

# Strings and Numbers

- Many programming problems need to be solved using smaller units of data such as strings and numbers.
- In this chapter, we will look at several shell features that are used to manipulate strings and numbers. The shell provides a variety of parameter expansions that perform string operations.
- In addition to arithmetic expansion, there is a well-known command line program called `bc`, which performs higher-level math.

# Parameter Expansion: Basic Parameters

- The simplest form of parameter expansion is reflected in the ordinary use of variables.
- Here's an example:  
    [`\$a`](#)
- When expanded, this becomes whatever the variable `a` contains. Simple parameters may also be surrounded by braces.  
    [`\${a}`](#)
- This has no effect on the expansion, but is required if the variable is adjacent to other text, which may confuse the shell. In this example, we attempt to create a filename by appending the string `_file` to the contents of the variable `a`.

```
[me@linuxbox ~]$ a="foo"  
[me@linuxbox ~]$ echo "$a_file"
```

- If we perform this sequence of commands, the result will be nothing because the shell will try to expand a variable named `a_file` rather than `a`. This problem can be solved by adding braces around the “real” variable name.

```
[me@linuxbox ~]$ echo "${a}_file"  
foo_file
```

- We have also seen that positional parameters greater than nine can be accessed by surrounding the number in braces. For example, to access the eleventh positional parameter, we can do this:

`${11}`

# Expansions to Manage Empty Variables

- Several parameter expansions are intended to deal with non-existent and empty variables.
- These expansions are handy for handling missing positional parameters and assigning default values to parameters.  
    `${parameter:-word}`
- If parameter is unset (i.e., does not exist) or is empty, this expansion results in the value of word. If parameter is not empty, the expansion results in the value of parameter.

```
[me@linuxbox ~]$ foo=
[me@linuxbox ~]$ echo ${foo:-"substitute value if unset"}
substitute value if unset
[me@linuxbox ~]$ echo $foo

[me@linuxbox ~]$ foo=bar
[me@linuxbox ~]$ echo ${foo:-"substitute value if unset"}
bar
[me@linuxbox ~]$ echo $foo
bar
```

`${parameter:=word}`

- If parameter is unset or empty, this expansion results in the value of word. In addition, the value of word is assigned to parameter. If parameter is not empty, the expansion results in the value of parameter.

```
[me@linuxbox ~]$ foo=
[me@linuxbox ~]$ echo ${foo:="default value if unset"}
default value if unset
[me@linuxbox ~]$ echo $foo
default value if unset
[me@linuxbox ~]$ foo=bar
[me@linuxbox ~]$ echo ${foo:="default value if unset"}
bar
[me@linuxbox ~]$ echo $foo
bar
```

`${parameter:?word}`

- If parameter is unset or empty, this expansion causes the script to exit with an error, and the contents of word are sent to standard error. If parameter is not empty, the expansion results in the value of parameter.

```
[me@linuxbox ~]$ foo=
[me@linuxbox ~]$ echo ${foo:? "parameter is empty"}
bash: foo: parameter is empty
[me@linuxbox ~]$ echo $?
1
[me@linuxbox ~]$ foo=bar
[me@linuxbox ~]$ echo ${foo:? "parameter is empty"}
bar
[me@linuxbox ~]$ echo $?
0
```

`${parameter:+word}`

- If parameter is unset or empty, the expansion results in nothing. If parameter is not empty, the value of word is substituted for parameter; however, the value of parameter is not changed.

```
[me@linuxbox ~]$ foo=
[me@linuxbox ~]$ echo ${foo:+ "substitute value if set"}

[me@linuxbox ~]$ foo=bar
[me@linuxbox ~]$ echo ${foo:+ "substitute value if set"}
substitute value if set
```

# Expansions That Return Variable Names

- The shell has the ability to return the names of variables. This is used in some rather exotic situations.  
    `${!prefix*}`  
    `${!prefix@}`
- This expansion returns the names of existing variables with names beginning with prefix.
- According to the bash documentation, both forms of this expansion perform identically.
- Here, we list all the variables in the environment with names that begin with BASH:

```
[me@linuxbox ~]$ echo ${!BASH*}  
BASH BASH_ARGC BASH_ARGV BASH_COMMAND BASH_COMPLETION  
BASH_COMPLETION_DIR BASH_LINENO BASH_SOURCE BASH_SUBSHELL  
BASH_VERSION BASH_VERSION
```

