

26. Draw a flowchart for a program that reads a value `temp`. If it is less than zero, print "Ice". If it is greater than 100, print "Steam". Otherwise, print "Liquid".

Practice It Now you can try these exercises at the end of the chapter: R3.12, R3.13, R3.14.



Computing & Society 3.1 Denver's Luggage Handling System

Making decisions is an essential part of any computer program. Nowhere is this more obvious than in a computer system that helps sort luggage at an airport. After scanning the luggage identification codes, the system sorts the items and routes them to different conveyor belts. Human operators then place the items onto trucks. When the city of Denver built a huge airport to replace an outdated and congested facility, the luggage system contractor went a step further. The new system was designed to replace the human operators with robotic carts. Unfortunately, the system plainly did not work. It was plagued by mechanical problems, such as luggage falling onto the tracks and jamming carts. Equally frustrating were the software glitches. Carts would uselessly accumulate at some locations when they were needed elsewhere.

The airport had been scheduled to open in 1993, but without a functioning luggage system, the opening was delayed for over a year while the contractor tried to fix the problems. The contractor never succeeded, and ultimately a manual system was installed. The delay cost the city and airlines close to a billion dollars, and the contractor, once the leading luggage systems vendor in the United States, went bankrupt.

Clearly, it is very risky to build a large system based on a technology that has never been tried on a smaller scale. As robots and the software that controls them get better over time, they will take on a larger share of luggage handling in the future. But it is likely that this will happen in an incremental fashion.



The Denver airport originally had a fully automatic system for moving luggage, replacing human operators with robotic carts. Unfortunately, the system never worked and was dismantled before the airport was opened.

3.6 Problem Solving: Test Cases

Consider how to test the tax computation program from Section 3.3. Of course, you cannot try out all possible inputs of marital status and income level. Even if you could, there would be no point in trying them all. If the program correctly computes one or two tax amounts in a given bracket, then we have good reason to believe that all amounts will be correct.

You want to aim for complete *coverage* of all decision points. Here is a plan for obtaining a comprehensive set of test cases:

- There are two possibilities for the marital status and two tax brackets for each status, yielding four test cases.
- Test a handful of *boundary* conditions, such as an income that is at the boundary between two brackets, and a zero income.
- If you are responsible for error checking (which is discussed in Section 3.9), also test an invalid input, such as a negative income.

Each branch of your program should be covered by a test case.

Make a list of the test cases and the expected outputs:

Test Case	Expected Output	Comment
30,000 s	3,000	10% bracket
72,000 s	13,200	3,200 + 25% of 40,000
50,000 m	5,000	10% bracket
104,000 m	16,400	6,400 + 25% of 40,000
32,000 s	3,200	boundary case
0 s	0	boundary case

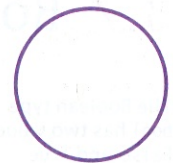
When you develop a set of test cases, it is helpful to have a flowchart of your program (see Section 3.5). Check off each branch that has a test case. Include test cases for the boundary cases of each decision. For example, if a decision checks whether an input is less than 100, test with an input of 100.

It is always a good idea to design test cases *before* starting to code. Working through the test cases gives you a better understanding of the algorithm that you are about to implement.

It is a good idea to design test cases before implementing a program.



27. Using Figure 1 on page 93 as a guide, follow the process described in Section 3.6 to design a set of test cases for the `elevatorsim.py` program in Section 3.1.
28. What is a boundary test case for the algorithm in How To 3.1 on page 102? What is the expected output?
29. Using Figure 4 on page 111 as a guide, follow the process described in Section 3.6 to design a set of test cases for the `earthquake.py` program in Section 3.3.
30. Suppose you are designing a part of a program for a medical robot that has a sensor returning an x - and y -location (measured in cm). You need to check whether the sensor location is inside the circle, outside the circle, or on the boundary (specifically, having a distance of less than 1 mm from the boundary). Assume the circle has center $(0, 0)$ and a radius of 2 cm. Give a set of test cases.



Practice It Now you can try these exercises at the end of the chapter: R3.15, R3.16.

Programming Tip 3.3



Make a Schedule and Make Time for Unexpected Problems

Commercial software is notorious for being delivered later than promised. For example, Microsoft originally promised that its Windows Vista operating system would be available late in 2003, then in 2005, then in March 2006; it finally was released in January 2007. Some of the early promises might not have been realistic. It was in Microsoft's interest to let prospective customers expect the imminent availability of the product. Had customers known the actual delivery date, they might have switched to a different product in the meantime. Undeniably, though, Microsoft had not anticipated the full complexity of the tasks it had set itself to solve.

Microsoft can delay the delivery of its product, but it is likely that you cannot. As a student or a programmer, you are expected to manage your time wisely and to finish your assignments on time. You can probably do simple programming exercises the night before the due date, but an assignment that looks twice as hard may well take four times as long, because more things can go wrong. You should therefore make a schedule whenever you start a programming project.