards into the sequence in which you'll use them in writing the rough draft. There are three ways of recording the information on notecards:

- Directly quoting it, copying the information directly from the source word-for-word
- Paraphrasing it, retaining the full detail of the information but in your own words
- Summarizing it, condensing the main points in the information *in your own words*

See what the Purdue OWL has to say about these methods.

**Direct quotation.** In most technical reports, direct quotation is needed only for the following situations:

- Statements by important or well-known authorities or leaders
- Controversial statements you do not want attributed to you
- Statements expressed in unusual, vivid, or memorable language

Here is an example notecard with a direct quotation:

![Figure 4. Original passage and notecard with direct quotation](http://distanceed.hss.kennesaw.edu/technicalcommunication/chapters/5_1WritingProcess/5_1WritingProcess_print.html)

**Figure 4. Original passage and notecard with direct quotation**

When you copy a direct quotation onto a notecard, remember to do a few extra things that will save time and frustration later on:

- Write a lead-in to introduce the quotation, citing the author's name and any other important information about the author.
- Write a brief explanation, interpretation, or comment on the quotation you've just copied.

There are essentially two types of direct quotation: "block" quotations and "running" quotations. Here is an example of a block quotation (any quotation over 3 lines long, which is indented):

```
In Myers' view, the nuclear power industry has every reason to comply
```

http://distanceed.hss.kennesaw.edu/technicalcommunication/chapters/5_1WritingProcess/5_1WritingProcess_print.html
with the NRC's regulations to the very letter: The NRC issues an order to
shut down or imposes civil fines only after repeated violations have in-
dicated what the NRC considers "a pattern of non-compliance." The
NRC argues that, particularly with power plants, civil penalties are
unnecessary for the most part. "The greatest penalty," one official said,
"is to require the plant to shut down, forcing it to buy replacement power
(often at a cost of $100,000 to $200,000 per day) elsewhere. A civil
penalty's largest cost—the NRC is limited to a $5,000-per-violation ceiling
per 30 days—is the stigma attached to it." (8:46) The "stigma" refers to
the fact that, once a nuclear power plant is fined, it will likely be the target
of public con-cern and even more stringent and frequent NRC
inspection.

Figure 5. Block quotation and a running quotation

"Running" quotations are direct quotations that are trimmed down and worked into the regular sentences of a report. Notice
how much smoother and more efficient the running quotation is in the revised version below:

Ineffective direct quotation There are two types of light water reactors: the
pressurized water reactor and the boiling water reactor. LWRs of both
types convert heat to electricity with an efficiency of about 32 percent—
significantly less than the best fossil-fueled plants, although about equal
to the national average for all thermal electricity generation [13:438]. As
for harnessing the energy potential of uranium, LWRs are estimated to
average only between 0.5 and 1.0 percent.

Revision with running quotation There are two types of light water
reactors: the pressurized water reactor and the boiling water reactor.
According to Paul Ehrlich, who has been a consistent critic of nuclear
power, both these types of LWRs "convert heat to electricity with an
efficiency of about 32 percent—significantly less than the best fossil-
fueled plants, although about equal to the national average for all thermal
electricity generation" (13:438). As for harnessing the energy potential of
uranium, LWRs are estimated to average only between 0.5 and 1.0
percent.

Figure 6. An ineffective block quotation revised as a running quotation

Guide for using direct quotations

When you use direct quotations in your report, keep these guidelines in mind.

Figure 7. Using ellipsis in direct quotations. The three dots "...", show that words are omitted from the sentence. The brackets
"[ ]" indicate changes made by the writer using the quotation so that it would read as good English and make sense.

- Never use "free-floating" quotations in reports. Always "attribute" direct quotations; that is, explain who made the
  quoted statement. Notice how this is done in Figure 6.
- Always provide adequate introduction for direct quotations and explain their meaning and importance to your readers.
  Notice how the block quotation above on NRC penalties (a) prepares the reader for the quotation, and, afterwards, (b)
  provides interpretive comment, on the meaning of the word "stigma" in particular.
- Use indented or "block" quotations whenever a direct quotation goes over three lines long. With any lengthy quotation,
  make sure that it is important enough to merit direct quotation.
- Whenever possible, "trim" the quotation so that it will fit into your own writing. Notice how the words that are less
  important are omitted in Figure 5.
- Punctuate direct quotations correctly. You can see the rules for punctuating direct quotations; however, here are some
  examples of the most common ways to punctuate quotations:

According to Desaix Myers in his The Nuclear Power Debate, "The NRC has nearly 400
staff members assigned to inspect nuclear plants now operating or under construction." NRC
officials also inspect nuclear power plants "an average of 50 times during the period
before operation" when they are under construction and "a minimum of four times a year"
after the plants go into operation. Myers points out that standardization of nuclear power
plant design is an important next step: "The NRC estimates that by standardizing plants...
the time between a decision to go nuclear and start-up of plant operations can be reduced
from 11 to 6 years."
Use ellipses to shorten direct quotations. When you do, however, make sure that the resulting quotation reads as good English. Here is an example passage:

Ehrlich argues that a mistaken notion of the breeder reactor has been promoted in the United States: [Although breeder reactors] can harness so much more of the potential energy in uranium and thorium than non-breeder[s], it is worth emphasizing that a breeder does not get something for nothing.... Paul R. Ehrlich, Anne H. Ehrlich and John P. Holdren, Ecoscience: Population, Resources, and Environment, (San Francisco: Freeman, 1977), p. 441. Ehrlich goes on to argue that breeder reactors are ...

Use direct quotations only when necessary: if the passage doesn't fit one of the reasons for direct quotation cited at the beginning of this section, paraphrase or summarize it instead.

Paraphrasing. In technical-report writing, usually the better approach to note-taking is to paraphrase. When you paraphrase, you convey the information fact-by-fact, idea-by-idea, and point-by-point in your own words. The writer of the original passage ought to be able to read your paraphrase and say that it is precisely what she or he had meant. Here are some example paraphrased notecards:

BWR—fuel assembly (III,A,1,3) fuel assembly—63 f rods spaced, supported in a sq (8 x 8) arrangement by upper + lower plate 3 kinds: (a) tie rods; (b) water rod; (c) stand f rods 3rd, 6th f rods on a bundle's outer edge act as tie rods the 8 tie rods screw into cast of lower tie plate water rod: acts as spacer support rod, as source of moderator material close to the center of f bundle K, 2001

BWR—fuel assem (III,A,1,3) fuel channel—enclosure for f bundle; f bundle + f channel make up fuel assem is a tube with a square shape, made of Zircaloy dimensions: 5.518 in. X 5.518 in. X 166.9 in. function: channel core cool thru f bundle and guide control rods K, 2001

Figure 8. Paraphrased notecards

Paraphrases are necessary and preferable for a number of reasons:

- You paraphrase because the content of the passage is so important to your report that you need every bit of it.
- When you paraphrase, you adjust the wording of the original to meet the needs of your audience, the purpose of your report, and your own writing style. In other words, you "translate" other writers' material into your own.
- A report of mostly direct quotations would be hard to read.
- Readers tend to skip over direct quotations, particularly long ones.
- One final reason for paraphrasing: you are actually writing bits of the rough draft of your report as you paraphrase.

Here is an example of an original passage and its paraphrases, with the unique wording of the original (which must be changed in the paraphrase) underlined.

Original passage About a third of light-water reactors operating or under construction in the United States are boiling-water reactors. The distinguishing characteristic of a BWR is that the reactor vessel itself serves as the boiler of the nuclear steam supply system. This vessel is by far the major component in the reactor building, and the steam it produces passes directly to the turbogenerator. The reactor building also contains emergency core cooling equipment, a major part of which is the pressure suppression pool which is an integral part of the containment structure. . . . earlier BWRs utilized a somewhat different containment and pressure suppression system. All the commercial BWRs sold in the United States have been designed and built by General Electric. Several types of reactors that use boiling water in pressure tubes have been considered, designed, or built. In a sense, they are similar to the CANDU, described in Chapter 7, which uses pressure tubes and separates the coolant and moderator. The CANDU itself can be designed to use boiling light water as its coolant. The British steam-generating heavy-water reactor has such a system. Finally, the principal reactor type now being constructed in the Soviet Union uses a boiling-water pressure tube...
Paraphrased version

Boiling water reactors, according to Anthony V. Nero in his Guidebook to Nuclear Reactors, either completed or constructed, make up about one third of the light-water reactors in the U.S. The most important design feature of the BWR is that the reactor vessel itself acts as the nuclear steam supply system. The steam this important component generates goes directly to the turbogenerator. Important too in this design is the emergency core cooling equipment which is housed with the reactor vessel in the reactor building. One of the main components of this equipment is the pressure suppression pool. The containment and pressure suppression system currently used in BWRs has evolved since the early BWR designs. General Electric is the sole design-er and builder of these BWRs in the U.S. The different kinds of reactors that use boiling water in pressure tubes are similar to the CANDU, which separates coolant and moderator and uses pressure tubes also. CANDU can also use boiling light water as a coolant. The British have designed a reactor generated steam from heavy water that uses just such a system. Also, the Soviets have developed and are now building as their main type of reactor a boiling pressure tube design that uses carbon as the moderator. [12:232]

Figure 9. Avoiding the original wording in paraphrases

Guide for writing and using paraphrases

Here are some guidelines to remember when paraphrasing:

- In most cases, paraphrase rather than use direct quotation.
- Avoid the distinctive wording of the original passage.
- Do not interpret, criticize, or select from the original passage.
- Include bibliographic information on the author, source, and page numbers.
- In the rough draft, cite the author's name and other important details about her or him just as you would if were quoting directly. In Figure 9, notice how the paraphrased author's name is given early.
- Refer to the paraphrased author in such a way to make it clear where the paraphrase begins and ends. (See Figure 9.)
- Document a paraphrase just as you would a direct quotation. Mark the area of the paraphrase by citing the paraphrased author's name at the beginning of the paraphrase and by inserting a footnote or parenthetical reference at the end. (Again, see Figure 9.)
- See what the Purdue OWL has to say about paraphrasing.

Summary

Summaries are usually much shorter than their originals. A summary concentrates on only those points or ideas in a passage that are important. Unlike in a paraphrase, the information in a summary can be rearranged. Here is a passage from which summaries below will be taken:

Numerous systems are available for controlling abnormalities [in boiling water reactors]. In the event that control rods cannot be inserted, liquid neutron absorber (containing a boron compound) may be injected into the reactor to shut down the chain reaction. Heat removal systems are available for cooling the core in the event the drywell is isolated from the main cooling systems. Closely related to the heat removal systems are injection systems for coping with decreases in coolant inventory.

Both abnormalities associated with the turbine system and actual loss of coolant accidents can lead closing of the steam and feedwater lines, effectively isolating the reactor vessel within the drywell. Whenever the vessel is isolated, and indeed whenever feedwater is lost, a reactor core isolation cooling system is available to maintain coolant inventory by pumping water into the reactor via connections in the pressure vessel head. This system operates at normal pressures and initially draws water from tanks that store condensate from the turbine, from condensate from the residual heat removal system, or if necessary, from the suppression pool.

A network of systems performs specific ECC [emergency core cooling] functions to cope with LOCAs [loss-of-cool-ant accidents]. (See Figure 6.) These all depend on signals indicating low water level in the pressure vessel or high pressure in the drywell, or both.
The systems include low-pressure injection, utilization of the RHR system, and high- and low-pressure core spray systems. The high-pressure core spray is intended to lower the pressure within the pressure vessel and provide makeup water in the event of a LOCA. In the event the core is uncovered, the spray can directly cool the fuel assemblies. Water is taken from the condensate tanks and from the suppression pool. On the other hand, should it become necessary to use low-pressure systems, the vessel must be depressurized. This can be accomplished by opening relief valves to blow down the vessel contents into the drywell (and hence the suppression pool). Once this is done, the low-pressure core spray may be used to cool the fuel assemblies (drawing water from the suppression pool) or RHR low-pressure injection (again from the suppression pool) may be initiated, or both. The RHR system may also be used simply to cool the suppression pool. (Two other functions of the RHR are to provide decay heat removal under ordinary shutdown conditions and, when necessary, to supplement the cooling system for the spent fuel pool and the upper containment pool.)


---

**Figure 6. BWR emergency core cooling systems**

---

**Figure 10. Passage to be summarized**

**Sentence-length summaries.** Often summaries are only a sentence long. To create sentence-length summaries, use one or a combination of the following methods:

- Locate a sentence or two in the original passage that summarizes the information that you want, and simply rewrite it in your own words. Find the sentence in the third paragraph of the original that is the basis for this summary:

  BWR—safety sys (IV,B,2) The systems that perform emergency core cooling functions in loss-of-coolant accidents include low-pressure injection, utilization of the RHR system, and high- and low-pressure core spray systems. I, 104

- If no individual sentence will work, locate several sentences that contain the right information, and combine them. (This summary sentence is built from paragraphs 1 and 2 of Figure 10.)

  BWR—safety sys (IV,B,2) In case of problems with control rods or
loss of coolant, BWRs use an absorber to stop the reaction or emergency systems to replenish and maintain coolant around the reactor core, respectively. I, 104-107

- Sometimes, the summary sentence is like a new sentence, scarcely resembling any in the original. Here is a different summary sentence on the passage above; notice how new it seems:

BWR—safety sys (IV,B,2) If the control rods malfunction, a substance can be introduced to shut down the reaction altogether, and if water is prevented from reaching the reactor core, BWRs are equipped with backup sources of coolant that can be sprayed or injected into the pressure vessel. I, 104-107

Extended summaries. A summary can be longer than a single sentence because of the important information contained in the original passage. (Remember, however, that a paraphrase is a point-by-point recap of the original, while the summary is a selection, reordering and condensation of the original.) Here's an extended summary of the passage above on BWR emergency safety systems (Figure 10):

Boiling water reactors use numerous systems to control abnormalities in reactor operations. If a problem with control rods occurs, a liquid neutron absorber can be injected to halt the chain reaction. If coolant is cut off from the reactor core, a reactor core isolation cooling system can maintain coolant inventory by pumping water from various storage areas. This system includes low-pressure injection, the residual heat removal system, and the high- and low-pressure core spray systems. The water supply for these various emergency systems ultimately come from the suppression pool.

Guide for using summaries

Whenever you summarize, you must handle the resulting summary the same way you would a direct quotation or paraphrase.

- Cite the name of the author and other important information about that author.
- Document that summary using whichever system is appropriate for your report.
- If it is an extended summary, make it clear where that summary begins and ends, for example, by referring to the author's name at the beginning and placing a footnote or parenthetical reference at the end.

Plagiarism. If you follow the guidelines presented in the preceding, plagiarism should not be a problem at all, but make sure you understand what it is. Plagiarism refers to two kinds of theft:

Reports with plagiarized information are often easy to spot for several reasons:

- Plagiarism is the practice—whether deliberate or not—in which a writer borrows other people's facts, ideas, or concepts and presents them as if they were her or his own.
- Plagiarism is also the practice—again whether deliberate or not—in which a writer uses other writers' exact words without quotation marks.
- In all cases, plagiarism is the lack of proper documentation: documentation refers to any system of footnoting or reference that indicates the author and source of the borrowed information.
- A reader may recognize the ideas or facts in the report as those of someone else. An expert in a field of knowledge can spot this theft of information right away.
- A reader may realize that the report writer could not possibly have developed certain information in the report. If a writer who is at the beginning of his studies sounds like an advanced physicist, something is fishy.
- Most readers can also spot a sudden change in the style or tone of the language of a report. Most people's writing style is as readily identifiable as their voices over the telephone.

Plagiarism is bad business: the plagiarizer can fail an academic course or lose his or her reputation among business and professional associates. It only takes simple documentation to transform a report with plagiarized material in it into one with legally borrowed material. The section on documentation explains these procedures in detail.

Updating the outline

As you take notes, you must regularly update the locators on all your notecards because as you read, take notes, and learn more about your technical subject, your outline may either change or become more specific. Imagine that you started with this excerpt of a rough outline and had taken these notecards:
### Rough sketch outline

|---|

### Corresponding notecards

**BWR—safety sys (IV,B)**
- safety sys incl control rods, containmt bldg, resid heat removl sys there work like those in PWR unique to BWR: drywell, emergency core coolg sys 1 I, 100

**BWR—safety sys (IV,B)**
- drywell—encloses react vess + assoc equip (includes recirc sys, press relief valves on main steam lines) 2 I, 100

**BWR—safety sys (IV,B)**
- emergency core coolg sys—handles loss-of-coolt accidents; includes reactor core iso sys, hi- press core spray sys, lo-press core spray sys (figure for this, p.106) 3 I, 105-6

**BWR—safety sys (IV,B)**
- react core iso coolg sys: if loss-of-coolt accidt (causg closing of steam lines, feedwtr lines to react vessel), RCICS activated (maintains coolt inventory by pumpg water to reactor via connex in press vess head 4 I, 104

**BWR—safety sys (IV,B)**
- hi-press core spray: lowers press w/in press vessel, provides suppl water in loss-of-coolt accidt. with uncovered cores, spray directly cools fuel assemblies (wtr fr condensed wtr storge tanks + suppress pool 5 I, 104

---

### Figure 11. Notecards and the corresponding outline before updating

As you took these notecards, you would update your outline periodically; at the end, the outline might look like this:

**Revised outline**

|---|

---

### Figure 12. Updated outline

Notice that all five of these notecards are about "IV. B. Boiling Water Reactor Safety Systems." Notecard 1 divides this safety system into the drywell and the emergency core cooling systems. This division produces "1" and "2" under "B." Notecards 3 through 5, about the subsystems making up the emergency systems, produce "a," "b," and "c" under "2."

If you had taken these notes and updated your outline, you would revise the locators on the individual notecards like this:

<table>
<thead>
<tr>
<th>Notecard Original Updated Alternate no. locators locators locators</th>
</tr>
</thead>
</table>

---

### Figure 13. Revised locators

Remember that if you don't like the number-combinations as locators, you can substitute short phrases, as is shown in the alternate locators above.

### Final stages in the notetaking process

As you take notes, check off sections of your outline for which you gather sufficient information, as is done in this outline excerpt. In this example, the writer has taken sufficient notes for much of IV.B. but still needs information for the rest of the outline.

---

Figure 14. An outline for which note-taking is partially complete

In the final step in notetaking, you arrange the notecards in the order that you'll use them as you write the rough draft. Read through your cards several times to make sure the sequence is right and that there are no gaps in the information you've gathered. When you're sure that the order is right, write sequence numbers on each of the cards to preserve the order (see the sequence numbers on the notecards in the next section). With the notecards in the right order and numbered, you are ready to write the first draft, which is discussed in the section on rough drafting.

Other systems of notetaking

There are plenty of other ways to take notes. The main point of any form of note-taking of course is to make your report work easier and less time-consuming. You may prefer some other note-taking system because of your own work style or because of your report project. Or, you may end up using some other system in combination with the traditional one. Any system that enables you to get your work done efficiently is a good one.

- Mental notetaking. With short reports, it is possible to remember all the information and not writing any of it down is possible. But few of us are able to remember all of the information for long, highly technical reports.
- Book marks. If you use only a few articles or books, you can mark the important passages with slips of paper and write the rough draft with them. If you have many books and articles, this approach can get to be quite chaotic.
- Photocopying. You can also photocopy everything you think you need in your report. With the photocopied pages, you highlight the important passages, or cut out the important passages and paste them on notecards. Two problems with this approach are that (a) you may photocopy many unnecessary pages and waste money and (b) you still have the job of paraphrasing and summarizing ahead of you. Still, this is a system some report writers use occasionally to supplement their more traditional note-taking procedures.
- Exploratory drafts. If you are already familiar with your report subject, you can try writing a rough skeletal draft to show you what information you need. You may discover that all you lack is specific names, statistics, or terminology. You can take notes and plug the information into the draft (especially if you have computerized word processing). Writing the exploratory draft shows you what you know and don't know.
- Notetaking by the source. If you have only a few sources, you can also use one other fairly common system of notetaking:
  1. You take notes from individual sources onto long sheets of paper rather than onto notecards.
  2. You take all the information you need from the source onto as many sheets of paper as necessary; you don't split it up into bits of information on separate notecards.
  3. At the top of each notesheet, you give full bibliographic information on the book or article.
  4. Throughout each notesheet, you indicate the exact pages the information comes from.
  5. Also, you label these pages of notes with locators, the letter-number combinations from the outline.
  6. You mark off sections of the outline as you gather sufficient information for them.
  7. In some cases, you can cut up these full-page notes and actually handle them as if they were notecards. Here is an example sheet of notes using this approach:

Outline Source: J Pages area 1. BWR core—large nbr of fuel assembls (94) ea one a sq array 7 X 7 or 8 X 8 III,A,1 fuel pin: active length 12 ft contains water rod (providg (95) moderator w/in f bundles) III,A,2 large BWR contains 764 assems w 40-50,000 f rods + about 180 tons of uran. diox 2. reactor vessel—contains core (99-100) and assoc equip, also control rods above core, steam separators/dryers 3. vessel dimensions: 72 ft high, 21 ft diam (100) material: carbon steel, 6-7 in thick III,A,3 clad w 1/8 in stainls steel withstands 1000 psi at operatg temps 4. coolant—recirculates w/in react vessel of BWR IV,B,2-3 no external loop jet pumps in annulus (101) pump: reactor inlet nozzles

Figure 15. Sample notesheet: taking notes by the source
In this system, the source (book, article, report, etc.) is indicated at the top of the page; the page numbers are indicated down the right margin in parentheses; and the sheet of notes is keyed to the outline down the left margin in parentheses.
Audience Analysis
David McMurray

The audience of a technical report—or any piece of writing for that matter—is the intended or potential reader or readers. For most technical writers, this is the most important consideration in planning, writing, and reviewing a document. You "adapt" your writing to meet the needs, interests, and background of the readers who will be reading your writing.

The principle seems absurdly simple and obvious. It's much the same as telling someone, "Talk so the person in front of you can understand what you're saying." It's like saying, "Don't talk rocket science to your six-year-old." Do we need a course in that? Doesn't seem like it. But, in fact, lack of audience analysis and adaptation is one of the root causes of most of the problems you find in professional, technical documents—particularly instructions where it surfaces most glaringly.

Note: Once you've read this chapter on audience analysis, try using the audience planner below. You fill in blanks with answers to questions about your audience and then e-mail it to yourself. Use the audience planner for any writing project as a way of getting yourself to think about your audience in detail.

If you can't see the audience planner above, click here.

Types of Audiences

One of the first things to do when you analyze an audience is to identify its type (or types—it's rarely just one type). The common division of audiences into categories is as follows:

- **Experts**: These are the people who know the theory and the product inside and out. They designed it, they tested it, they know everything about it. Often, they have advanced degrees and operate in academic settings or in research and development areas of the government and technology worlds. The nonspecialist reader is least likely to understand what these people are saying—but also has the least reason to try. More often, the communication challenge faced by the expert is communicating to the technician and the executive.

- **Technicians**: These are the people who build, operate, maintain, and repair the stuff that the experts design and theorize about. Theirs is a highly technical knowledge as well, but of a more practical nature.

- **Executives**: These are the people who make business, economic, administrative, legal, governmental, and/or political decisions on the stuff that the experts and technicians work with. If it's a new product, they decide whether to produce and market it. If it's a new power technology, they decide whether the city should implement it. Executives are likely to have as little technical knowledge about the subject as nonspecialists.

- **Nonspecialists**: These readers have the least technical knowledge of all. Their interest may be as practical as technicians', but in a different way. They want to use the new product to accomplish their tasks; they want to understand the new power technology enough to know whether to vote for or against it in the upcoming bond election. Or, they may just be curious about a specific technical matter and want to learn about it—but for no specific, practical reason.

Crossword Activity

Audience Analysis

It's important to determine which of the four categories just discussed the potential readers of your document belong to, but that's not the end of it. Audiences, regardless of category, must also be analyzed in terms of characteristics such as the following:

- **Background—knowledge, experience, training**: One of your most important concerns is just how much knowledge, experience, or training you can expect in your readers. If you expect some of your readers to lack certain background, do you automatically supply it in your document? Consider an example: imagine you're writing a guide to using a software product that runs under Microsoft Windows. How much can you expect...
your readers to know about Windows? If some are likely to know little about Windows, should you provide that information? If you say no, then you run the risk of customers’ getting frustrated with your product. If you say yes to adding background information on Windows, you increase your work effort and add to the page count of the document (and thus to the cost). Obviously, there’s no easy answer to this question—part of the answer may involve just how small a segment of the audience needs that background information.

- **Needs and interests:** To plan your document, you need to know what your audience is going to expect from that document. Imagine how readers will want to use your document and what will they demand from it. For example, imagine you are writing a manual on how to use a new smart phone—what are your readers going to expect to find in it? Imagine you're under contract to write a background report on global warming for a national real estate association—what do they want to read about; and, equally important, what do they not want to read about?

- **Other demographic characteristics:** And of course there are many other characteristics about your readers that might have an influence on how you should design and write your document—for example, age groups, type of residence, area of residence, gender, political preferences, and so on.

Audience analysis can get complicated by at least three other factors: mixed audience types for one document, wide variability within audience, and unknown audiences.