# String Operations

- There is a large set of expansions that operate on strings. Many of these expansions are particularly well suited for operations on pathnames.  
    `${#parameter}`
- expands into the length of the string contained by parameter.  
Normally, parameter is a string; however, if parameter is either `@` or `*`, then the expansion results in the number of positional parameters.

```
[me@linuxbox ~]$ foo="This string is long."  
[me@linuxbox ~]$ echo "'$foo' is ${#foo} characters long."  
'This string is long.' is 20 characters long.
```

`${parameter:offset}`

`${parameter:offset:length}`

- These expansions are used to extract a portion of the string contained in parameter.
- The extraction begins at offset characters from the beginning of the string and continues until the end of the string, unless length is specified.

```
[me@linuxbox ~]$ foo="This string is long."  
[me@linuxbox ~]$ echo ${foo:5}  
string is long.  
[me@linuxbox ~]$ echo ${foo:5:6}  
string
```

- If the value of offset is negative, it is taken to mean it starts from the end of the string rather than the beginning. Note that negative values must be preceded by a space to prevent confusion with the `${parameter:-word}` expansion.
- *length*, if present, must not be less than zero. If parameter is `@`, the result of the expansion is length positional parameters, starting at offset.

```
[me@linuxbox ~]$ foo="This string is long."  
[me@linuxbox ~]$ echo ${foo: -5}  
long.  
[me@linuxbox ~]$ echo ${foo: -5:2}  
lo
```

`${parameter#pattern}`

`${parameter##pattern}`

- These expansions remove a leading portion of the string contained in parameter defined by *pattern*.
- *pattern* is a wildcard pattern like those used in pathname expansion. The difference in the two forms is that the `#` form removes the shortest match, while the `##` form removes the longest match.

```
[me@linuxbox ~]$ foo=file.txt.zip  
[me@linuxbox ~]$ echo ${foo#*.}  
txt.zip  
[me@linuxbox ~]$ echo ${foo##*.}  
zip
```

`${parameter%pattern}`  
`${parameter%%pattern}`

- These expansions are the same as the previous `#` and `##` expansions, except they remove text from the end of the string contained in `parameter` rather than from the beginning.

```
[me@linuxbox ~]$ foo=file.txt.zip
[me@linuxbox ~]$ echo ${foo%.*}
file.txt
[me@linuxbox ~]$ echo ${foo%%.*}
file
```

`${parameter/pattern/string}`  
`${parameter//pattern/string}`  
`${parameter/#pattern/string}`  
`${parameter/%pattern/string}`

- This expansion performs a search-and-replace operation upon the contents of `parameter`.
- If text is found matching wildcard pattern, it is replaced with the contents of `string`.
- In the normal form, only the first occurrence of pattern is replaced. In the `//` form, all occurrences are replaced.
- The `/#` form requires that the match occur at the beginning of the string, and the `/%` form requires the match to occur at the end of the string. In every form, `/string` may be omitted, causing the text matched by pattern to be deleted.

```
[me@linuxbox ~]$ foo=JPG.JPG
[me@linuxbox ~]$ echo ${foo/JPG/jpg}
jpg.JPG
[me@linuxbox ~]$ echo ${foo//JPG/jpg}
jpg.jpg
[me@linuxbox ~]$ echo ${foo/#JPG/jpg}
jpg.JPG
[me@linuxbox ~]$ echo ${foo/%JPG/jpg}
JPG.jpg
```

- Parameter expansion is a good thing to know. The string manipulation expansions can be used as substitutes for other common commands such as sed and cut.
- Expansions can improve the efficiency of scripts by eliminating the use of external programs. As an example, we will modify the longest-word program discussed in the previous chapter to use the parameter expansion `${#j}` in place of the command substitution `$(echo -n $j | wc -c)` and its resulting subshell, like so:

```
#!/bin/bash

# longest-word3: find longest string in a file

for i; do
    if [[ -r "$i" ]]; then
        max_word=
        max_len=0
        for j in $(strings $i); do
            len="${#j}"
            if (( len > max_len )); then
                max_len="$len"
                max_word="$j"
            fi
        done
        echo "$i: '$max_word' ($max_len characters)"
    fi
done
```

- Next, we will compare the efficiency of the two versions by using the time command.

```
[me@linuxbox ~]$ time longest-word2 dirlist-usr-bin.txt
dirlist-usr-bin.txt: 'scrollkeeper-get-extended-content-list' (38
characters)

real    0m3.618s
user    0m1.544s
sys 0m1.768s
[me@linuxbox ~]$ time longest-word3 dirlist-usr-bin.txt
dirlist-usr-bin.txt: 'scrollkeeper-get-extended-content-list' (38
characters)

real    0m0.060s
user    0m0.056s
sys 0m0.008s
```

- The original version of the script takes 3.618 seconds to scan the text file, while the new version, using parameter expansion, takes only 0.06 seconds — a significant improvement.

