

beginner

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Chapter 1

beginner

1.1 beginner.guide

A Beginner's Guide to Amiga E

This Guide gives an introduction to the Amiga E programming language and, to some extent, programming in general.

Part One: Getting Started

- Introduction to Amiga E
- Understanding a Simple Program
- Variables and Expressions
- Program Flow Control
- Summary

Part Two: The E Language

- Format and Layout
- Procedures and Functions
- Constants
- Types
- More About Statements and Expressions
- E Built-In Constants Variables and Functions
- Modules
- Exception Handling
- Floating-Point Numbers
- Recursion

Part Three: Worked Examples

- Introduction to the Examples
- Timing Expressions
- Argument Parsing
- Gadgets IDCMP and Graphics
- Recursion Example

Part Four: Appendices

Common Problems
Other Information

Indices

E Language Index
Main Index

1.2 beginner.guide/Introduction to Amiga E

Introduction to Amiga E

To interact with your Amiga you need to speak a language it understands. Luckily, there is a wide choice of such languages, each of which fits a particular need. For instance, BASIC (in most of its flavours) is simple and easy to learn, and so is ideal for beginners. Assembly, on the other hand, requires a lot of effort and is quite tedious, but can produce the fastest programs so is generally used by commercial programmers. These are two extremes and most businesses and colleges use C or Pascal/Modula-2, which try to strike a balance between simplicity and speed.

E programs look very much like Pascal or Modula-2 programs, but E is based more closely on C. Anyone familiar with these languages will easily learn E, only really needing to get to grips with E's unique features and those borrowed from other languages. This guide is aimed at people who haven't done much programming and may be too trivial for competent programmers, who should find the 'E Reference Manual' more than adequate.

Part One (this part) goes through some of the basics of the E language and programming in general. Part Two delves deeper into E, covering the more complex topics and the unique features of E. Part Three goes through a few example programs, which are a bit longer than the examples in the other Parts. Finally, Part Four contains the Appendices, which is where you'll find some other, miscellaneous information.

A Simple Program

1.3 beginner.guide/A Simple Program

A Simple Program
=====

If you're still reading you're probably desperate to do some programming in E but you don't know how to start. We'll therefore jump straight in the deep end with a small example. You'll need to know two things before we start: how to use a text editor and the Shell/CLI.

The code
Compilation
Execution

1.4 beginner.guide/The code

The code

Enter the following lines of code into a text editor and save it as the file 'simple.e' (taking care to copy each line accurately). (Just type the characters shown, and at the end of each line press the RETURN or ENTER key.)

```
PROC main()
  WriteF('My first program')
ENDPROC
```

Don't try to do anything different, yet, to the code: the case of the letters in each word is significant and the funny characters are important. If you're a real beginner you might have difficulty finding the ' character. On my GB keyboard it's on the big key in the top left-hand corner directly below the ESC key. On a US and most European keyboards it's two to the right of the L key, next to the ; key.

1.5 beginner.guide/Compilation

Compilation

Once the file is saved (preferably in the RAM disk, since it's only a small program), you can use the E compiler to turn it into an executable program. All you need is the file 'ec' in your 'C:' directory or somewhere else on your search path (advanced users note: we don't need the 'Emodules:' assignment because we aren't using any modules). Assuming you have this and you have a Shell/CLI running, enter the following at the prompt after changing directory to where you saved your new file:

```
ec simple
```

If all's well you should be greeted, briefly, by the E compiler. If anything went wrong then double-check the contents of the file 'simple.e', that your CLI is in the same directory as this file, and that the program 'ec' is in your 'C:' directory (or on your search path).

1.6 beginner.guide/Execution

Execution

Once everything is working you can run your first program by entering the following at the CLI prompt:

```
simple
```

As a help here's the complete transcript of the whole compilation and execution process (the CLI prompt, below, is the bit of text beginning with '1.' and ending in '>'):

```
1.Workbench3.0:> cd ram:
1.Ram Disk:> ec simple
Amiga E Compiler/Assembler/Linker v3.0 (c) 91/92/93/94 $#!
lexical analysing ...
parsing and compiling ...
no errors
1.Ram Disk:> simple
My first program1.Ram Disk:>
```

Your display should be something similar if it's all worked. Notice how the output from the program runs into the prompt (the last line). We'll fix this soon.

1.7 beginner.guide/Understanding a Simple Program

Understanding a Simple Program

To understand the example program we need to understand quite a few things. The observant amongst you will have noticed that all it does is print out a message, and that message was part of a line we wrote in the program. The first thing to do is see how to change this message.

```
Changing the Message
Procedures
Parameters
Strings
Style Reuse and Readability
The Simple Program
```

1.8 beginner.guide/Changing the Message

Changing the Message

=====

Edit the file so that line contains a different message between the two

' characters and compile it again using the same procedure as before. Don't use any ' characters except those around the message. If all went well, when you run the program again it should produce a different message. If something went wrong, compare the contents of your file with the original and make sure the only difference is the message between the ' characters.

Tinkering with the example
Brief overview

1.9 beginner.guide/Tinkering with the example

Tinkering with the example

Simple tinkering is a good way to learn for yourself so it is encouraged on these simple examples. Don't stray too far, though, and if you start getting confused return to the proper example pretty sharpish!

1.10 beginner.guide/Brief overview

Brief overview

We'll look in detail at the important parts of the program in the following sections, but we need first to get a glimpse of the whole picture. Here's a brief description of some fundamental concepts:

- * **Procedures:** We defined a procedure called 'main' and used the (built-in) procedure 'WriteF'. A procedure can be thought of as a small program with a name.
- * **Parameters:** The message in parentheses after 'WriteF' in our program is the parameter to 'WriteF'. This is the data which the procedure should use.
- * **Strings:** The message we passed to 'WriteF' was a series of characters enclosed in ' characters. This is known as a "string".

1.11 beginner.guide/Procedures

Procedures
=====

As mentioned above, a procedure can be thought of as a small program with a name. In fact, when an E program is run the procedure called

'main' is executed. Therefore, if your E program is going to do anything you must define a 'main' procedure. Other (built-in or user-defined) procedures may be run (or "called") from this procedure (as we did 'WriteF' in the example). For instance, if the procedure 'fred' calls the procedure 'barney' the code (or mini-program) associated with 'barney' is executed. This may involve calls to other procedures, and when the execution of this code is complete the next piece of code in the procedure 'fred' is executed (and this is generally the next line of the procedure). When the end of the procedure 'main' has been reached the program has finished. However, lots can happen between the beginning and end of a procedure, and sometimes the program may never get to finish. Alternatively, the program may "crash", causing strange things to happen to your computer.

Procedure Definition
Procedure Execution
Extending the example

1.12 beginner.guide/Procedure Definition

Procedure Definition

Procedures are defined using the keyword 'PROC', followed by the new procedure's name (in lowercase letters), a description of the parameters it takes (in parentheses), a series of lines forming the code of the procedure and then the keyword 'ENDPROC'. Look at the example program again to identify the various parts. See The code.

1.13 beginner.guide/Procedure Execution

Procedure Execution

Procedures can be called (or executed) from within the code part of another procedure. You do this by giving its name, followed by some data in parentheses. Look at the call to 'WriteF' in the example program. See The code.

1.14 beginner.guide/Extending the example

Extending the example

Here's how we could change the example program to define another procedure:

```
PROC main()
  WriteF('My first program')
  fred()
ENDPROC

PROC fred()
  WriteF('...slightly improved')
ENDPROC
```

This may seem complicated, but in fact it's very simple. All we've done is define a second procedure called 'fred' which is just like the original program--it outputs a message. We've "called" this procedure in the 'main' procedure just after the line which outputs the original message. Therefore, the message in 'fred' is output after this message. Compile the program as before and run it so you don't have to take my word for it.

1.15 beginner.guide/Parameters

Parameters
=====

Generally we want procedures to work with particular data. In our example we wanted the 'WriteF' procedure to work on a particular message. We passed the message as a "parameter" (or "argument") to 'WriteF' by putting it between the parentheses (the '(' and ')' characters) that follow the procedure name. When we called the 'fred' procedure, however, we did not require it to use any data so the parentheses were left empty.

When defining a procedure when define how much and what type of data we want it to work on, and when calling a procedure we give the specific data it should use. Notice that the procedure 'fred' (like the procedure 'main') has empty parentheses in its definition. This means that the procedure cannot be given any data as parameters when it is called. Before we can define our own procedure that takes parameters we must learn about variables. We'll do this in the next chapter. See Global and local variables.

1.16 beginner.guide/Strings

Strings
=====

A series of characters between two ' characters is known as a string. Almost any character can be used in a string, although the \ and ' characters have a special meaning. For instance, a linefeed is denoted by the two characters '\n'. We now know how to stop the message running into the prompt. Change the program to be:

```
PROC main()
```

```
        WriteF('My first program\n')
        fred()
    ENDPROC

PROC fred()
    WriteF('...slightly improved\n')
ENDPROC
```

Compile it as before, and run it. You should notice that the messages now appear on lines by themselves, and the second message is separated from the prompt which follows it. We have therefore cured the linefeed problem we spotted earlier (see Execution).

1.17 beginner.guide/Style Reuse and Readability

Style, Reuse and Readability

=====

The example has grown into two procedures, one called 'main' and one called 'fred'. However, we could get by with only one procedure:

```
PROC main()
    WriteF('My first program\n')
    WriteF('...slightly improved\n')
ENDPROC
```

What we've done is replace the call to the procedure 'fred' with the code it represents (this is called "inlining" the procedure). In fact, almost all programs can be easily re-written to eliminate all but the 'main' procedure. However, splitting a program up using procedures normally results in more readable code. It is also helpful to name your procedures so that their function is apparent, so our procedure 'fred' should probably have been named 'message' or something similar. A well-written program in this style can read just like English (or the any other spoken language).