- **More than one audience.** You're likely to find that your report is for more than one audience. For example, it may be seen by technical people (experts and technicians) and administrative people (executives). What do you do? You can either write all the sections so that all the audiences of your document can understand them (good luck!). Or you can write each section strictly for the audience that would be interested in it, then use headings and section introductions to alert your audience about where to go and what to avoid in your report.

- **Wide variability in an audience.** You may realize that, although you have an audience that fits into only one category, there is a wide variability in its background. This is a tough one—if you write to the lowest common denominator of reader, you're likely to end up with a cumbersome, tedious book-like thing that will turn off the majority of readers. But if you don't write to that lowest level, you lose that segment of your readers. What to do? Most writers go for the majority of readers and sacrifice that minority that needs more help. Others put the supplemental information in appendixes or insert cross-references to beginners' books.

**Sexy Technical Communication Home**

**Audience Adaptation**

Okay! So you've analyzed your audience until you know them better than you know yourself. What good is it? How do you use this information? How do you keep from writing something that will still be incomprehensible or useless to your readers?

The business of writing to your audience may have a lot to do with in-born talent, intuition, and even mystery. But there are some controls you can use to have a better chance to connect with your readers. The following "controls" have mostly to do with making technical information more understandable for nonspecialist audiences:

- **Add information readers need to understand your document.** Check to see whether certain key information is missing—for example, a critical series of steps from a set of instructions, important background that helps beginners understand the main discussion, or definition of key terms.

- **Omit information your readers do not need.** Unnecessary information can also confuse and frustrate readers—after all, it's there so they feel obligated to read it. For example, you can probably chop theoretical discussion from basic instructions.

- **Change the level of the information you currently have.** You may have the right information but it may be "pitched" at too high or too low a technical level. It may be pitched at the wrong kind of audience—for example, at an expert audience rather than a technician audience. This happens most often when product-design notes are passed off as instructions.

- **Add examples to help readers understand.** Examples are one of the most powerful ways to connect with audiences, particularly in instructions. Even in noninstructional text, for example, when you are trying to
explain a technical concept, examples are a major help—analogy in particular.

- **Change the level of your examples.** You may be using examples but the technical content or level may not be appropriate to your readers. Homespun examples may not be useful to experts; highly technical ones may totally miss your nonspecialist readers.

- **Change the organization of your information.** Sometimes, you can have all the right information but arrange it in the wrong way. For example, there can be too much (or too little) background information up front such that certain readers get lost. Sometimes, background information needs to be consolidated into the main information—for example, in instructions it’s sometimes better to feed in chunks of background at the points where they are immediately needed.

- **Strengthen transitions.** It may be difficult for readers, particularly nonspecialists, to see the connections between the main sections of your report, between individual paragraphs, and sometimes even between individual sentences. You can make these connections much clearer by adding transition words and by echoing key words more accurately. Words like "therefore," "for example," "however" are transition words—they indicate the logic connecting the previous thought to the upcoming thought. You can also strengthen transitions by carefully echoing the same key words. In technical prose, it’s not a good idea to vary word choice—use the same words so that people don’t get any more confused than they may already be.

- **Write stronger introductions**—both for the whole document and for major sections. People seem to read with more confidence and understanding when they have the "big picture"—a view of what’s coming, and how it relates to what they’ve just read. Therefore, make sure you have a strong introduction to the entire document—one that makes clear the topic, purpose, audience, and contents of that document. And for each major section within your document, use mini-introductions that indicate at least the topic of the section and give an overview of the subtopics to be covered in that section.

- **Create topic sentences for paragraphs and paragraph groups.** It can help readers immensely to give them an idea of the topic and purpose of a section (a group of paragraphs) and in particular to give them an overview of the subtopics about to be covered. Roadmaps help when you’re in a different state!

- **Change sentence style and length.** How you write—down at the individual sentence level—can make a big difference too. In instructions, for example, using imperative voice and "you" phrasing is vastly more understandable than the passive voice or third-personal phrasing. For some reason, personalizing your writing style and making it more relaxed and informal can make it more accessible and understandable. Passive, person-less writing is harder to read—put people and action in your writing. Similarly, go for active verbs as opposed to being verb phrasing. All of this makes your writing more direct and immediate—readers don’t have to dig for it. And obviously, sentence length matters as well. An average of somewhere between 15 and 25 words per sentence is about right; sentences over 30 words are to be mistrusted.

- **Work on sentence clarity and economy.** This is closely related to the previous "control" but deserves its own spot. Often, writing style can be so wordy that it is hard or frustrating to read. When you revise your rough drafts, put them on a diet—go through a draft line by line trying to reduce the overall word, page, or line count by 20 percent. Try it as an experiment and see how you do. You’ll find a lot of fussy, unnecessary detail and inflated phrasing you can chop out.

- **Use more or different graphics.** For nonspecialist audiences, you may want to use more graphics—and simpler ones at that. Graphics for specialists are more detailed, more technical. In technical documents for nonspecialists, there also tend to be more "decorative" graphics—ones that are attractive but serve no strict informative or persuasive purpose at all.

- **Break text up or consolidate text into meaningful, usable chunks.** For nonspecialist readers, you may need to have shorter paragraphs. Maybe a 6- to 8-line paragraph is the usual maximum. Notice how much longer paragraphs are in technical documents written for specialists.

- **Add cross-references to important information.** In technical information, you can help nonspecialist readers by pointing them to background sources. If you can’t fully explain a topic on the spot, point to a section or chapter where it is.

- **Use headings and lists.** Readers can be intimidated by big dense paragraphs of writing, uncut by anything other than a blank line now and then. Search your rough drafts for ways to incorporate headings—look for...
changes in topic or subtopic. Search your writing for listings of things—these can be made into vertical lists. Look for paired listings such as terms and their definitions—these can be made into two-column lists. Of course, be careful not to force this special formatting—don’t overdo it.

- **Use special typography, and work with margins, line length, line spacing, type size, and type style.** For nonspecialist readers, you can do things like making the lines shorter (bringing in the margins), using larger type sizes, and other such tactics. Certain type styles are believed to be friendlier and more readable than others. (Try to find someone involved with publishing to get some insights on fonts.)

These are the kinds of “controls” that professional technical writers use to finetune their work and make it as readily understandable as possible. And in contrast, it’s the accumulation of lots of problems in these areas—even seemingly trivial ones—that add up to a document being difficult to read and understand. Nonprofessionals often question why professional writers and editors insist on bothering with such seemingly picky, trivial, petty details in writing—but they all add up! It reminds me of the ancient Chinese execution method called "death by a thousand cuts." However, in this case, it would be "perplexity by a thousand minor problems."
Task Analysis and Task-Oriented Documentation

When you write instructions, procedures, and "guide" or user-guide information (generally called documentation), you normally must use a task approach. That means providing steps and explanations for all the major tasks that users may need to perform.

Of course, some instructions involve only one task—for example, changing the oil in a car. But we are concerned here with more complex procedures. While this chapter uses computer software as an example, these techniques can apply to any multi-task procedure—for example, operating a microwave oven.

Chapter Objectives

At the end of this chapter, students will be able to

1. Define documentation
2. Identify and analyze tasks in order to create documentation
3. Differentiate between function and task orientation and explain the pros and cons of each approach
4. Explain how to begin writing documentation

Identifying Tasks

To write in a task-oriented manner, you first have to do some task analysis. That means studying how users use the product or do the task, interviewing them, and watching them. It can also mean interviewing marketing and product development people. If you can get your hands on the kinds of questions that help-desk people receive, that helps too.

But sometimes, you may not be in a position to do a thorough task analysis. Typically, product developers don't think about documentation until rather late. In these circumstances, it's often difficult to get marketing, development, engineering, and programming people to spend enough time with you to explain the product thoroughly. And so you end up doing a certain amount of educated guesswork. The developer is more likely to review your draft and let you know if your guesswork is right.

To develop your own task analysis, you can study the user interface (buttons, menus, options, etc.) of the product. This process goes for both hardware and software. Consider the interface for an icon editing tool shown below:
From just this snippet of the interface, you can identify several obvious tasks:

- Start a new icon project
- Open an existing icon project for editing
- Rename an icon project (Save As)
- Exit AZ Icon Edit

Now, look at the menu options for the next parts of the menu. You can see that when people are using this icon editor, they'll also most likely be doing these tasks:
• Undo a mistake
• Capture an image or some part of it
• Cut something out of an icon project
• Copy something out of an icon project
• Paste something into an icon project
• Flip the entire image horizontally or vertically
• Rotate the image left
• Clear the project, which probably means start over
• Restore, which you'll have to ask around, experiment with, or dig into the programming spec to find out about
• Draw with a thick, medium, or thin line.

But now look at the interface without the menu options hanging down. What additional tasks can you see? As with a lot of graphical user interfaces, some of the icons duplicate the menu options. For example, the bulleted-list icon enables you to select a thin, medium, or thick line the same way clicking on Options does. However, there are some new tools here, not available elsewhere in the interface:

• Draw straight lines (you'll have to experiment to see the difference between the two pencil icons)
• Draw freehand lines (the wavy-line icon)
• Draw unfilled rectangles (sharp edges) and unfilled rectangles (rounded edges)
• Draw unfilled ovals and filled ovals
• Fill with color (the hypodermic needle)
• Select portions of the image to move, cut, or rotate (the dotted-line icon)
• Capture images—or parts of images—(the net, but how does it work?)
• Draw filled rectangles (sharp edges) and filled rectangles (rounded edges)
• Select background color (the Screen button)
• Select line or fill color (the double-box icon)

There's a lot you still don't know about this software, but you've already done a lot of guesswork toward defining the major tasks. You'd want to group and consolidate things much more tightly than above, perhaps like the following:

• Creating, editing, renaming, and saving icons
• Selecting foreground and background color
• Drawing lines, rectangles, and ovals
• Cutting, pasting, and copying objects
• Moving, flipping, and rotating objects

You can see that in this rough task list, there is no trace of tasks such as filling an object with color, capturing images, clearing the workspace, undoing a mistake, or restoring. But as you work, these details will begin to find their place in your scheme. Now, stand back from the details of the interface and put yourself in the place of an icon software user. What questions is that individual likely to ask? How do I change the color of the background? We've got that covered. How do I change the thickness of the lines I draw? Got that one covered too. How do I make the background transparent? Hmmm . . . that will be an issue for the color section, but it will take some research.

Different Approaches to Documentation

When you write for users, you have a choice of two approaches, function orientation and task orientation, the latter of which is by far the better choice. A function orientation lists buttons or icons and then lets readers know what the function of each item is. For example, "The save button allows you to save your project for later use." This information is helpful for a user (although probably most users know what the save button does). While it is helpful to quickly list major buttons and what they do, it's not sufficient to help readers truly use the software or appliance. Task-oriented documentation, created for specific goals that you anticipate users will want to achieve (such as, "Capturing Images") allows users to begin using the product quickly and achieving their goals satisfactorily (which hopefully leads to a high level of satisfaction with the product and your documentation).

Writing with a function orientation.

It ought to be obvious how to proceed after a task analysis, but apparently not. Computer publications—if not technical publications in general—often seem to stray into a non-task-oriented style of writing. But, no! That just doesn't work!

Another reason why some user guide instructions are not task oriented can be blamed on product specifications. Product specifications, which are written by and for programmers, engineers, developers, are written in terms of required function:

| File menu button | Enables user to create a new file, open an existing file, rename a file, etc. |
| Crop icon        | Enables user to cut selected segment of image. |

You might call this approach function-oriented writing because it systematically explains each function, feature, or interface element of a product. Unfortunately, this approach shows up in user guides meant for nontechnical readers—perhaps because the writers are inexperienced, untrained, or untechnical; or else the writers have been called in too late to do much else but polish the developers' spec.

The function-oriented approach almost works sometimes. But "almost" and "sometimes" are not good enough. It almost works because the names of interface elements and functions sometimes match the tasks they support. For example, the Open menu option is pretty intuitive: open an existing file. Others are not. For example, what do you suppose is restored by the Restore button in the AZ Icon Edit interface? Also, some interface elements don't accomplish tasks all by themselves. In Photoshop, for example, you can't crop text by pressing the Crop menu option. You have to first click the text-selection button, then draw a selection box around the part of the image you want to keep, then press the Crop button.

Writing with a task orientation.

Instead of the function-oriented approach, use the task-oriented approach. Identify the tasks users will need to perform with the product, and then structure your document accordingly. Make your headings and subheadings task oriented in their phrasing. Task-oriented phrasing means phrasing like "How to adjust the volume," "Adjusting the volume," or "Adjust the volume." It does not mean phrasing like "Volume" or "Volume Adjustment." Here are some additional examples:
<table>
<thead>
<tr>
<th>Problem phrasing</th>
<th>Task-oriented phrasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture</td>
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<tr>
<td>Screen button</td>
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<tr>
<td>Rectangles</td>
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<tr>
<td>Oval icon</td>
<td>Drawing ovals and circles</td>
</tr>
</tbody>
</table>

When you have defined user tasks, organized them into logical groups, and have defined task-oriented headings, you're ready to write! Here's an excerpt:

**Drawing Rectangles and Ovals** You can use the icon editor to draw squares, rectangles, ovals, and circles. **Draw a rectangle.** To draw a rectangle:

1. Ensure that you have selected the foreground color you want. (See "Selecting foreground color.")
2. Click the rectangle icon.
3. Position the mouse pointer in the drawing area where you want the rectangle to appear, hold down the left mouse button, and drag to create the rectangle.

**Draw an oval.** To draw an oval:

1. Ensure that . . .

In this excerpt, you can see that an overall task-oriented approach is taken and that task-oriented phrasing is used for the headings (Drawing). Notice too that numbered lists are used to guide readers step by step through the actions involved in the task.

Click here to view sample documentation on creating checklists with Desire2Learn (D2L). D2L is a learning management system that university faculty might use to share class materials with students. The checklist function helps university faculty to let students know what tasks need to be completed within a course module or unit of time.
Articulating Technical Discussions

The ability to explain complex, technical matters with ease, grace, and simplicity so that nonspecialist readers understand almost effortlessly is one of the most important skills you can develop as a technical writer. This ability to "translate" or articulate difficult-to-read technical discussions is important because so much of technical writing is aimed at nonspecialist audiences. These audiences include important people such as supervisors, executives, investors, financial officers, government officials, and, of course, customers.

This chapter provides you with some strategies for articulating technical discussions, that is, specific strategies you can use to make difficult technical discussions easier for nonspecialist readers to understand.

You use your understanding of your audience to decide

- What information to include in the document
- What information to exclude from the document
- How to discuss the information you do include in the document

Articulating is particularly important because it means supplying the right kinds of information to make up for the reader's lack of knowledge or capability. Articulating thus enables readers to understand and use your document. Some combination of the techniques discussed in this chapter should help you create a readable, understandable translation:

<table>
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<tr>
<th>Defining unfamiliar terms</th>
<th>The &quot;in-other-words&quot; technique</th>
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<tbody>
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This list by no means exhausts the possibilities. Other techniques include:

- **Headings.** See the section on using headings that break up text and emphasize points and on how to construct headings that guide readers from section to section.
- **Lists.** See the section on constructing lists that break up text and emphasize points and on how to construct headings that guide readers from section to section.

*Note to readers*: Move your mouse pointer over the highlighted words in the following examples to see discussion.

**Definitions of unfamiliar terms**

Defining potentially unfamiliar terms in a report is one of the most important ways to make up for readers' lack of knowledge in the report subject.

**Facial Characteristics of FAS** Taken as a whole, the face of patients with fetal alcohol syndrome (FAS), is very distinctive. Structural deficiencies are thought to be the result of reduced cellular proliferation in the developing stages of the embryo because of the direct action of the alcohol. The face has a drawn-out appearance with characteristics that include short palpebral fissures, epicanthic folds, low nasal bridge, a short upturned nose, indistinct philtrum, small midface, and a thinned upper vermilion.
Comparisons to familiar things

Comparing technical concepts to ordinary and familiar things in our daily lives makes them easier to understand. For example, things in the world of electronics and computer—a downright intimidating area for many people—can be compared to channels of water, the five senses of the human body, gates and pathways, or other common things. Notice how comparison (highlighted) is used in these passages:

The helical configuration of the DNA strands is not haphazard. The nitrogen bases on each strand align themselves to form nitrogen base pairs. The pairs are T-A and C-G. Each pair is held together by hydrogen bonds. The pairing of the bases serves to fasten the two helical nucleotide strands together much the same way as the teeth of a zipper hold the zipper together. The existence of the complementary base pairs explain the constant ratios of T/A and C/G. For every T there must be a complementary A and for every G there must be a complementary C.


All the death and all the misery from a virus so small that 2-1/2 million of them in a line would take up one inch. Flu viruses fall into three types: A, B, and C. Type A, the most variable, causes pandemics as well as regular seasonal outbreaks; type B causes smaller outbreaks and is just now receiving greater attention; type...
C rarely causes serious health problems. In appearance, a flu virus somewhat resembles the medieval mace—a ball of iron studded with spikes. Hemagglutinin is the substance that in effect bashes into a cell during infection and allows the virus access to the cell interior where it can replicate.


Comparison used for articulation

Elaborating the process

Explaining in detail the processes involved in the report subject can also help readers. Consider a paragraph like this one, containing only a sketchy reference to the process:

The Video Alert and Control dashboard system, a newly developed system to help drivers avoid accidents, graphically projects an image of hazards in the road.

This brief reference can be converted into a more complete explanation as is illustrated here:

The Video Alert and Control dashboard systems uses a number of components to help drivers avoid accidents. The infrared detector is the key detecting device in that it searches for warm objects in or near the path ahead of the car. The infrared detector senses the upcoming trouble well before the driver by sensing warm-bloodedness and then alerts the driver. The infrared detector also senses the heat of oncoming traffic. All of these objects are shown graphically on the video screen. To differentiate wildlife from other cars, the x-ray unit is used to check for metal in the object ahead. Thus, if a warm object is detected with metal in it, the computer reads it as a car and shows it on the screen as a yellow dot. On other hand, if no metal is detected in the warm object, it is read as an animal and plotted as a red dot....

Providing descriptive detail

Descriptions also help nonspecialist readers by making the report discussion more concrete and down-to-earth:

Jarvik and his colleagues have been working on other designs, such as a portable artificial heart, which they think will be ready for a patient within the next two years. **Electrohydraulic Heart** Jarvik has been developing electric-energy converters and blood pumps during the past year. The electrohydraulic energy converter has only one moving part. The impeller of an axial-flow pump is attached to the rotor of a brushless direct-current motor, with the impeller and the rotor supported by a single hydrodynamic bearing. Reversing the rotation of the pump reverses the direction of the hydraulic flow. The hydraulic fluid (silicone oil of low viscosity) actuates the diaphragm of a blood pump just as compressed air does in the Jarvik-7 heart design. This hydraulic fluid is pumped back and forth between the right and left ventricles. The energy converter is small and simple and therefore can be implanted without damaging vital structures. It weighs nearly 85 grams and occupies nearly 30 cubic centimeters. The converter
requires an external battery and an electronics package, which is connected to
the heart by a small cable through the patient's chest. The batteries weigh 2 to 5
pounds and can be worn on a vest or belt. The battery unit requires new or
recharged batteries once or twice a day. The cable through which the power is
transmitted from the battery to the heart also carries control signals from the

microcomputer controller.

Figure 12. Electrically driven artificial heart system. Source: Jarvik, Robert K.
R. Mudd, *Report on Artificial Methods of Combating Heart Disease*, University of
Texas at Austin, May 6, 1983.

*Description used to articulate technical discussion*

**Providing illustrations**

Illustrations—typically, simple diagrams—can help readers understand technical descriptions and explanations of processes. You
can see the use of illustration in the FAS example above: epicanthic folds and the philtrum are defined under the diagram.

**Providing examples and applications**

Equally useful in articulating complex or abstract technical discussions are examples or explanations of how a thing can be used.
For example, if you are trying to explain a LINUX command, showing how it is used in an example program helps readers greatly. If
you are explaining a new design for a solar heating and cooling system, showing its application in a specific home can help also.

**Continuous Speech**

Continuous speech causes many problems in computerized
speech recognition. For example, for examples such as "plea" and "please," while
some words have similar acoustics, such as "what" and "watt."

Heidi E. Cootes, *Report on Computers that Recognize Speech*, University of Texas at
Austin, May 6, 1983.

**Articulation with examples**

Now here is a passage with a longer, extended example:
...The user "scrolls" the worksheet right and left or up and down to bring different parts of it into view. Each position (that is, each intersection of a column and a row) on a screen corresponds to a record in memory. The user sets up his own matrix by assigning to each record either a label, an item of data or a formula; the corresponding position on the screen displays the assigned the label, the entered datum or the result of applying the formula. Consider a simple example.


Discussion of applications used to articulate technical discussion

Sexy Technical Communication Home

Shorter sentences and paragraphs

As simple a technique as it may seem, reducing the length of sentences can make a technical discussion easier to understand. Consider the following pairs of example passages, the second versions of which contain shorter sentences. (The passage still needs other translating techniques, particularly definitions, but the shorter sentences do make it more readable.) Notice, too, that shorter paragraphs can help in the articulating process, not only in the example below but throughout this chapter.

Original version: longer sentences

UV-fluorescence was determined on aliquots of the hexane extracts of subsurface water using the Perkin-Elmer MPF-44A dual-scanning fluorescence spectrophotometer upon mousse sample NOAA-16, considered the best representative of cargo oil. Every day that samples were processed, a new calibration curve was developed from serial dilutions of the reference mousse (NOAA-16) at an emission wavelength of ca. 360 nm, and other samples were compared to it as the standard. Emission was scanned from 275-500 nm, offset 25 nm from the excitation wavelength, with the major peak occurring at 360 nm for the reference mousse solutions. In each sample, the concentration of fluorescent material, a total oil estimate, was calculated from its respective fluorescence, using the linear relationship of fluorescence vs. concentration of the reference mousse "standard," with a correction factor applied to account for the reference mousse containing only about 30 percent.

Revised version: shorter sentences

UV-fluorescence was determined on aliquots of the hexane extracts of the subsurface water. These measurements were performed using a Perkin-Elmer MPF-44A dual-scanning fluorescence spectrophotometer. Mousse sample NOAA-16 was used as the best representative of cargo sample. Other samples were compared to it as the standard. Every day that samples were processed, a new calibration curve was developed from serial dilutions of the reference mousse (NOAA-16). Tests were run at an emission wavelength of ca. 360 nm. Emission was scanned from 275-500 nm, offset 25 nm from the excitation wavelength. The major peak occurred at 360 nm for the reference mousse solutions. In each sample, the concentration of fluorescent material, a total estimate, was calculated from its respective fluorescence. The linear relationship of fluorescence vs. concentration of the reference mousse "standard." A correction factor was applied to account for the reference mousse containing only about 30 percent oil.

Stronger Transitions and Overviews

Transitions and overviews guide readers through text. In difficult technical material, transitions and overviews are important. (For in-depth discussion, see transitions.)
• **Repetition of key words.** As unlikely as it may seem, using the same words for same ideas is a critical technique for comprehension in technical discussions. In other words, don't refer to the hard drive as a "fixed-disk drive" one place and as "DASD" (an old IBM term meaning direct access stationary drive) in another. Same goes for verbs: stick with either "boot up" or "system reset," and don't vary.

• **Arrangement of key words.** Equally important is how you introduce keywords in sentences. If your focus stays on the topic in each sentence of a paragraph, place the keyword at or near the beginning of the second and following sentences. However, if the topic focus shifts from one sentence to the next, use the old-to-new pattern: start the following sentence with the old topic and end the sentence with the new topic.

• **Transition words and phrases.** Examples of transition words and phrases are "for example," "however," and so on. When the discussion is particularly difficult and when repetition and arrangement of keywords is not enough, use transition words and phrases.

• **Reviews of topics covered and topics to be covered.** At certain critical moments within and between paragraph (or groups of paragraphs) occurs a transitional device that either captures what has been discussed in a short phrase, previews what is to be discussed in the following paragraphs, or both. The latter device is also called a topic sentence.

**Sexy Technical Communication Home**

### The "in-other-words" Technique

In technical writing, you occasionally see questions posed to the readers. Such questions are not there for readers to answer; they are meant to stimulate readers' curiosity, renew their interest, introduce a new section of the discussion, or allow for a pause:

---

When an animal runs, its legs swing back and forth through large angles to provide balance and forward drive. We have found that such swinging motions of the leg do not have to be explicitly programmed for a machine but are a natural outcome of the interactions between the controllers for balance and attitude. Suppose the vehicle is traveling at a constant horizontal rate and is landing with its body upright. What must the attitude controller do during the stance to maintain the upright attitude? It must make sure that no torques are generated at the hip. Since the foot is fixed on the ground during stance, the leg must sweep back through an angle in order to guarantee that the torque on the hip will be zero while the body moves forward.