# Case Conversion

- bash has four parameter expansions and two declare command options to support the uppercase/lowercase conversion of strings. So what is case conversion good for?
- Aside from the obvious aesthetic value, it has an important role in programming. Let's consider the case of a database lookup. Imagine that a user has entered a string into a data input field that we want to look up in a database.
- It's possible the user will enter the value in all uppercase letters or lowercase letters or a combination of both. We certainly don't want to populate our database with every possible permutation of uppercase and lowercase spellings. What to do?
- A common approach to this problem is to normalize the user's input. That is, convert it into a standardized form before we attempt the database lookup. We can do this by converting all the characters in the user's input to either lower or uppercase and ensure that the database entries are normalized the same way.
- The declare command can be used to normalize strings to either uppercase or lowercase. Using declare, we can force a variable to always contain the desired format no matter what is assigned to it.

```
#!/bin/bash

# ul-declare: demonstrate case conversion via declare

declare -u upper
declare -l lower

if [[ $1 ]]; then
    upper="$1"
    lower="$1"
    echo "$upper"
    echo "$lower"
fi
```

- In the preceding script, we use declare to create two variables, upper and lower.
- We assign the value of the first command line argument (positional parameter 1) to each of the variables and then display them on the screen.

```
[me@linuxbox ~]$ ul-declare aBc
ABC
abc
```

- As we can see, the command line argument (aBc) has been normalized.

- In addition to declare, there are four parameter expansions that perform upper/lowercase conversion as described in the table

Format	Result
<code>\${parameter,,pattern}</code>	Expand the value of <i>parameter</i> into all lowercase. <i>pattern</i> is an optional shell pattern (for example, [A-F]) that will limit which characters are converted. See the <code>bash</code> man page for a full description of patterns.
<code>\${parameter,pattern}</code>	Expand the value of <i>parameter</i> , changing only the first character to lowercase.
<code>\${parameter^^pattern}</code>	Expand the value of <i>parameter</i> into all uppercase letters.
<code>\${parameter^pattern}</code>	Expand the value of <i>parameter</i> , changing only the first character to uppercase (capitalization).

- Here is a script that demonstrates these expansions:

```
#!/bin/bash

# ul-param: demonstrate case conversion via parameter expansion

if [[ "$1" ]]; then
    echo "${1,,}"
    echo "${1,}"
    echo "${1^^}"
    echo "${1^}"
fi
```

- Here is the script in action:

```
[me@linuxbox ~]$ ul-param aBc
abc
aBc
ABC
ABc
```

- Again, we process the first command line argument and output the four variations supported by the parameter expansions. While this script uses the first positional parameter, parameter may be any string, variable, or string expression.

# Arithmetic Evaluation and Expansion

- We looked at arithmetic expansion earlier. It is used to perform various arithmetic operations on integers. Its basic form is as follows:  
\$(expression)
- where expression is a valid arithmetic expression.
- This is related to the compound command (( )) used for arithmetic evaluation (truth tests) we encountered previously.
- In previous chapters, we saw some of the common types of expressions and operators.
- Here, we will look at a more complete list.

# Number Bases

- We got a look at octal (base 8) and hexadecimal (base 16) numbers. In arithmetic expressions, the shell supports integer constants in any base. The table lists the notations used to specify bases.

Notation	Description
<i>number</i>	By default, numbers without any notation are treated as decimal (base 10) integers.
<i>0number</i>	In arithmetic expressions, numbers with a leading zero are considered octal.
<i>0xnumber</i>	Hexadecimal notation.
<i>base#number</i>	<i>number</i> is in <i>base</i>

- Here are some examples:

```
[me@linuxbox ~]$ echo $((0xff))
255
[me@linuxbox ~]$ echo $((2#11111111))
255
```

- In the previous examples, we print the value of the hexadecimal number ff (the largest two-digit number) and the largest eight-digit binary (base 2) number.