Another reason for having procedures is to reuse code, rather than having to write it out every time you use it. Imagine you wanted to print the same, long message fairly often in your program--you'd either have to write it all out every time, or you could write it once in a procedure and call this procedure when you wanted the message printed. Using a procedure also has the benefit of having only one copy of the message to change, should it ever need changing.

1.18 beginner.guide/The Simple Program

The Simple Program

=====

The simple program should now (hopefully) seem simple. The only bit

that hasn't been explained is the built-in procedure `'WriteF'`. E has many built-in procedures and later we'll meet some of them in detail. The first thing we need to do, though, is manipulate data. This is really what a computer does all the time--it accepts data from some source (possibly the user), manipulates it in some way (possibly storing it somewhere, too) and outputs new data (usually to a screen or printer). The simple example program did all this, except the first two stages were rather trivial. You told the computer to execute the compiled program (this was some user input) and the real data (the message to be printed) was retrieved from the program. This data was manipulated by passing it as a parameter to `'WriteF'`, which then did some clever stuff to print it on the screen. To do our own manipulation of data we need to learn about variables and expressions.

1.19 beginner.guide/Variables and Expressions

Variables and Expressions

Anybody who's done any school algebra will probably know what a variable is--it's just a named piece of data. In algebra the data is usually a number, but in E it can be all sorts of things (e.g., a string). The manipulation of data like the addition of two numbers is known as an "expression". The result of an expression can be used to build bigger expressions. For instance, `'1+2'` is an expression, and so is `'6-(1+2)'`. The good thing is you can use variables in place of data in expressions, so if `'x'` represents the number 1 and `'y'` represents 5, then the expression `'y-x'` represents the number 4. In the next two sections we'll look at what kind of variables you can define and what the different sorts of expressions are.

Variables

Expressions

1.20 beginner.guide/Variables

Variables

=====

Variables in E can hold many different kinds of data (called "types"). However, before a variable can be used it must be defined, and this is known as "declaring" the variable. A variable declaration also decides whether the variable is available for the whole program or just during the code of a procedure (i.e., whether the variable is "global" or "local"). Finally, the data stored in a variable can be changed using "assignments". The following sections discuss these topics in slightly more detail.

Variable types

Variable declaration
Assignment
Global and local variables
Changing the example

1.21 beginner.guide/Variable types

Variable types

In E a variable is a storage place for data (and this storage is part of the Amiga's RAM). Different kinds of data may require different amounts of storage. However, data can be grouped together in "types", and two pieces of data from the same type require the same amount of storage. Every variable has an associated type and this dictates the maximum amount of storage it uses. Most commonly, variables in E store data from the type 'LONG'. This type contains the integers from -2,147,483,648 to 2,147,483,647, so is normally more than sufficient. There are other types, such as 'INT' and 'LIST', and more complex things to do with types, but for now knowing about 'LONG' is enough.

1.22 beginner.guide/Variable declaration

Variable declaration

Variables must be declared before they can be used. They are declared using the 'DEF' keyword followed by a (comma-separated) list of the names of the variables to be declared. These variables will all have type 'LONG' (later we will see how to declare variables with other types). Some examples will hopefully make things clearer:

```
DEF x
```

```
DEF a, b, c
```

The first line declares the single variable 'x', whilst the second declares the variables 'a', 'b' and 'c' all in one go.

1.23 beginner.guide/Assignment

Assignment

The data stored by variables can be changed and this is normally done using "assignments". An assignment is formed using the variable's name and an expression denoting the new data it is to store. The symbol ':='

separates the variable from the expression. For example, the following code stores the number two in the variable 'x'. The left-hand side of the ':=' is the name of the variable to be affected ('x' in this case) and the right-hand side is an expression denoting the new value (simply the number two in this case).

```
x := 2
```

The following, more complex example uses the value stored in the variable before the assignment as part of the expression for the new data. The value of the expression on the right-hand side of the ':=' is the value stored in the variable 'x' plus one. This value is then stored in 'x', over-writing the previous data. (So, the overall effect is that 'x' is incremented.)

```
x := x + 1
```

This may be clearer in the next example which does not change the data stored in 'x'. In fact, this piece of code is just a waste of CPU time, since all it does is look up the value stored in 'x' and store it back there!

```
x := x
```

1.24 beginner.guide/Global and local variables

Global and local variables (and procedure parameters)

There are two kinds of variable: "global" and "local". Data stored by global variables can be read and changed by all procedures, but data stored by local variables can only be accessed by the procedure to which they are local. Global variables must be declared before the first procedure definition. Local variables are declared within the procedure to which they are local (i.e., between the 'PROC' and 'ENDPROC'). For example, the following code declares a global variable 'w' and local variables 'x' and 'y'.

```
DEF w

PROC main()
  DEF x
  x:=2
  w:=1
  fred()
ENDPROC

PROC fred()
  DEF y
  y:=3
  w:=2
ENDPROC
```

The variable 'x' is local to the procedure 'main', and 'y' is local to

'fred'. The procedures 'main' and 'fred' can read and alter the value of the global variable 'w', but 'fred' cannot read or alter the value of 'x' (since that variable is local to 'main'). Similarly, 'main' cannot read or alter 'y'.

The local variables of one procedure are, therefore, completely different to the local variables of another procedure. For this reason they can share the same names without confusion. So, in the above example, the local variable 'y' in 'fred' could have been called 'x' and the program would have done exactly the same thing.

```
DEF w

PROC main()
  DEF x
  x:=2
  w:=1
  fred()
ENDPROC

PROC fred()
  DEF x
  x:=3
  w:=2
ENDPROC
```

This works because the 'x' in the assignment in 'fred' can refer only to the local variable 'x' of 'fred' (the 'x' in 'main' is local to 'main' so cannot be accessed from 'fred').

If a local variable for a procedure has the same name as a global variable then in the rest of the procedure the name refers only to the local variable. Therefore, the global variable cannot be accessed in the procedure, and this is called "descopeing" the global variable.

The parameters of a procedure are local variables for that procedure. We've seen how to pass values as parameters when a procedure is called (the use of 'WriteF' in the example), but until now we haven't been able to define a procedure which takes parameters. Now we know a bit about variables we can have a go:

```
DEF y

PROC onemore(x)
  y:=x+1
ENDPROC
```

This isn't a complete program so don't try to compile it. Basically, we've declared a variable 'y' (which will be of type 'LONG') and a procedure 'onemore'. The procedure is defined with a parameter 'x', and this is just like a (local) variable declaration. When 'onemore' is called a parameter must be supplied, and this value is stored in the (local) variable 'x' before execution of 'onemore''s code. The code stores the value of 'x' plus one in the (global) variable 'y'. The following are some examples of calling 'onemore':

```
onemore(120)
```

```
onemore(52+34)
onemore(y)
```

A procedure can be defined to take any number of parameters. Below, the procedure 'addthem' is defined to take two parameters, 'a' and 'b', so it must therefore be called with two parameters. Notice that values stored by the parameter variables ('a' and 'b') can be changed within the code of the procedure.

```
DEF y

PROC addthem(a, b)
  a:=a+2
  y:=a*b
ENDPROC
```

The following are some examples of calling 'addthem':

```
addthem(120,-20)
addthem(52,34)
addthem(y,y)
```

1.25 beginner.guide/Changing the example

Changing the example

Before we change the example we must learn something about 'WriteF'. We already know that the characters '\n' in a string mean a linefeed. However, there are several other important combinations of characters in a string, and some are special to procedures like 'WriteF'. One such combination is '\d', which is easier to describe after we've seen the changed example.

```
PROC main()
  WriteF('My first program\n')
  fred()
ENDPROC

PROC fred()
  WriteF('...brought to you by the number \d\n', 236)
ENDPROC
```

You might be able to guess what happens, but compile it and try it out anyway. If everything's worked you should see that the second message prints out the number that was passed as the second parameter to 'WriteF'. That's what the '\d' combination does--it marks the place in the string where the number should be printed. Here's the output the example should generate:

```
My first program
...brought to you by the number 236
```

Try this next change:

```
PROC main()
  WriteF('My first program\n')
  fred()
ENDPROC

PROC fred()
  WriteF('...the number \d is quite nice\n', 16)
ENDPROC
```

This is very similar, and just shows that the `'\d'` really does mark the place where the number is printed. Again, here's the output it should generate:

```
My first program
...the number 16 is quite nice
```

We'll now try printing two numbers.

```
PROC main()
  WriteF('My first program\n')
  fred()
ENDPROC

PROC fred()
  WriteF('...brought to you by the numbers \d and \d\n', 16, 236)
ENDPROC
```

Because we're printing two numbers we need two lots of `'\d'`, and we need to supply two numbers as parameters in the order in which we want them to be printed. The number 16 will therefore be printed before the word `'and'` and before the number 236. Here's the output:

```
My first program
...brought to you by the numbers 16 and 236
```

We can now make a big step forward and pass the numbers as parameters to the procedure `'fred'`. Just look at the differences between this next example and the previous one.

```
PROC main()
  WriteF('My first program\n')
  fred(16, 236)
ENDPROC

PROC fred(a,b)
  WriteF('...brought to you by the numbers \d and \d\n', a,b)
ENDPROC
```

This time we pass the (local) variables `'a'` and `'b'` to `'WriteF'`. This is exactly the same as passing the values they store (which is what the previous example did), and so the output will be the same. In the next section we'll manipulate the variables by doing some arithmetic with `'a'` and `'b'`, and get `'WriteF'` to print the results.

1.26 beginner.guide/Expressions

Expressions

=====

The E language includes the normal mathematical and logical operators. These operators are combined with values (usually in variables) to give "expressions" which yield new values. The following sections discuss this topic in more detail.