On the other hand, what must the balance servo do during flight to maintain balance? Since the foot must spend about as much time in front of the vehicle's center of gravity as behind it, the rate of travel and the duration of stance dictate a forward foot position for landing that will place the foot in a suitable spot for the next stance period. Thus during each flight the leg must swing forward under the direction of the balance servo, and during each stance it must sweep backward under the control of the attitude servo; the forward and back sweeping motions required for running are obtained automatically from the interplay of the servo-control loops for balance and attitude.
Explaining the Importance

Some translating articulating work because they motivate readers. Sometimes readers need to be talked into concentrating on difficult technical discussion: one way is to explain to them or to remind them of the importance of what is being discussed. In this example, the last paragraph emphasizes the importance:

It was Linus Pauling and his coworkers who discovered that sickle cell anemia was a molecular disease. This disease affects a very high percentage of black Africans, as high as 40 percent in some regions. About 9 percent of black Americans are heterozygous for the gene that causes the disease. People who are heterozygous for sickle cell anemia contain one normal gene and one sickle cell gene. Since neither gene in this case is dominant, half the hemoglobin molecules will be normal and half sickled. The characteristic feature of this disease is a sickling of the normally round, or platelike, red blood cells under conditions of slight oxygen deprivation. The sickled red blood cells clog small blood vessels and capillaries. The body’s response is to send out white blood cells to destroy the sickled red blood cells, thus causing a shortage of red blood cells, or anemia. The sickle cell gene originated from a mistake in information. A DNA molecule somehow misplaced a base, which in turn caused an RNA molecule to direct the cell to make hemoglobin with just one different amino acid unit among the nearly 600 normally constituting a hemoglobin molecule. So finely tuned is the human organism that this tiny difference is enough to cause death. Since the disease is nearly always fatal before puberty, how can a gene for a fatal childhood disease get so widespread in a population? The answer to this question gives some fascinating insight into the mechanism and purposes of evolution, or natural selection. The distribution of sickle cell anemia very closely parallels the distribution of a particularly deadly malaria-causing protozoan by the name of Plasmodium falciparum, and it turns out that there is a close connection between sickle cell anemia and malaria. Those people who are heterozygous for the sickle cell gene are relatively immune to malaria and, except under reasonably severe oxygen deprivation such as that found at high altitudes, they experience no noticeable effects due to the sickle cell gene they carry. Half the hemoglobin molecules in the red cells of heterozygous people are normal and half are sickled. Thus, under ordinary circumstances the normal hemoglobin carries on the usual respiratory functions of blood cells and there is little discomfort. On the other hand, the sickled hemoglobin molecules precipitate, in effect, when the malaria-causing protozoan enters the blood. The precipitated hemoglobin seems to crush the malaria protozoan, thus keeping the malaria from being fatal. The significance of all this should be pondered.

Explaining the importance as a way of articulating technical discussions

Providing Historical Background

Discussion of the historical background of a technical subject helps readers because it gives them less technical, more general, and sometimes more familiar information. It gives them a base of understanding from which to launch into the more difficult sections of the discussion:

Now that alcohol is being used in more and more social settings, it extremely important to recognize its teratogenic effects. Teratogenic, or malforming, agents produce an abnormal presence or absence of a substance that is required in physical development. Although Sullivan first reported on the effects of maternal drinking during pregnancy in 1899, the serious implications of his findings were virtually ignored for the next 50 years. It was not until the dramatic identification of a pattern of malformations, termed the fetal alcohol syndrome (FAS) by Jones et al in 1973, that the scientific community acknowledged the potential dangers of heavy maternal alcohol use. Since then, there has been increasing recognition that alcohol may be the most common drug in causing problems of malformations in humans.

Each morning in the soft, coral flush of daybreak, a laser dawns on Mars. Forty miles above frigid deserts of red stone and dust, it flares in an atmosphere of carbon dioxide. Infrared sunlight kindles in this gas a self-intensifying radiance that continuously generates as much energy as a thousand nuclear reactors. Our eyes are blind to it, but from sunrise to sunset Mars bathes in dazzling lasershine. The red planet may have lased in the sun for eons before astronomers identified its sky-high natural laser in 1980. The wonder is that its existence was unknown for so long. In 1898, in The War of the Worlds, H.G. Wells scourged earth with Martian invaders and a laserlike death ray. Pitiless, this "ghost of a beam of light" blasted brick, fired trees, and pierced iron as if it were paper.

In 1917 Albert Einstein speculated that under certain conditions atoms or molecules could absorb light or other radiation and then be stimulated to shed their borrowed energy. In the 1950s Soviet and American physicists independently theorized how this borrowed energy could be multiplied and repaid with prodigious interest. In 1960 Theodore H. Maiman invested the glare of a flash lamp in a rod of synthetic ruby; from that first laser on earth he extorted a burst of crimson light so brilliant it outshone the sun.


Reviewing Theoretical Background

To understand some phenomena, technologies, or their applications, readers must first understand the principle or theory behind them. Theoretical discussions need not be over the heads of nonspecialist readers. Discussion of theory is often little more than explanation of the root causes and effects at work in a phenomenon or mechanism. In this example, the writer establishes the theory and then can go on to discuss the findings that have come about through the use of NMR on living tissue.

To the extent that objections persist about the validity of modern biochemistry, they continue to be about reducing the processes of life to sequences of chemical reactions. "The reactions may take place in the test tube," one hears, "but do they really happen that way inside the living cell? And what happens in multicellular organisms?" One technique is beginning to answer these questions by detecting chemical reactions as they occur inside cells, tissues and organisms including those of human beings. The technique is nuclear-magnetic-resonance (NMR) spectroscopy. It relies on the fact that atomic nuclei with an odd number of nucleons (protons and neutrons) have an intrinsic magnetism that makes each such nucleus a magnetic dipole: in essence a bar magnet. Such nuclei include the proton (H-1), which is the nucleus of 99.98 percent of all hydrogen atoms occurring in nature, the carbon-13 nucleus (C-13), which is the nucleus of 1.1 percent of all carbon atoms, and the phosphorus-31 nucleus (P-31), which is the nucleus of all phosphorus atoms.

Theoretical background as an articulation technique

Sexy Technical Communication Home
Combining the Articulating Techniques

This last section concludes the techniques for articulating difficult technical prose to be presented here. However, take a look at writing in fields you know about, and look for other kinds of articulating techniques used there. Now, here are several extended passages of technical writing that combine several of these strategies.

**Fine-tuning the spectrum** To know lasers, one must first know the electromagnetic spectrum, which ranges from long radio waves to short, powerful gamma rays. The narrow band of the spectrum we know as visible, or white, light is made up of red, orange, yellow, green, blue, and violet light. These frequencies, as well as all radiation waves, are jumbled or diffused, much as noise is a collection of overlapping, interfering sounds. Laser light is organized and concentrated, like a single, clear musical note. In lasers, nature’s disorder is given coherence, and photons—the basic units of all radiation—are sent out in regular ranks of one frequency. Because the waves coincide, the photons enhance one another, increasing their power to pass on energy and information. The first devices to emit concentrated radiation operated in the low-energy microwave frequencies. Today, laser technology is extending beyond ultraviolet toward the high-energy realms of X-rays. Each wavelength boasts its own capacities as a tool for man. A laser’s beam can be modulated into an infinite number of wavelengths using fluorescent dyes like those produced at Exciton Chemical Company in Ohio. At Hughes Research Laboratories in California, a blue-green laser reflected at an acute angle anneals silicon microchips, while a low-energy red laser monitors the process.

**Harnessing light** As a bow stores energy and releases it to drive an arrow so lasers store energy in atoms and molecules, concentrate it, and release it in powerful waves. When an atom expands the orbits of its electrons, they instantly snap back, shedding energy in the form of a photon. When a molecule vibrates or changes its geometry, it also snaps back to emit a photon. In most lasers a medium of crystal, gas, or liquid is energized by high-intensity light, an electric discharge, or even nuclear radiation. When a photon reaches an atom, the energy exchange stimulates the emission of another photon in the same wavelength and direction, and so on, until a cascade of growing energy sweeps through the medium. The photons travel the length of the laser and bounce off mirrors—one a full mirror, one partially silvered—at either end. Photons, reflected back and forth, finally gain so much energy that they exit the partially silvered end, emerging as powerful beam. **Out of the darkness: laser eye surgery** Sight-saving shafts of light able to enter the eye without injuring it, lasers are revolutionizing eye surgery. Using techniques of New York ophthalmologist Frances L’Esperance, eye surgeons employ four levels of laser energy. Exposure time ranges from 30 minutes for low-energy photoradiation to several billionths of a second for photodisruption. With microscopic focus, beams weld breaks in the retina or seal leaking blood vessels by photocoagulation. A painless 20-minute operation calls an iridectomy relieves this excess fluid buildup of glaucoma. When an artificial lens is placed behind the iris, the supportive membrane often grows milky. A laser beam is pinpointed on the taut tissue in a series of minute explosions. This photodisruption causes the tissue to unzip and part like a curtain. Bloodless scalpels, lasers can make extremely delicate incisions, cauterize blood vessels, and leave tissue unaffected only a few cell widths away. **Beams that heal** Surgical trauma, the jarring aftermath of the surgeon’s knife, may one day be consigned to the annals of primitive medicine—thanks to a procedure called “least invasive surgery” by its growing number of practitioners. Using an endoscope, surgeons can view the interior of the body and operate with the least amount of damage. An end view of the flexible tube ... shows a large optical fiber to light the way. Smaller openings facilitate fluid suction and gas suction. A forceps, controlled by a cable near the microscope viewing lens, extracts tissue for analysis. A laser, controlled by dials to the left of the eyepiece, streams from another tube, ready to perform wherever the doctor directs it. Twisting and probing the end of the scope, he can identify and coagulate a bleeding ulcer in the stomach or blast tumors in the esophagus. The beam is fed through the scope by an optical fiber from a laser machine ... that might cost the hospital from $20,000 to $150,000.

Power-Revision Techniques

The linked chapters here cover some of the most important aspects of writing—what's more important than the information you put in a document, how you organize it, how you link it all up together?

When you look at all these powerful ways you can review (look for potential problems) and then revise (fix those problems), you might think they're tedious and time-consuming. They do take some time, but don't worry...this stuff becomes second nature rather quickly. If you spend some time analyzing writing in the ways outlined in this chapter, the way you write and the way you review what you write will change. You'll start operating—even if you don't consciously realize it—with these ideas in mind.

This chapter covers two major categories of problems you can revise: **structure-level problems** and **sentence-level problems**.

The section on **structure-level problems** includes tips for checking your documents’

- informational value
- internal organization
- topic sentences and overviews
- transitions
- paragraph lengths

The section on **sentence-level problems** includes tips for how to revise

- nominalizations
- noun stacks
- redundant phrasing
- expletives
- weak use of passive voice verbs
- subject-verb mismatches
- readability, sentence lengths, and sentence structures

Power-Revision Techniques: Structure-Level Problems

Informational Value

One of the most important ways you can review a rough draft is to check its contents for informational value. All the good transitions, good organization, and clear sentence structure in the world can't help a technical document that doesn't have the right information for its audience.

- **Information is missing.** For example, imagine that somebody wrote a technical report on "virtual communities" but never bothered to define what "virtual community" means. The reader would be utterly lost.

- **Information is there, but not enough.** Take the same example, and imagine that the writer only made a few vague statements about virtual communities. The reader (unless she is an expert on virtual communities) needed at least a paragraph on the subject, if not a full-blown three- or four-page section.

- **Information is there, but at the wrong level for the audience.** Imagine that the report's writer included a two-page explanation of virtual communities but included highly technical information and phrased it in
If you can get a sense of how information does or doesn't match your audience, you should be well on your way to knowing what specifically to do to revise. One useful brainstorming tool is to think in terms of types of content.

**Internal Organization**

If you have the necessary and audience-appropriate information in a technical document, you're on the right track. However, that information may still not be sufficiently organized—like when you've just moved and everything is a mess or still in boxes—and you need to consider the rough draft's internal organization. Always consider these two aspects of internal organization, on both an individual-paragraph and whole-document level:

- the levels of information
- the sequence of information

**Levels of Information**

Some paragraphs and sentences contain general information or broader statements about the topic being discussed. Others contain more specific information, or go into greater depth. The first elements form a "framework" that supports the second, "subordinate" elements.

When you revise, check if the document's framework is easy to follow. The most common and effective way to arrange general and specific information is to introduce the framework first, then follow it with specifics. This overarching pattern holds for sentences inside paragraphs and paragraphs inside longer documents, even if the paragraph or document uses a different sequence of information.

**Sequence of Information**

Match a technical document's internal sequence of information to the document's audience, context, and purpose. Here are some examples of common informational sequences:

- **General → specific.** Arrange chunks of information from general to specific. For example, defining *all* solar collectors is a more general discussion than discussing the different types of solar collectors. And describing the operation of a specific type of solar collector is even less general. This pattern is illustrated here:
## Problem version

There are various types of solar collectors; however the flat-plate solar collector is currently the most common and will be the focus of discussion here. The most important part of a solar heating system is the solar collector whose function is to heat circulating water necessary for space heating. A typical solar collector has layers of glass with intervening air spaces to produce a heat-trapping effect. Most solar collectors consist of a black absorber plate covered by one or more of these transparent cover plates made either of glass or plastic with the sides and the bottom of the collector insulated.

## Revised version

The most important part of a solar heating system is the solar collector whose function is to heat circulating water necessary for space heating. There are various types of solar collectors; however the flat-plate solar collector is currently the most common and will be the focus of discussion here. A typical flat-plate solar collector has layers of glass with intervening air spaces to produce a heat-trapping effect. Most solar collectors consist of a black absorber plate covered by one or more of these transparent cover plates made either of glass or plastic with the sides and the bottom of the collector insulated.

### Revision with the general-to-specific organizational pattern. Defining what all solar collectors do, then moving on to their different types, seems to be a more natural sequence.

- **simple → complex.** Begin with the simple, basic, fundamental concepts and then move on to the more complex and technical.

- **thing-at-rest → thing-in-motion.** Describe the thing (as if in a photograph), then discuss its operation or process (as if in a video).

- **spatial movement.** Describe a pattern of physical movement; for example, top to bottom, left to right, or outside to inside.

- **temporal movement.** Describe events in relation to what happens first, second, and so on.

- **concept → application of the concept / examples.** Discuss a concept in general terms, then discuss the concept's application and/or examples of the concept.

- **data → conclusions.** Present data (observations, experimental data, survey results) then move on to the conclusions that can be drawn from that data. (This pattern is sometimes reversed: present the conclusion first, then the data that supports it.)

- **problem / question → solution / answer.** Introduce a problem or raise a question, then move on to the solution or answer.

- **simplified version → detailed version.** Discuss a simplified version of the thing, establish a solid understanding of it, then explain it all again, but this time laying on the technical detail. (This approach is especially useful for explaining technical matters to nonspecialists.)

- **most important → least important.** Begin with the most important, eye-catching, dramatic information, and move on to information that is progressively less so. (This pattern can be reversed: you can build up to a climax, rather than start with it.)
• **strongest → weakest.** Start with the most strong argument for your position—to get everybody's attention—then move on to less and less strong ones. (This pattern can also be reversed: you can build up to your strongest arguments, but the weakest → strongest pattern is often less persuasive.)

These are just a few possibilities. Whichever sequence you choose, be consistent with it, and avoid mixing these approaches randomly. For example, presenting some data, stating a few conclusions, and then switching back and forth between data and conclusions haphazardly will only confuse your reader.

### Topic Sentences

One of the best structural revision techniques you can use is to backtrack through a rough draft and insert topic sentences at key points.

A topic sentence is a sentence occurring toward the beginning of a paragraph that in some way tips the reader off as to the focus, purpose, contents of that paragraph (and perhaps one or more paragraphs following). At its best, it focuses the reader's attention; it says, "Hey, here's what we're talking about!"

Often, when authors create technical documents, they don't consciously think about each paragraph's contents and logic; instead, authors focus on getting words onto the page, and they figure out what they mean while they're writing. Sometimes the results can seem disjointed. Accordingly, authors should go back and insert topic sentences that can help readers understand where they are going, what's coming up next, (often) where they've just been, and how what they are reading connects to the document as a whole.

### Types of Topic Sentences

Your best guide for deciding when to use topic sentences and which type to use is probably your own instincts and intuition. But here are some ideas and examples:

- **keyword topic sentence.** This type of topic sentence contains a keyword that hints about the content and organization of the upcoming material. Use one if your section (one or more paragraphs) discusses multiple similar things (for example, problems, solutions, causes, consequences, reasons, aspects, factors).

  During Samhain there are a number of activities the Celts took part in that resemble some customs we observe on Halloween today.

- **overview topic sentence.** This type of topic sentence names all the subtopics in the upcoming material. Use one if you want to specify all the subtopics you will address.

  Most brains exhibit a visible distinction between gray matter and white matter.

- **thesis-statement topic sentence.** This type of topic sentence makes an assertion—an argument—that the rest of paragraph must support. Use one if your section proves a point and includes multiple supporting statements.

  Although Babbage's machines were mechanical monsters, their basic architecture was astonishingly similar to a modern computer.

- **topic definition.** This type of topic sentence names the term being defined, identifies the class it belongs to, and describes its distinguishing characteristics. It must contain highly specific information. Use one if your section introduces an unfamiliar term.
Stress is a measure of the internal reaction between elementary particles of a material in resisting separation, compacting, or sliding that tend to be induced by external forces.

- **topic reference.** This type of topic sentence simply mentions the general subject at hand. It does not forecast what will be said about the subject. Use one to remind your reader about the general subject.

  *The surface of Mars is thought to be primarily composed of basalt, based upon the Martian meteorite collection and orbital observations.*

- **no topic sentence.** Sometimes, you may not need or want a topic sentence. If your materials contain a story that leads to a point, or are part of a popular-science or -technology writing project, a topic sentence up front may be heavy, stodgy, and inappropriate.

## Transitions

You may have audience-appropriate information in your technical document, and you may have organized that information well, but you also need to integrate those various pieces of information into a unified whole. If you don't make the document's "flow" of ideas clear, the document will read like a random assortment of ideas, and the reader will not understand how the chunks of information relate or connect to each other.

Use "transitions"—various devices that help readers connect the different sections of a document—to guide your reader from one idea to the next. You need to make clear the logic that connects every sentence in a document.

Here are some common types of transitional words and phrases:

- **additive.** Use these words to demonstrate that one idea is added to another. Examples include *moreover, as well as, too, in addition to, furthermore, also, additionally.*

- **narrative / chronological / temporal.** Use these words to demonstrate that one idea can follow, precede, or occur simultaneously with another. Examples include *then, next, after, before, since, subsequently, following, later, as soon as, as, when, while, during, until, once.*

- **contrastive / comparative.** Use these words to demonstrate differences or similarities. Examples include *but, on the other hand, unlike, as opposed to, than, although, though, instead, similarly.*

- **alternative.** Use these words to demonstrate that two ideas can act as alternatives or substitutes for each other. Examples include *either, or, nor, on the other hand, however, neither, otherwise.*

- **causal.** Use these words to demonstrate that one idea can be the cause or the result (effect, consequence, etc.) of another. Examples include *thus, then, unless, subsequently, therefore, because, consequently, as a result, if, in order to/that, for, so.*

- **illustrative.** Use these words to demonstrate that one idea can be an example or an illustration of another. Examples include *for example, for instance, to illustrate, as an example.*

- **repetitive / reiterative.** Use these words to rephrase an idea using other, perhaps more familiar, terms. Examples include *in other words, in short, that is, stated simply, to put it another way.*

- **spatial / physical.** Use these words to emphasize spatial relationships between things. Examples include *in other words, in short, that is, stated simply, to put it another way.*

Here are some more advanced types of transitions:
• **summary transitions.** Use a brief phrase (sometimes even a single word) to summarize the concepts in the preceding material. Then, in the same sentence, make a statement about that summary phrase, introduce the upcoming materials, and demonstrate their conceptual link. This technique is especially useful for establishing logical links between short sections.

In the following sample paragraph, the words in green summarize the concepts, and dark red words perform the other functions.

> The simplest semiconductor is called a diode. A diode serves as a rectifier to conduct alternating current (ac) to direct current (dc). While the usual current in the U.S. is ac with a frequency of 60 Hz, many electronic devices require dc for at least part of their function. The diode solves this mismatch of current types by its basic design in which a p- and an n-type semiconductor are joined together.

• **review-preview transitions.** Use a relatively short phrase or sentence to summarize the topic of the preceding material, use another relatively short phrase or sentence to summarize the upcoming material, and tie them together using transitional words.

In the following sample paragraph, the words in green summarize the previous ideas. The words in dark red summarize the following materials. The word in purple is the transitional word.

> Coring and core analysis techniques are adequate only to a certain extent, as the previous section shows. However, a much faster and less expensive method of detecting fractures is increasingly being used in exploratory wells: wire-line logging analysis.

**Paragraph length**

One last way to revise your rough draft at the structural level is to check for paragraph breaks.

Paragraphs are odd creatures—some scholars of writing believe they don't exist and are just arbitrary break points that writers toss in whenever and wherever they please. This idea may be true for creative or expressive writing, but in technical writing, the paragraph is a key player in the battle for clarity and comprehension. Insert paragraph breaks where there is some shift in topic or subtopic, or some shift in the way a topic is being discussed.

Here are some suggestions for paragraph length:

- If your technical document needs a great deal of expository writing and will be printed in hard copy, you can probably use relatively long paragraphs. A singlespaced page full of text will probably contain one to four paragraph breaks. (There’s nothing magical about that average, so don't treat it as if it were law.)
- If your technical document does not require long blocks of text, consider breaking it up into short paragraphs. Three sentences per paragraph is a widely accepted average.
- If your technical document will be posted online, use short paragraphs. People generally find it easier to read short paragraphs online than to read long paragraphs online.

In any case, look at long blocks of text and think about breaking them up into bite-sized chunks.

**Sexy Technical Communication Home**

**Power-Revision Techniques: Sentence-Level Revision**

You've probably heard plenty of times that writing should be lean, mean, clear, direct, succinct, active, and so on. This statement is one of those self-evident truths—why would anyone set out to write any other way? But what does this advice really mean? What do sentences that are not "lean, mean" and so on look like? What sorts of things are wrong with them? How do you fix them?
Sentences do have ways of becoming flabby, redundant, wordy, unclear, indirect, passive, and just plain old hard to understand. Even so, they remain grammatically "correct"—all their subjects and verbs agree, the commas are in the right places, the words are spelled correctly. Still, these sentences are far more difficult to read than a sentence with just a comma problem.

The following sections can't pretend to cover all of the ways sentences can go bad at this higher level, but they do cover seven of the most common problems and show you ways of fixing them. And knowing these seven will probably enable you to spot others we have not trapped and labeled yet.

**Nominalizations**

Check your writing for sentences that use "to be" as the main verb and use a nominalization as the sentence's subject. (A nominalization is a verb that has been converted into a noun; look for -tion, -ment, -ance, and other suffixes. For example, "nominalization" is itself a nominalization; the root verb is "to nominate." The "to be" verbs are *am, is, are, was, were.*)

These sentences are probably weak and indirect. Revise them by changing the nominalization into a verb and replacing the "to be" verb. Your sentences will sound more active, and they will be easier for the reader to understand.

Sometimes, you can't convert a nominalization into a main verb, or a nominalization needs to remain the a sentence's subject. (For example, "information" is a nominalization, but try converting "information" into a main verb. The sentence will be awkward, at best.) More often, though, you can convert that nominalization into a main verb.

The following examples demonstrate this problem and how to fix it. In each revised version, notice how a noun has been converted into the sentence's main verb and replaced the original "to be" main verb.

<table>
<thead>
<tr>
<th>Problem Sentence:</th>
<th>Revised Sentence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The contribution of Quality Circles is mostly to areas of training and motivating people to produce higher quality work.</td>
<td>Quality Circles contribute to the training and the motivating of people to produce high quality work.</td>
</tr>
<tr>
<td>Measurement of temperature is done in degrees of Fahrenheit or Celsius, and its indications are by colored marks on the outside of the thermometer.</td>
<td>Temperature is measured in degrees of Fahrenheit or Celsius and is indicated by colored marks on the outside of the thermometer.</td>
</tr>
<tr>
<td>The beginning of the clonic phase is when the sustained tonic spasm of the muscles gives way to sharp, short, interrupted jerks.</td>
<td>The clonic phase begins when the sustained tonic spasm of the muscle gives way to sharp, short, interrupted jerks.</td>
</tr>
<tr>
<td>During speech, the generation of sound is by vocal chords and the rushing of air from the lungs.</td>
<td>During speech, sound is generated by the vocal cords and rushing air from the lungs.</td>
</tr>
<tr>
<td>The response of the normal ear to sounds is in the audio-frequency between about 20-20,000 Hz.</td>
<td>The normal ear responds to sounds within the audio-frequency range of about 20-20,000 Hz.</td>
</tr>
</tbody>
</table>

**Noun Stacks**

Search your writing for sentences that contain long, piled-up strings of nouns. Their effect on a reader is similar being hit in the head with a large, blunt object.

Revise these sentences and "unpack" or "unstack" their long noun strings into multiple verbs, clauses, and phrases.

The following examples demonstrate this problem and how to fix it. In each revised version, notice how a long string of nouns has been broken apart:

<table>
<thead>
<tr>
<th>Problem Sentence:</th>
<th>Revised Sentence:</th>
</tr>
</thead>
</table>
There is a growing awareness of organizational employee creative capacity.

Position acquisition requirements are any combination of high school graduation and years of increasingly responsible secretarial experience.