# Unary Operators

- There are two unary operators, + and -, which are used to indicate whether a number is positive or negative, respectively. An example is -5.

## Simple Arithmetic

- The ordinary arithmetic operators are listed in the table.

Operator	Description
+	Addition
-	Subtraction
*	Multiplication
/	Integer division
**	Exponentiation
%	Modulo (remainder)

- Since the shell's arithmetic operates only on integers, the results of division are always whole numbers.

```
[me@linuxbox ~]$ echo $(( 5 / 2 ))  
2
```

- This makes the determination of a remainder in a division operation more important.

```
[me@linuxbox ~]$ echo $(( 5 % 2 ))  
1
```

- By using the division and modulo operators, we can determine that 5 divided by 2 results in 2, with a remainder of 1.
- Calculating the remainder is useful in loops. It allows an operation to be performed at specified intervals during the loop's execution.

- In the following example, we display a line of numbers, highlighting each multiple of 5:

```
#!/bin/bash

# modulo: demonstrate the modulo operator

for ((i = 0; i <= 20; i = i + 1)); do
    remainder=$((i % 5))
    if (( remainder == 0 )); then
        printf "<%d> " "$i"
    else
        printf "%d " "$i"
    fi
done
printf "\n"
```

- When executed, the results look like this:

```
[me@linuxbox ~]$ modulo
<0> 1 2 3 4 <5> 6 7 8 9 <10> 11 12 13 14 <15> 16 17 18 19 <20>
```

# Assignment

- Although its uses may not be immediately apparent, arithmetic expressions may perform assignment. We have performed assignment many times, though in a different context.
- Each time we give a variable a value, we are performing assignment. We can also do it within arithmetic expressions.

```
[me@linuxbox ~]$ foo=
[me@linuxbox ~]$ echo $foo

[me@linuxbox ~]$ if (( foo = 5 )); then echo "It is true."; fi
It is true.
[me@linuxbox ~]$ echo $foo
5
```

- In the preceding example, we first assign an empty value to the variable foo and verify that it is indeed empty. Next, we perform an if with the compound command (( foo= 5 )). This process does two interesting things: it assigns the value of 5 to the variable foo, and it evaluates to true because foo was assigned a non-zero value.

- In addition to the = notation, the shell also provides notations that perform some very useful assignments as shown in the table.
- These assignment operators provide a convenient shorthand for many common arithmetic tasks. Of special interest are the increment (++) and decrement (--) operators, which increase or decrease the value of their parameters by one.
- This style of notation is taken from the C programming language and has been incorporated into a number of other programming languages, including bash.

Notation	Description
<i>parameter = value</i>	Simple assignment. Assigns <i>value</i> to <i>parameter</i> .
<i>parameter += value</i>	Addition. Equivalent to <i>parameter = parameter + value</i> .
<i>parameter -= value</i>	Subtraction. Equivalent to <i>parameter = parameter - value</i> .
<i>parameter *= value</i>	Multiplication. Equivalent to <i>parameter = parameter * value</i> .
<i>parameter /= value</i>	Integer division. Equivalent to <i>parameter = parameter / value</i> .
<i>parameter %= value</i>	Modulo. Equivalent to <i>parameter = parameter % value</i> .
<i>parameter++</i>	Variable post-increment. Equivalent to <i>parameter = parameter + 1</i> (however, see the following discussion).
<i>parameter--</i>	Variable post-decrement. Equivalent to <i>parameter = parameter - 1</i> .
<i>++parameter</i>	Variable pre-increment. Equivalent to <i>parameter = parameter + 1</i> .
<i>--parameter</i>	Variable pre-decrement. Equivalent to <i>parameter = parameter - 1</i> .

- The operators may appear either at the front of a parameter or at the end. While they both either increment or decrement the parameter by one, the two placements have a subtle difference.
- If placed at the front of the parameter, the parameter is incremented (or decremented) before the parameter is returned.
- If placed after, the operation is performed after the parameter is returned. This is rather strange, but it is the intended behavior. Here is a demonstration:

```
[me@linuxbox ~]$ foo=1
[me@linuxbox ~]$ echo $((foo++))
1
[me@linuxbox ~]$ echo $foo
2
```

