Mexico, during World War II, these teams consisted of the wives of the scientists on the project, using mechanical calculators to do the arithmetic, before they were replaced with computers.

In the early days of computing, engineers and scientists had to write programs from scratch to implement numerical methods. Today, there are libraries of numerical software available for solving a broad range of problems, such as finding areas, interpolating values between points on a curve, solving systems of equations, and finding an optimal point where a function has a minimum or maximum value. Most of the time when engineers use a numerical method, they aren't even aware of it, because it's embedded in a computer-aided design tool such as a simulator. A high-realism video game, for example, performs the same type of calculation as finding the area under a curve millions of times per second in order to simulate the motion of an object.

PROBLEMS

1. Open-Ended Problems
What is an "open-ended" problem?

2. TryEngineering.org
TryEngineering.org (www.tryengineering.org) has some online video games designed to introduce students to aspects of the engineering method. Play some of these games and review them in terms of which were the most interesting and why.

3. Exploring Interrelationships
Section 1.3.2 and Figure 1.8 discuss how the miniaturization of integrated circuits over the last few decades—Moore's Law—involved a network of interrelated activities among many different people, businesses, and applications. Develop a presentation or brief report that tells a similar story focused on a different problem area. The description doesn't have to be heavily researched; the important thing is to focus on the complexity of connections, and where engineering fits into the picture. Web searches can be a very good way to get snapshots of some specific businesses or people involved in the process, similar to the brief bios used in the text. Some example areas of focus include:

- Public transportation systems
- Fast food
- Personal music/multimedia systems
- Clothing

4. Research Activities at Your School
In addition to teaching undergraduate courses, engineering professors typically also engage in research. Find out about a research project involving engineering faculty at your school and answer the following questions:

(a) What is the title of the project?
(b) In a few sentences, what are the goals of the project?
(c) How is the project funded?
(d) How many people are involved in the project, including faculty and students? Is more than one school involved?

(e) Are undergraduate students involved in the project? If so, give an example of a contribution that an undergraduate has made. What background did the student have before joining the project?

5. Roles of Engineering Disciplines

Using the descriptions in Section 1.4 as a basis, discuss the roles that engineers from two or more different disciplines might play in addressing the following issues:

- providing an adequate energy supply for household use or transportation
- preventing or containing an epidemic such as influenza
- producing a motion picture

6. Interview a Senior

Interview an engineering student from your school who is graduating this year, asking at least the following questions:

- What was his or her major?
- What were his or her favorite classes?
- What were his or her most difficult classes? Most difficult year?
- What was the most interesting project that he or she worked on?
- What suggestions does he or she have to help you be successful in your major?
- What are his or her plans for after graduation?

7. Interview an Engineer

Section 1.4.1 makes the statement that engineers need to be prepared to adapt, and that few of the author's friends and colleagues 20–25 years out of college are doing what they thought they would be doing when they graduated. Interview an engineer (perhaps arranged through local industry or an alumni organization) who graduated at least 10 years ago and report on what you've learned.

8. Engineering Professional Societies

The Sloan Career Cornerstone Center provides links to the major engineering professional societies and organizations (http://www.careercornerstone.org/engineering/engprofassn.htm). Choose one that is of interest to you and answer the following questions:

(a) What are the main objectives of this organization?

(b) What are the main benefits that it offers to its members?

(c) Does the organization have a special student membership? If so, what benefits and activities does it specifically offer for students? Is there a student branch of this organization on your campus?

track called a race. When they work *properly*, ball bearings provide extremely low friction. Because they're made of steel, they're also durable. Fabricating a ball bearing set, however, requires the ability to shape metal to very precise tolerances, which in turn requires very specialized equipment and highly skilled labor. An alternative bearing design is a plastic "top hat" bearing, also shown in Figure 2.53. While this design would wear more quickly than steel ball bearings, it can be cheaply and easily fabricated with a mold. Thus the plastic top hat bearing could be easily manufactured in a developing nation, whereas the ball bearings would likely have to be imported, which has significant impact on cost.

PROBLEMS

1. **Short-Term Memory**
   Come up with an example, similar to "doing math in your head," where the limiting factor in solving a problem clearly seems to be the limited ability to keep information in your short-term memory.

2. **Why Won't My Car Start?**
   Write a set of 3–5 rules or productions that might help diagnose why someone's car won't start.

3. **Planning a Solution to a Problem**
   Think of some project that you've worked on in the past—either in school, at work, or for fun—where you were part of a team that spent at least a day or two in coming up with the solution to a problem.

   - Give an example of where you applied a divide-and-conquer strategy to solving the problem.
   - Give an example of working forwards (forward chaining), working backwards (backward chaining), and working from the middle in piecing together a solution for this problem.