The Quality Circle participation roles and tasks and time/cost requirements of Quality Circle organizational implementation will be described.

Proper integrated circuit packaging type identification and applications are crucial to electrical system design and repair.

Cerebral-anoxia-associated neonatal period birth injuries can lead to epileptic convulsions.

Awareness of the creative capacity of employees in all organizations is growing.

To qualify for the position, you’ll need to be a high school graduate and have had increasingly responsible secretarial experience.

The tasks of the participants in Quality Circles and the time and cost requirements involved in the implementation of Quality Circles will be discussed.

Identifying the proper type of packaging for integrated circuits is crucial to the design and repair of electrical systems.

Birth injuries associated with cerebral anoxia in the neonatal period can lead to epileptic convulsions.

Redundant Phrasing

Eliminate redundant phrases in your writing. They can come from these three sources (but there are probably plenty more):

- **wordy set phrases**: Look for four- to five-word phrases; you can usually chop them to a one- to two-word phrase without losing meaning. For example, "in view of the fact that" can be reduced to "since" or "because."

- **obvious qualifiers.** Look for a word that is implicit in the word it modifies. For example, phrases like "anticipate in advance," "completely finish," or "important essentials" are examples of obvious qualifiers.

- **scattershot phrasing.** Look for two or more compounded synonyms. For example, "thoughts and ideas" (what's the difference?) or "actions and behavior" (if there is a difference between these two, does the writer mean to use it?) are common.

Here are some classic examples of wordy set phrases and their revised versions:

<table>
<thead>
<tr>
<th>Wordy Phrase:</th>
<th>Revised Phrase:</th>
</tr>
</thead>
<tbody>
<tr>
<td>in view of the fact that</td>
<td>since, because</td>
</tr>
<tr>
<td>at this point in time</td>
<td>now, then</td>
</tr>
<tr>
<td>it is recommended that</td>
<td>we recommend</td>
</tr>
<tr>
<td>as per your request</td>
<td>as you requested</td>
</tr>
<tr>
<td>in light of the fact that</td>
<td>since, because</td>
</tr>
<tr>
<td>being of the opinion that</td>
<td>I believe</td>
</tr>
<tr>
<td>in the near future</td>
<td>soon</td>
</tr>
<tr>
<td>during the time that</td>
<td>when</td>
</tr>
<tr>
<td>it would be advisable to</td>
<td>should, ought</td>
</tr>
</tbody>
</table>
due to the fact that | since, because
in this day and age | now, currently
for the reason that | since, because
in my own personal opinion | I believe, in my opinion, I think
to the fullest extent possible | fully
in accordance with your request | as you requested
four in number | four
predicated upon the fact that | based on
inasmuch as | since, because
pursuant to your request | as you requested
in connection with | related to
take cognizance of the fact that | realize
it has come to my attention that | I have learned that
with reference to the fact that | concerning, about
with regard to | concerning, about
in close proximity to | near, close, about
to the extent that | as much as
in the neighborhood of | near, close, about
until such time as | until
has the ability to | can
that being the case | therefore

Expletives

In grammar, an "expletive" is a word that serves a function but has no meaning. The most common expletive phrases in English are "it is/are" and "there is/are." They are sometimes useful, but they are more often redundant and weaken a sentence's impact. If you can, delete them from technical documents.

Here are some examples of sentences with expletives and their revised versions without expletives.

<table>
<thead>
<tr>
<th>Problem Sentence:</th>
<th>Revised Sentence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>When there is a very strong build-up at the front of the plane, it is what is known as a shock wave.</td>
<td>When a very strong build-up occurs at the front end of the plane, a shock wave forms.</td>
</tr>
<tr>
<td>When there is decay of a radioactive substance, there is the emission of some form of a high-energy particle—an alpha particle, a beta particle, or a gamma ray.</td>
<td>When a radioactive substance decays, some form of a high-energy particle—an alpha particle,</td>
</tr>
</tbody>
</table>
It is the results of studies of the central region of the M87 galaxy that have shown that there are stars near the center that move around as though there were some huge mass at the center that was attracting them.

Recent studies of the central region of the M87 galaxy have shown stars near the center moving around as though some huge mass at the center were attracting them.

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**Weak Use of Passive-voice Verbs**

One of the all-time worst offenders for creating unclear, wordy, indirect writing is the passive-voice construction.

Look for a "to be" verb coupled with a past participle (a past-tense verb, often ending in -ed). Change it to an active verb, and rearrange the sentence to make grammatical sense.

It's easy enough to convert a sentence from active voice to passive voice, and back again:

<table>
<thead>
<tr>
<th>Passive Voice:</th>
<th>Active Voice:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The report was written by the student.</td>
<td>The student wrote the report.</td>
</tr>
</tbody>
</table>

However, the passive voice can be a shifty operator—it can cover up its source, that is, who's doing the acting, as this example shows:

<table>
<thead>
<tr>
<th>Passive Voice:</th>
<th>Active Voice:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The papers will be graded according to the criteria stated in the syllabus. (Graded by whom, though?)</td>
<td>The teacher will grade the papers according to the criteria stated in the syllabus. (Oh! that guy...)</td>
</tr>
</tbody>
</table>

It's this ability to conceal the actor or agent of the sentence that makes the passive voice a favorite of people in authority—policemen, city officials, and, yes, teachers. At any rate, you can see how the passive voice can cause wordiness, indirectness, and comprehension problems.

<table>
<thead>
<tr>
<th>Passive Voice:</th>
<th>Active Voice:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your figures have been reanalyzed in order to determine the coefficient of error. The results will be announced when the situation is judged appropriate. (Who analyzes, and who will announce?)</td>
<td>We have reanalyzed your figures in order to determine the range of error. We will announce the results when the time is right.</td>
</tr>
<tr>
<td>Almost all home mortgage loans nowadays are made for twenty-five years. With the price of housing at such inflated levels, those loans cannot be paid off in any shorter period of time. (Who makes the loans, and who can’t pay them off?)</td>
<td>Almost all home mortgage loans nowadays are for twenty-five years. With the price of housing at such inflated levels, homeowners cannot pay off those loans in any shorter period of time.</td>
</tr>
<tr>
<td>However, market share is being lost by 5.25-inch diskettes, as is shown in the graph in Figure 2. (Who or what is losing market share, who or what shows it?)</td>
<td>However, 5.25-inch diskettes are losing market share, as the graph in Figure 2 shows.</td>
</tr>
</tbody>
</table>
| For many years, federal regulations concerning the use of wire-tapping have been ignored. Only recently have tighter restrictions been imposed on the circumstances that warrant it. (Who has | For many years, government officials have ignored federal regulations concerning the use of wire-tapping. Only recently has the federal government imposed tighter
The solution was heated to 28.4 degrees Celsius and was stirred for 9 minutes and 1 second.  (Who heated the solution, and who or what stirred it?)

Don't get the idea that the passive voice is always wrong. It is a good writing technique if

- the subject is obvious or too-often-repeated
- the actor is unknown
- the actor isn't important
- we want to stress the action more than who did it
- we need to rearrange words in a sentence for emphasis.

Notice that the passive voice is really all right in the last two examples above.

**Subject-Verb Mismatches**

In dense, highly technical writing, it's easy to lose track of the real subject and pick a verb that just does not make sense. The result is a noun physically not able to do what the verb says it is doing, or some abstract thing performing something nitty-gritty real-world action.

Check to make sure every sentence's noun matches the main verb.

Here are some examples and their revisions:

<table>
<thead>
<tr>
<th>Problem Sentence:</th>
<th>Revised Sentence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The causes of the disappearance of early electric automobiles were devastating to the future of energy conservation in the U.S.</td>
<td>The disappearance of early electric automobiles destroyed the future of energy conservation in the U.S.</td>
</tr>
<tr>
<td>Presently, electric vehicles are experimenting with two types of energy sources.</td>
<td>Presently, research on electric vehicles involves two types of energy sources.</td>
</tr>
<tr>
<td>Consequently, the body is more coordinated and is less likely to commit mental mistakes.</td>
<td>Consequently, workers will be more coordinated and commit fewer mental errors.</td>
</tr>
</tbody>
</table>

**Readability, Sentence Lengths, and Sentence Structures**

When you are writing about highly technical subject matter, it is easy to construct long sentences that become hard to read, or to bore your reader with highly repetitive sentence lengths and grammatical structures.

**Readability**
The reader of a technical document needs to be able to extract information from it as easily as possible, so most technical documents are written at the 8th-grade level. The average sentence length should be about fifteen words.

When you revise, look for long sentences that contain lots of information. Break them into shorter, bite-sized chunks that contain single ideas, and run the resulting sentences through a readability checker. For example, MS Word has a built-in readability tool that will tell you the number of words per sentence and the Flesch-Kincaid model's estimate of the text's grade level. (Open your document in MS Word, click File > Options > Proofing, check the "Show readability statistics" box, and run the spellchecker.)

**Sentence Length**

The average sentence in a technical document should contain about fifteen words, but you can use significantly longer or shorter sentences if necessary. Any sentence over thirty-five or forty words almost definitely needs to be broken up. An occasional short sentence (say, five to ten words) can be very effective, but lots of them can cause writing to be choppy and hard to follow.

Similarly, if the document contains a string of sentences that are close to the same length (for example, six sentences of exactly fifteen words each), the reader will fall into a rhythm and find it hard to pay attention. Break apart or combine sentences to create variety in their length.

**Sentence Structures**

In English, there are four basic sentence structures:

- **simple.** This type of sentence contains a single independent clause.
- **compound.** This type of sentence contains two independent clauses.
- **complex.** This type of sentence contains an independent clause and a dependent clause.
- **compound complex.** This type of sentence contains a compound sentence and at least one dependent clause.

Technical writing usually uses simple and compound sentences, and sometimes complex sentences. It very rarely uses compound complex sentences. Look for these sentence structures and revise your technical document accordingly.

Also, as with sentence lengths, if all your sentences use the same grammatical structure, your reader will fall into a rhythm and find it hard to pay attention. Break apart or combine sentences to create variety in their grammatical structure.

Here are some examples of overly long, complex sentences and their revised versions:

<table>
<thead>
<tr>
<th>Problem Sentence:</th>
<th>Revised Sentence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>In order to understand how a solid, liquid or gas can be made to give off radiation in the form of a laser beam, one must understand some of the basic theory behind laser light.</td>
<td>A solid, liquid or gas can be made to give off radiation in the form of a laser beam. Understanding this process requires some knowledge about the basic theory behind laser light.</td>
</tr>
<tr>
<td>Length: 35 words Grade Level: 15.2</td>
<td>Average Length: 16 words Grade Level: 9.0</td>
</tr>
<tr>
<td>Laser beams, which have many properties that distinguish them from ordinary light, result from the emission of energy from atoms in the form of electromagnetic waves whose range in most laser beams is $10^{-3}$ to $10^{-7}$ meters.</td>
<td>Laser beams are just beams of light, but they have special properties that distinguish them from ordinary light. Laser beams come from atoms that emit energy as electromagnetic waves. The average wavelength ranges from $10^{-3}$ to $10^{-7}$ meters.</td>
</tr>
<tr>
<td>Length: 37 words Grade Level: 19.5</td>
<td>Average Length: 12.6 words Grade Level: 10.7</td>
</tr>
</tbody>
</table>
Searching Libraries, Documentating Borrowed Information, Cross-Referencing

This section in this appendix focuses on:

- Libraries—Finding information libraries
- Documentation—Indicating sources of borrowed information
- Cross-referencing—Pointing to other information in your own documents and those of others.

Information Search

This section focuses on finding information for your technical-documentation projects online and in physical libraries. Your job is to get good, specific, up-to-date information for your formal report project. You may not be able to read it all—you're not writing a dissertation, nor is your knowledge about your topic expected to be anywhere close to that level. But at least you know what's out there.

Check out the Library System at Kennesaw State University. Here you will find research help 24/7.

How do I get started with research?

Find a Topic, Narrow It, Brainstorm It

Before you head for the library or its Internet equivalent, you need a topic, some idea of the specific aspect of the topic you want to focus on, and some ideas about what to say about that narrowed topic. Problems finding a topic and thinking of what to say about it are often called the dreaded writer's block.

A virtual ocean to topics is here in topic ideas.

Narrowing a topic is that process in which you go from an impossibly huge topic such as nanotechnology to something more manageable such as applications of nanotechnology in brain surgery. You can find a nice system for this process in narrowing topics.

Brainstorming a topic is that process in which you think of everything you can that you might write about in relation to your topic. You can find a nice system for this process in brainstorming and invention.

Know Your Booleans for Searching Online or in Databases

An important tool to have when you go searching for information—either in libraries or in the Internet—has to do with Boolean operators: AND, OR, NOT and a few esoteric other. The following table will help you become an expert in narrowing search parameters, especially in a huge database such as that provided by the university.

<table>
<thead>
<tr>
<th>Technique</th>
<th>What it does</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truncation — adding a symbol to the root of the word to retrieve related terms and variant endings for the root</td>
<td>Expands your search</td>
<td>structur* finds structure, structuring, structures, etc. *elasticity will find</td>
</tr>
<tr>
<td>Term. Some databases have left- and right-hand truncation.</td>
<td>Boolean AND — retrieves only those records containing all your search terms</td>
<td>Boolean OR — retrieves records containing any of your search terms; especially useful for synonyms, alternate spellings, or related concepts</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Narrows your search</td>
<td>Broadens your search</td>
</tr>
<tr>
<td></td>
<td>elasticity, aeroelasticity, viscoelasticity</td>
<td>finite AND element AND methods</td>
</tr>
</tbody>
</table>

**Types of Resources for Information Research**

**Encyclopedias and Other Reference Works**

If you are beginning at ground zero with your technical report topic, a good strategy would be to read some articles in general encyclopedias: As a researcher, you need to know something about the topic so you will know what kinds of questions to ask and how to organize your data. If you are knowledgeable, the entire research process will be more efficient and even enjoyable.

worldbookonline.com/ (yes, even this one!)
www.britannica.com/
www.accessscience.com/ for online access to the *McGraw-Hill Encyclopedia of Science and Technology*

Can you build a legitimate technical report based on encyclopedia articles that you summarize and paraphrase? NO! Most college level instructors will not accept encyclopedias as legitimate sources because their information is broad, not specific. You may not be able to gather enough information to create a report of any reasonable length. We could go on about this for a long time, but do not consider using an encyclopedia, not even wikipedia.com, as part of your cited research data...only as a place for you to begin building a background of knowledge.

You can find reference books like encyclopedias by typing in a couple of words of the title in an online library catalog (for example, mechanical engineer* handbook, "encyclopedia engineering", or "encyclopedia and engineering"), truncating any words that could have variant endings, and eliminating any prepositions or articles (*of, for, the, a, an*).

Here are some examples of what you might find:

- *Prentice-Hall Encyclopedia of Information Technology*
- *McGraw-Hill Dictionary of the Life Sciences*
- *Robotics Sourcebook and Dictionary*
- *Energy: A Guide to Organizations and Information Resources in the United States*
- *McGraw-Hill Yearbook of Science and Technology*
Books

Books can provide excellent background, a historical treatment of your subject and depth. Check a book's table of contents and index to see if it has what you are looking for. For some current research topics, however, books tend to be too general. To obtain more specific information on technological advancements, go to journal articles, technical reports, or other sources discussed later in this chapter.

Try these resources; search "drone aircraft" on each to see which has the most up to date resources:

onlinebooks.library.upenn.edu/subjects.html
catalog.loc.gov
www.worldcat.org

Here are some sites that consolidate access to thousands of libraries worldwide:

LibDex: http://www.libdex.com/
The WWW Library Directory: www.travelinlibrarian.info/libdir/other.html
LibWeb: http://lists.webjunction.org/libweb/

Periodicals

Periodicals is a librarian's word for stuff that comes out periodically—like magazines, journals, newspapers. Magazines, which are by definition for general audiences, are not likely to have much that is useful to your report. At the college level, you will be expected to use scholarly, or peer reviewed journals for research. You can find these in the university database, or you can borrow from other systems through an system of inter-library loans. When in doubt, pay a visit to your campus library and make friends with the librarians there.

Directory of Open Access Journals: www.doaj.org/. DOAJ offers free access to over 3,500 full-text, quality-controlled scientific and scholarly journals, over 1,200 of which are searchable at the article level.

Most of the following are services you pay for; some offer a free 30-ay trial. Your local library may subscribe to some of these, giving you free access:

Applied Science and Technology: http://www.ebscohost.com/academic/applied-science-technology-full-text
Academic Search Complete: http://www.ebscohost.com/academic/academic-search-complete
INSPEC: http://www.theiet.org/resources/inspec/
ScienceDirect: http://www.elsevier.com/online-tools/promo-page/science-direct/et_sd_adwordsgeneric_nov2013/home

Technical Reports

National Technical Information Service (NTIS) www.ntis.gov/
IEEE Xplore http://ieeexplore.ieee.org/Xplore/guesthome.jsp
NASA Technical Reports Server http://ntrs.nasa.gov/search.jsp

Associations and Interest Groups

Organizations like asociations, special-interest groups, advocacy groups are a good potential for information on your topic—or a terrible ideological swamp. Keep in mind that associations and interest groups generally have an agenda or a bias about their topic. Encyclopedia of Associations may be a good resource. Ask your librarian for help with this kind of resource.

Library and Subject Guides

Research assistance, subject guides, useful resources and web sites compiled by the friendly librarians at Austin Community College, for example, occupational therapy, business and technical communications, and other department and field names: These are presented here.
Your own library at Kennesaw State University also has awesome resources for you to use!

libguides.kennesaw.edu

Other Information Resources

There are certainly other kinds of information sources such as patents, standards, product literature, conference proceedings. Again, ask your librarian for help with these kinds of resources.

Evaluate Your Research Findings

The following is a system of evaluating the reliability of Internet information developed by the Cornell University Library: This information is especially important if you are using Internet sources and need to defend their validity and reliability.

| Point of view | Does this article or book seem objective, or does the author have a bias or make assumptions? What was the author's method of obtaining data or conducting research? Does the website aim to sell you something or just provide information? What is the author's purpose for researching and writing this article or book? |
| Authority | Who wrote the material? Is the author a recognized authority on the subject? What qualifications does this author have to write on this topic? Is it clear who the intended audience is? What is the reputation of the publisher or producer of the book or journal? Is it an alternative press, a private or political organization, a commercial press, or university press? What institution or Internet provider supports this information? (Look for a link to the homepage.) What is the author's affiliation to this institution? |
| Reliability | What body created this information? Consider the domain letters at the end of a Web address (URL) to judge the site's quality or usefulness. What kind of support is included for the information? Are there facts, interviews, and statistics that can be verified? Is the evidence convincing to you? Is there any evidence provided to support the author's conclusions, such as charts, maps, bibliographies, and documents? Compare the information provided to other factual sources. |
| Timeliness | Has the site been recently updated? Look for this information at the bottom of a web page. How does the copyright of a book or publication date of an article impact the information contained in it? Do you need historical or recent information? Does the resource provide the currency you need? |
| Scope | Consider the breadth and depth of an article, book, website, or other material. Does it cover what you expected? Who is the intended audience? Is the content aimed at a general or a scholarly audience? Based on your information need, is the material too basic, too technical, or too clinical? |

In addition to the above, if you are looking at Internet sites, pay careful attention to any advertising on page. Online gambling or magis weight loss solutions might not be the kind of company your research needs to keep.

As a rule of thumb, steer clear of any resource that has "wiki" or "about" in the title or url. Your safest bets are sites sponsored by the U.S. government (.gov) or educational institutions (.edu).
Citing Sources of Borrowed Information

When you write a technical report, you can and should borrow information like crazy—to make it legal, all you have to do is "document" it. If your report makes you sound like a rocket scientist but there's not a single source citation in it and you haven't even taken college physics yet, people are going to start wondering. (In Night Court, you'd be guilty of plagiarism. Fine—an F on the paper in question.) However, if you take that same report and load it up properly with source citations (those little indicators that show that you are borrowing information and from whom), everybody is all the more impressed—plus they're not secretly thinking you’re a shady character. A documented report (one that has source indicators in it) says to readers that you've done your homework, that you're up on this field, that you approach these things professionally—that you are no slouch. Most importantly, you've shown that you respect the rights of the original authors, the owners of the intellectual property you are using.

The following resources will provide all the guidance you need to correctly document, or give credit to, your sources.

Research and Citation Resources. Overview from the Purdue OWL with links to specific systems.
APA Documentation. From Austin Community College.
MLA Documentation. From Austin Community College.
Turabian Documentation. From Austin Community College.
CSE Documentation: Name-Year Method. From Austin Community College.
CSE Documentation: Citation-Sequence System. From Austin Community College.
IEEE Citation Style Guide. From Georgia Tech. (The IEEE system is very similar to the system described in the following.)

Number System of Documentation

If you've taken other college writing courses recently, you have probably been exposed to other documentation systems—specifically the MLA, or works-cited system. The problem with that system is that it is rather limited to the literature and humanities field. Unfortunately, it is not widely used outside that field—especially not in technical and scientific fields. One of the more common systems used in technical fields is the number system, a formatting procedure that is easy to learn and use. The citation-sequence version of the CSE (Scientific) Documentation (see the link above) is one of the specific incarnations of the number system. (Notice here that we use brackets, not parentheses for the source indicators.)

In this number system, you list your information sources alphabetically, number them, and put the list at the back of your report. Then in the body of your report, whenever you borrow information from one of those sources, you put the source number and, optionally, the page number in brackets at that point in the text where the borrowed information occurs. The illustration below shows how this system works. However, in a hypothetical example:

- [4] would refer to source 4 in the list.
- [4;7] would indicate that the information was borrowed from source 4 and source 7.

What to Document

This question always comes up: how do I decide when to document information—when, for example, I forgot where I learned it from, or when it really seems like common knowledge? There is no neat, clean answer. You may have heard it said that anything in an encyclopedia or in an introductory textbook is common knowledge and need not be documented. Don't believe it. If it really isn't common knowledge for you, at least not yet, document it! If you just flat can't remember how you came by the information, then it has safely become common knowledge for you. (All that's really going on here is that we're trying to protect the efforts of those poor devils who worked themselves into the ground originating the information we want to borrow—give 'em a break, give 'em their due!)

One other question that is often asked: do I document information I find in product brochures or that I get in conversations with knowledgeable people? Yes, most certainly. You document any information you did not create, regardless whether it is in print, in electronic bits, magnetic spots, or in thin air. While you probably studied this in high school, it becomes a very serious issue in a university which expects research to not only be useful, but honest.
How to Place the Source Indicators

It’s a bit tricky deciding exactly where to place the source indicators—at the beginning of the passage containing the borrowed information, at the end? If it makes sense to "attribute" the source (cite the name of the author or the title of the information), you can put the attribution at the beginning and the bracketed source indicator at the end (as is shown in the following).

Example page with bracketed source indicators and corresponding source list

In the number documentation system, the code numbers in the text of the report are keyed to the references page. For example, [6:5] in the middle of the page from the body of the report indicates that the information came from source 6 (in References), page 5. Notice that the attribution of the quotation indicates the beginning of the borrowed information and the bracketed source indicator marks the end.

How to Set up the Sources List

A bit more challenging is setting up the list of information sources—that numbered, alphabetized list you put at the end of the document. (The context here is still the number system.) The best way to learn is to use examples. The following examples show you how to handle books, government reports, articles from magazines and journals, encyclopedia articles, and personal interviews.

Internet and Web information sources. For format on citing Internet and Web information sources, see any of the resources listed above. As you will see, there are quite a few variations. However, a simple functional partice would be this in this order:

http://distanceed.hss.kennesaw.edu/technicalcommunication/chapters/5_6LibrariesDocumentationCross-Ref/5_6LibrariesDocumentationCross-Ref_p... 6/10
1. Author name, last name first. If that's not available, use the organization’s name, followed by a period.

2. Next, the title of the page.

3. After that the publication date of the web page, if available; otherwise, use the "N.d" indicator.

4. Next, the full URL of the page.

5. And finally an indication of the date you accessed the page, for example, Accessed June 6, 1988.

Books. For books, put the name of the author (first name last) first, followed by a period, followed by the title of the book in italics, followed by a period, followed by the city of the publisher, followed by a colon, followed by the publisher’s name (but delete all those tacky "Inc.", "Co.", and "Ltd." things), followed by the year of publication, ending with a period. In this style, you don’t indicate pages.

Example: book entry


Magazine and journal articles. Start with the author’s name first (last name first), followed by a period, then the title of the article in quotation marks and ending with a period, followed by the name of the magazine or journal in italics, followed by a period, followed by the date of issue of the magazine the article occurs in, followed by the beginning and ending page. If the article spread out across the magazine, you can write "33+." or "33(5)." The (5) in the preceding is an estimate of how many pages the article would be if it were continuous.

If there is no author, start with the article or book title. If there are two authors, add "and" and the second author’s name, first name first. If there are too many authors, use the first one (last name first), followed by "et al.," which means "and others."

Example: magazine entry


Encyclopedia articles. Encyclopedia articles are easy! Start with the title of the article in quotation marks ending with a period, followed by the name of the encyclopedia (in italics if you have it; otherwise, underline), followed by a period, then the year of the edition of the encyclopedia.