Mathematics

Logic and comparison

Precedence and grouping

1.27 beginner.guide/Mathematics

Mathematics

All the standard mathematical operators are supported in E. You can do addition, subtraction, multiplication and division. Other functions such as sine, modulus and square-root can also be used as they are part of the Amiga system libraries, but we only need to know about simple mathematics at the moment. The '+' character is used for addition, '-' for subtraction, '*' for multiplication (it's the closest you can get to a multiplication sign on a keyboard without using the letter 'x'), and '/' for division (be careful not to confuse the '\' used in strings with '/' used for division). The following are examples of expressions:

```
1+2+3+4
15-5
5*2
330/33
-10+20
3*3+1
```

Each of these expressions yields ten as its result. The last example is very carefully written to get the precedence correct (see Precedence and grouping).

All the above expressions use integer operators, so they manipulate integers, giving integers as results. "Floating-point" numbers are also supported by E, but using them is quite complicated (see Floating-Point Numbers). (Floating-point numbers can represent both very small fractions and very large integers, but they have a limited accuracy, i.e., a limited number of *significant* digits.)

1.28 beginner.guide/Logic and comparison

Logic and comparison

Logic lies at the very heart of a computer. They rarely guess what to do next; instead they rely on hard facts and precise reasoning. Consider the password protection on most games. The computer must decide whether you entered the correct number or word before it lets you play the game. When you play the game it's constantly making decisions: did your laser hit the alien, have you got any lives left, etc. Logic controls the operation of a program.

In E, the constants 'TRUE' and 'FALSE' represent the truth values true and false (respectively), and the operators 'AND' and 'OR' are the standard logic operators. The comparison operators are '=' (equal to), '>' (greater than), '<' (less than), '>=' (greater than or equal to), '<=' (less than or equal to) and '<>' (not equal to). All the following expressions are true:

```
TRUE
TRUE AND TRUE
TRUE OR FALSE
1=1
2>1
3<>0
```

And these are all false:

```
FALSE
TRUE AND FALSE
FALSE OR FALSE
0=2
2<1
(2<1) AND (-1=0)
```

The last example must use parentheses. We'll see why in the next section (it's to do with precedence, again).

The truth values 'TRUE' and 'FALSE' are actually numbers. This is how the logic system works in E. 'TRUE' is the number -1 and 'FALSE' is zero. The logic operators 'AND' and 'OR' expect such numbers as their parameters. In fact, the 'AND' and 'OR' operators are really bit-wise operators (see Bitwise AND and OR), so most of the time any non-zero number is taken to be 'TRUE'. It can sometimes be convenient to rely on this knowledge, although most of the time it is preferable (and more readable) to use a slightly more explicit form. Also, these facts can cause a few subtle problems as we shall see in the next section.

1.29 beginner.guide/Precedence and grouping

Precedence and grouping

At school most of us are taught that multiplications must be done

before additions in a sum. In E it's different--there is no operator precedence. This means that expressions like `'1+3*3'` do not give the results a mathematician might expect. In fact, `'1+3*3'` represents the number 12 in E. This is because the addition, `'1+3'`, is done before the multiplication, since it occurs before the multiplication. If the multiplication were written before the addition it would be done first (like we would normally expect). Therefore, `'3*3+1'` represents the number 10 in E and in school mathematics.

To overcome this difference we can use parentheses to group the expression. If we'd written `'1+(3*3)'` the result would be 10. This is because we've forced E to do the multiplication first. Although this may seem troublesome to begin with, it's actually a lot better than learning a lot of rules for deciding which operator is done first (in C this can be a real pain, and you usually end up writing the brackets in just to be sure!).

The logic examples above contained the expression:

```
(2<1) AND (-1=0)
```

This expression was false. If we'd left the parentheses out, E would have seen it as:

```
((2<1) AND -1) = 0
```

Now the number -1 shouldn't really be used to represent a truth value with 'AND', but we do know that 'TRUE' is the number -1, so E will make sense of this and the E compiler won't complain. We will soon see how 'AND' and 'OR' really work (see Bitwise AND and OR), but for now we'll just work out what E would calculate for this expression:

1. Two is not less than one so `'2<1'` can be replaced by `'FALSE'`.

```
(FALSE AND -1) = 0
```

2. 'TRUE' is -1 so we can replace -1 by 'TRUE'.

```
(FALSE AND TRUE) = 0
```

3. 'FALSE AND TRUE' is 'FALSE'.

```
(FALSE) = 0
```

4. 'FALSE' is really the number zero, so we can replace it with zero.

```
0 = 0
```

5. Zero is equal to zero, so the expression is 'TRUE'.

```
TRUE
```

So E calculates the expression to be true. But the original expression (with parentheses) was false. Bracketing is therefore very important! It is also very easy to do correctly.

1.30 beginner.guide/Program Flow Control

Program Flow Control

A computer program often needs to repeatedly execute a series of statements or execute different statements according to the result of some decision. For example, a program to print all the numbers between one and a thousand would be very long and tedious to write if each print statement had to be given individually--it would be much better to use a variable and repeatedly print its value and increment it. Also, things sometimes go wrong and a program must decide whether to continue or print an error message and stop--this part of a program is a typical example of a conditional block.

Conditional Block

Loops

1.31 beginner.guide/Conditional Block

Conditional Block

=====

There are two kinds of conditional block: 'IF' and 'SELECT'. Examples of these blocks are given below as fragments of E code (i.e., the examples are not complete E programs).

```
IF x>0
  x:=x+1
  WriteF('Increment: x is now \d\n', x)
ELSEIF x<0
  x:=x-1
  WriteF('Decrement: x is now \d\n', x)
ELSE
  WriteF('Zero: x is 0\n')
ENDIF
```

In the above 'IF' block, the first part checks if the value of 'x' is greater than zero, and, if it is, 'x' is incremented and the new value is printed (with a message saying it was incremented). The program will then skip the rest of the block, and will execute the statements which follow the 'ENDIF'. If, however, 'x' it is not greater than zero the 'ELSEIF' part is checked, so if 'x' is less than zero it will be decremented and printed, and the rest of the block is skipped. If 'x' is not greater than zero and not less than zero the statements in the 'ELSE' part are executed, so a message saying 'x' is zero is printed. The 'IF' conditional is described in more detail below.

IF block

IF expression

```

SELECT x
  CASE 0
    WriteF('x is zero\n')
  CASE 10
    WriteF('x is ten\n')
  CASE -2
    WriteF('x is -2\n')
  DEFAULT
    WriteF('x is not zero, ten or -2\n')
ENDSELECT

```

The 'SELECT' block is similar to the 'IF' block--it does different things depending on the value of 'x'. However, 'x' is only checked against specific values, given in the series of 'CASE' statements. If it is not any of these values the 'DEFAULT' part is executed.

There's also a variation on the 'SELECT' block (known as the 'SELECT..OF' block) which matches ranges of values and is quite fast. The two kinds of 'SELECT' block are described in more detail below.

```

SELECT block
SELECT..OF block

```

1.32 beginner.guide/IF block

'IF' block

The 'IF' block has the following form (the bits like EXPRESSION are descriptions of the kinds of E code which is allowed at that point--they are not proper E code):

```

IF EXPRESSIONA
  STATEMENTSA
ELSEIF EXPRESSIONB
  STATEMENTSB
ELSE
  STATEMENTSC
ENDIF

```

This block means:

- * If EXPRESSIONA is true (i.e., represents 'TRUE' or any non-zero number) the code denoted by STATEMENTSA is executed.
- * If EXPRESSIONA is false (i.e., represents 'FALSE' or zero) and EXPRESSIONB is true the STATEMENTSB part is executed.
- * If both EXPRESSIONA and EXPRESSIONB are false the STATEMENTSC part is executed.

There does not need to be an 'ELSE' part but if one is present it must be the last part (immediately before the 'ENDIF'). Also, there can be any

number of 'ELSEIF' parts between the 'IF' and 'ELSE' parts.

An alternative to this vertical form (where each part is on a separate line) is the horizontal form:

```
IF EXPRESSION THEN STATEMENTA ELSE STATEMENTB
```

This has the disadvantage of no 'ELSEIF' parts and having to cram everything onto a single line. Notice the presence of the 'THEN' keyword to separate the EXPRESSION and STATEMENT. This horizontal form is closely related to the 'IF' expression, which is described below (see IF expression).

To help make things clearer here are a number of E code fragments which illustrate the allowable 'IF' blocks:

```
IF x>0 THEN x:=x+1 ELSE x:=0
```

```
IF x>0
  x:=x+1
ELSE
  x:=0
ENDIF
```

```
IF x=0 THEN WriteF('x is zero\n')
```

```
IF x=0
  WriteF('x is zero\n')
ENDIF
```

```
IF x<0
  Write('Negative x\n')
ELSIF x>2000
  Write('Too big x\n')
ELSIF (x=2000) OR (x=0)
  Write('Worrying x\n')
ENDIF
```

```
IF x>0
  IF x>2000
    WriteF('Big x\n')
  ELSE
    WriteF('OK x\n')
  ENDIF
ELSE
  IF x<-800 THEN WriteF('Small x\n') ELSE Write('Negative OK x')
ENDIF
```

In the last example there are "nested" 'IF' blocks (i.e., an 'IF' block within an 'IF' block). There is no ambiguity in which 'ELSE' or 'ELSEIF' parts belong to which 'IF' block because the beginning and end of the 'IF' blocks are clearly marked. For instance, the first 'ELSE' line can only be interpreted as being part of the innermost 'IF' block.

As a matter of style the conditions on the 'IF' and 'ELSEIF' parts should not "overlap" (i.e., at most one of the conditions should be true). If they do, however, the first one will take precedence. Therefore, the

following two fragments of E code do the same thing:

```
IF x>0
  WriteF('x is bigger than zero\n')
ELSEIF x>200
  WriteF('x is bigger than 200\n')
ELSE
  WriteF('x is too small\n')
ENDIF

IF x>0
  WriteF('x is bigger than zero\n')
ELSE
  WriteF('x is too small\n')
ENDIF
```

The 'ELSEIF' part of the first fragment checks whether 'x' is greater than 200. But, if it is, the check in the 'IF' part would have been true ('x' is certainly greater than zero if it's greater than 200), and so only the code in the 'IF' part is executed. The whole 'IF' block behaves as if the 'ELSEIF' was not there.