- If we assign the value of one to the variable foo and then increment it with the ++ operator placed after the parameter name, foo is returned with the value of one. However, if we look at the value of the variable a second time, we see the incremented value.
- If we place the ++ operator in front of the parameter, we get the more expected behavior.

```
[me@linuxbox ~]$ foo=1  
[me@linuxbox ~]$ echo $((++foo))  
2  
[me@linuxbox ~]$ echo $foo  
2
```

- For most shell applications, prefixing the operator will be the most useful.
- The ++ and -- operators are often used in conjunction with loops. We will make some improvements to our modulo script to tighten it up a bit.

```
#!/bin/bash

# modulo2: demonstrate the modulo operator

for ((i = 0; i <= 20; ++i )); do
    if ((i % 5 == 0 )); then
        printf "<%d> " "$i"
    else
        printf "%d " "$i"
    fi
done
printf "\n"
```

# Bit Operations

- One class of operators manipulates numbers in an unusual way. These operators work at the bit level. They are used for certain kinds of low-level tasks, often involving setting or reading bit-flags. The bit operators are listed in the table.

Operator	Description
~	Bitwise negation. Negate all the bits in a number.
<<	Left bitwise shift. Shift all the bits in a number to the left.
>>	Right bitwise shift. Shift all the bits in a number to the right.
&	Bitwise AND. Perform an AND operation on all the bits in two numbers.
	Bitwise OR. Perform an OR operation on all the bits in two numbers.
^	Bitwise XOR. Perform an exclusive OR operation on all the bits in two numbers.

- Note that there are also corresponding assignment operators (for example, <<=) for all but bitwise negation.

- Here we will demonstrate producing a list of powers of 2, using the left bitwise shift operator:

```
[me@linuxbox ~]$ for ((i=0;i<8;++i)); do echo $((1<<i)); done  
1  
2  
4  
8  
16  
32  
64  
128
```

# Logic

- As we discovered in Chapter 27, the `(( ))` compound command supports a variety of comparison operators. There are a few more that can be used to evaluate logic. The table provides the complete list.

Operator	Description
<code>&lt;=</code>	Less than or equal to.
<code>&gt;=</code>	Greater than or equal to.
<code>&lt;</code>	Less than.
<code>&gt;</code>	Greater than.
<code>==</code>	Equal to.
<code>!=</code>	Not equal to.
<code>&amp;&amp;</code>	Logical AND.
<code>  </code>	Logical OR.
<code>expr1?expr2:expr3</code>	Comparison (ternary) operator. If expression <i>expr1</i> evaluates to be non-zero (arithmetic true), then <i>expr2</i> ; else <i>expr3</i> .

- When used for logical operations, expressions follow the rules of arithmetic logic; that is, expressions that evaluate as zero are considered false, while non-zero expressions are considered true. The `(( ))` compound command maps the results into the shell's normal exit codes.

```
[me@linuxbox ~]$ if ((1)); then echo "true"; else echo "false"; fi
true
[me@linuxbox ~]$ if ((0)); then echo "true"; else echo "false"; fi
false
```

- The strangest of the logical operators is the ternary operator. This operator (which is modeled after the one in the C programming language) performs a stand-alone logical test. It can be used as a kind of if/then/else statement.
- It acts on three arithmetic expressions (strings won't work), and if the first expression is true (or non-zero), the second expression is performed. Otherwise, the third expression is performed. We can try this on the command line:

```
[me@linuxbox ~]$ a=0
[me@linuxbox ~]$ ((a<1?++a:--a))
[me@linuxbox ~]$ echo $a
1
[me@linuxbox ~]$ ((a<1?++a:--a))
[me@linuxbox ~]$ echo $a
0
```

- Here we see a ternary operator in action. This example implements a toggle. Each time the operator is performed, the value of the variable `a` switches from zero to one or vice versa.
- Please note that performing assignment within the expressions is not straightforward. When attempted, bash will declare an error.

```
[me@linuxbox ~]$ a=0
[me@linuxbox ~]$ ((a<1?a+=1:a-=1))
bash: ((: a<1?a+=1:a-=1: attempted assignment to non-variable (error
token is "-=1")
```

- This problem can be mitigated by surrounding the assignment expression with parentheses.

```
[me@linuxbox ~]$ ((a<1?(a+=1):(a-=1)))
```

- Next is a more complete example of using arithmetic operators in a script that produces a simple table of numbers.

```
#!/bin/bash

# arith-loop: script to demonstrate arithmetic operators

finished=0
a=0
printf "a\ta**2\ta**3\n"
printf "=\t====\t====\n"

until ((finished)); do
    b=$((a**2))
    c=$((a**3))
    printf "%d\t%d\t%d\n" "$a" "$b" "$c"
    ((a<10?++a:(finished=1)))
done
```

- In this script, we implement an until loop based on the value of the finished variable.
- Initially, the variable is set to zero (arithmetic false), and we continue the loop until it becomes non-zero. Within the loop, we calculate the square and cube of the counter variable a.
- At the end of the loop, the value of the counter variable is evaluated. If it is less than 10 (the maximum number of iterations), it is incremented by one, or else the variable finished is given the value of one, making finished arithmetically true, thereby terminating the loop.