Example: encyclopedia entry


Reports. With reports, you’re likely to dealing with government reports or local informally produced reports. With most reports, you may not have an individual author name; in such cases, you use the group name as the author. For government reports, the publisher is often the Government Printing Office; and the city of publication, Washington, D.C. Also, for government documents, you should include the document number, as is shown in the following example.

http://distanceed.hss.kennesaw.edu/technicalcommunication/chapters/5_6LibrariesDocumentationCross-Ref/5_6LibrariesDocumentationCross-Ref_p... 7/10
Searching Libraries, Documentating Information, Cross-Referencing

Example: entry for a report

Personal interviews, correspondence, and other nonprint sources. With these sources, you treat the interviewee or the e-mail or letter writer as the author, follow that name with the person's title, followed by a period, then the company name, followed by a period, then the city and state, followed by a period, then what the information was ("Personal interview" or "Personal correspondence") followed by a period, ending with the date.

Example: entry for unpublished information

Product brochures. For these kinds of information sources, treat the company name as the author, followed by a period, use something identifying like the product name (including the specific model number), followed by anything that seems like the title of the brochure, followed by a period, ending with a date if you can find one (otherwise, put "N.d.").

Example: entry for a product brochure

Documenting borrowed graphics. It's certainly legal to copy graphics from other sources and use them in your own work—as long as you document them. You indicate the source of a borrowed graphic in the figure title (caption), which is located just below the graphic. In the figure title, you can show the source of the graphic in two ways—the long traditional way or the shorter way that uses the format of the number system:
Two ways to indicate the source of borrowed graphics.

Cross-Referencing

Technical reports and instructions often require cross-references—those pointers to other places in the same document or to other information sources where related information can be found.

A cross-reference can help readers in a number of different ways:

- It can point them toward more basic information if, for example, they have entered into a document more complex than their level of understanding.
- It can point them to more advanced information if, for example, they already know the stuff you’re trying to tell them.
- Also, it can point them to related information.

Related information is the hardest area to explain because ultimately everything is related to everything else—there could be no end to the cross-references. But here’s an example from DOS—that troll that lurks inside PC-type computers and supposedly helps you. There are several ways you can copy files: the COPY command, the DISKCOPY command, and XCOPY command. Each method offers different advantages. If you were writing about the COPY command, you’d want cross-references to these other two so that readers could do a bit of shopping around.

Of course, the preceding discussion assumed cross-references within the same document. If there is just too much background to cover in your document, you can cross-reference some external website, book, or article that does provide that background. That way, you are off the hook for having to explain it all!

Now, a decent cross-reference consists of several elements:

- Name of the source being referenced—This can either be the title or a general subject reference. If it is a chapter title or a heading, put it in quotation marks; if it is the name of a book, magazine, report, or reference work, put it in italics or underline. (Individual article titles also go in quotation marks.)
- Page number—Required if it is in the same document; optional if it is to another document.
- Subject matter of the cross-reference—Often, you need to state what’s in the cross-referenced material and indicate why the reader should go to the trouble of checking it out. This may necessitate indicating the subject matter of the cross-referenced material or stating explicitly how it is related to the current discussion.

These guidelines are shown in the following illustration. Notice in that illustration how different the rules are when the cross-reference is "internal" (that is, to some other part of the same document) compared to when it is "external" (to information outside of the document).
For details on creating graphics and then incorporating them into a document, see the section on graphics in this guide on page 16.

For details on creating graphics and then incorporating them into a document, see “Graphics” in the *Online Technical Writing Guide*.

For details on creating graphics and then incorporating them into a document, see the chapter on graphics in the *Online Technical Writing Guide*.

For details on creating graphics and then incorporating them into a report, see “Brighten Up That Monthly Report!” in the *Office Information Newsletter*.

In this internal cross-reference, the section is referenced generically. It’s standard to cite the page number in internal cross-references.

The title of the chapter is in double quotation marks. The title of the book that the chapter occurs is italicized.

If you don’t want to cite the exact titles of the chapter, just use lowercase.

If you cite an article in a periodical, put the article in quotation marks and italicize the name of the periodical.

**Examples of cross-references.** Internal cross-references are cross-references to other areas within your same document; external ones are those to information resources external to your document.

**Demonstrate your research expertise! Activities and Exercises**

1. Locate several journals in your major field and find the information for writers section. What formatting protocols are expected if you want to be published?

2. In small groups, visit the Purdue OWL Research and Citation Section and explore it. What can you learn about the different formatting styles? When would you use APA? MLA? IEEE? Chicago?

3. In small groups or a discussion forum, share some of your own research techniques...what has been effective for you in the past? What advice would you offer others in the class for becoming a good researcher?

4. Locate your school’s policy on plagiarism and academic honesty. How important do you think this is? Find some sources that reveal cases of academic dishonesty...how does lack of integrity in research affect the individuals and the university?
This section is a quick review of the fundamentals of the sentence. If you encounter unfamiliar terminology in this textbook or in your class, refer to this section for help. For more on sentence grammar, see *English Fundamentals* by Emery, Kierzek, and Lindblom (Macmillan) for a thorough discussion of sentence grammar, along with exercises.

**Basic Sentence Patterns**

**Subject + verb**

The simplest of sentence patterns is composed of a subject and verb without a direct object or subject complement. It uses an intransitive verb, that is, a verb requiring no direct object.

<table>
<thead>
<tr>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control <em>rods remain</em> inside the fuel assembly of the reactor.</td>
</tr>
<tr>
<td>The <em>development</em> of wind power practically <em>ceased</em> until the early 1970s.</td>
</tr>
<tr>
<td>All amplitude-modulation (AM) <em>receivers work</em> in the same way.</td>
</tr>
<tr>
<td>The <em>cross-member</em> exposed to abnormal stress eventually <em>broke</em>.</td>
</tr>
<tr>
<td>Only two <em>types</em> of charge <em>exist</em> in nature.</td>
</tr>
</tbody>
</table>

**Subject + linking verb + subject complement**

Another simple pattern uses the linking verb, any form of the to be verb without an action verb.

<table>
<thead>
<tr>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>The chain <em>reaction is</em> the basis of nuclear power.</td>
</tr>
<tr>
<td>The <em>debate</em> over nuclear power <em>has</em> often <em>been</em> bitter.</td>
</tr>
<tr>
<td><em>Folding</em> and <em>faulting</em> of the earth's surface <em>are</em> important geologic processes.</td>
</tr>
<tr>
<td><em>Windspeed seems</em> to be highest during the middle of the day.</td>
</tr>
<tr>
<td>The silicon solar cell <em>can be</em> difficult and expensive to manufacture.</td>
</tr>
</tbody>
</table>

**Subject + verb + direct object**

Another common sentence pattern uses the direct object.

<table>
<thead>
<tr>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon conducts <em>electricity</em> in an unusual way.</td>
</tr>
<tr>
<td>The anti-reflective coating on the the silicon cell reduces <em>reflection</em> from 32 to 22 percent.</td>
</tr>
<tr>
<td>Prestressing of the concrete increases the load-carrying <em>capacity</em> of the members.</td>
</tr>
</tbody>
</table>

**Subject + verb + indirect object + direct object**

The sentence pattern with the indirect object and direct object is similar to the preceding pattern.

<table>
<thead>
<tr>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>The walls are usually painted <em>black</em>.</td>
</tr>
<tr>
<td>The plant shutdown left the entire <em>area</em> an economic <em>disaster</em>.</td>
</tr>
</tbody>
</table>
The committee declared the new **design** a **breakthrough** in energy efficiency.

The low cost of the new computer made **competition** much too **difficult** for some of the other companies.

**Passive voice pattern**

The passive voice is not ordinarily considered a "pattern," but it is an important and often controversial construction. It reverses the subject and object and, in some cases, deletes the subject. Compare these example active and passive voice sentences.

<table>
<thead>
<tr>
<th>Passive voice</th>
<th>Active voice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saccharin is now permitted as an additive in food.</td>
<td>The FDA now permits saccharin as an additive in food.</td>
</tr>
<tr>
<td>This report is divided into three main sections.</td>
<td>I have divided this report into three main sections.</td>
</tr>
<tr>
<td>Windmills are classified as either lift or drag types.</td>
<td>Engineers classify windmills as either lift or drag types.</td>
</tr>
<tr>
<td>The valves used in engine start are controlled by a computer.</td>
<td>A computer usually controls the valves used in an engine start.</td>
</tr>
<tr>
<td>The remains of Troy were destroyed by later builders on the site.</td>
<td>Later builders on the site of Troy destroyed the remains of citadel.</td>
</tr>
<tr>
<td>Some restaurant locations can be leased.</td>
<td>You can lease some restaurant locations.</td>
</tr>
</tbody>
</table>

**Simple sentences**

A simple sentence is one that contains subject and a verb and no other independent or dependent clause.

**One** of the tubes is attached to the manometer part of the instrument indicating the pressure of the air within the cuff.

To measure blood pressure, a **device** known as a sphygmomanometer and a **stethoscope are needed.** *(compound subject)*

There are **basically two types** of stethoscopes. *(inverted subject and verb)*

The **sphygmomanometer is usually covered** with cloth and **has** two rubber tubes attached to it. *(compound verb)*

**Compound sentences**

A compound sentence is made up of two or more independent clauses joined by a coordinating conjunction *(and, or, nor, but, yet, for)* and a comma, an adverbial conjunction and a semicolon, or a semicolon.

In sphygmomanometers, too narrow a cuff can result in erroneously high readings, and too wide a cuff can result in erroneously low readings.

**Some cuff hook together; others wrap or snap into place.**

**Compound predicates**

A predicate is everything in the verb part of the sentence **after** the subject (unless the sentence uses inverted word order). A compound predicate is two or more predicates joined by a coordinating conjunction. Traditionally, the conjunction in a sentence consisting of just two compound predicates is not punctuated.

Another library media specialist **has been using** Accelerated Reader for ten years *and*
has seen great results.

This cell phone app lets users share pictures instantly with followers and categorize photos with hashtags.

Sexy Technical Communication Home

Basic Parts of the Sentence

Subject

The subject of a sentence is that noun, pronoun, or phrase or clause about which the sentence makes a statement.

Einstein's general theory of relativity has been subjected to many tests of validity over the years.

Although a majority of caffeine drinkers think of it as a stimulant, heavy users of caffeine say the substance relaxes them.

Surrounding the secure landfill on all sides are impermeable barrier walls.

(inverted sentence pattern)

In a secure landfill, the soil on top and the cover block storm water intrusion into the landfill.

(compound subject)

Verb phrase

The main verb, or verb phrase, of a sentence is a word or words that express an action, event, or a state of existence. It sets up a relationship between the subject and the rest of the sentence.

The first high-level language to be widely accepted, FORTRAN, was implemented on an IBM 704 computer.

Instruction in the source program must be translated into machine language. (passive construction)

The operating system controls the translation of the source program and carries out supervisory functions. (compound verb)

Predicate

The predicate is the rest of the sentence coming after the subject. It can include the main verb, subject complement, direct object, indirect object, and object complement.

The pressure in a pressurized water reactor varies from system to system.

The pressure is maintained at about 2250 pounds per square inch to prevent steam from forming.

The pressure is then lowered to form steam at about 600 pounds per square inch.

In contrast, a boiling water reactor operates at constant pressure.

Subject complement
The subject complement is that noun, pronoun, adjective, phrase, or clause that comes after a linking verb (some form of the *be* verb):

```
The maximum allowable concentration is ten parts \( \text{H}_2\text{S} \) per million parts breathable air.
```

```
The deadening of the sense of smell caused by \( \text{H}_2\text{S} \) is the result of the effects of \( \text{H}_2\text{S} \) on the olfactory nerves of the brain. Continuous exposure to toxic concentrations of \( \text{H}_2\text{S} \) can be fatal.
```

**Direct object**

A direct object—a noun, pronoun, phrase, or clause acting as a noun—takes the action of the main verb. A direct object can be identified by putting *what?*, *which?*, or *whom?* in its place.

```
The housing assembly of a mechanical pencil contains the mechanical workings of the pencil.
```

```
Lavoisier used curved glass discs fastened together at their rims, with wine filling the space between, to focus the sun’s rays to attain temperatures of 3000° F.
```

```
The dust and smoke lofted into the air by nuclear explosions might cool the earth’s atmosphere some number of degrees.
```

```
A 20 percent fluctuation in average global temperature could reduce biological activity, shift weather patterns, and ruin agriculture. (compound direct object)
```

```
The cooler temperatures brought about by nuclear war might end all life on earth.
```

```
On Mariners 6 and 7, the two-axis scan platforms provided much more capability and flexibility for the scientific payload than those of Mariner 4. (compound direct object)
```

**Indirect object**

An indirect object—a noun, pronoun, phrase, or clause acting as a noun—receives the action expressed in the sentence. It can be identified by inserting *to* or *for*.

```
In the application letter, tell [to] the potential employer that a resume accompanies the letter.
```

```
The company is designing [for] senior citizens a new walkway to the park area.
```

```
Do not send [to] the personnel office a resume unless someone there specifically requests it.
```

**Object complement**

An object complement—a noun or adjective coming after a direct object—adds detail to the direct object. To identify object complements, insert *[to be]* between the direct object and object complement.

```
The supervisor found the program [to be] faulty.
```

```
The company considers the new computer [to be] a major breakthrough.
```

```
Most people think the space shuttle [to be] a major step in space exploration.
```
Parts of Speech and Other Sentence Elements

Nouns

A noun is the name of a person (Dr. Sanders), place (Lawrence, Kansas, factory, home), thing (scissors, saw, book), action (operation, irrigation), or idea (love, truth, beauty, intelligence). Remember that, while a word may look like a noun, it must function in the sentence as a noun:

- The one experiment that has been given the most attention in the debate on saccharin is the 1977 Canadian study done on rats.
- The Calorie Control Council, a group of Japanese and American manufacturers of saccharin, spent $890,000 in the first three months of the 1977 ban on saccharin on lobbying, advertisements, and public relations.
- A flat-plate collector located on a sloping roof heats water which circulates through a coil and is pumped back to the collector.
- The blades start turning when the windspeed reaches 10 mph, and an anemometer is attached to the shaft to measure windspeed.
- The multifuel capacity of the Stirling engine gives it a versatility not possible in the internal combustion engine.
- The regenerative cooling cycle in the engines of the Space Shuttle is made up of high pressure hydrogen that flows in tubes connecting the nozzle and the combustion chamber.

Pronouns

A pronoun stands in the place of a noun. There are several types: personal pronouns, demonstrative and indefinite pronouns, and relative and interrogative pronouns. Pronouns have antecedents, a reference to a word they take the place of.

*Personal pronouns* include nominative case, objective case, and possessive case pronouns.

**Nominative Case**

Nominative case pronouns are used in the positions of subjects or subjective complements; they include:

<table>
<thead>
<tr>
<th>I</th>
<th>we</th>
</tr>
</thead>
<tbody>
<tr>
<td>you</td>
<td>you</td>
</tr>
<tr>
<td>he, she, it</td>
<td>they</td>
</tr>
</tbody>
</table>

**Objective Case**

Objective case pronouns are used as direct objects, indirect objects, and objects of prepositions; they include:
Basic Patterns and Elements of the Sentence

Possessive Case

Possessive case pronouns show possession; they include:

<table>
<thead>
<tr>
<th>me</th>
<th>us</th>
</tr>
</thead>
<tbody>
<tr>
<td>you</td>
<td>you</td>
</tr>
<tr>
<td>him, her, it</td>
<td>them</td>
</tr>
</tbody>
</table>

Demonstrative and Indefinite Pronouns

Demonstrative pronouns substitute for things being pointed out; indefinite pronouns substitute for unknown or unspecified things:

<table>
<thead>
<tr>
<th>Demonstrative pronouns</th>
<th>Indefinite pronouns</th>
</tr>
</thead>
<tbody>
<tr>
<td>this, these</td>
<td>each, either</td>
</tr>
<tr>
<td>that, those</td>
<td>any, neither</td>
</tr>
<tr>
<td></td>
<td>anybody, some</td>
</tr>
<tr>
<td></td>
<td>every, somebody</td>
</tr>
<tr>
<td></td>
<td>everybody, someone</td>
</tr>
</tbody>
</table>

Relative and Interrogative Pronouns

Relative and interrogative pronouns link dependent to independent clauses; they link adjective or noun clauses to simple sentences. Relative pronouns include:

<table>
<thead>
<tr>
<th>who</th>
<th>when</th>
<th>which</th>
</tr>
</thead>
<tbody>
<tr>
<td>whom</td>
<td>where</td>
<td>whether</td>
</tr>
<tr>
<td>whose</td>
<td>why</td>
<td>that</td>
</tr>
</tbody>
</table>

Here are some examples of relative pronouns in use:

Until the early 1960s, desk calculators, which performed only the basic arithmetic operations, were essentially mechanical in operation.

The invention of the transistor in 1948 and the integrated circuit in 1964 were two events that formed the basis of the electronic calculator revolution.

The form in which memory is presented to the software is sometimes called local address space.

George Boole, who was a self-taught man, is famous for his pioneering efforts to express logical concepts in mathematical form.

In 1855, Boole married Mary Everest, a niece of Sir George Everest after whom Mount Everest was named.

Lemaître proposed that all the matter in the Universe was concentrated into what he termed the primeval atom, whose explosion scattered material into space to form galaxies, which have been flying outward ever since.
Interrogative pronouns, similar to relative pronouns, are used in question sentences:

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the fundamental unit of storage in a computer?</td>
</tr>
<tr>
<td>When did the first exhibit of computer graphics occur?</td>
</tr>
<tr>
<td>Who were the mathematicians that arranged that first exhibit?</td>
</tr>
<tr>
<td>Where was the first computer graphics exhibit held?</td>
</tr>
<tr>
<td>Why is computer-aided art not considered art by some?</td>
</tr>
</tbody>
</table>

**Verbs**

Traditionally, verbs are divided into four groups: active verbs, linking verbs, auxiliary verbs, and modals.

**Active Verbs**

Active verbs express some sort of action and can be subdivided into intransitive and transitive verbs. Intransitive verbs do not take direct objects while transitive verbs do, as these two sets of examples show:

<table>
<thead>
<tr>
<th>Intransitive verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>The rearrangement or division of a heavy nucleus may occur naturally (spontaneous fission) or under bombardment with neutrons.</td>
</tr>
<tr>
<td>The probability of an accident leading to the melting of the fuel core was estimated to be one chance in 20,000 reactor-years of operations.</td>
</tr>
<tr>
<td>The fuels used in ramjet engines burn in only a narrow range of fuel-air ratios.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transitive verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>The generation of electric energy by a nuclear power plant requires the use of heat to produce steam or to heat gases in order to drive turbogenerators.</td>
</tr>
<tr>
<td>In an auxiliary relay, when the applied current or voltage exceeds a threshold value, the coil activates the armature, which either closes the open contacts or opens the closed contacts.</td>
</tr>
<tr>
<td>The solar power satellite absorbs the energy in geosynchronous orbit.</td>
</tr>
<tr>
<td>In the photovoltaic solar power system, solar cells convert the light energy into electricity.</td>
</tr>
</tbody>
</table>

**Linking Verbs**

A linking verb is any form of the verb *to be* without an action verb; it sets up something like an equal sign between the items it links. Linking verbs of a sentence can be longer than one word:

<table>
<thead>
<tr>
<th>Linking Verb</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>had been</td>
<td>That word processing program seems adequate for our needs.</td>
</tr>
<tr>
<td>was being</td>
<td>This calculus problem looks difficult.</td>
</tr>
<tr>
<td>had to have been</td>
<td>Since the oil spill, the beach has smelled bad.</td>
</tr>
<tr>
<td>had to have been</td>
<td>He quickly grew weary of computer games.</td>
</tr>
<tr>
<td>would have been</td>
<td>This calculus problem looks difficult.</td>
</tr>
<tr>
<td>might have been</td>
<td>Since the oil spill, the beach has smelled bad.</td>
</tr>
<tr>
<td>will have been</td>
<td>He quickly grew weary of computer games.</td>
</tr>
</tbody>
</table>

A few linking verbs do not use *to be* but function like it:
Auxiliary Verbs

Auxiliary verbs "help" the main part of the verb. Here are some auxiliary verbs:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>By 1967, about 500 U.S. citizens had received heart transplants.</td>
<td></td>
</tr>
<tr>
<td>Better immunosuppression management in transplant operations has yielded better results.</td>
<td></td>
</tr>
<tr>
<td>Researchers have found propranolol to be effective in the treatment of heartbeat irregularities.</td>
<td></td>
</tr>
</tbody>
</table>

Modals

Modal verbs change the meaning of the verb in a variety of ways as illustrated in the examples below:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracks in the welding can only be detected by x-rays.</td>
<td></td>
</tr>
<tr>
<td>Liquid oxygen could have leaked into the turbine and cause the fire.</td>
<td></td>
</tr>
<tr>
<td>The light metal fast-breeder reactor must be operated under extreme safety precautions.</td>
<td></td>
</tr>
</tbody>
</table>

Verbs are used together in a complex variety of tenses. In the chart below, keep in mind that "continuous" tenses are those that use -ing and "perfect" tenses are those that use some form of the auxiliary verb have.

<table>
<thead>
<tr>
<th>Tense</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple present</td>
<td>works</td>
</tr>
<tr>
<td>Present continuous</td>
<td>is working</td>
</tr>
<tr>
<td>Present perfect</td>
<td>has worked</td>
</tr>
<tr>
<td>Simple past</td>
<td>worked</td>
</tr>
<tr>
<td>Past continuous</td>
<td>was working</td>
</tr>
<tr>
<td>Past perfect</td>
<td>had worked</td>
</tr>
<tr>
<td>Simple future</td>
<td>will work</td>
</tr>
<tr>
<td>Future continuous</td>
<td>will be working</td>
</tr>
<tr>
<td>Future perfect</td>
<td>will have worked</td>
</tr>
<tr>
<td>Present perfect continuous</td>
<td>has been working</td>
</tr>
<tr>
<td>Past perfect continuous</td>
<td>had been working</td>
</tr>
<tr>
<td>Future perfect continuous</td>
<td>will have been working</td>
</tr>
</tbody>
</table>

Adjectives

An adjective provides more detail about a noun; that is, it modifies a noun. Adjectives occur just before the nouns they modify, or after a linking verb:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The armature is a rectangular ring about which another coil of wire is wound.</td>
<td></td>
</tr>
<tr>
<td>The generator is used to convert mechanical energy into electrical energy.</td>
<td></td>
</tr>
<tr>
<td>The steel pipes contain a protective sacrificial anode and are surrounded by packing material.</td>
<td></td>
</tr>
</tbody>
</table>

Adverbs

An adverb provides more information about a verb, adjective, or another adverb; that is, it "qualifies" the verb, adjective, or adverb:
The desk is made of an especially corrosion-resistant industrial steel.
The drilling bit actually tears rock apart to get at the oil.
The power company uses huge generators which are generally turned by steam turbines.
The debate over nuclear power has often been bitter.

Conjunctions

Conjunctions link words, phrases, and whole clauses to each other and are divided into coordinating, adverbial, and subordinating conjunctions. In this list, only the list of coordinating conjunctions is complete:

<table>
<thead>
<tr>
<th>Coordinating conjunctions</th>
<th>Subordinating conjunctions</th>
<th>Adverbial conjunctions</th>
</tr>
</thead>
<tbody>
<tr>
<td>and</td>
<td>although</td>
<td>therefore</td>
</tr>
<tr>
<td>or</td>
<td>since</td>
<td>however</td>
</tr>
<tr>
<td>nor</td>
<td>because</td>
<td>in other words</td>
</tr>
<tr>
<td>but</td>
<td>when</td>
<td>thus</td>
</tr>
<tr>
<td>yet</td>
<td>while</td>
<td>then</td>
</tr>
<tr>
<td>for</td>
<td>if</td>
<td>otherwise</td>
</tr>
<tr>
<td>whereas</td>
<td>as if</td>
<td>nevertheless</td>
</tr>
<tr>
<td>as</td>
<td></td>
<td>on the other hand</td>
</tr>
</tbody>
</table>

Coordinating Conjunctions

Coordinating conjunctions link words, phrases, and clauses. Here are some examples:

Nuclear-powered artificial hearts proved to be complicated, bulky, and expensive.

In the 1960s, artificial heart devices did not fit well and tended to obstruct the flow of venous blood into the right atrium.

The blood vessels leading to the device tended to kink, obstructing the filling of the chambers and resulting in inadequate output.

The small clots that formed throughout the circulatory system used up so much of the clotting factor that uncontrolled bleeding from external or internal injury became a risk.

Current from the storage batteries can power lights, but the current for appliances must be modified within an inverter.

Adverbial Conjunctions

Adverbial conjunctions link two separate sentences, but require a semicolon or colon:

The Kedeco produces 1200 watts in 17 mph using a 16-foot rotor; on the other hand, the Dunlite produces 2000 watts in 25 mph winds.

The first artificial hearts were made of smooth silicone rubber which apparently caused excessive clotting and, therefore, uncontrolled bleeding.

(This example does not contain two sentences; no semicolon, therefore, is needed.) For short periods, the fibers were beneficial; however, the eventual buildup of fibrin on the inner surface of the devise would impair its function.
The atria of the heart contributes a negligible amount of energy; in fact, the total power output of the heart is only about 2.5 watts.