1.33 beginner.guide/IF expression

'IF' expression

'IF' is such a commonly used construction that there is also an 'IF' expression. The 'IF' block is a statement and it controls which lines of code are executed, whereas the 'IF' expression is an expression and it controls its own value. For example, the following 'IF' block:

```
IF x>0
  y:=x+1
ELSE
  y:=0
ENDIF
```

can be written more succinctly using an 'IF' expression:

```
y:=(IF x>0 THEN x+1 ELSE 0)
```

The parentheses are unnecessary but they help to make the example more readable. Since the 'IF' block is just choosing between two assignments to 'y' it isn't really the lines of code that are different (they are both assignments), rather it is the values that are assigned to 'y' that are different. The 'IF' expression makes this similarity very clear. It chooses the *value* to be assigned in just the same way that the 'IF' block choose the *assignment*.

As you can see, 'IF' expressions are written like the horizontal form of the 'IF' block. However, there must be an 'ELSE' part and there can be no 'ELSEIF' parts. This means that the expression will always have a value, and it isn't cluttered with lots of cases.

Don't worry too much about 'IF' expressions, since there are only useful in a handful of cases and can always be rewritten as a more wordy 'IF' block. Having said that they are very elegant and a lot more readable than the equivalent 'IF' block.

1.34 beginner.guide/SELECT block

'SELECT' block

The 'SELECT' block has the following form:

```
SELECT VARIABLE
CASE EXPRESSIONA
    STATEMENTSA
CASE EXPRESSIONB
    STATEMENTSB
DEFAULT
    STATEMENTSC
ENDSELECT
```

The value of the selection variable (denoted by VARIABLE in the 'SELECT' part) is compared with the value of the expression in each of the 'CASE' parts in turn. If there's a match, the statements in the (first) matching 'CASE' part are executed. There can be any number of 'CASE' parts between the 'SELECT' and 'DEFAULT' parts. If there is no match, the statements in the 'DEFAULT' part are executed. There does not need to be an 'DEFAULT' part but if one is present it must be the last part (immediately before the 'ENDSELECT').

It should be clear that 'SELECT' blocks can be rewritten as 'IF' blocks, with the checks on the 'IF' and 'ELSEIF' parts being equality checks. For example, the following code fragments are equivalent:

```
SELECT x
CASE 22
    WriteF('x is 22\n')
CASE (y+z)/2
    WriteF('x is (y+x)/2\n')
DEFAULT
    WriteF('x isn't anything significant\n')
ENDSELECT

IF x=22
    WriteF('x is 22\n')
ELSEIF x=(y+z)/2
    WriteF('x is (y+x)/2\n')
ELSE
    WriteF('x isn't anything significant\n')
ENDIF
```

Notice that the 'IF' and 'ELSEIF' parts come from the 'CASE' parts, the 'ELSE' part comes from the 'DEFAULT' part, and the order of the parts is

preserved. The advantage of the 'SELECT' block is that it's much easier to see that the value of 'x' is being tested all the time, and also we don't have to keep writing 'x=' in the checks.

1.35 beginner.guide/SELECT..OF block

'SELECT..OF' block

The 'SELECT..OF' block is a bit more complicated than the normal 'SELECT' block, but can be very useful. It has the following form:

```
SELECT MAXRANGE OF EXPRESSION
CASE CONSTA
  STATEMENTS A
CASE CONSTB1 TO CONSTB2
  STATEMENTS B
CASE RANGE1, RANGE2
  STATEMENTS C
DEFAULT
  STATEMENTS D
ENDSELECT
```

The value to be matched is EXPRESSION, which can be any expression, not just a variable like in the normal 'SELECT' block. However, the MAXRANGE, CONSTA, CONSTB1 and CONSTB2 must all be explicit numbers, i.e., constants (see Constants). MAXRANGE must be a positive constant and the other constants must be between zero and MAXRANGE.

The 'CASE' values to be matched are specified using "ranges". A simple range is a single constant (the first 'CASE' above). The more general range is shown in the second 'CASE', using the 'TO' keyword (CONSTB2 must be greater than CONSTB1). A general 'CASE' in the 'SELECT..OF' block can specify a number of possible ranges to match against by separating each range with a comma, as in the third 'CASE' above. For example, the following 'CASE' lines are equivalent and can be used to match any number from one to five (inclusive):

```
CASE 1 TO 5

CASE 1, 2, 3, 4, 5

CASE 1 TO 3, 3 TO 5

CASE 1, 2 TO 3, 4, 5

CASE 1, 5, 2, 4, 3

CASE 2 TO 3, 5, 1, 4
```

If the value of the EXPRESSION is outside the range zero to MAXRANGE, or it does not match any of the constants in the 'CASE' ranges, then the statements in the 'DEFAULT' part are executed. Otherwise the statements in the first matching 'CASE' part are executed. As in the normal 'SELECT'

block, there does not need to be a 'DEFAULT' part.

The following 'SELECT..OF' block prints the (numeric) day of the month nicely:

```
SELECT 31 OF day
CASE 1, 21, 31
    WriteF('The \dst day of the month\n', day)
CASE 2, 22
    WriteF('The \dnd day of the month\n', day)
CASE 3, 23
    WriteF('The \drd day of the month\n', day)
CASE 4 TO 20, 24 TO 30
    WriteF('The \dth day of the month\n', day)
DEFAULT
    WriteF('Error: invalid day=\d\n', day)
ENDSELECT
```

The MAXRANGE for this block is 31, since that is the maximum of the values used in the 'CASE' parts. If the value of 'day' was 100, for instance, then the statements in the 'DEFAULT' part would be executed, signalling an invalid day.

This example can be rewritten as an 'IF' block:

```
IF (day=1) OR (day=21) OR (day=31)
    WriteF('The \dst day of the month\n', day)
ELSEIF (day=2) OR (day=22)
    WriteF('The \dnd day of the month\n', day)
ELSEIF (day=3) OR (day=23)
    WriteF('The \drd day of the month\n', day)
ELSEIF ((4<=day) AND (day<=20)) OR ((24<=day) AND (day<=30))
    WriteF('The \dth day of the month\n', day)
ELSE
    WriteF('Error: invalid day=\d\n', day)
ENDIF
```

The comma separating two ranges in the 'CASE' part has been replaced by an 'OR' of two comparison expressions, and the 'TO' range has been replaced by an 'AND' of two comparisons. (It is worth noticing the careful bracketing of the resulting expressions.)

Clearly, the 'SELECT..OF' block is much more readable than the equivalent 'IF' block. It is also a lot faster, mainly because none of the comparisons present in 'IF' block have to be done in the 'SELECT..OF' version. Instead the value to be matched is used to immediately locate the correct 'CASE' part. However, it's not all good news: the MAXRANGE value directly affects the size of compiled executable, so it is recommended that 'SELECT..OF' blocks be used only with small MAXRANGE values. See the 'Reference Manual' for more details.

1.36 beginner.guide/Loops

Loops

=====

Loops are all about making a program execute a series of statements over and over again. Probably the simplest loop to understand is the 'FOR' loop. There are other kinds of loops, but they are easier to understand once we know how to use a 'FOR' loop.

```
FOR loop
WHILE loop
REPEAT..UNTIL loop
```

1.37 beginner.guide/FOR loop

'FOR' loop

If you want to write a program to print the numbers one to 100 you can either type each number and wear out your fingers, or you can use a single variable and a small 'FOR' loop. Try compiling this E program (the space after the '\d' is needed to separate the printed numbers):

```
PROC main()
  DEF x
  FOR x:=1 TO 100
    WriteF('\d ', x)
  ENDFOR
  WriteF('\n')
ENDPROC
```

When you run this you'll get all the numbers from one to 100 printed, just like we wanted. It works by using the (local) variable 'x' to hold the number to be printed. The 'FOR' loop starts off by setting the value of 'x' to one (the bit that looks like an assignment). Then the statements between the 'FOR' and 'ENDFOR' lines are executed (so the value of 'x' gets printed). When the program reaches the 'ENDFOR' it increments 'x' and checks to see if it is bigger than 100 (the limit we set with the 'TO' part). If it is, the loop is finished and the statements after the 'ENDFOR' are executed. If, however, it wasn't bigger than 100, the statements between the 'FOR' and 'ENDFOR' lines are executed all over again, and this time 'x' is one bigger since it has been incremented. In fact, this program does exactly the same as the following program (the '...' is not E code--it stands for the 97 other 'WriteF' statements):

```
PROC main()
  WriteF('\d ', 1)
  WriteF('\d ', 2)
  ...
  WriteF('\d ', 100)
  WriteF('\n')
ENDPROC
```


The general form of the 'FOR' loop is as follows:

```
FOR VAR := EXPRESSIONA TO EXPRESSIONB STEP NUMBER
  STATEMENTS
ENDFOR
```

The VAR bit stands for the loop variable (in the example above this was 'x'). The EXPRESSIONA bit gives the start value for the loop variable and the EXPRESSIONB bit gives the last allowable value for it. The 'STEP' part allows you to specify the value (given by NUMBER) which is added to the loop variable on each loop. Unlike the values given for the start and end (which can be arbitrary expressions), the 'STEP' value must be a constant (see Constants). The 'STEP' value defaults to one if the 'STEP' part is omitted (as in our example). Negative 'STEP' values are allowed, but in this case the check used at the end of each loop is whether the loop variable is *less than* the value in the 'TO' part. Zero is not allowed as the 'STEP' value.

