so that the results of a calculation can reach the outside world.

Now there are two ways in which you can increase your understanding of these issues. One way is to remember the general ideas and then go home and try to figure out what commands you need and make sure you don't leave one out. Make the set shorter or longer for convenience and try to understand the tradeoffs by trying to do problems with your choice. This is the way I would do it because I have that kind of personality! It's the way I study — to understand something by trying to work it out or, in other words, to understand something by creating it. Not creating it one hundred percent, of course; but taking a hint as to which direction to go but not remembering the details. These you work out for yourself.

The other way, which is also valuable, is to read carefully how someone else did it. I find the first method best for me, once I have understood the basic idea. If I get stuck I look at a book that tells me how someone else did it. I turn the pages and then I say "Oh, I forgot that bit", then close the book and carry on. Finally, after you've figured out how to do it you read how they did it and find out how dumb your solution is and how much more clever and efficient theirs is! But this way you can understand the cleverness of their ideas and have a framework in which to think about the problem. When I start straight off to read someone else's solution I find it boring and uninteresting, with no way of putting the whole picture together. At least, that's the way it works for me!

Throughout the book, I will suggest some problems for you to play with. You might feel tempted to skip them. If they're too hard, fine. Some of them are pretty difficult! But you might skip them thinking that, well, they've probably already been done by somebody else; so what's the point? Well, of *course* they've been done! But so what? Do them for the *fun* of it. That's how to learn the knack of doing things when you have to do them. Let me give you an example. Suppose I wanted to add up a series of numbers,

$$1 + 2 + 3 + 4 + 5 + 6 + 7 \ldots$$

up to, say, 62. No doubt you know how to do it; but when you play with this sort of problem as a kid, and you haven't been shown the answer . . . it's *fun* trying to figure out how to do it. Then, as you go into adulthood, you develop a certain confidence that you can discover things; but if they've already been discovered, that shouldn't bother you at all. What one fool can do, so can another, and the fact that some other fool beat you to it shouldn't disturb you:

you should get a kick out of having discovered something. Most of the problems
I give you in this book have been worked over many times, and many ingenious
solutions have been devised for them. But if you keep proving stuff that others
have done, getting confidence, increasing the complexities of your solutions —
for the fun of it — then one day you'll turn around and discover that *nobody
actually did that one!* And that's the way to become a computer scientist.

I'll give you an example of this from my own experience. Above, I
mentioned summing up the integers. Now, many years ago, I got interested in
the generalization of such a problem: I wanted to figure out formulae for the
sums of squares, cubes, and higher powers, trying to find the sum of m things
each up to the nth power. And I cracked it, finding a whole lot of nice relations.
When I'd finished, I had a formula for each sum in terms of a number, one for
each n, that I couldn't find a formula for. I wrote these numbers down, but I
couldn't find a general rule for getting them. What was interesting was that they
were integers, until you got to $n=13$ — when it wasn't (it was something just
over 691)! Very shocking! And fun.

Anyway, I discovered later that these numbers had actually been
discovered back in 1746. So I had made it up to 1746! They were called
"Bernoulli Numbers". The formula for them is quite complicated, and unknown
in a simple sense. I had a "recursion relation" to get the next one from the one
before, but I couldn't find an arbitrary one. So I went through life like this,
discovering next something that had first been discovered in 1889, then
something from 1921 . . . and finally I discovered something that had the same
date as when I discovered it. But I get so much fun out of doing it that I figure
there must be others out there who do too, so I am giving you these problems
to enjoy yourselves with. (Of course, everyone enjoys themselves in different
ways.) I would just urge you not to be intimidated by them, nor put off by the
fact that they've been done. You're unlikely to discover something new without
a lot of practice on old stuff, but further, you should get a heck of a lot of fun
out of working out funny relations and interesting things. Also, if you read what
the other fool did, you can appreciate how hard it was to do (or not), what he
was trying to do, what his problems were, and so forth. It's much easier to
understand things after you've fiddled with them before you read the solution.
So for all these reasons, I suggest you have a go.

Problem 1.1: (a) Go back to our dumb file clerk and the problem of finding
out the total number of sales in California. Would you advise the management
to hire two clerks to do the job quicker? If so, how would you use them, and
could you speed up the calculation by a factor of two? You have to think about