Subordinating Conjunctions

Subordinating conjunctions combine separate sentences in a different way: they turn one of the sentences into an adverb clause. Here are some examples of subordinating conjunctions:

- Whenever an electron acquired enough energy to leave its orbit, the atom is positively charged.
- If the wire is broken, electrons will cease to flow and current is zero.

Phrases and clauses

Phrases and clauses are groups of words that act as a unit and perform a single function within a sentence. A phrase may have a partial subject or verb but not both; a dependent clause has both a subject and a verb (but is not a complete sentence). Here are a few examples (not all phrases are highlighted because some are embedded in others):

<table>
<thead>
<tr>
<th>Phrases</th>
<th>Clauses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity has to do with those physical phenomena involving electrical charges and their effects when in motion and when at rest. <em>(involving electrical charges and their effects is also a phrase.)</em></td>
<td>Electricity manifests itself as a force of attraction, independent of gravitational and short-range nuclear attraction, when two oppositely charged bodies are brought close to one another.</td>
</tr>
<tr>
<td>Electricity manifests itself as a force of attraction, independent of gravitational and short-range nuclear attraction, when two oppositely charged bodies are brought close to one another.</td>
<td>The symbol that denotes a connection to the grounding conductor is three parallel horizontal lines, each of the lower ones being shorter than the one above it.</td>
</tr>
<tr>
<td>In 1800, A. Volta constructed and experimented with the voltaic pile, the predecessor of modern batteries.</td>
<td>These studies led Planck to postulate that electromagnetic radiation is emitted in discrete amounts, called quanta.</td>
</tr>
<tr>
<td>In 1833, Faraday’s experimentation with electrolysis indicated a natural unit of electrical charge, thus pointing to a discrete rather than continuous charge. <em>(to a discrete rather than continuous charge is also a phrase.)</em></td>
<td>Since the frequency is the speed of sound divided by the wavelength, a shorter wavelength means a higher wavelength.</td>
</tr>
<tr>
<td>The symbol that denotes a connection to the grounding conductor is three parallel horizontal lines, each of the lower ones being shorter than the one above it.</td>
<td>Nuclear units planned or in construction have a total capacity of 186,998 KW, which, if current plans hold, will bring nuclear capacity to about 22% of all electrical capacity by 1995. <em>(if current plans hold is a clause within a clause)</em></td>
</tr>
</tbody>
</table>

Prepositional phrases

A prepositional phrase, composed of a preposition and its object, shows relationships involving time, direction, or space:

- An artificial heart was installed in a human subject for the first time in 1969.
The current leads to the field coils and into an external circuit. Alternators are not compatible with wind systems because of their high rpm requirements.

The operation of a wind generator is based upon Faraday's law of induced voltage which states that the voltage between the ends of a loop of wire is proportional to the rate of change in the magnetic field lines within the loop. (four prepositional phrases in the last highlighted area.)

Appositives

An appositive, a word or phrase that renames a noun or pronoun, adds information about a noun but in a way different than do adjectives:

In 1972, Richard Nixon, president of the U.S., approved the development of a reusable space vehicle, the Space Shuttle.

Broad principles about space flight were laid down by the Austrian astronautical pioneer, Dr. Eugen Sanger.

The external tank of the Space Shuttle's main engines is composed of two tanks—a large hydrogen tank and a smaller oxygen tank.

An upper air inversion, a layer of stable air, is usually present over large areas of the tradewinds as a hurricane develops.

Participial phrases

A participial phrase is a group of words acting as an adjective and modifying a noun or pronoun. A participle is the -ed or -ing form of a verb:

The Eagle Generator uses a 6-pole, shunt-wound generator designed to reach maximum power at 20 mph.

Because of the design created by Kwan-Gett, endothelial cells could grow on the fibrin layer, making the interior surfaces of the artificial heart similar to those of the natural heart.

The wire is wrapped around field cores made of steel laminations.

Gerunds and gerund phrases

Similar in appearance to a participial phrase, the gerund plays the role of noun. A gerund is a single word with -ing used as a noun. A gerund phrase is a single word with -ing accompanied by its objects, complements, and modifiers; it is a group of words acting as noun:

In the iron-core type transformer, the winding is wrapped around an iron bar.

The splitting of an atom produces a great amount of energy.

The cloning of a cell produces an identical cell.

Jarvik changed his artificial heart design in 1974 by fitting his model with a highly flexible three-layer diaphragm made of smooth polyurethane.

The Jarvik-7 design then in 1979 achieved a record time of sustaining life in a calf for 221 days.

Reversing the rotation of the electrohydraulic heart pump reverses the direction of the hydraulic flow.
Adjective clauses

An adjective clause is almost a complete sentence—but not quite. It functions the same way a single-word adjective does: both modify, that is, add more information to our understanding of a noun. Adjective clauses contain (1) a relative pronoun, (2) in some cases, a subject, (3) a complete verb, and (4) any other accompanying predicates or objects:

Typically, one portable drilling rig, which requires two tug boats to bring it to the site, and several other boats are used in the exploratory drilling phase.

The company holds many patents on its wind energy systems, such as the flyball governor which varies the pitch of the blades in high winds and the slow-speed generator whose performance curve matches that of the propeller.

The idea of the artificial heart arose in part from the need to treat people who cannot receive a donor heart.

Nose designed a "biolized" heart in which the surfaces that came into contact with blood were made from natural tissues treated with chemical fixatives to make them tougher and immunologically inert. (an adjective clause within another adjective clause)

The regular CPR class people are taking everywhere now only lasts an evening.

Adverb clauses

An adverb clause is also nearly a complete sentence; it functions like an adverb does by explaining the how, when, where, and why of the discussion. The adverb clause usually contains a subordinating conjunction, a subject, a complete verb, and any other related phrases or clauses:

Because the shortage in donor hearts is so severe, transplant surgery is limited to people with the best chances of surviving.

As long as the wind speed is sufficient, the electrical energy will be continuously generated.

If an oil spill occurs away from shore, it is unlikely to affect many birds, unless they are directly in a major migratory path at a migrating season.

Noun clauses

A noun clause is a group of words used as a noun. Introduced by a relative pronoun, a noun clause can play any of the functions a noun plays: subject, direct object, object of preposition, subjective or object complement. Here are example noun clauses, with their functions labelled:

Estimates indicate that 20 million Americans owned hand-held calculators by 1974. (direct object)

Computer systems are often measured by how much main memory their architectures allow and by how fast that memory can be accessed. (object of preposition—two of them!)

Lemaitre proposed that all matter in the Universe was once concentrated into what he termed the primeval atom. (direct object; in this sentence, what he termed the primeval atom is also a noun clause.)

The choice of furnace wall construction depends on how sophisticated the gas-cleaning equipment is and on whether a large amount of waste is to be recovered. (object of preposition—two of them)

Most microcomputers use what are called flexible diskettes for program and data storage. (direct object)
The major disadvantage of sequential files is that they are slow. (subject complement)

Coordinated elements

Many of the sentence elements described above can be "coordinated"; that is, they can be doubled, tripled, or even quadrupled and linked with coordinating conjunctions like and and or. For example, in the phrase "a black and white Datsun 240Z," two adjectives are are coordinated. Here are some examples of coordinated sentence elements:

In 1800, A. Volta constructed and experimented with the voltaic pile, the predecessor of the modern battery. (two verbs)

Maxwell's theory not only synthesized theories about electricity and magnetism, but also showed optics to be a branch of electromagnetism. (two predicates)

Heat exchangers can be so designed that chemical reactions or energy-generation processes can be carried out in them. (two noun phrases)

Heat exchangers find wide applications in the chemical process industries, in the food industry, in the generation of steam for production of power and electricity, in aircraft and space vehicles, and in the field of cryogenics for low-temperature separation of gases. (nine total prepositional phrases)
Common Grammar, Usage, and Punctuation Problems

In this chapter, we will cover only those grammar, punctuation, usage, and spelling problems that give people the biggest headaches.

Technical writing professionals try to simplify grammar rules as much as possible without hurting the language or putting themselves in straitjackets. Typically, they work in teams and frequently move in and out of projects—so that the same document may be worked on by different writers and editors during the space of just a few years. That's why any guidelines based on interpretation or personal style or judgment must be avoided.

Commas

Punctuation is a good example of this effort to use clearly defined rules in technical writing. In journalistic punctuation style, you punctuate according to what you feel are the needs for clarity. But this is likely to be viewed differently by different people. Therefore, punctuation style in technical writing is based on the structure of the sentence.

Introductory Elements

Use a comma after all introductory elements. Any element, regardless of length, coming before the main clause should be punctuated with a comma. (The main clause is that core part of a sentence that makes it a complete sentence; that is, it expressed a complete thought.) Here are some examples:

When an atom acquires enough energy to leave its orbit, the atom is positively charged.

As for the energy required to produce plastic automobile parts, the auto makers view the additional cost as justified by the savings in petroleum by a lighter car during its lifetime.

Because the high-pressure turbopumps rotate at speeds of 30,000 rpm, the weight distribution on the turbine blades must be balanced with great accuracy.

Because there is no belt of doldrums in the Atlantic south of the equator, hurricanes do not usually occur there.

Between 40 and 50 degrees west and just south of 10 degrees north in the western end of the doldrums belt, calms do occur with frequency, and hurricanes originate there with great frequency.

In 1831, Michael Faraday discovered that if a magnet was moved in the vicinity of a coil, a current could be induced in the coil. (Punctuate even short introductory phrases like this and the next two sentences.)

Using this concept, Faraday arrived at a relation between the changing flux and the induced electromagnetic field.

Today, the computer consortium of IBM, Motorola, and Apple is announcing its new PowerPC chip.

Unnecessary Commas

Double check commas between parts of a sentence. A single comma should never break the flow of the main subject, verb, and object or complement of a sentence. Instead, commas should occur in pairs. Here are some examples (the bracketed commas indicate where commas are typically but mistakenly placed):

The discovery that moving a magnet within a coil could produce current[,] was a major breakthrough in the history of electronics. (Yes, it's a long way from the subject "discovery" to the verb "was," but there should be no comma.)

Decreasing the radar operating frequency[,] increases the effective velocity coverage for the same sampling rate. (The whole phrase "decreasing the radar operating frequency" is the subject of the verb "increases"--no comma.)

It can be assumed that[,] precipitation particles move with the air in their environment and are therefore good tracers for air motion. (Don't know why people would put a comma here--does it feel like a pause?)
The separator between black mix and the zinc electrode consists of a paper barrier coated with cereal or methyl cellulose. (No comma here either.)

That European refuse incineration costs are substantially lower than U.S. costs is particularly evident when income from by-product recovery and salvage operations is included. (The whole clause, "that European refuse incineration costs are substantially lower then U.S. costs," is the subject for the verb "is"—no comma.)

### Compound Sentences

Use a comma between all independent clauses. Whenever you have a compound sentence (those are the ones joined by and, but, yet, or, not, for, whereas), put a comma before the conjunction (the words I just listed). The length of the compound sentence does not matter. Here are some examples:

- The tank is made of aluminum, but the outer surface is protected by a spray-on foam.
- By the mid-1970s, the free-spending ways of the Apollo program were gone, and NASA now had to grapple with large technical challenges on a limited budget.
- It first appeared that Hurricane Betsy would reach the eastern U.S., but a looping path took her around the tip of Florida and into the Gulf instead.
- Gamma rays produce few pairs, but they travel farther.
- One grate turns at 50 mph, but the others turn at 15 mph.
- Type your name, and then press the Enter key.

You should type your name and then press the Enter key. (In this case, "you" is the subject for the compound verb—it's the subject for both "should type" and "press." This is not a compound sentence, and therefore there is no comma before "and." )

### Compound Predicates

Do not use a comma between two compound verb phrases. Watch out about what you think are compound sentences. A complete sentence has to be on both sides of the conjunction (that means subject, verb, object, or complement—the works). Compare the following examples:

- Offspring exposed to significant amounts of alcohol in utero are much more active than controls and sometimes seem to fly around the room. (This is a compound verb phrase, not a compound sentence: "offspring" is subject for both verbs.)
- Plastic parts are not weldable and must be repaired by other methods.
- The observation and measurement of such small frequency shifts require excellent radar frequency-stability characteristics that are not usually found in conventional radar but can be added without a drastic increase in equipment costs.
- Pulse Doppler radar effectively samples the backscattered signal at the radar repetition rate and therefore can provide unambiguous Doppler frequency observations only in the frequency range allowed by the sampling rate.
- The manganese dioxide used in batteries is usually obtained from natural ore (mainly from Gabon, Greece, and Mexico) but can be a synthetic product by chemical precipitation or by electrolytic methods.

The last three sentences above probably seem incredibly long to you and needy of commas at and but. Rather than break our rule (and remember it's not breaking the rule that matters; it's creating more and more exceptions that will drive us all crazy), why not split these into two sentences each as in the following?

- The observation and measurement of such small frequency shifts require excellent radar frequency-stability characteristics that are not usually found in conventional radar. However, this same observation and measurement can be added without a drastic increase in equipment cost.
- Pulse Doppler radar effectively samples the backscattered signal at the radar repetition rate. This type of radar therefore can provide unambiguous Doppler frequency observations only in the frequency range allowed by the

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http://distanceed.hss.kennesaw.edu/technicalcommunication/chapters/5_8GrammarUsagePunctuation/5_8GrammarUsagePunctuation_print.html
The manganese dioxide used in batteries is usually obtained from natural ore (mainly from Gabon, Greece, and Mexico). It can also be a synthetic product prepared by chemical precipitation or electrolytic methods.

### Nonrestrictive Elements

Use commas around all nonrestrictive elements. Nonrestrictive elements are phrases and clauses that are nonessential to the grammar of the sentence. These elements can be taken out of the sentence without hurting its basic message. Use commas around these nonrestrictive elements. Here are some examples:

- Eighty percent of the work done by the heart is carried out by the left centricle, which pumps blood into the arteries serving the organs and the tissues. (Nice of the writer to remind us what the left ventricle does, but the sentence could live without it; it would still make sense.)
- The test produced a speed in the high-pressure hydrogen turbopump of 7000 ROM, which is 19 percent of the design speed. (This is additional detail, not essential to the sense of the sentence.)
- The Coriolis force, caused by the rotation of the earth, always acts at right angles to the pressure gradient in the northern hemisphere. (This is a helpful definition but again is not essential to the sentence.)
- The bulky equipment, although placed on a rolling cart, must always remain within 6 feet of the heart transplant patient. (Nonessential stuff—put commas around it!)
- The formation of hurricane, a type of atmospheric vortex, involves the combined effect of pressure and circular wind.
- Researchers also found that heavy drinkers--women drinking at least 1.6 ounces of absolute alcohol during pregnancy--have infants averaging 59 grams less than the infants of lighter drinkers. (Nonessential stuff—put commas around it, or in this case dashes, which are commas by another name.)
- Adding waterproofing material to a fabric increases the contact angle, making the fabric water-repellent. (Nonessential stuff—put commas around it!)
- Molecules may also have some degree of ordering as well as disordered motion, in which case the total energy is the sum of the mechanical and thermal energies. (Nonessential stuff—put commas around it!)

### Restrictive Elements

Do not use commas around restrictive elements. Restrictive elements are phrases and clauses that a sentence desperately needs to make sense, to say what it means to say. If you take restrictive elements out of a sentence, you wreck the sentence!

<table>
<thead>
<tr>
<th>Problem</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>You can use the system[,] when the login prompt appears.</td>
<td>You can use the system when the login prompt appears.</td>
</tr>
<tr>
<td>(The way this sentence is punctuated implies that you can use the system any old time! The comma indicates that the clause beginning with &quot;when&quot; can be lifted from the sentence.)</td>
<td>(The clause beginning with &quot;when&quot; is restrictive— it can't be omitted from the sentence and therefore should not be punctuated. Now the sentence means that you can use the system only when the prompt appears.)</td>
</tr>
</tbody>
</table>

Here are some additional examples of this rather tricky rule:

- A turbopump is a essentially pump that is turned by the action of a turbine that shares a common shaft with the pump. (It's not any old pump; it's the one that does what the latter part of this sentence says it does. Imagine this sentence ending at "essentially a pump.")
- Eighty percent of the work done by the heart is carried out by the left ventricle. (Imagine this sentence without "done by the heart," which is the restrictive element in this sentence. No commas here!)
- A drop of water almost flattens out when it is placed on a glass plate. (Imagine this sentence without "when it is placed on a glass plate," which is the restrictive element here. No commas need apply!)
In one study, 11 percent of the offspring whose mothers consumed 2 to 4 drinks per day showed partial features of fetal alcohol syndrome (FAS), while 19 percent of those whose mothers consumed 4 or more drinks per day showed FAS features. (Imagine this sentence without "whose mothers consumed 2 to 4 drinks per day" or without "whose mothers consumed 4 or more drinks per day." The sentence simply wouldn't make any sense. No commas!)

### Series Elements

Use a comma before the "and" in a series of three or more. In a series of three or more words or phrases, go ahead and put the comma before the and that occurs before the final element. You may have heard that this series-and comma rule is optional. However, there are situations where the lack of the series-and comma (also known as the Oxford comma) can cause confusion. And when you consider that using the Oxford comma can hurt the sense of the sentence, it makes sense to use it in all cases. Here are some examples:

- Instrument panels, bumper components, door liners, seat covers, and grille panels are the most common parts produced directly by automakers.
- A 12-ounce can or beer, a 5-ounce glass of wine, and a mixed drink with 1.5 ounces of 80-proof liquor all contain approximately the same amount of alcohol.
- The development years involved designing the components for the Space Shuttle's engines, testing the original designs, and retesting the redesigned components.
- In humans, the period of rapid brain development begins at mid-pregnancy, peaks in the third trimester, and ends by the postnatal year.

### Two-element Series

Do not use a comma between a series of only two. Be careful not to apply the Oxford comma rule to a series of only two elements. Watch out also for those situations where it looks like you have a series of three elements but it is actually a series of two noun phrases and a compound verb phrase. See the example:

- We brought bread and cheese and read poetry. (Sorry for the Dick-and-Jane sentence, but notice that "bread," "cheese," and "poetry" are not really in a series. No commas for either "and" here.)

### Series Adjectives

Punctuate series adjectives carefully. It gets tricky knowing how to punctuate when two or more adjectives pile up in front of a noun. One fairly reliable technique is this: if you can switch the order of the adjectives or if you can insert and between them without making the phrase sound weird, then you can consider using commas. (Remember that in no case is there a comma between the final series adjective and the noun it modifies.)

- He's having his third mid-life crisis. Now he wants a new red sports car. (You couldn't say "mid-life third crisis" nor could you say "sports red new car"--so no commas in or amongst these adjectives.)
- Each door is held shut with an adjustable, spring-loaded door latch. (You probably could switch "adjustable" and "spring-loaded"--use a comma here.)
- As each rack passes through the wash chamber, the dishes get a thorough soil-stripping wash and a final, automatic hot-water rinse. (You probably could switch "final" and "automatic"--use a comma here.)

These last two examples may have felt a bit "iffy" to you—the technique is only "fairly" reliable.

NOTE: This doesn't cover all comma rules; see a standard handbook like the ones mentioned in the introduction to this chapter. (Incidentally, you'll notice a lot more flexibility in the rules in those standard reference books—they weren't written for the technical-documentation context.)
Although the colon has other uses in writing, its most important function is to act as a signal to the reader—it says something like "Okay, reader! Here it comes!" In the first example, notice the words before the colon make a complete statement—at least grammatically:

To make a kite, you need the following items: string, paper, thin sticks, glue, and scissors.

The main engines of the Space Shuttle consist of six main components: the external tank, the low-pressure turbopump, the high-pressure turbopumps, the preburners, the combustion chamber, and the nozzle.

Hurricane size is expressed in three ways: the strength of the maximum winds, the diameter of the hurricane-force winds, the diameter of the gale-force winds, and the overall size the cyclone circulation.

To make a metal dashboard, three steps are required: (1) the metal must be stamped; (2) the texture must be stamped into the metal; and (3) the part must be painted.

Notice in the last example that the first sentence introduces a series of complete sentences. You can use the colon to connect two complete sentences as long as the first sentence introduces or prepares for the second. Here are some examples of this possibility:

The grades of the students in the caffeine research project told a dramatic story: the higher the caffeine intake, the lower the grades, both for semester and overall grade point average.

In general, shelf-life increases as the cell size of the battery becomes smaller: with well-constructed cells, shelf-lives of three years with a No. 6 telephone cell and ten years with a penlight cell are possible.

The line-of-sight in a communication satellite can be a problem: communication satellites can see the earth's surface only between about 83 degrees north latitude and 83 degrees south latitude.

Many of the new applications of microcomputer are "interactive": there is frequent interaction between the computer and one or more users.

However, don't use a colon inside a complete sentence. It should connect only complete sentences to complete sentences or connect complete sentences to lists.

<table>
<thead>
<tr>
<th>Problem:</th>
<th>The typical Doppler velocity sensor consists of: a transistor, an antenna, and a receiver.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision:</td>
<td>The typical Doppler velocity sensor consists of a transistor, an antenna, and a receiver.</td>
</tr>
<tr>
<td>Problem:</td>
<td>Three significant types of generating plants are: hydroelectric, fossil-fuel-electric, and nuclear-electric.</td>
</tr>
<tr>
<td>Revision:</td>
<td>Three significant types of generating plants are hydroelectric, fossil-fuel-electric, and nuclear-electric.</td>
</tr>
<tr>
<td>Problem:</td>
<td>You will need: string, paper, thin sticks, glue, and scissors, to make a kite.</td>
</tr>
<tr>
<td>Revision:</td>
<td>You will need the following items—string, paper, thin sticks, glue, and scissors—to make a kite.</td>
</tr>
</tbody>
</table>

Look at this last example closely: the grammatical core of the sentence is "You will need the following items...to make a kite." You don't want to break up the core grammar of a sentence this way with a colon.

### Semicolons

The semicolon could be called a strong comma. Its two main uses are to connect two (or more) sentences that seem very closely related and to clarify the punctuation of a series of items that have their own internal commas.

You may have had some unhappy encounters with run-ons and comma splices in the past. These two "comma faults" usually result from the writer's sense that the sentences involved in the problem are very closely related—the full stop signaled by the period seems like too full of a stop. (It's almost like music; makes you wonder why we don't have the equivalent of whole, half, quarter, and eighth rests in punctuation.) Often, these run-on sentences and comma splices can be fixed by substituting a semicolon for the offending comma.

But not always. Some writers go way overboard in sensing close relations between sentences. Well, yes, every sentence in a document is related to every other—they ought to be! But they need to be reeeaaaally closely related. Here are some examples:

"Plaque-fissuring" refers to the formation of an opening from the lumen to the intima; it leads to an intra-intimal thrombus containing not just red cells but mainly fibrin and platelets.
In 1940, philanthropy accounted for 24 per cent of the total operating budget of nonprofit hospitals in New York City; in 1948, it had dropped to 17 per cent.

Gray mold is one of the most important fungal diseases in Italian viticulture; its growth causes serious production losses and adversely affects wine quality.

The other use of the semicolon worth noting here is how it can clarify items in a series that have commas within them already:

Injury caused by pollutants can easily be mistaken for injury caused by other stresses; or, just the opposite, injury symptoms from adverse temperature or moisture relations may resemble, and can be incorrectly attributed to, air pollutants.

Possible research areas announced recently have included genetics, fermentation microbiology, and immobilized biocatalysts; but environment biotechnology, such as metal recovery and waste recycling, is also included.

A typical membrane potential of about one-tenth of a volt sounds relatively small; but, because it occurs across a membrane that is only about 10 nanometers thick, it represents an enormous voltage gradient of about 10 million volts per meter.

The heart undergoes two cardiac cycle periods: diastole, when blood enters the ventricles; and systole, when the ventricles contract and blood is pumped out.

An organization may be functional, with responsibility assigned on the basis of buying, selling, promotion, distribution, and other tasks; production-oriented, with production managers for each product category and brand managers for each individual brand in addition to functional categories; or market-oriented, with managers assigned on the basis of geographical markets and customer types in addition to functional categories.

Electric power substations are used for some or all of the following purposes: connection of generators, transmission or distribution lines, and loads to each other; transformation of power from one voltage level to another; interconnection of alternate sources of power; and detection of faults, monitoring and recording of information, power measurement, and remote communication.

A common misuse of the semicolon is to plunk it down between what appear to be two complete sentences:

<table>
<thead>
<tr>
<th>Problem:</th>
<th>The slide rule was an important device for scientists and engineers for many years; although its use has all but vanished since the advent of the pocket calculator.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision:</td>
<td>The slide rule was an important device for scientists and engineers for many years, although its use has all but vanished since the advent of the pocket calculator.</td>
</tr>
</tbody>
</table>

(Alternatively, you could have: The slide rule was important device for scientists and engineers for many years; although its use has all but vanished since the advent of the pocket calculator."

