PROBLEMS

1. Concept Map: Expertise and the Learning Process

Draw a concept map of Section 3.2, "Expertise and the Learning Process."

- Start by either listing or highlighting approximately 10–12 key concepts from the section.
- Add relationships to the concept map and organize the map roughly into a hierarchy.
- Extend the map to include links to approximately five additional concepts from Section 2.1, "What We Think About How We Think."

2. Concept Map: Engineering Disciplines

As part of a team of 3–4 students, develop a concept map that encompasses 3–4 of the disciplines described in Section 1.4, "Engineering Disciplines and Majors." Each student should individually develop a concept map based on one discipline, and then the group should meet and combine these into a single map. The final map should include connections between disciplines wherever they can be added meaningfully.

3. Studying with Music

Do you ever study with music in the background? Do you find it helpful or distracting? What impact do you suspect music would have in terms of the cognitive model presented in the chapter?

4. Levels of Understanding: Making Copies

Determine the levels of understanding needed in each of the steps in the following scenario and give reasons for your assessment.

(a) Mike gets a job working as a copyboy. Today is his first day, and within the first hour, the copier runs out of paper. Mike refills the copier.

(b) Mike needs to make copies of 10 articles for one of his business's employees.

(c) The paper jams in the middle of making the copies. Mike needs to fix the copier and finish making the copies. Luckily, the screen on the copier gives explicit directions for removing the paper jam.

(d) Mike is having a very trying day. When he tries to remove the paper jam, he accidentally changes some settings on the copier and the copies are not the same as the original ones. Mike rectifies this situation.

(e) A message shows up on the copier panel telling Mike that the toner is low. He must fix this problem as well.

(f) Finally, Mike's day ends. He is upset with the issues with the copier, and he is contemplating getting a new job that he enjoys more. In the process of finding a job, he does a lot of research and eventually finds the perfect job: as a go-kart tester.

5. Levels of Understanding: Making Up Your Own Questions

Make up example questions that test understanding at each of the levels of Bloom's taxonomy:

(a) based on material that you've covered thus far in this course,

(b) based on material that you've covered in other courses that you are currently taking or have taken recently.

For each example, give a brief justification for why that question illustrates the stated level of understanding.

6. Hmm ...
What level of understanding does this problem test?

7. Practice with the Problem-Solving Framework
The following problems come from a standard pre-algebra textbook. We'll use them to practice applying the problem-solving framework introduced and illustrated in Sections 3.5 and 3.6. Strive for clarity in writing up your solutions, patterned after the example in Figures 3.11 and 3.12. Pay special attention to giving a succinct description of the plan, even if it seems obvious to you. In your comments at the end of the solution, note any heuristics that you may have used.

- In one long-distance phone call, Amy talked to her parents for twice as long as her brother talked. Her sister talked for 12 minutes longer than Amy. If Amy's phone call was 62 minutes long, how long did each person talk on the phone?
- Roberto needs to draw a line that is 5 inches long, but he does not have a ruler. He does have some sheets of notebook paper that are each 1.5 inches wide and 11 inches long. Describe how Roberto can use the notebook paper to measure 6 inches.
- As the hands of a clock move from 6:00 AM to 6:00 PM, how many times do the hands form a right angle?
- Alice, Nathan, and Marie play in the school band. One plays the drum, one plays the saxophone, and one plays the flute. Alice is a senior. Alice and the saxophone player practice together after school. Nathan and the flute player are sophomores.

8. Assumptions and Approximations in Solving Energy Problems
Solve each of the following problems, making an assumption or approximation as necessary. Use the framework presented in Section 3.5 and illustrated with the example in Section 3.6 as a guide. If you need to look up any information in making your assumptions, be sure to cite your sources.

(a) Estimate the cost of the electricity bill in your household last month. Find out what it actually was. How close was your estimate? Note that power consumption for electrical appliances and equipment is typically measured in watts (W), which has units of energy per unit time, while electricity is typical sold by utility companies in units of kilowatt-hours.

(b) How much ethanol could a corn field of area 1 square kilometer produce? How much gasoline would it take to produce the corn, from preparing the fields through harvest, and to deliver it to an ethanol processing plant?

(c) How far would one have to walk to burn the calories contained in your favorite candy bar?

9. Storing Text on a DVD
One way of representing text in a computer is to use what is called the *ASCII code*, where each letter requires one *byte* of data. (A byte is a string of 8 bits of data.) Approximately how many DVDs would it take to store the text of all of the books in your school's library in ASCII format? Pattern your solution after

the example in Section 3.6 and be sure to cite all sources that you may have used in determining your answer.