- Running the script gives this result:

```
[me@linuxbox ~]$ arith-loop
a  a**2 a**3
=  ====
0  0     0
1  1     1
2  4     8
3  9     27
4  16    64
5  25    125
6  36    216
7  49    343
8  64    512
9  81    729
10 100   1000
```

# bc – An Arbitrary Precision Calculator Language

- We have seen how the shell can handle integer arithmetic, but what if we need to perform higher math or even just use floating-point numbers? The answer is, we can't. At least not directly with the shell. To do this, we need to use an external program. There are several approaches we can take. Embedding Perl or AWK programs is one possible solution, but unfortunately, it's outside the scope of this book.
- Another approach is to use a specialized calculator program. One such program found on many Linux systems is called bc.
- The bc program reads a file written in its own C-like language and executes it. A bc script may be a separate file, or it may be read from standard input. The bc language supports quite a few features including variables, loops, and programmer-defined functions.
- We won't cover bc entirely here, just enough to get a taste. bc is well documented by its man page.

- Let's start with a simple example. We'll write a bc script to add 2 plus 2.

```
/* A very simple bc script */  
  
2 + 2
```

- The first line of the script is a comment. bc uses the same syntax for comments as the C programming language. Comments, which may span multiple lines, begin with `/*` and end with `*/`.

# Using bc

- If we save the previous bc script as foo.bc, we can run it this way:

```
[me@linuxbox ~]$ bc foo.bc
bc 1.06.94
Copyright 1991-1994, 1997, 1998, 2000, 2004, 2006 Free Software
Foundation, Inc.
This is free software with ABSOLUTELY NO WARRANTY.
For details type `warranty'.
4
```

- If we look carefully, we can see the result at the very bottom, after the copyright message.
- This message can be suppressed with the -q (quiet) option.
- bc can also be used interactively.

```
[me@linuxbox ~]$ bc -q
2 + 2
4
quit
```

- When using bc interactively, we simply type the calculations we want to perform, and the results are immediately displayed. The bc command quit ends the interactive session.
- It is also possible to pass a script to bc via standard input.

```
[me@linuxbox ~]$ bc < foo.bc  
4
```

- The ability to take standard input means that we can use here documents, here strings, and pipes to pass scripts. This is a here string example:

```
[me@linuxbox ~]$ bc <<< "2+2"  
4
```

# An Example Script

- As a real-world example, we will construct a script that performs a common calculation, monthly loan payments. In the script below, we use a here document to pass a script to bc:

```
#!/bin/bash

# loan-calc: script to calculate monthly loan payments

PROGNAME="${0##*/}" # Use parameter expansion to get basename

usage () {
    cat << _EOF_
Usage: $PROGNAME PRINCIPAL INTEREST MONTHS
```

Where:

PRINCIPAL is the amount of the loan.  
INTEREST is the APR as a number (7% = 0.07).  
MONTHS is the length of the loan's term.

```
_EOF_
}

if (($# != 3)); then
    usage
    exit 1
fi

principal=$1
interest=$2
months=$3

bc <<- EOF
    scale = 10
    i = $interest / 12
    p = $principal
    n = $months
    a = p * ((i * ((1 + i) ^ n)) / (((1 + i) ^ n) - 1))
    print a, "\n"
EOF
```

- When executed, the results look like this:

```
[me@linuxbox ~]$ loan-calc 135000 0.0775 180  
1270.7222490000
```

- This example calculates the monthly payment for a \$135,000 loan at 7.75 percent APR for 180 months (15 years). Notice the precision of the answer.
- This is determined by the value given to the special scale variable in the bc script.
- A full description of the bc scripting language is provided by the bc man page.
- While its mathematical notation is slightly different from that of the shell (bc more closely resembles C), most of it will be quite familiar, based on what we have learned so far.