Chapter 2

This chapter introduces some basic ideas about computers and programming. Exercises that support those ideas will help students to gain familiarity with those ideas.

1. This chapter includes an algorithm for entering numbers into the calculator or computer. No program is given for that algorithm because implementing it demands a structure not introduced in this text. But we can model the algorithm in a modified way. Enter the following program INPUT in your calculator:

```
Program: INPUT
: 0 STO> V
: Prompt D
: While D≥0
:  10V+D STO> V
:  Prompt D
:  End
:  Disp V
```

This program is designed to input a positive integer digit by digit. Where it differs from the algorithm of the book is the test associated with the While loop. We do not have a structure to check if D is a non-digit. To terminate this loop you will have to respond to D? with a negative number. Run the program to enter numbers like 327 and 555067.

2. Add to lines to the program INPUT to create the following program:

```
Program: INPUT
: 0 STO> V
: Prompt D
: While D≥0
:  10V+D STO> V
:  Disp V
:  Pause
:  Prompt D
:  End
:  Disp V
```

This will allow you to see your result being built up as you enter each digit. Run the program in this form for 327 and 555067.

3. There is an even more serious "escape" problem with programming synthetic substitution. Again you need a way of terminating the While loop, and the following program again calls for a negative number to terminate the loop. But this creates another problem: it forces us to use only positive values for X in the process.

```
Program: SYNSUB
: 0 STO> V
: Prompt X
: Prompt C
```
While \( C \geq 0 \):
\[
X \times V + C \leftarrow V
\]
Prompt \( C \)
End
Disp \( V \)

What value of \( X \) would reduce this program to that of Exercise 1?

4. Enter the program \textsc{SynSub} in your calculator and use it to evaluate the polynomial \( x^3 + 4x^2 + 9x + 13 \) for \( x = 7 \).

5. Check your answer in Exercise 3 by calculating the polynomial value directly; that is, as:
\[
7^3 + 4 \times 7^2 + 9 \times 7 + 13.
\]

6. Read Appendix E and enter the program for long division, \textsc{LongDiv} in your calculator. Use this program to calculate the quotient \( \frac{12345.678}{100} \). (Does your answer confirm what you know about division by powers of 10?)

7. Edit your program \textsc{LongDiv}, changing the line
\[
: R \times 10 \leftarrow N
\]
to
\[
: R \times 100000 \leftarrow N
\]
With the new program recalculate the quotient \( \frac{12345.678}{100} \).

8. Use \textsc{LongDiv} in the form you have created in Exercise 7 to explore the number of digits in repeating decimals for fractions with prime number denominators from 2 to 97. This is a rather complicated project, but once you get started you will find that, with a few exceptions, it goes quickly.

Prime numbers are the positive integers that have exactly two divisors, in each case the number itself and one. The numbers being considered here are: 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89 and 97.

Here's how to get started:

a. Make a table headed Denominator, Digits and Length. In the Denominator column, you will list those primes from 2 through 97. The beginning of your table will look like this:

<table>
<thead>
<tr>
<th>Denominator</th>
<th>Digits</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. For each of these Denominator or \( D \) values, you will run your \textsc{LongDiv} program, in each case using the numerator \( N = 1 \).
c. The first few values will give you simple results. 1/2 gives you \(0.50000000\ldots\), for example, and the length will be 1 for you only have to consider the digits, in this case 0s, being repeated. Similarly 1/3 gives you \(0.3333333333\ldots\) and again the length is 1.

d. Only when you get to \(D = 7\) do things become interesting. Now you should get \(0.14285714285714\ldots\). You should see that the digits 124857 are being repeated, so the length is 6.

  e. Continue to fill in your table values.

  f. Once you have finished constructing the table, try to come up with some ideas about the length of the repeated digits in general.