As with the 'IF' block there is a horizontal form of a 'FOR' loop:

```
FOR VAR := EXPA TO EXPB STEP EXPC DO STATEMENT
```

1.38 beginner.guide/WHILE loop

'WHILE' loop

The 'FOR' loop used a loop variable and checked whether that variable had gone past its limit. A 'WHILE' loop allows you to specify your own loop check. For instance, this program does the same as the program in the previous section:

```
PROC main()
  DEF x
  x:=1
  WHILE x<=100
    WriteF('\d ', x)
    x:=x+1
  ENDWHILE
  WriteF('\n')
ENDPROC
```

We've replaced the 'FOR' loop with initialisation of 'x' and a 'WHILE' loop with an extra statement to increment 'x'. We can now see the inner workings of the 'FOR' loop and, in fact, this is exactly how the 'FOR' loop works.

It is important to know that our check, 'x<=100', is done before the loop statements are executed. This means that the loop statements might not even be executed once. For instance, if we'd made the check 'x>=100' it would be false at the beginning of the loop (since 'x' is initialised to one in the assignment before the loop). Therefore, the loop would have terminated immediately and execution would pass straight to the statements after the 'ENDWHILE'.

Here's a more complicated example:

```
PROC main()
  DEF x,y
  x:=1
  y:=2
  WHILE (x<10) AND (y<10)
    WriteF('x is \d and y is \d\n', x, y)
    x:=x+2
    y:=y+2
  ENDWHILE
ENDPROC
```

We've used two (local) variables this time. As soon as one of them is ten or more the loop is terminated. A bit of inspection of the code reveals that 'x' is initialised to one, and keeps having two added to it. It will, therefore, always be an odd number. Similarly, 'y' will always be even. The 'WHILE' check shows that it won't print any numbers which are greater than or equal to ten. From this and the fact that 'x' starts at one and 'y' at two we can decide that the last pair of numbers will be seven and eight. Run the program to confirm this. It should produce the following output:

```
x is 1 and y is 2
x is 3 and y is 4
x is 5 and y is 6
x is 7 and y is 8
```

Like the 'FOR' loop, there is a horizontal form of the 'WHILE' loop:

```
WHILE EXPRESSION DO STATEMENT
```

Loop termination is always a big problem. 'FOR' loops are guaranteed to eventually reach their limit (if you don't mess with the loop variable, that is). However, 'WHILE' loops (and all other loops) may go on forever and never terminate. For example, if the loop check were '1<2' it would always be true and nothing the loop could do would prevent it being true! You must therefore take care that you make sure your loops terminate in some way if you want to program to finish. There is a sneaky way of terminating loops using the 'JUMP' statement, but we'll ignore that for now.

1.39 beginner.guide/REPEAT..UNTIL loop

'REPEAT..UNTIL' loop

A 'REPEAT..UNTIL' loop is very similar to a 'WHILE' loop. The only difference is where you specify the loop check, and when and how the check is performed. To illustrate this, here's the program from the previous two sections rewritten using a 'REPEAT..UNTIL' loop (try to spot the subtle differences):

```

PROC main()
  DEF x
  x:=1
  REPEAT
    WriteF('\d ', x)
    x:=x+1
  UNTIL x>100
  WriteF('\n')
ENDPROC

```

Just as in the 'WHILE' loop version we've got an initialisation of 'x' and an extra statement in the loop to increment 'x'. However, this time the loop check is specified at the end of the loop (in the 'UNTIL' part), and the check is only performed at the end of each loop. This difference means that the code in a 'REPEAT..UNTIL' loop will be executed at least once, whereas the code in a 'WHILE' loop may never be executed. Also, the logical sense of the check follows the English: a 'REPEAT..UNTIL' loop executes **until** the check is true, whereas the 'WHILE' loop executes **while** the check is true. Therefore, the 'REPEAT..UNTIL' loop executes while the check is false! This may seem confusing at first, but just remember to read the code as if it were English and you'll get the correct interpretation.

1.40 beginner.guide/Summary

Summary

This is the end of Part One, which was hopefully enough to get you started. If you've grasped the main concepts you are good position to attack Part Two, which covers the E language in more detail.

This is probably a good time to look at the different parts of one of the examples from the previous sections, since we've now used quite a bit of E. The following examination uses the 'WHILE' loop example. Just to make things easier to follow, each line has been numbered (don't try to compile it with the line numbers on!).

```

1.  PROC main()
2.    DEF x,y
3.    x:=1
4.    y:=2
5.    WHILE (x<10) AND (y<10)
6.      WriteF('x is \d and y is \d\n', x, y)
7.      x:=x+2
8.      y:=y+2
9.    ENDWHILE
10.  ENDPROC

```

Hopefully, you should be able to recognise all the features listed in the table below. If you don't then you might need to go back over the previous chapters, or find a much better programming guide than this!

Line(s)	Observation
---------	-------------

```

-----
1-10    The procedure definition.

      1    The declaration of the procedure 'main', with no
           parameters.

      2    The declaration of local variables 'x' and 'y'.

3, 4    Initialisation of 'x' and 'y' using assignment
         statements.

5-9     The 'WHILE' loop.

      5    The loop check for the 'WHILE' loop using the
           logical operator 'AND', the comparison operator
           '<', and parentheses to group the expression.

      6    The call to the (built-in) procedure 'WriteF'
           using parameters. Notice the string, the place
           holders for numbers, '\d', and the linefeed,
           '\n'.

7, 8    Assignments to 'x' and 'y', adding two to
         their values.

      9    The marker for the end of the 'WHILE' loop.

10      The marker for the end of the procedure.

```

1.41 beginner.guide/Format and Layout

Format and Layout

In this chapter we'll look at the rules which govern the format and layout of E code. In the previous Part we saw examples of E code that were quite nicely indented and the structure of the program was easily visible. This was just a convention and the E language does not constrain you to write code in this way. However, there are certain rules that must be followed. (This chapter refers to some concepts and parts of the E language which were not covered in Part One. Don't let this put you off--those things will be dealt with in later chapters, and it's maybe a good idea to read this chapter again when they have been.)

Identifiers

Statements

Spacing and Separators

Comments

1.42 beginner.guide/Identifiers

Identifiers
=====

An "identifier" is a word which the compiler must interpret rather than treating literally. For instance, a variable is an identifier, as is a keyword (e.g., 'IF'), but anything in a string is not (e.g., 'fred' in 'fred and wilma' is not an identifier). Identifiers can be made up of upper- or lower-case letters, numbers and underscores (the '_' character). There are only two constraints:

1. The first character cannot be a number (this would cause confusion with numeric constants).
2. The case of the first few characters of identifiers is significant.

For keywords (e.g., 'ENDPROC'), constants (e.g., 'TRUE') and assembly mnemonics (e.g., 'MOVE.L') the first two characters must both be uppercase. For E built-in or Amiga system procedures/functions the first character must be uppercase and the second must be lowercase. For all other identifiers (i.e., local, global and procedure parameter variables, object names and element names, procedure names and code labels) the first character must be lowercase.

Apart from these constraints you are free to write identifiers how you like, although it's arguably more tasteful to use all lowercase for variables and all uppercase for keywords and constants.

1.43 beginner.guide/Statements

Statements
=====

A "statement" is normally a single line of an instruction to the computer. Each statement normally occupies a single line. If a procedure is thought of as a paragraph then a statement is a sentence. Variables, expressions and keywords are the words which make up the sentence.

So far in our examples we have met only two kinds of statement: the single line statement and the multi-line statement. The assignments we have seen were single line statements, and the vertical form of the 'IF' block is a multi-line statement. The horizontal form of the 'IF' block was actually the single line statement form of the 'IF' block. Notice that statements can be built up from other statements, as is the case for 'IF' blocks. The code parts between the 'IF', 'ELSEIF', 'ELSE' and 'ENDIF' lines are sequences of statements.

Single line statements can often be very short, and you may be able to fit several of them onto a single line without the line getting too long. To do this in E you use a semi-colon (the ';' character) to separate each statement on the line. For example, the following code fragments are equivalent:

```
fred(y,z)
y:=x
x:=z+1

fred(y,z); y:=x; x:=z+1
```

On the other hand you may want to split a long statement over several lines. This is a bit more tricky because the compiler needs to see that you haven't finished the statement when it gets to the end of a line. Therefore you can only break a statement at certain places. The most common place is after a comma that is part of the statement (like in a procedure call with more than one parameter), but you can also split a line after binary operators and anywhere between opening and closing brackets. The following examples are rather silly but show some allowable line breaking places.

```
fred(a, b, c,
      d, e, f) /* After a comma */

x:=x+
  y+
  z           /* After a binary operator */

x:=(1+2
     +3)      /* Between open...close brackets */

list:= [ 1,2,
        [3,4],
        ]     /* Between open...close brackets */
```

The simple rule is this: if a complete line can be interpreted as a statement then it will be, otherwise it will be interpreted as part of a statement which continues on the following lines.

Strings may also get a bit long. You can split them over several lines by breaking them into several separate strings and using '+' between them. If a line ends with a '+' and the previous thing on the line was a string then the E compiler takes the next string to be a continuation. The following calls to 'WriteF' print the same thing:

```
WriteF('This long string can be broken over several lines.\n')

WriteF('This long string ' +
      'can be broken over several lines.\n')

WriteF('This long' +
      ' string can be ' +
      'broken over several ' +
      'lines.\n')
```

1.44 beginner.guide/Spacing and Separators

Spacing and Separators

=====

The examples we've seen so far used a rigid indentation convention which was intended to illuminate the structure of the program. This was just a convention, and the E language places no constraints on the amount of "whitespace" (spaces, tabs and linefeeds) you place between statements. However, within statements you must supply enough spacing to make the statement readable. This generally means that you must put whitespace between adjacent identifiers which start or end with a letter, number or underscore (so that the compiler does not think it's one big identifier!). In practice this means you should put a space after a keyword if it might run into a variable or procedure name. Most other times (like in expressions) identifiers are separated by non-identifier characters (a comma, parenthesis or other symbol).