4. **Using Graphs to Convey Information**
   Give a specific example or two of the use of a graph (nodes and edges) to convey information in some common, everyday application.

5. **Organization of a Parts Catalog**
   Go to the web site of some engineering parts supplier. Your instructor may help you pick one. Draw a hierarchical concept map with at least ten concepts that reflects how the supplier organizes its products. Is the organization primarily by form or by purpose?

6. **Construct a Concept Map: River, Beam, etc.**
   Organize the following words into a concept map and identify the domain:

river	paint	beams
cables	joints	foundations
bolts	steel rebar	catenary
concrete	roadbed	asphalt
forms	truss	toll

7. Construct a Concept Map: Sausage, Vegemite, etc.
Organize the following words into a concept map and identify the domain:

sausage	Vegemite	orange juice	congee	butter
beverages	coffee	yoghurt	cereal	sugar
Cap'n Crunch	fruit	oatmeal	over easy	grapefruit
toast	tea	jam	Wheaties	poached
scrambled	meat	banana	breakfast	bacon
bagel	beans	yeast	eggs	carbohydrates

8. Concept Map: U.S. Government
In the two columns below are listed concepts and relation words that characterize aspects of the U.S. government. Draw a concept map that shows the relationship between each of the concepts. Each relationship should be used at least once, and several may be used more than once.

Concepts	Relationships
Government	Has part
Legislative	Passes
Executive	Can veto
Judicial	Reviews
Laws	Appoints
Rulings	Approves

9. How Stuff Works
Go to the web site www.howstuffworks.com and find an article describing some engineering system of interest to you. Using the car example from Chapter 2 as a guide, construct a concept map with approximately 10 concepts in it. Describe the use of hierarchy in your final organization.

10. Product Specifications and Design Objectives
Look up online the specifications of some product of interest to you. Write down 3–5 elements of the specifications in the form of mathematical constraints. In addition, write down 3–5 objectives that are not listed as part of the specifications, but which you think would be important considerations in the design of the product.

11. Form, Purpose, and Environment
Similar to the example of clock used in Chapter 2, pick another type of artifact that can have a variety of forms. State what the purpose of the artifact is, and then give examples of how the environment—either engineering environment, operating environment, or both—affects the specific form. Some possibilities are (there are many more):

- automobiles
- yoghurt (different forms of packaging include fruit mixed in cups, fruit on the bottom of cups, tubes)
- video entertainment systems
- bridges

12. Purchase of a Faulty Product
Discuss an example of what you consider to be a violation of a constraint in the operating environment for some product you bought. What was the constraint and what was the violation?

13. An Ill-Conceived Product
Give an example of a product (good, process, or service) that you think "missed the mark" because the producer and the consumer had misaligned views on the acceptable region. Explain.

14. Design Alternatives and Constraints
Pick a scenario similar to the problem of lifting a weight onto a shelf. Identify a set of constraints on the problem. Brainstorm a set of alternative approaches (3–5) and discuss whether or not each alternative is compatible with the constraints.

15. Snow Removal System
A fact of life in many cold climates is snow removal during the winter. Snow must be removed from roads and driveways so that vehicles can pass. Heavy snows and especially ice should also be removed from roofs as it may cause damage.

(a) Draw a diagram similar to Figure 2.22 describing the design considerations from the producer perspective and the consumer perspective for a system for removing snow from a driveway.

(b) Draw a diagram similar to Figure 2.22 describing the design considerations from the producer perspective and the consumer perspective for a system for removing snow from a roof.

(c) One way of removing snow is by melting it, using electric heating coils. Evaluate this as a possible solution for removing snow from a driveway and from a roof, according to the criteria that you defined above.

16. The X Prize
Search the Ansari X Prize online and look up the basic rules of the competition. Analyze the winning entry built by Burt Rutan and Paul Allen and determine how the rules of the competition provided the constraints and design considerations that went into creating Space Ship One. In about 200–300 words, describe how the final design of the spacecraft was shaped by the engineering environment as well as the constraints imposed by the rules of the competition.

17. Alternative Pump Designs
Come up with a variety of pump design concepts that could be operated by one or more children and could have better flow rates than a handpump.

18. Gear Pumps
A piston pump is but one of several common pump designs. Another popular design is the *gear pump*.

(a) Draw a schematic for an external gear pump and explain briefly how it works.

(b) Draw a schematic for an internal gear pump and explain briefly how it works. What's another name for an internal gear pump?

(c) List the advantages and disadvantages of piston pumps versus gear pumps. Describe an operating environment where a gear pump would be preferred over a piston pump and vice versa.