**Apostrophes**

Pity the poor apostrophe—it's practically an endangered species. The problem with the apostrophe is that it has some conflicting tasks: it is used primarily to show possession, mark contractions, and, minimally, to show plurals. But people have gotten it all mixed up. For example, the likes of "John love's Mary" was becoming pretty common in telephone booths before the rise of the cell phone. A scant two or three hundred years ago, people didn't even use apostrophes (yes-a world without apostrophes!). But the thing does add precision to writing; it does prevent confusion. The rules are super simple; here they are:

- To show possession for singular words not ending in s, add 's:

<table>
<thead>
<tr>
<th>Earth's shadow</th>
<th>the fish's ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>the Moon's orbit</td>
<td>India's population</td>
</tr>
<tr>
<td>this company's profits</td>
<td>the family's car</td>
</tr>
</tbody>
</table>

- To show possession for singular words ending in s, add 's or just an ' (usage varies on this, but this is a safe choice):

"The student's book is on the table; the student's brother was visiting.

However, "student's" is a possessive adjective, so you would say, "The student's book is on the table; the student's brother was visiting.

(The "although" clause is not complete; it can't stand on its own.)
• To show possession for plural words ending in s, add ' to the plural form of the word (but don't add another s):

<table>
<thead>
<tr>
<th>Venus's (or Venus') orbit</th>
<th>Mars's (or Mars') shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>James's (or James') calculator</td>
<td>tennis's (or tennis') popularity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>these companies' employees</th>
<th>planets' orbits</th>
</tr>
</thead>
<tbody>
<tr>
<td>these species' niches</td>
<td>these countries' population</td>
</tr>
<tr>
<td>southern states' capitals</td>
<td>these computers' capabilities</td>
</tr>
</tbody>
</table>

• To show possession for plural words not ending in s, add 's:

<table>
<thead>
<tr>
<th>women's rights</th>
<th>men's rights</th>
</tr>
</thead>
<tbody>
<tr>
<td>children's education</td>
<td>geese's honking</td>
</tr>
</tbody>
</table>

• To show the plural of numbers or letters when they are discussed as such, add 's (again usage varies on this, but this is a safe choice):

Do you know how many c's and s's are in the word ne-e-ry?

On a computer, O's are represented by O's and 0's with 0's.

His speech was filled with annoying uh's, okay's, and you know's.

• To show possession for possessive pronouns, don't use the apostrophe (don't ask me why):

This book is yours.

This CRT is theirs, not ours.

• And, now, everybody's personal favorite—the one that English teachers and copyeditors can spot from outer space—the rules for its and it's. Its is the possessive form of it; it's is the contraction for it is (exactly opposite, I realize):

The SGO density gauge is missing one of its adjusting knobs.

It's unfortunate that our language has so many exceptions to its rules—or is it?

Now, there are others rules involving apostrophes such as for contractions or for quotes within quotes, but we'll leave those for the reference books to handle.

Sexy Technical Communication Home

**Hyphens**

Someone once said, "Take hyphens seriously and you will surely go mad." They weren't lying! (By the way, this previous sentence has a pronoun-reference problem.)

Hyphens are supposed to keep us from misreading things and show us how words in complex phrases relate to each other. The problem is that the rules for hyphens just cannot be applied absolutely consistently—you end up hyphenating everything including the kitchen sink. Professional editors end up keeping long lists of exactly which word pairs they will hyphenate in a specific document (so that they don't end up in therapy).

Hyphens do matter, however (save the hyphen!). Our language culture seems to be very "into" piling up ambitious noun phrases. These sentences verge on having a problem called "noun stacks." To read this kind of stuff, we need hyphens—they show us what goes with what. Hyphens show that a pair of words is acting as a unit and must be read that way. The
Common types of unit modifiers—which are two or more words acting as a unit—are discussed in the following (but it’s by no means exhaustive):

- Although styles vary on this, do not hyphenate the common prefixes such as pre, anti, multi, and so on (unless it spells some other word or just looks hopelessly weird). However, do hyphenate prefix words such as self-.

<table>
<thead>
<tr>
<th>self-lubricating hinges</th>
<th>nonprescription drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>multistep reaction</td>
<td>precooked foods</td>
</tr>
<tr>
<td>antibiotic agent</td>
<td>mid-1970s</td>
</tr>
<tr>
<td>nonmalarial areas</td>
<td>micro-universe</td>
</tr>
<tr>
<td>reusabolysis</td>
<td>subnuclear</td>
</tr>
<tr>
<td>re-sent</td>
<td>anti-icing</td>
</tr>
</tbody>
</table>

- Hyphenate a unit modifier (“5-year” in the first example) made up of a number followed by a unit of measurement:

<table>
<thead>
<tr>
<th>5-year grant</th>
<th>10-month period</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-megabyte memory</td>
<td>3.5-inch diskette</td>
</tr>
<tr>
<td>8-oz. cup</td>
<td>4-gallon tub</td>
</tr>
</tbody>
</table>

- Hyphenate an elliptical form of a longer phrase that is acting as a unit modifier:

<table>
<thead>
<tr>
<th>below-average rainfall</th>
<th>warm-up period</th>
</tr>
</thead>
<tbody>
<tr>
<td>built-in scale</td>
<td>on-board timer</td>
</tr>
<tr>
<td>start-up costs</td>
<td>pay-off period</td>
</tr>
<tr>
<td>in-service accuracy</td>
<td>written-out number</td>
</tr>
<tr>
<td>immune-deficient animals</td>
<td></td>
</tr>
</tbody>
</table>

- Hyphenate a non-verb element and a verb-like element acting as a unit:

<table>
<thead>
<tr>
<th>drought-producing system</th>
<th>water-repellent fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>coffee-flavored ice cream</td>
<td>nutrient-rich waters</td>
</tr>
<tr>
<td>government-sponsored programs</td>
<td>corrosion-resistant metal</td>
</tr>
<tr>
<td>pressure-induced melting</td>
<td>water-soluble reactants</td>
</tr>
<tr>
<td>spring-balanced doors</td>
<td>salt-free diet</td>
</tr>
<tr>
<td>health-related costs</td>
<td>caffeine-containing substances</td>
</tr>
</tbody>
</table>

- Watch out for three or more words acting as a unit to modify a following noun:

<table>
<thead>
<tr>
<th>case-by-case basis</th>
<th>a three-to-one ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>the right-to-die statutes</td>
<td>the air-to-ground voice transmission</td>
</tr>
<tr>
<td>on-the-job experience</td>
<td></td>
</tr>
</tbody>
</table>

- Don’t hyphenate units in which the first word ends in -ly:

| highly developed country | fully equipped computer |

The toughest area for hyphenation are those combinations that look like adjective + noun + noun or like noun + noun + noun. (True, only the last noun is really a noun, but let's not worry about that.) If the initial adjective or noun modifies the final (and real) noun, do not use a hyphen. If the initial adjective or noun modifies the noun directly following it, consider using a hyphen.
These examples do not need a hyphen:

<table>
<thead>
<tr>
<th>embryonic stem cells</th>
<th>poor economic performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high process yields</td>
<td></td>
</tr>
</tbody>
</table>

These examples could use hyphens according to some styles:

<table>
<thead>
<tr>
<th>cell-replacement strategies</th>
<th>cell-surface markers</th>
</tr>
</thead>
<tbody>
<tr>
<td>big-name automakers</td>
<td>large-scale production</td>
</tr>
</tbody>
</table>

If you are in doubt about whether to use a hyphen, don't use it. The best resource on hyphens is *Garner's Modern American Usage*; "Phrasal adjectives."

Once you get a partial feel for hyphens, watch out! You might start acting like Lucy in that show where she has been on the assembly line too long and starts going after everything and everybody with her wrenches. Everything will seem like it needs a hyphen! When that happens, back off, and ask yourself—could someone misread this sentence without a hyphen, even if they were just being mean? If it positively cannot be misread, then give your hyphen key a break.

**Comma Splices and Runons**

The comma-splice and run-on sentence (and the fused sentence, as a variant is called) are all examples of the problem in which two or more sentences are improperly joined. In the typical *comma-splice* sentence, two sentences are joined by a comma without an intervening coordinating conjunction (*and*, *or*, *nor*, *but*, *yet*). Technically, the *run-on* sentence is a sentence that goes on and on and needs to be broken up; it's likely to be a comma splice as well. A *fused* sentence is two complete sentence just jammed together without any punctuation and without any conjunction.

We write comma-splice and run-on sentences because we sense that the sentences involved are closely related—a full-stop period just doesn't seem right. Actually, the semicolon *is* the right choice in these situations (although it's easy to go semicolon crazy when you first start using them). Here are some examples of this type of problem and their revisions:

<table>
<thead>
<tr>
<th>Problem:</th>
<th>Sometimes, books do not have the most complete information, it is a good idea then to look for articles in specialized periodicals.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision:</td>
<td>Sometimes, books do not have the most complete information; it is a good idea then to look for articles in specialized periodicals.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problem:</th>
<th>Most of the hours I've earned toward my associate's degree do not transfer, however, I do have at least some hours the University will accept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision:</td>
<td>Most of the hours I've earned toward my associate's degree do not transfer. However, I do have at least some hours the University will accept.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problem:</th>
<th>The opposite is true of stronger types of stainless steel, they tend to be more susceptible to rust.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision:</td>
<td>The opposite is true of stronger types of stainless steel: they tend to be more susceptible to rust.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problem:</th>
<th>Some people were highly educated professionals, others were from small villages in underdeveloped countries.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision:</td>
<td>Some people were highly educated professionals, while others were from small villages in underdeveloped countries.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problem:</th>
<th>This report presents the data we found concerning the cost of the water treatment project, then it presents comparative data from other similar projects.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision:</td>
<td>This report first presents the data we found concerning the cost of the water treatment project and then comparative data from other similar projects.</td>
</tr>
</tbody>
</table>
### Fragments

Fragments are simply incomplete sentences—grammatically incomplete. They usually come about because the sentence may already seem too long. Also, in conversation, we typically speak in fragments. Here are some examples and their revisions:

<table>
<thead>
<tr>
<th>Problem</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most of this firm's contracts have been with major metropolitan hospitals, included among them is Memorial East in Luckenbach.</td>
<td>Most of this firm's contracts have been with major metropolitan hospitals, included among which is Memorial East in Luckenbach.</td>
</tr>
</tbody>
</table>

**Problem:**

Mary appeared at the committee meeting last week. And made a convincing presentation of her ideas about the new product.

**Revision:**

Mary appeared at the committee meeting last week and made a convincing presentation of her ideas about the new product.

**Problem:**

The committee considered her ideas for a new marketing strategy quite powerful. The best ideas that they had heard in years.

**Revision:**

The committee considered her ideas for a new marketing strategy quite powerful, the best ideas that they had heard in years.

**Problem:**

In a proposal, you must include a number of sections. For example, a discussion of your personnel and their qualifications, your expectations concerning the schedule of the project, and a cost breakdown.

**Revision:**

In a proposal, you must include a number of sections: for example, a discussion of your personnel and their qualifications, your expectations concerning the schedule of the project, and a cost breakdown.

**Problem:**

The research team has completely reorganized the workload. Making sure that members work in areas of their own expertise and that no member is assigned proportionately too much work.

**Revision:**

The research team has completely reorganized the workload. They made sure that members work in areas of their own expertise and that no member is assigned proportionately too much work.

**Problem:**

She spent a full month evaluating his computer-based instructional materials. Which she eventually sent to her supervisor with the strongest of recommendations.

**Revision:**

She spent a full month evaluating his computer-based instructional materials. Eventually, she sent the evaluation to her supervisor with the strongest of recommendations.

**Problem:**

The corporation wants to begin a new marketing push in educational software. Although the more conservative executives of the firm are skeptical.

**Revision:**

Although the more conservative executives of the firm are skeptical, the corporation wants to begin a new marketing push in educational software.
Problem modifiers

Modifier problems occur when the word or phrase that a modifier is supposed to modify is unclear or absent, or when the modifier is located in the wrong place within the sentence. A modifier is any element—a word, phrase, or clause—that adds information to a noun or pronoun in a sentence. Modifier problems are usually divided into two groups: misplaced modifiers and dangling modifiers:

<table>
<thead>
<tr>
<th>Misplaced modifiers</th>
<th>They found out that the walkways had collapsed on the late evening news. <em>(Was that before or after sports?)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The committee nearly spent a hundred hours investigating the accident. <em>(Did they spend even a minute?)</em></td>
</tr>
<tr>
<td></td>
<td>The supervisor said after the initial planning the in-depth study would begin. <em>(Just when did she say that, and when will the study begin?)</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dangling modifiers</th>
<th>Having damaged the previous one, a new fuse was installed in the car. <em>(Who damaged that fuse?)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After receiving the new dumb waiter, household chores became so much easier in the old mansion. <em>(Who received the dumb waiter?)</em></td>
</tr>
<tr>
<td></td>
<td>Using a grant from the Urban Mass Transportation Administration, a contraflow lane was designed for I-45 North. <em>(Who used that money?)</em></td>
</tr>
<tr>
<td></td>
<td>Pointing out the productivity and health problems plaguing US workers, aerobic fitness programs may become much more common in American industry, according to the spokeswoman. <em>(Who pointed that out?)</em></td>
</tr>
</tbody>
</table>

To correct misplaced modifier problems, you can usually relocate the misplaced modifier (the word or phrase). To correct dangling modifiers, you can rephrase the dangling modifier, or rephrase the rest of the sentence that it modifies.

<table>
<thead>
<tr>
<th>Revisions</th>
<th>On the late evening news, we heard that the walkways had collapsed.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The committee spent nearly a hundred hours investigating the accident.</td>
</tr>
<tr>
<td></td>
<td>The supervisor said that the in-depth study would begin after the initial planning.</td>
</tr>
<tr>
<td></td>
<td>Because the previous fuse had been damaged, a new one had to be installed.</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>Having damaged the previous one, I had to install a new fuse in my car.</td>
</tr>
<tr>
<td></td>
<td>After we received the dumb waiter, it was immediately installed.</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>After receiving the dumb waiter, we immediately installed it.</td>
</tr>
<tr>
<td></td>
<td>When the Urban Mass Transportation Administration granted funds to the city, planners began designing a contraflow lane for I-45 North.</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>Using a grant from the Urban Mass Transportation Administration, city planners designed a contraflow lane for I-45 North.</td>
</tr>
<tr>
<td></td>
<td>Because of the productivity and health problems plaguing US workers, aerobic fitness programs may become much more common in American industry, according to the spokeswoman.</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>Pointing out the productivity and health problems plaguing US workers, the spokeswoman said that aerobic fitness programs may become much more common in American industry.</td>
</tr>
</tbody>
</table>
One particularly effective way to correct dangling modifiers is to create a summary appositive, that is, a noun or pronoun summarizing what was just said followed by an adjective clause:

<table>
<thead>
<tr>
<th>Dangling modifier problems</th>
<th>Summary appositive revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stars that were formed relatively recently should have higher concentrations of heavy elements than do the older stars, which is confirmed by observation.</td>
<td>Stars that were formed relatively recently should have higher concentrations of heavy elements than do the older stars, a prediction that is confirmed by observation.</td>
</tr>
<tr>
<td>Most astronomers now believe that the energy of quasars comes from giant black holes in the cores of the quasars, which fits the growing belief that black holes are present in the cores of many galaxies, our own included.</td>
<td>Most astronomers now believe that the energy of quasars comes from giant black holes in the holes of quasars, a theory that fits the growing belief that black holes are present in the cores of many galaxies, our own included.</td>
</tr>
</tbody>
</table>

**Parallelism**

Parallelism refers to the way that items in a series are worded. You want to use the same style of wording in a series of items—it makes it easier on the reader. Widely varied wording is distracting and potentially confusing to readers. Here are some examples, with revisions and some comments:

**Problem:** The report discusses how telescopes work, what types are available, mounts, accessories, and techniques for beginning star gazers. (The "how" and the "why" clauses are not parallel to the "mounts," "accessories," and "techniques" phrases.)

**Revision:** The report discusses how telescopes work; what types of telescopes, mounts, and accessories are available; and how to begin your hobby as a star gazer.

**Problem:** Customers often call the showroom to inquire about pricing, what items are available, and to place orders. (The "what items are available" clause does not go with the two phrases beginning with "to.")

**Revision:** Customers often call the showroom to inquire about prices, check on the availability of certain items, and place orders.

**Problem:** While the dialysis solution remains in the peritoneal cavity, the dialysis is achieved, a process that includes the removal of nitrogenous wastes and correcting electrolyte imbalances and fluid overloads. (The "removal" phrase and the "correcting" phrase are not parallel to each other.)

**Revision:** While the dialysis solution remains in the peritoneal cavity, the dialysis is achieved, a process that includes the removal of nitrogenous wastes and the correction of electrolyte imbalances and fluid overloads.

**Problem:** This report is intended for people with some electronics background but have little or no knowledge of geophysical prospecting. (The "with" phrase is not parallel with the "have little" clause—this one is not even grammatical.)

**Revision:** This report is intended for people with some electronics background but with little or no knowledge of geophysical prospecting.

Parallelism problems have to do when same types of phrasing are not used in the same areas of a document: such as for list items in a vertical list, or for all headings at a certain level within a specific part of a document. At times, working on parallelism of phrasing is pedantic and unnecessary. However, in many instances, parallel phrasing can give readers important cues about how to interpret information. A jumble of dissimilar styles of phrasing for similar elements can be confusing. Shown below are those different styles:

**Styles of Phrasing**

<table>
<thead>
<tr>
<th>Questions</th>
<th>Noun Phrasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>How are groundwater samples collected?</td>
<td>Method of groundwater sample collection</td>
</tr>
<tr>
<td>How should soil samples be handled?</td>
<td>Soil sample handling</td>
</tr>
<tr>
<td>Must monitor wells be used to collect groundwater for laboratory analysis?</td>
<td>Purpose of monitor wells in groundwater collection for laboratory analysis</td>
</tr>
<tr>
<td>What should the samples be analyzed for?</td>
<td>Purpose of soil sample analysis</td>
</tr>
</tbody>
</table>
Gerund Phrasing | Sentences
---|---
Collecting groundwater samples | Groundwater samples must be collected properly.
Handling soil samples | Soil samples must be handled using the specified method.
Using monitor wells in groundwater collection for laboratory analysis | Monitor wells must be used to collect groundwater for laboratory analysis.
Analyzing samples | Samples must be analyzed for specific elements.

| Infinitives | Imperatives
---|---
To collect groundwater samples | Collect groundwater samples.
To handle soil samples | Handle soil samples properly.
To use monitor wells in groundwater collection for laboratory analysis | Use monitor wells in groundwater collection for laboratory analysis.
To analyze samples | Analyze samples.

### Subject-verb agreement

With subject-verb agreement problems, either a singular subject is matched with a plural verb, or vice versa. (Remember that some singular verbs end in -s.) Sometimes it’s hard to spot the true subject, particularly in these cases:

- When several words come between the subject and verb:

| Agreement problems | Revisions |
---|---
The communications between the programmer and the rest of the company tends to be rather informal. | The communications between the programmer and the rest of the company tend to be rather informal. |
The purpose of the monorails have changed from one of carrying food to one of carrying people to work in crowded urban areas. | The purpose of the monorails has changed from one of carrying food to one of carrying people to work in crowded urban areas. |
The shortage of available infants and the availability of children with special needs has changed the focus of adoption for many parents. | The shortage of available infants and the availability of children with special needs have changed the focus of adoption for many parents. |

- When there are two or more subjects joined by and or or:

| Agreement problems | Revisions |
---|---
In the computer's memory is stored the program and the data to be manipulated by that program. | In the computer's memory are stored the program and the data to be manipulated by that program. |
Either BASIC or Pascal are the high-level computer language you should take first. | Either BASIC or Pascal is the high-level computer language you should take first. |
Skyrocketing charges for data preparation, the need to keep pace with rapidly increasing amounts of data, and requirements for fast system response has led to a search for more efficient input devices. | Skyrocketing charges for data preparation, the need to keep pace with rapidly increasing amounts of data, and requirements for fast system response have led to a search for more efficient input devices. |
The magnetic-ink character-recognition device and the optical character-recognition device is two important advances in the preparation of batch input. | The magnetic-ink character-recognition device and the optical character-recognition device are two important advances in the preparation of batch input. |

- When the normal subject-verb order is inverted:

| Agreement problems | Revisions |
---|---
| |
In the computer's memory is stored the program and the data to be manipulated by that program.

Introduced in 1968 by the Computer Machine Corporation was the concept of key-to-disk processing and the concept of shared processing.

Equivalent to more than 3000 punched cards are the single diskette, first introduced in 1972.

Through the center of the core runs several sense wires.

- When the subject is a word like each, every, none, either, neither, no one, and nobody, especially when followed by a plural object of a preposition:

<table>
<thead>
<tr>
<th>Agreement problems</th>
<th>Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each of the steps in the process are treated in a separate chapter of this report.</td>
<td>Each of the steps in the process is treated in a separate chapter of this report.</td>
</tr>
<tr>
<td>Neither of the two high-level languages offer a facility for designing your own variables.</td>
<td>Neither of the two high-level languages offers a facility for designing your own variables.</td>
</tr>
</tbody>
</table>

- When the subject is a phrase or clause acting as a unit:

<table>
<thead>
<tr>
<th>Agreement problems</th>
<th>Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printing 54,000 chars. per 60 seconds were considered a high speed for printers at one time.</td>
<td>Printing 54,000 chars. per 60 seconds was considered a high speed for printers at one time.</td>
</tr>
<tr>
<td>Reversing the direction of currents through the wires change the magnetic state of the core.</td>
<td>Reversing the direction of currents through the wires changes the magnetic state of the core.</td>
</tr>
<tr>
<td>What is truly amazing about bits cells in integrated circuits are that 30 cells lined up side by side are about as wide as a human hair.</td>
<td>What is truly amazing about bits cells in integrated circuits is that 30 cells lined up side by side are about as wide as a human hair.</td>
</tr>
</tbody>
</table>

**Pronoun reference**

Pronoun reference is an area that has caused international conflict and created major rifts in the women's movement—so don't expect this little section to explain it all. A pronoun, as you may know, is a word like "he," "they," "him," "them," "which," "this," "everyone," "each," and so on. It's like a variable in programming—it points to some other word that holds its meaning.

Problems arise when you can't figure out what the pronoun is pointing to (its "reference") and when it doesn't "agree" in number or gender with what it is pointing to. You may have experienced the first type of problem: you're reading along in some incredibly technical thing, and it up and refers to something as "this." You look back up at the sea of words you have just been laboriously reading through—you say "this what?!" You have just experienced one form of the pronoun-reference problem. Here's another example:

<table>
<thead>
<tr>
<th>Agreement problems</th>
<th>Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lasers have also been used to study the reaction by which nitric oxide and ozone make nitrogen dioxide (NO2) and molecular oxygen. It plays an important role in the chemistry of the ozone layer that surrounds the earth and protects us from the sun's harmful ultraviolet radiation. (&quot;It&quot; what?)</td>
<td>Lasers have also been used to study the reaction by which nitric oxide and ozone make nitrogen dioxide (NO2) and molecular oxygen. This process plays an important role in the chemistry of the ozone layer that surrounds the earth and protects us from the sun's harmful ultraviolet radiation. (Okay, now we see...)</td>
</tr>
</tbody>
</table>
The second kind of pronoun-reference problem arises over lack of agreement between the pronoun and what it refers to. Here is one common example:

**Problem:** Motorola has just announced their new PowerPC chip.

**Revision:** Motorola has just announced its new PowerPC chip.

The problem here is that "Motorola" is a singular thing, while "their" is a plural thing—they don't agree in number! Now, maybe anyone knows what's being said here, but this is imprecise writing, and it can lead to serious problems, given the right situation. Here is a second example:

<table>
<thead>
<tr>
<th>Problem</th>
<th>These days, every student needs to own their own computer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision 1</td>
<td>Revision 1: These days, students need to own their own computers.</td>
</tr>
<tr>
<td>Revision 2</td>
<td>These days, every student needs to own his or her own computer.</td>
</tr>
<tr>
<td>Revision 3</td>
<td>These days, every student needs to own a computer.</td>
</tr>
</tbody>
</table>

The problem in this example is that "student" does not agree with "their": one is singular; the other, plural. Some call this usage acceptable (Merriam-Webster). However, it is imprecise—and we care greatly about precision in technical writing. We have to search for the plural noun we think is being referred to by "their." Not a good idea in technical writing. As you can see from the revisions, there sometimes is no good way to fix the problem. Whenever it works, try converting the singular noun to a plural—the plural pronoun will then be okay (but don't forget to change the verb to plural). Here are some additional examples:

<table>
<thead>
<tr>
<th>Problem</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASA hoped that, by using production tooling rather than by making each tool individually, they could save time and money.</td>
<td>NASA hoped that, by using production tooling rather than by making each tool individually, it could save time and money.</td>
</tr>
<tr>
<td>If an energy efficient system can be developed, electrical vehicles could become as popular as its conventional counterpart.</td>
<td>If an energy-efficient system can be developed, electrical vehicles could become as popular as their conventional counterpart.</td>
</tr>
<tr>
<td>Currently, Houston has $328.2 million in their 1984-1985 budget to help fund a new form of mass transportation.</td>
<td>Currently, Houston has $328.2 million in its 1984-1985 budget to help fund a new form of mass transportation.</td>
</tr>
<tr>
<td>Aerobic fitness programs help to improve an employee's physical condition by strengthening their circulatory, muscular, and respiratory systems.</td>
<td>Aerobic fitness programs help to improve employees' physical condition by strengthening their circulatory, muscular, and respiratory systems.</td>
</tr>
<tr>
<td>American industry should implement aerobic fitness programs for the betterment of their employees even if there is some opposition to it at first. (A double dose of pronoun-reference grief! It refers to what?)</td>
<td>American industry should implement aerobic fitness programs for the betterment of its employees even if there is some opposition to such programs at first.</td>
</tr>
</tbody>
</table>

**Pronoun case (who, whom)**

Yes, you too can learn the proper usage of who and whom. Who is used in the same slots that words like he, she, they, and we are used; whom is used in the same slots that him, her, them, and us are used. So if you can run a little replacement test, you can figure out which to use. Here's the test:

1. Imagine that you start out with sentences like these (admittedly not an eloquent crew but they'll do):
   It was the NBS engineers [who, whom?] Sen. Eagleton's office contacted on July 17.
   It was the NBS engineers [who, whom?] performed the tests on the walkways.
Send a copy of the report to [whoever, whomever?] wants one.
No one is sure [who, whom?] will be the next mayor.
It was the NBS engineers to [who, whom?] Sen. Eagleton's office made the request for technical assistance.