1.45 beginner.guide/Comments

Comments

=====

A "comment" is something that the E compiler ignores and is only there to help the reader. Remember that one day in the future you may be the reader, and it may be quite hard to decipher your own code without a few decent comments! Comments are therefore pretty important.

You can write comments anywhere you can write whitespace that isn't part of a string. There are two kinds of comment: one uses `'/*'` to mark the start of the comment text and `'*/'` to mark the end, and the other uses `'->'` to mark the start, with the comment text continuing to the end of the line. You must be careful not to write `'/*'`, `'*/'` or `'->'` as part of the comment text, unless part of a nested comment. In practice a comment is best put on a line by itself or after the end of the code on a line.

```
/* This line is a comment */
x:=1 /* This line contains an assignment then a comment */
/* y:=2 /* This whole line is a comment with a nested comment */*/

x:=1 -> Assignment then a comment
-> y:=2 /* A nested comment comment */
```

1.46 beginner.guide/Procedures and Functions

Procedures and Functions

A "function" is a procedure which returns a value. This value can be any expression so it may depend on the parameters with which the function was called. For instance, the addition operator `'+'` can be thought of as

a function which returns the sum of its two parameters.

Functions
One-Line Functions
Default Arguments
Multiple Return Values

1.47 beginner.guide/Functions

Functions

=====

We can define our own addition function, 'add', in a very similar way to the definition of a procedure. (The only difference is that a function explicitly returns a value.)

```
PROC main()
  DEF sum
  sum:=12+79
  WriteF('Using +, sum is \d\n', sum)
  sum:=add(12,79)
  WriteF('Using add, sum is \d\n', sum)
ENDPROC

PROC add(x, y)
  DEF s
  s:=x+y
ENDPROC s
```

This should generate the following output:

```
Using +, sum is 91
Using add, sum is 91
```

In the procedure 'add' the value 's' is returned using the 'ENDPROC' label. The value returned from 'add' can be used in expressions, just like any other value. You do this by writing the procedure call where you want the value to be. In the above example we wanted the value to be assigned to 'sum' so we wrote the call to 'add' on the right-hand side of the assignment. Notice the similarities between the uses of '+' and 'add'. In general, 'add(a,b)' can be used in exactly the same places that 'a+b' can (more precisely, it can be used anywhere '(a+b)' can be used).

The 'RETURN' keyword can also be used to return values from a procedure. If the 'ENDPROC' method is used then the value is returned when the procedure reaches the end of its code. However, if the 'RETURN' method is used the value is returned immediately at that point and no more of the procedure's code is executed. Here's the same example using 'RETURN':

```
PROC add(x, y)
  DEF s
  s:=x+y
  RETURN s
```



```
ENDPROC
```

The only difference is that you can write 'RETURN' anywhere in the code part of a procedure and it finishes the execution of the procedure at that point (rather than execution finishing when it reaches the end of the code). In fact, you can use 'RETURN' in the 'main' procedure to prematurely finish the execution of a program.

Here's a slightly more complicated use of 'RETURN':

```
PROC limitedadd(x,y)
  IF x>10000
    RETURN 10000
  ELSEIF x<-10000
    RETURN -10000
  ELSE
    RETURN x+y
  ENDIF
  x:=1
  IF x=1 THEN RETURN 9999 ELSE RETURN -9999
ENDPROC
```

This function checks to see if 'x' is greater than 10,000 or less than -10,000, and if it is a limited value is returned (which is generally not the correct sum!). If 'x' is between -10,000 and 10,000 the correct answer is returned. The lines after the first 'IF' block will never get executed because execution will have finished at one of the 'RETURN' lines. Those lines are therefore just a waste of compiler time and can safely be omitted.

If no value is given with the 'ENDPROC' or 'RETURN' keyword then zero is returned. Therefore, all procedures are actually functions (and the terms "procedure" and "function" will tend to be used interchangeably). So, what happens to the value when you write a procedure call on a line by itself, not in an expression? Well, as we will see, the value is simply discarded (see Turning an Expression into a Statement). This is what happened in the previous examples when we called the procedures 'fred' and 'WriteF'.

1.48 beginner.guide/One-Line Functions

One-Line Functions
=====

Just as the 'IF' block and 'FOR' loop have horizontal, single line forms, so does a procedure definition. The general form is:

```
PROC NAME (ARG1, ARG2, ...) IS EXPRESSION
```

Alternatively, the 'RETURN' keyword can be used:

```
PROC NAME (ARG1, ARG2, ...) RETURN EXPRESSION
```

At first sight this might seem pretty unusable, but it is useful for very

simple functions and our 'add' function in the previous section is a good example. If you look closely at the original definition you'll see that the local variable 's' wasn't really needed. Here's the one-line definition of 'add':

```
PROC add(x,y) IS x+y
```

1.49 beginner.guide/Default Arguments

Default Arguments

=====

Sometimes a procedure (or function) will quite often be called with a particular (constant) value for one of its parameters, and it might be nice if you didn't have to fill this value in all the time. Luckily, E allows you to define "default" values for a procedure's parameters when you define the procedure. You can then just leave out that parameter when you call the procedure and it will default to the value you defined for it. Here's a simple example:

```
PROC play(track=1)
  WriteF('Starting to play track \d\n', track)
  /* Rest of the code... */
ENDPROC

PROC main()
  play(1)  -> Start playing from track 1
  play(6)  -> Start playing from track 6
  play()   -> Start playing from track 1
ENDPROC
```

This is an outline of a program to control something like a CD player. The 'play' procedure has one parameter, 'track', which represents the first track that should be played. Often, though, you just tell the CD player to play, and don't specify a particular track. In this case, play starts from the first track. This is exactly what happens in the example above: the 'track' parameter has a default value of 1 defined for it (the '=1' in the definition of the 'play' procedure), and the third call to 'play' in 'main' does not specify a value for 'track', so the default value is used.

There are two constraints on the use of default arguments:

1. Any number of the parameters of a procedure may have default values defined for them, although they may only be the right-most parameters. This means that for a three parameter procedure, the second parameter can have a default value only if the last parameter does as well, and the first can have one only if both the others do. This should not be a big problem because you can always reorder the parameters in the procedure definition.

The following examples show legal definitions of procedures with default arguments:

```

PROC fred(x, y, z) IS x      -> No defaults

PROC fred(x, y, z=1) IS x    -> z defaults to 1

PROC fred(x, y=23, z=1) IS x -> y and z have defaults

PROC fred(x=9, y=23, z=1) IS x -> All have defaults

```

On the other hand, these definitions are all illegal:

```

PROC fred(x, y=23, z) IS x    -> Illegal: no z default

PROC fred(x=9, y, z=1) IS x   -> Illegal: no y default

```

2. When you call a procedure which has default arguments you can only leave out the right-most parameters. This means that for a three parameter procedure with all three parameters having default values, you can leave out the second parameter in a call to this procedure only if you also leave out the third parameter. The first parameter may be left out only if both the others are, too.

The following example shows which parameters are considered defaults:

```

PROC fred(x, y=23, z=1)
  WriteF('x is \d, y is \d, z is \d\n', x, y, z)
ENDPROC

PROC main()
  fred(2, 3, 4) -> No defaults used
  fred(2, 3)    -> z defaults to 1
  fred(2)       -> y and z default
  fred()        -> Illegal: x has no default
ENDPROC

```

In this example, you cannot leave out the 'y' parameter in a call to 'fred' without leaving out the 'z' parameter as well. To make 'y' have its default value and 'z' some value other than its default you need to supply the 'y' value explicitly in the call:

```
fred(2, 23, 9) -> Need to supply 23 for y
```

These constraints are necessary in order to make procedure calls unambiguous. Consider a three-parameter procedure with default values for two of the parameters. If it is called with only two parameters then, without these constraints, it would not be clear which two parameters had been supplied and which had not. If, however, the procedure were defined and called according to these constraints, then it must be the third parameter that needs to be defaulted (and the two parameters with default values must be the last two).

1.50 beginner.guide/Multiple Return Values

Multiple Return Values

=====

So far we've only seen functions which return only one value, since this is something common to most programming languages. However, E allows you to return up to three values from a function. To do this you list the values separated by commas after the 'ENDPROC', 'RETURN' or 'IS' keyword, where you would normally have specified only one value. A good example is a function which manipulates a screen coordinate, which is a pair of values: the x- and y-coordinates.

```
PROC movediag(x, y) IS x+8, y+4
```

All this function does is add 8 to the x-coordinate and 4 to the y-coordinate. To get to the return values other than the first one you must use a multiple-assignment statement:

```
PROC main()
  DEF a, b
  a, b:=movediag(10, 3)
  /* Now a should be 10+8, and b should be 3+4 */
  WriteF('a is \d, b is \d\n', a, b)
ENDPROC
```

'a' is assigned the first return value and 'b' is assigned the second. You don't need to use all the return values from a function, so the assignment in the example above could have assigned only to 'a' (in which case it would not be a multiple-assignment anymore). A multiple-assignment makes sense only if the right-hand side is a function call, so don't expect things like the following example to set 'b' properly:

```
a,b:=6+movediag(10,3)  -> No obvious value for b
```

If you use a function with more than one return value in any other expression (i.e., something which is not the right-hand side of an assignment), then only the first return value is used. The first return value is called the "regular" value of the function, and the other values are the "optional" values.

```
PROC main()
  DEF a, b
  /* The next two lines ignore the second return value */
  a:=movediag(10, 3)
  WriteF('x-coord of movediag(21, 4) is \d\n', movediag(21,4))
```

1.51 beginner.guide/Constants

Constants

A "constant" is a value that does not change. A (literal) number like 121 is a good example of a constant--its value is always 121. We've already met another kind of constant: string constants (see Strings). As you can doubtless tell, constants are pretty important things.