10. Problem Solving Strategies and Heuristics

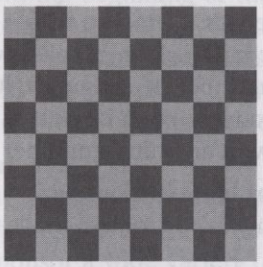
Solve each of the following problems, which come from a pre-algebra textbook [EDNK92]. State which heuristics you used in determining your solution, and give a brief justification of why the heuristic applies.

(a) There are 10 hockey players on the ice at the end of a game. Each player shakes hands with each of the other players. What is the total number of handshakes?

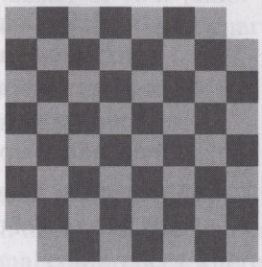
(b) Connect all points in the figure below by drawing exactly four line segments without lifting your pencil off the paper. Do not draw through any one point more than once.

11. Proofs Come in Handy: The Mutilated Chessboard

The Mutilated Chessboard is a classic problem devised by Martin Gardner, who wrote the "Mathematical Games" column of *Scientific American* magazine from 1956 to 1981. In this exercise, we'll use this example to probe some of the strengths and limitations of physical demonstrations in solving problems. The figure below illustrates both a standard chessboard and a "mutilated chessboard." The standard chessboard has 64 squares arranged in 8 rows and 8 columns, while the mutilated chessboard has two diagonally opposite corners removed, for a total of 62 squares.



standard chessboard



mutilated chessboard

(a) First, suppose that you have a collection of dominoes that are each exactly the same size as two squares on a chessboard. Is it possible to cover all of the squares on a standard, non-mutilated board with exactly 32 dominoes? How do you know?

(b) Now, is it possible to cover all of the squares in a mutilated chessboard with exactly 31 dominoes? How do you know? If it turns out that it's not possible, how can you prove this? *Try to solve this problem without looking up the answer, even though it's readily available online.*

(c) Explain how this problem illustrates both strengths and limitations of physical demonstrations in solving problems.

12. Guess and Check to Determine an Average

The Guess and Check method (Section 3.8.13) can be useful when you are faced with limited "computing" resources, or are restricted in the operations that you may use. To illustrate, we'll find the average of a small group of numbers, but without using division. The approach is as follows: you first guess an average; you then multiply the average by the length of the list of numbers, and see how far off this product is from the sum of the numbers. That will then lead you to modify your initial guess, and you proceed from there to converge to the correct average.

Consider the numbers 16, 28, 12, 17, 23, 21. Find their average using Guess and Check. Again, you may add, subtract, and multiply, but may not use division. Show all your steps—how many guesses did it take?

13. Rabbit and Turtles

Two turtles, A and B, start 300 m apart and move towards each other. Turtle A moves at 80 m/h, train B at 70 m/h. A rabbit starts hopping from turtle A, moving at 137 m/h, straight towards turtle B. When it reaches turtle B, it reverses direction and runs towards turtle A, until it reaches it. The rabbit continues running back and forth between the two turtles until they meet. Find the distance that the rabbit will have traveled.

Note how this problem can be solved either with great difficulty or very easily, depending on whether you look at it from a distance perspective or a from a time perspective.

14. Does Multiplication Equal Addition?

You want to test your friend by making the claim that adding two numbers is the same thing as multiplying them. He of course doesn't give any credence to your claim, so you tell him that $2 + 2$ and 2×2 give the same result. He still doesn't take you seriously in spite of that one very well known example. So you tell him that $3 + 1.5$ and 3×1.5 also produce the same result. And the same is true for $5 + 1.25$ and 5×1.25. You tell him that you can actually come up with an infinite number of similar examples to make your point. All in good jest of course, since your initial claim is ludicrous. Come up with a formula that produces pairs of numbers to support your initial claim. Explain why even when you can support a claim with an infinite number of examples, it does not make the claim true. Come up with another example of an obviously false claim that can nonetheless be made to appear true with an infinite number of examples.

15. What Do These Problems Have in Common?

Which two of the following three problems have the most in common? Explain.

(a) Find the acceleration produced on a given mass by a given force.

(b) Find the current flowing through a given resistor when a given voltage is applied across it.

(c) Find the volume of a container that houses a gas at a given pressure and given temperature.

16. Graphical Insights on Quadratic Equations

In Section 3.8.20, you saw how a change of representation can help you see a problem in a better light. Graphical representations are often used for that very purpose. A common example is with quadratic equations, where plotting the corresponding parabola curve can help you visualize whether or not there are any real roots, and where they are.