2. Now, strike out all the words up to the who or whom including prepositions:
It was the NBS engineers [who, whom?] Sen. Eagleton's office contacted on July 17.
It was the NBS engineers [who, whom?] performed the tests on the walkways.
Send a copy of the report to [whoever, whomever?] wants one.
No one is sure [who, whom?] will be the next mayor.
It was the NBS engineers to [who, whom?] Sen. Eagleton's office made the request for technical assistance.

3. Next, juggle the remaining words so that they make a complete sentence:

Sen. Eagleton's office contacted the NBS engineers.
The NBS engineers performed the tests on the walkways.
[Who, whom] wants one?
[Who, whom] will be the next mayor?
Sen. Eagleton's office made the request for the technical assistance to [them].

4. If it sounds right to substitute I, he, she, they, we, use who. If it sounds right to substitute me, him, her, us, them, use whom:

Sen. Eagleton's office contacted them. => (whom)
They performed the tests on the walkways. => (who)
He wants one? => (who)
She will be the next mayor? => (who)
Sen. Eagleton's office made the request for the technical assistance to them. => (whom)

5. Here are the results:

It was the NBS engineers whom Sen. Eagleton's office contacted on July 17.
It was the NBS engineers who performed the tests on the walkways.
Send a copy of the report to whoever wants one.
No one is sure who will be the next mayor.
It was the NBS engineers to whom Sen. Eagleton's office made the request for technical assistance.

This trick works without having to toss around terms like nominative case and objective case. (Incidentally, the third example, which contains "whoever wants one," is typically missed by people who pride themselves on their grammar. The rule about always using whom when it comes after a preposition does not work!)

Caution: You can get whom exactly grammatically right but sound fussy and pedantic. The famous day-time quiz show in which Johnny Carson got his start was called Who Do you Trust? not Whom Do you Trust?. You have to have an ear for the language. If it sounds fussy and pedantic to use whom, use who.

Capitalization

One of the big problems in technical writing involves capitalization. Technical people, developers, and other nonprofessional writers tend to use capital letters for everything that feels important—particularly the stuff that they've worked on. Problem is that this practice breaks all our standard capitalization rules and, more importantly, makes text harder to read. Most professionals in publishing, writing, and editing believe that excessive and unnecessary capitalization is distracting and confusing for readers. Capitalization should not be used for emphasis (use underscores or italics for that, or for really important things, use special notices).

Capital letters should be used for proper names—formal, official names of things and people. For example, Tandem Corporation is a proper name; Mosaic is the proper name of a software product. However, a loose reference to the "development area" at IBM does not need caps; it's not the official name of that area. Similarly, WordPerfect is a proper name, but not its grammar-checking feature. In technical writing, the impulse is often to use caps for the components of a thing—no! For example, if we were discussing the disk drive, the monitor, the CPU unit, the modem, the mouse, or the printer of a computing system, none of it should be capitalized. However, if we were talking about the the Dell NL40 Notebook computer, the Microsoft Mouse, or the IBM 6091 Display, then certainly caps are in order.

Of course, there are some exceptions. For example, in instructions, you want to reproduce the capitalization style shown on buttons, knobs, and other physical features of products as well as on the display screens of computer programs as they are shown on the hardware—but not if all caps are used. If I have a Service button on my computer, I'd write it as Service but not SERVICE, no matter how it is shown on the machine.
A common misuse of capitalization involves acronyms. You know that whenever you use an acronym in your text, you should spell it out first then show its acronym in parentheses. Writers often want to put the spelled-out version in initial caps; you would do so only if the spelled-out version were a proper name in its own right:

The North Atlantic Treaty Organization (NATO) was formed just after World War II.

When you turn your computer on, it normally goes through a process called initial program load (IPL).

Standard rules for caps:

- Use capital letters for names of people, races, cities, regions, counties, states, nations, languages, and other such proper names:

  The Early Bird satellite was launched by Intelst, a consortium of Western countries including the United States, France, the United Kingdom, and Germany.

  Samuel Morse invented the coding system called the Morse code.

  Among Muslims, Ramadan commemorates the first revelation of the Koran and is celebrated by fasting.

  The population of Quebec is largely French speaking.

  The Middle East, culturally speaking, refers to those lands in that part of the world that are predominantly Islamic in culture.

  The Midwest includes Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, and Nebraska.

  In her sophomore semester Gilda took English, French, astronomy, biology, geology and a special course called "Key Concepts in Western Science."

- Use capital letters for points of the compass only when they refer to well-established regions, but not when they simply refer to a direction of travel:

  In the 1970s and 1980s, the major population and economic growth regions of the United States have been the South and Southwest.

  The dam is located to the west of the city.

  Oil imports from South America have been decreasing recently.

  Drive ten miles north from Baldwin City, Kansas, and you'll be in Lawrence.

- Use capital letters for titles of offices when the title precedes the name of an officeholder but not when the title occurs alone. This rule is often ignored within organizations that need to use capitalize titles of positions. Another exception to this rule involves the president of the U.S.; some styles require this title to use a capital letter, even when it occurs alone.

  The first electronic computer was assembled in the years 1940 to 1942 by Professor John V. Atanasoff and Clifford Berry, a student, at Iowa State University.

  A professor and a student assembled the world’s first electronic computer in the years between the wars.

  In the U.S., the president holds the power of veto over any legislation passed by the Congress.

  Last week, mayors from several cities in the region met to discuss an integrated system of health care.

- Use capital letters for academic subjects only when they are part of a specific course title or when they are derived from the name of a person, country, or language. (This capitalization rule often get bent a little in resumes and application letters. Typically, names of occupations and fields, and job titles get initial caps. By
standard capitalization rules, that's not correct, but the usage is so strong in these two types of documents that it has become acceptable.)

She took a course in world history called "The Shaping of Western Thought" at Baker University in Kansas. They consider Chemistry 301 a difficult course even though they are all chemistry majors. This semester Majorie plans to take French, finance, and physics.

- Use capital letters for the **days of the week, months, special days, and holidays**—but *not* for the names of the seasons:

  On Monday, July 24, 1978, they celebrated her birthday at a local restaurant.
  Last fall they spent Thanksgiving in Denmark.
  In the United States, the national independence day is July the Fourth; in Mexico, it's called *Cinco de Mayo*.

- Use capital letters for **religions, religious groups, historical events, periods of history, and historical documents**:

  The telegraph played an important role in the Civil War.
  The term *Protestantism* is used to distinguish this faith from the other major Christian faiths: Roman Catholicism and Eastern Orthodoxy.
  At the Casablanca Conference, the Allies agreed to continue the war until the unconditional surrender of the Axis powers.
  The Allies landed on Normandy Beach on July 6, 1944, a day known as D-Day.
  The Great Depression in the United States was supposedly precipitated by the stock-market crash of 1929.
  Under compulsion by English barons and the church, King John signed the *Magna Carta* in 1215.

- Use capital letters for **organization names** (commercial, governmental, and non-profit) as well as their **products and services**:

  In the late 1950s, the U.S. Department of Defense initiated a number of projects, such as Project Courier, which finally resulted in the Initial Defense Communications Satellite Program (IDCSP).
  The IDCSP satellites were launched by the U.S. Air Force in 1966.
  Saudi Arabia has its own air force and its own integrated defense system.
  After the FCC's 1971 adoption of a "limited skies" policy, three domestic carriers initiated operations during 1974: American Satellite Corporation, a subsidiary of Fairchild industries, Inc.; Americom of RCA; and Western Union.
  On March 24, 1980, Pennsylvania Governor Richard Thornburgh asked the Union of Concerned Scientists to make an independent evaluation of the krypton problem at the Three Mile Island nuclear power plant.
  Recently, Apple Corporation introduced its Macintosh to compete with IBM's Personal Computer.

- Use capital letters for **references to most numbered or lettered items** (figures, tables, chapters, parts, volumes, rooms, buildings, etc.):

  In Figure 3 a simple telegraph arrangement is shown. Unfortunately, this small amount of krypton is uniformly mixed with the roughly 2 million cubic feet of air in the sealed Three Mile Island Unit 2 reactor containment building.

  In this book, Chapter 6 discusses how to convert instructions written by engineers into instructions that can be read and understood by ordinary nonspecialists.
In Part I of this book, the basic patterns of technical writing and compared to those of traditional English composition.

- Use capital letters for objects that have individualized names:

  The first operational communications satellite, *Early Bird*, was launched in 1965.
  
  Until the *Challenger* space shuttle, expendable launch vehicles such as the Thor Delta, Alpha-Centaur, and Titan were used for launching space communications satellites.
  
  The Golden Gate Bridge was opened in 1937 and it is one of the most extraordinary bridges in the world.
  
  Dr. Smith has her offices in the Woods Building.

- Use capital letters for the earth, sun, moon, and universe when they are discussed with other celestial bodies or systems:

  The Sun is 1.4 km from Earth.
  
  The theory that the Universe is constantly expanding is based on the observation of red-shifts.

- Use capital letters for most acronyms, although a few such as ac and dc are not. When in doubt, check your dictionary. Use capital letters for the spelled-out version of acronyms only if the spelled-out versions are proper nouns in their own right:

  In 1969, an experiment at the Stanford Linear Accelerator (SLAC) shattered protons with electrons.
  
  In 1977 and 1978, NASA launched the first two High-Energy Astronomy Observation (HEAO) satellites to study black holes.
  
  The "brain" of the computer is the central processing unit (CPU).

**Sexy Technical Communication Home**

**Numbers vs Words**

In the section on hyphens, it was pointed out that worrying too much about hyphens will drive you crazy—so will numbers. The main hurdle to overcome is to learn that in technical contexts, we use numerals in text—even ones below 10—if they are critical values. In other words, we break the rules that are taught in regular writing courses and that are used in normal publishing and copyediting practice. That's because in the technical and scientific context, we are vitally interested in numbers, statistical data, even if it's a 2 or 5 or—even a 0.

The difficulty is in defining the rules. You should use numerals, not words, when the number is a key value, an exact measurement value, or both. For example, in the sentence "Our computer backup system uses 4 mm tape" the numeral is in order. Also in "This recipe calls for 4 cups of unbleached flour." But consider this one: "There are four key elements that define a desktop publishing system." A word, not a numeral, is preferable here because—well, how to explain it? The number of elements is exact all right, but it's just no big deal. Four, five—who cares?

To summarize the rules that we normally apply:

- Don't start sentences with numerals—write the number out or, better yet, rephrase the sentence so that it doesn't begin the sentence.
- For decimal values less than 1, add a 0 before the decimal point: for example, .08 should be 0.08.
- Make a firm decision on how to handle 0 and 1 when they refer to key, exact values and stick with it. (Style varies wildly in technical writing on these two villains.) Some technical styles choose to use words for these; they resign themselves to the slight inconsistency but better readability.
- Use numerals for important, exact values, even when those values are below 10.
- Use words for numerical values that are unimportant, such as in the sentence "There are six data types in the C programming language."
- When you must use fractions, avoid the symbols that may be available in the character set used by your software. Construct the fraction like this: 5-1/4. Be sure and put the hyphen between the whole number and the fraction.
- It would be nice if all fractions could be reset as decimals, but such is not the case when you have things like 1/8 floating around. Stay consistent with either decimals or fractions in these situations.
Common Grammar, Usage, and Punctuation Problems

- Don't make numerical values look more exact than they are. For example, don't add ",.00" to a dollar amount if the amount is rounded or estimated.
- For large amounts, you can write things like 36 million or 45 billion, but, for some reason, not 23 thousand.
- Apply these rules in specifically technical, scientific contexts only. Be sensitive to what the standard practices are in the context in which you are writing.

Here are some examples where these rules are applied:

Some 19 million tons of sulphur dioxide are discharged from US sources alone each year, and another 14 million tons from Canada. (Using the number "19" and the word "million" indicates an approximate amount. "19,000,000" might make some readers think it was an exact amount.)

It was not until after December 1952, when 4000 people died in London from air pollution in just a few days, that real gains in pollution-control legislation were made.

The US Army's standard airborne Doppler navigator weighs 28 lb (12.7 kg), requires 89 W of power, and operates at 13.325-GHz frequency.

All vitrain of the European classification, if more than 14 micrometers thick, has been regarded as anthraxylon.

In 1971, 11 countries accounted for about 91 percent of world production of coal.

The Department of the Interior has just published a report that reviews 65 different coal gasification processes.

Combustion turbines total about 8% of the total installed capability of US utility systems and supply less than 3% of the total energy generated.

Internal combustion engines in small power plants account for about 1% of the total power-system generating capability of the US.

The water-cement ratio will generally range from 4 gal of water per sack of cement to about 9 gal per sack. (These are exact values here; in technical writing, use the numeral even if it is below 10.)

The problem is located in piston number 6. (When there are enumerated items or parts, technical writing uses the number, as in this example. But notice that no "#" or "No." is used.)

The signal occurs in 6-second intervals.

The order is for 6-, 8-, and 12-foot two-by-fours.

Use Code 3 if a system shutdown occurs.

Mined coals commonly contain between 5 and 15 percent mineral matter.

The above illustration shows a 20-unit coaxial cable with 9 working coaxial pairs and 2 standby coaxials, which automatically switch in if the electronics of the regular circuits fail.

There are 59 different species of the coffee shrub, but only 4 are of commercial importance.

Most grinds of coffee contain particles ranging in size from 0.023 to 0.055 inches in diameter.

Using carrier frequencies between 0.535 MHz and 1.605 MHz in the US, AM broadcasting stations sprang up all over the country beginning in the 1910s.

As a base from which to work, 2-1/2 to 3 gal of water are needed for each sack of cement for complete hydration and maximum strength. (These are exact values; therefore, in the technical-writing context, we use numerals. Notice how fractional values are handled: put a hyphen between the whole number and the fraction to prevent misreading.)

The order for twelve 30-foot beams was placed yesterday.

The order was for 30 fifteen-gallon tubs.

They used six 8-pound sacks of nails.

The microprocessors of the 70s and 80s operated under the control of clocks running at 1 to 5 MHz, that is, 1 to 5 million counts per second.
Symbols and Abbreviations
In technical-writing contexts, you may often have to decide whether to use " or ' for "inches" or "feet" or whether to use "inches," "in," or "in."

First of all, remember that symbols and abbreviations are distracting to readers; they are different from the normal flow of words. However, there are plenty of cases where the written-out version is more distracting than the symbol or abbreviation. Also, the context (specifically, technical or nontechnical) has a lot to do with which to use.

Imagine a technical document which has only one or two references to numerical measurements in inches. There is no reason to use symbols or abbreviations here—just write the thing out. But imagine a technical document with numerous feet and inch references: using symbols or abbreviations in this case is better, more readable, more efficient for both reader and writer. But which? Imagine the amount of foot and inch references there would be in a carpentry project (for example, a dog house). In this case, the symbols, " and ' would be greatly preferable. However, this would be an extreme case; otherwise, use the abbreviations.

When you do use symbols, especially for feet, inches, and some math symbols, use a symbols-type font. Avoid the "smart" quotes for feet and inches. Use the multiplication symbol for measurement contexts.

Which are the standard symbols and abbreviations to use? Go with the standards in the field in which you are writing, or with those found in a standard reference book such as a dictionary. Don't make them up yourself (for example, "mtrs" for meters!)

What about plurals? Very few abbreviations take an s to indicate plural: for example 5 in. means 5 inches. For the few that you think might take the s, check a dictionary.

What about obscure abbreviations and symbols? If you are concerned that readers might not recognize the abbreviation or symbol, write its full name in regular text and then put the abbreviation and symbol in parentheses just after the first occurrence of that full name.

Here are some examples of abbreviations or symbols in text:

| High resolution displays use larger video bandwidths, up to 30 MHz or more. |
| Most touch-sensitive displays use a matrix of either LED/photodiodes or transparent capacitor arrays to detect a physical touch. |
| The part of the memory that is easily alterable by the operator consists of RAM chips. |
| A satellite in geostationary orbit looks at the earth with a cone angle of 17.30° corresponding to an arc of 18,080 km along the equator. |
| The arc from 53° W to 139° W will cover 48 states (excluding Alaska and Hawaii) and is said to provide conus coverage. |
| Fairchild Industries, Inc., was an early participant in commercial satellites. |
| The voice was compressed from the usual 64-kb/s pulse code modulation (PCM) to 32 kb/s per channel by near-instantaneous companding (a modified PCM technique). |
| Terrestrial microwave radio communications require repeaters spaced every 20 to 40 mi from each other. |
| Over a period of several days the spacecraft is tracked from the ground and positioned on station (i.e., in the preassigned orbital spot) in order to commence operations. |
| A velocity increment of approximately 155 ft/s per year is required to correct drift problems in satellites. |
| The ancient battery-like objects made by the Parthians in 250 BC were thin sheets of copper soldered into a cylinder 1.125 cm long and 2.6 cm in diameter. |
| The standard electrodes are the normal and the 0.1 normal (N) calomel electrodes in which the system is Hg|KCI solution saturated with HgCl. |
| Such batteries contain 4400 cc of water in which NaOH is dissolved. |
| Water pressure in the heat recovery loop can be as much as 25 psig. |
Resources

Here are some other sources to consult:

Grammar Girl Quick and Dirty Tips for Better Writing


Bedford-St. Martin companion website. Lots of diagnostics and exercises for grammar, usage, punctuation.

Who Made Up This Language?

For some writers, their main spelling problem is similar-sounding words, for example, *principle* and *principal* or *affect* and *effect*. These problems cannot be flagged by software spell-checking functions.

Here is a list of these commonly confused homophones (different spelling; same or very similar pronunciation), with examples of their correct use.

All definitions in this section are from the Merriam Webster dictionary via the Merriam Webster Dictionary mobile application.

**accept, except**

The construction form *accepted* the offer to build the bridge.
Everything has been finished *except* for the paint job.

**Merriam Webster Definitions**

Accept: (verb) to receive or take (something offered): to take (something) as payment: to be able or designed to take or hold (something)

Except: (preposition) not including (someone or something): other than (something or someone)

**advice, advise**

The construction firm ignored the engineer's *advice*.
The engineer *advised* the firm to use single-suspension walkways.

**Merriam Webster Definitions**

Advice: (noun) an opinion or suggestion about what someone should do

Advise: (verb) to give an opinion or suggestion to someone about what should be done: to give advice to (someone): to recommend or suggest (something): to give information to (someone)

**affect, effect**

The *effect* of the increased oil prices has been devastating on our economy.
The increased oil prices have *affected* our economy drastically.

**Merriam Webster Definitions**

Affect: (verb) have an effect on; make a difference to.

Effect: (noun) a change that results when something is done or happens: an event, condition, or state of affairs that is produced by a cause: a particular feeling or mood created by something: an image or a sound that is created in television, radio, or movies to imitate something real

**cite, site, sight**

The consulting engineer *cited* a paragraph from the building code.
At the construction *site*, the workers carefully erected the scaffolding.
The collapse of the walkways was a terrible *sight*.
**Merriam Webster Definitions**

Cite: (verb) to write or say the words of (a book, author, etc.): to mention (something) especially as an example or to support an idea or opinion: *law*: to order (someone) to appear before a court of law

Site: (noun) the place where something (such as a building) is, was, or will be located: a place where something important has happened: a place that is used for a particular activity

Sight: (noun) the sense through which a person or animal becomes aware of light, color, etc. by using the eyes: the ability to see: the act of seeing someone or something: a position in which someone or something can be seen

**complement, compliment**

The programmer has received many *compliments* on her new system. The colors that have been selected for the room do not *complement* each other.

**Merriam Webster Definitions**

Complement: (noun) something that completes something else or makes it better: the usual number or quantity of something that is needed or used: *grammar*: a word or group of words added to a sentence to make it complete

Compliment: (noun) a remark that says something good about someone or something: an action that expressed admiration or approval

**counsel, council, consul**

She was appointed *consul* to the embassy in Beirut. There was lengthy debate on the tax proposal at city *council* last night. He *counselled* her to get a degree in technical communication.

**Merriam Webster Definitions**

Counsel: (verb) to give advice to (someone): to suggest or recommend (something)

Council: (noun) a group of people who are chosen to make rules, laws, or decisions about something: a group of people who provide advice or guidance on something

Consul: (noun) a government official whose job is to live in a foreign country and protect and help the citizens of his or her own country who are traveling, living, or doing business there: either one of two chief officials of the ancient Roman republic who were elected every year

**its, it's**

*It's* time to go home; *it's* getting late. The car has lost one of *its* headlights.

**Merriam Webster Definitions**

Its: (adjective) relating to or belonging to a certain thing, animal, etc.: made or done by a certain thing, animal, etc.

It's: (contraction) it is: it has

**lose, loose**

Your car *loses* power when it is out of tune. I have some *loose* change in my pocket. Don't let Mamie get *loose*!

**Merriam Webster Definitions**

Its: (adjective) relating to or belonging to a certain thing, animal, etc.: made or done by a certain thing, animal, etc.

It's: (contraction) it is: it has
Lose: (verb) to be unable to find (something or someone): to fail to win (a game, contest, etc.): to fail to keep or hold (something wanted or valued)

Loose: (adjective) not tightly fastened, attached, or held: not pulled or stretched tight: of clothing: not fitting close to your body: not tight

personal, personnel

They plan to take out a personal loan to build the deck.
Send your application to the personnel office.
The CEO wants to have a personal chat with all this company's personnel.

Merriam Webster Definitions

Personal: (adjective) belonging or relating to a particular person: made or designed to be used by one person -- used to describe someone whose job involved working for or helping a particular person

Personnel: (noun) the people who work for a particular company or organization: a department within a company or organization that deals with the people who work for it

principal, principle

The principal component of the solar panel is the collector.
Explain to me the principle of convection.

Merriam Webster Definitions

Principal: (adjective) most important

Principle: (noun) a moral rule or belief that helps you know what is right and wrong and that influences your actions: a basic truth or theory: an idea that forms the basis of something: a law or fact of nature that explains how something works or why something happens

stationary, stationery

Use company stationery for company business purposes only.
The derrick may not remain stationary during the gale-force winds.

Merriam Webster Definitions

Stationary: (adjective) not moving: staying in one place or position: not changing

Stationery: (noun) materials (such as paper, pens, and ink) that are used for writing or typing: paper that is used for writing letters and that usually has matching envelopes

than, then

My utility bill was higher this month than it was last month.
The hurricane reached the Texas coast; then it plunged right into the heart of Houston.

Merriam Webster Definitions

Than: (conjunction) rather than: other than: when

Then: (adverb) at that time: at the time mentioned -- used to indicate what happened or happens next -- used to indicate what should be done next

their, there, they're
Their calculus course is much harder than ours. Over there on the table is your calculus book. They’re not taking calculus this semester.

Merriam Webster Definitions

Their: (adjective) relating to or belonging to certain people, animals, or things: made or done by certain people animals, or things: his or her: his: her: its

There: (adverb) in that place: at that location: to or into that place: at that point in a process, activity, story, etc.

They’re: (contraction) they are

to, too, two

Are they going to pave the street today? It is still too rainy to pave the street. Two hours ago, the sky was clear.

Merriam Webster Definitions

To: (preposition) --used to indicate the place, person, or thing that someone or something moves toward --used to indicate the place where someone participates in a particular activity --used to indicate the direction of something

Too: (adverb) in addition: more than what is wanted, needed, acceptable, possible, etc.: to a high degree or extent: very or extremely

Two: (adjective) being more than one in number: being the second

whose, who's

Whose technical writing book is this? There is the woman whose technical report won top honors. Do you know who's in charge around here? He's a man who's not afraid of criticism.

Merriam Webster Definitions

Whose: (adjective) --used in questions to ask who owns something, has something, etc. --used to show which person or thing you are talking about --used to give more information about a person or thing that has already been mentioned

Who's: (contraction) who is

your, you're

Your technical writing book is on the table. You're going to have review Part 1 before writing that report.

Merriam Webster Definitions

Your: (adjective) relating to or belonging to you: made or done by you --used to refer to any person or to people in general --used in the titles or royalty, judges, etc.

You're: (contraction) you are