Numeric Constants
 String Constants Special Character Sequences
 Named Constants
 Enumerations
 Sets

1.52 beginner.guide/Numeric Constants

Numeric Constants
 =====

We've met a lot of numbers in the previous examples. Technically speaking, these were numeric constants (constant because they don't change value like a variable might). They were all decimal numbers, but you can use hexadecimal and binary numbers as well. There's also a way of specifying a number using characters. To specify a hexadecimal number you use a '\$' before the digits (and after the optional minus sign '-' to represent a negative value). To specify a binary number you use a '%' instead.

Specifying numbers using characters is more complicated, because the base of this system is 256 (the base of decimal is ten, that of hexadecimal is 16 and that of binary is two). The digits are enclosed in double-quotes (the " character), and there can be at most four digits. Each digit is a character representing its ASCII value. Therefore, the character 'A' represents 65 and the character '0' (zero) represents 48. This upshot of this is that character 'A' has ASCII value '"A"' in E, and '"0z"' represents ("0" * 256) + "z" = (48 * 256) + 122 = 12,410. However, you probably don't need to worry about anything other than the single character case, which gives you the ASCII value of the character.

The following table shows the decimal value of several numeric constants. Notice that you can use upper- or lower-case letters for the hexadecimal constants. Obviously the case of characters is significant for character numbers.

Number	Decimal value

21	21
-143	-143
\$1a	26
-\$B1	-177
%1110	14
-%1010	-10
"z"	122
"Je"	19,045
-"A"	-65

1.53 beginner.guide/String Constants Special Character Sequences

String Constants: Special Character Sequences

=====

We have seen that in a string the character sequence `'\n'` means a linefeed (see Strings). There are several other similar such special character sequences which represent useful characters that can't be typed in a string. The following table shows all these sequences. Note that there are some other similar sequences which are used to control formatting with built-in procedures like `'WriteF'`. These are listed where `'WriteF'` and similar procedures are described (see Input and output functions).

Sequence	Meaning

<code>\0</code>	A null (ASCII zero)
<code>\a</code>	An apostrophe <code>'</code>
<code>\b</code>	A carriage return (ASCII 13)
<code>\e</code>	An escape (ASCII 27)
<code>\n</code>	A linefeed (ASCII 10)
<code>\q</code>	A double quote (ASCII 34)
<code>\t</code>	A tab (ASCII 9)
<code>\</code>	A backslash <code>\</code>

An apostrophe can also be produced by typing two apostrophes in a row in a string. It's best to use this only in the middle of a string, where it's nice and obvious:

```
WriteF('Here\as an apostrophe.\n')      /* Using \a */
WriteF('Here''s another apostrophe.\n') /* Using '' */
```

1.54 beginner.guide/Named Constants

Named Constants

=====

It is often nice to be able to give names to certain constants. For instance, as we saw earlier, the truth value `'TRUE'` actually represents the value `-1`, and `'FALSE'` represents zero (see Logic and comparison). These are our first examples of named constants. To define your own you use the `'CONST'` keyword as follows:

```
CONST ONE=1, LINEFEED=10, BIG_NUM=999999
```

This has defined the constant `'ONE'` to represent one, `'LINEFEED'` ten and `'BIG_NUM'` 999,999. Named constants must begin with two uppercase letters, as mentioned before (see Identifiers).

You can use previously defined constants to give the value of a new constant, but in this case the definitions must occur on different `'CONST'` lines.

```
CONST ZERO=0
```

```
CONST ONE=ZERO+1
CONST TWO=ONE+1
```

The expression used to define the value of a constant can use only simple operators (no function calls) and constants.

1.55 beginner.guide/Enumerations

Enumerations
=====

Often you want to define a whole lot of constants and you just want them all to have a different value so you can tell them apart easily. For instance, if you wanted to define some constants to represent some famous cities and you only needed to know how to distinguish one from another then you could use an "enumeration" like this:

```
ENUM LONDON, MOSCOW, NEW_YORK, PARIS, ROME, TOKYO
```

The 'ENUM' keyword begins the definitions (like the 'CONST' keyword does for an ordinary constant definition). The actual values of the constants start at zero and stretch up to five. In fact, this is exactly the same as writing:

```
CONST LONDON=0, MOSCOW=1, NEW_YORK=2, PARIS=3, ROME=4, TOKYO=5
```

The enumeration does not have to start at zero, though. You can change the starting value at any point by specifying a value for an enumerated constant. For example, the following constant definitions are equivalent:

```
ENUM APPLE, ORANGE, CAT=55, DOG, GOLDFISH, FRED=-2,
    BARNEY, WILMA, BETTY

CONST APPLE=0, ORANGE=1, CAT=55, DOG=56, GOLDFISH=57,
    FRED=-2, BARNEY=-1, WILMA=0, BETTY=1
```

1.56 beginner.guide/Sets

Sets
=====

Yet another kind of constant definition is the "set" definition. This is useful for defining flag sets, i.e., a number of options each of which can be on or off. The definition is like a simple enumeration, but using the 'SET' keyword and this time the values start at one and increase as powers of two (so the next value is two, the next is four, the next eight, and so on). Therefore, the following definitions are equivalent:

```
SET ENGLISH, FRENCH, GERMAN, JAPANESE, RUSSIAN
```

```
CONST ENGLISH=1, FRENCH=2, GERMAN=4, JAPANESE=8, RUSSIAN=16
```

However, the significance of the values it is best shown by using binary constants:

```
CONST ENGLISH=%00001, FRENCH=%00010, GERMAN=%00100,
      JAPANESE=%01000, RUSSIAN=%10000
```

If a person speaks just English then we can use the constant 'ENGLISH'. If they also spoke Japanese then to represent this with a single value we'd normally need a new constant (something like 'ENG_JAP'). In fact, we'd probably need a constant for each combination of languages a person might know. However, with the set definition we can 'OR' the 'ENGLISH' and 'JAPANESE' values together to get a new value, '%01001', and this represents a set containing both 'ENGLISH' and 'JAPANESE'. On the other hand, to find out if someone speaks French we would 'AND' the value for the languages they know with '%00010' (or the constant 'FRENCH'). (As you might have guessed, 'AND' and 'OR' are really bit-wise operators, not simply logical operators. See Bitwise AND and OR.)

Consider this program fragment:

```
      speak:=GERMAN OR ENGLISH OR RUSSIAN  /* Speak any of these */
      IF speak AND JAPANESE
        /* Can speak Japanese */
        WriteF('Can speak Japanese\n')
      ELSE
        /* Can't speak Japanese */
        WriteF('Can\at speak Japenese\n')
      ENDIF
      IF speak AND (GERMAN OR FRENCH)
        /* Can speak German or French */
        WriteF('Can speak both German and French\n')
      ELSE
        /* Can't speak German or French */
        WriteF('Can\at speak neither German nor French\n')
      ENDIF
```

The assignment sets 'speak' to show that the person can speak German, English or Russian. The first 'IF' block tests whether the person can speak Japanese, and the second tests whether they can speak German or French.

When using sets be careful you don't get tempted to add values instead of 'OR'-ing them. Adding two different constants from the same set is the same as 'OR'-ing them, but adding a constant to itself isn't. This is not the only time addition doesn't give the same answer, but it's the most obvious. If you to stick to using 'OR' you won't have a problem.

1.57 beginner.guide/Types

Types

We've already met the 'LONG' type and found that this was the normal type for variables (see Variable types). The types 'INT' and 'LIST' were also mentioned. Learning how to use types in an effective and readable way is very important. The type of a variable (as well as its name) can give clues to the reader about how or for what it is used. There are also more fundamental reasons for needing types, e.g., to logically group data using objects (see OBJECT Type).

This is a very large chapter and you might like to take it slowly. One of the most important things to get to grips with is "pointers". Concentrate on trying to understand these as they play a large part in any kind of system programming.

- LONG Type
- PTR Type
- ARRAY Type
- OBJECT Type
- LIST and STRING Types
- Linked Lists

1.58 beginner.guide/LONG Type

'LONG' Type
=====

The 'LONG' type is the most important type because it is the default type and by far the most common type. It can be used to store a variety of data, including "memory addresses", as we shall see.

- Default type
- Memory addresses

1.59 beginner.guide/Default type

Default type

'LONG' is the default type of variables. It is a 32-bit type, meaning that 32-bits of memory (RAM) are used to store the data for each variable of this type and the data can take (integer) values in the range -2,147,483,648 to 2,147,483,647. Variables can explicitly be declared as 'LONG':

```
DEF x:LONG, y

PROC fred(p:LONG, q, r:LONG)
  DEF zed:LONG
  STATEMENTS
```

ENDPROC

The global variable 'x', procedure parameters 'p' and 'r', and local variable 'zed' have all been declared to be 'LONG' values. The declarations are very similar to the kinds we've seen before, except that the variables have ':LONG' after their name in the declaration. This is the way the type of a variable is given. Note that the global variable 'y' and the procedure parameter 'q' are also 'LONG', since they do not have a type specified and 'LONG' is the default type for variables.

1.60 beginner.guide/Memory addresses

Memory addresses

There's a very good reason why 'LONG' is the normal type. A 32-bit (integer) value can be used as a "memory address". Therefore we can store the address (or location) of data in a variable (the variable is then called a "pointer"). The variable would then not contain the value of the data but a way of finding the data. Once the data location is known the data can be read or even altered! The next section covers pointers and addresses in more detail. (see PTR Type.)

1.61 beginner.guide/PTR Type

'PTR' Type

=====

The 'PTR' type is used to hold memory addresses. Variables which have a 'PTR' type are called "pointers" (since they store memory addresses, as mentioned in the previous section). This section describes, in detail, addresses, pointers and the 'PTR' type.

Addresses

Pointers

Indirect types

Finding addresses (making pointers)

Extracting data (dereferencing pointers)

Procedure parameters

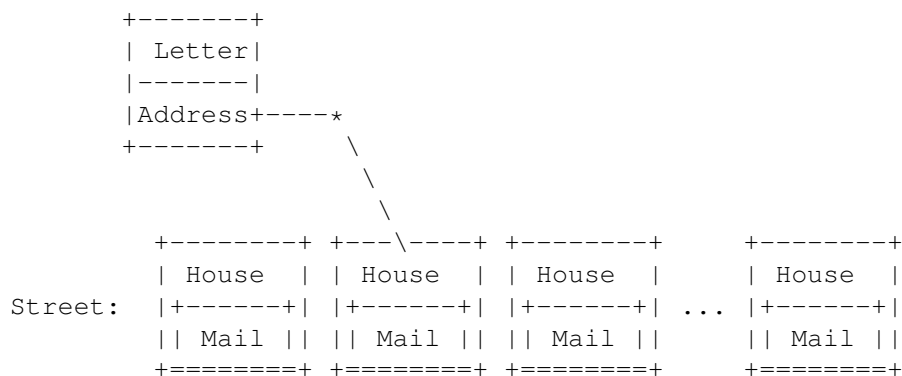
1.62 beginner.guide/Addresses

Addresses

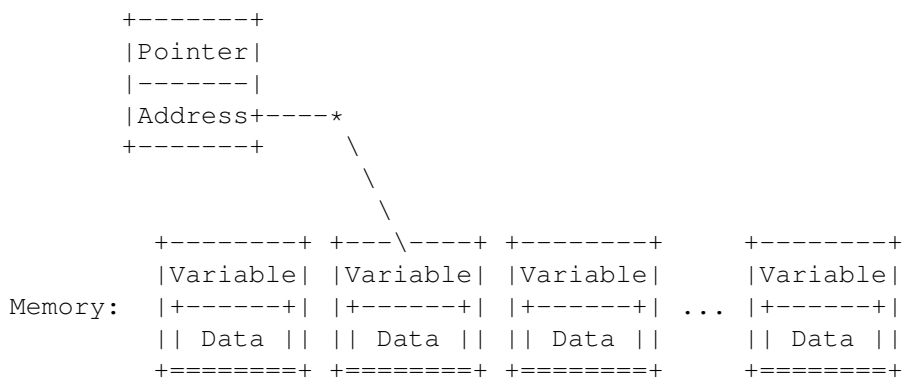
To understand memory addresses, a good analogy is to think of memory as

a road or street, each memory location as a post-box on a house, and each piece of data as a letter. If you were a postman you would need to know where to put your letters, and this information is given by the address of the post-box. As time goes by, each post-box is filled with different letters. This is like the value in a memory location (or variable) changing. To change the letters stored in your post-box, you tell your friends your address and they can send letters in and fill it. This is like letting some program change your data by giving it the address of the data.

The next two diagrams illustrate this analogy. A letter contains an address which points to a particular house (or lot of mail) on a street.



A pointer contains an address which points to a variable (or data) in memory.



1.63 beginner.guide/Pointers

Pointers

Variables which contain memory addresses are called "pointers". As we saw in the previous section, we can store memory addresses in 'LONG' variables. However, we then don't know the type of the data stored at those addresses. If it is important (or useful) to know this then the 'PTR' type (or, more accurately, one of the many 'PTR' types) should be used.

```
DEF p:PTR TO LONG, i:PTR TO INT,
    cptr:PTR TO CHAR, gptra:PTR TO gadget
```

The values stored in each of 'p', 'cptr', 'i' and 'gptra' are 'LONG' since they are memory addresses. However, the data at the address stored in 'p' is taken to be 'LONG' (a 32-bit value), that at 'cptr' is 'CHAR' (an 8-bit value), that at 'i' is 'INT' (a 16-bit value), and that at 'gptra' is 'gadget', which is an "object" (see OBJECT Type).

1.64 beginner.guide/Indirect types

Indirect types

In the previous example we saw 'INT' and 'CHAR' used as the destination types of pointers, and these are the 16- and 8-bit equivalents (respectively) of the 'LONG' type. However, unlike 'LONG' these types cannot be used directly to declare global or local variables, or procedure parameters. They can only be used in constructing types (for instance with 'PTR TO'). The following declarations are therefore *illegal*, and it might be nice to try compiling a little program with such a declaration, just to see the error message the E compiler gives.

```
/* This program fragment contains illegal declarations */
DEF c:CHAR, i:INT

/* This program fragment contains illegal declarations */
PROC fred(a:INT, b:CHAR)
    DEF x:INT
    STATEMENTS
ENDPROC
```

This is not much of a limitation because you can store 'INT' or 'CHAR' values in 'LONG' variables if you really need to. However, it does mean there's a nice, simple rule: every direct value in E is a 32-bit quantity, either a 'LONG' or a pointer. In fact, 'LONG' is actually short-hand for 'PTR TO CHAR', so you can use 'LONG' values like they were actually 'PTR TO CHAR' values.

1.65 beginner.guide/Finding addresses (making pointers)

Finding addresses (making pointers)

If a program knows the address of a variable it can directly read or alter the value stored in the variable. To obtain the address of a simple variable you use '{' and '}' around the variable name. The address of non-simple variables (e.g., objects and arrays) can be found much more easily (see the appropriate section), and in fact you will very rarely need to use '{VAR}'. However, if you understand how to explicitly make

pointers with `{VAR}` and use the pointers to get to data, then you'll understand the way pointers are used for the non-simple types much more quickly.

Addresses can be stored in a variable, passed to a procedure or whatever (they're just 32-bit values). Try out the following program:

```
DEF x

PROC main()
    fred(2)
ENDPROC

PROC fred(y)
    DEF z
    WriteF('x is at address \d\n', {x})
    WriteF('y is at address \d\n', {y})
    WriteF('z is at address \d\n', {z})
    WriteF('fred is at address \d\n', {fred})
ENDPROC
```

Notice that you can also find the address of a procedure using `{}` and `'{}`. This is the memory location of the code the procedure represents. Here's the output from one execution of this program:

```
x is at address 3758280
y is at address 3758264
z is at address 3758252
fred is at address 3732878
```

This is an interesting program to run several times under different circumstances. You should see that sometimes the numbers for the addresses change. Running the program when another is multi-tasking (and eating memory) should produce the best changes, whereas running it consecutively (in one CLI) should produce the smallest (if any) changes. This gives you a glimpse at the complex memory handling of the Amiga and the E compiler.

1.66 beginner.guide/Extracting data (dereferencing pointers)

Extracting data (dereferencing pointers)

If you have an address stored in a variable (i.e., a pointer) you can extract the data using the `^^` operator. This act of extracting data via a pointer is called "dereferencing" the pointer. This operator should only really be used when `{VAR}` has been used to obtain an address. To this end, `'LONG'` values are read and written when dereferencing pointers in this way. For pointers to non-simple types (e.g., objects and arrays), dereferencing is achieved in much more readable ways (see the appropriate section for details), and this operator is not used. In fact, `^^VAR` is seldom used in programs, but is useful for explaining how pointers work, especially in conjunction with `{VAR}`.

Using pointers can remove the scope restriction on local variables, i.e., they can be altered from outside the procedure for which they are local. Whilst this kind of use is not generally advised, it makes for a good example which shows the power of pointers. For example, the following program changes the value of the local variable 'x' for the procedure 'fred' from within the procedure 'barney'.

```
PROC main()
  fred()
ENDPROC

PROC fred()
  DEF x, p:PTR TO LONG
  x:=33
  p:={x}
  barney(p)
  WriteF('x is now \d\n', x)
ENDPROC

PROC barney(ptr:PTR TO LONG)
  DEF val
  val:=^ptr
  ^ptr:=val-6
ENDPROC
```

Here's what you can expect it to generate as output:

```
x is now 27
```

Notice that the '^' operator (i.e., dereferencing) is quite versatile. In the first assignment of the procedure 'barney' it is used (with the pointer 'ptr') to get the value stored in the local variable 'x', and in the second it is used to change this variable's value. In either case, dereferencing makes the pointer behave exactly as if you'd written the variable for which it is a pointer. To emphasise this, we can remove the 'barney' procedure, like we did above (see Style Reuse and Readability):

```
PROC main()
  fred()
ENDPROC

PROC fred()
  DEF x, p:PTR TO LONG, val
  x:=33
  p:={x}
  val:=x
  x:=val-6
  WriteF('x is now \d\n', x)
ENDPROC
```

Everywhere the 'barney' procedure used '^ptr' we've written 'x' (because we are now in the procedure for which 'x' is local). We've also eliminated the 'ptr' variable (the parameter to the 'barney' procedure), since it was only used with the '^' operator.

To make things clear the 'fred' and 'barney' example is deliberately 'wordy'. The 'val' and 'p' variables are unnecessary, and the pointer

types could be abbreviated to 'LONG' or even omitted, for the reasons outlined above (see LONG Type). This is the compact form of the example:

```
PROC main()
  fred()
ENDPROC

PROC fred()
  DEF x
  x:=33
  barney({x})
  WriteF('x is now \d\n', x)
ENDPROC

PROC barney(ptr)
  ^ptr:=^ptr-6
ENDPROC
```

By far the most common use of pointers is to address (or reference) large structures of data. It would be extremely expensive (in terms of CPU time) to pass large amounts of data from procedure to procedure, so addresses to such data are passed instead (and, as we know, these are just 32-bit values). The Amiga system functions (such as ones for creating windows) require a lot of structured data, so if you plan to do any real programming you are going to have to understand and use pointers.

1.67 beginner.guide/Procedure parameters

Procedure parameters

Only local and global variables have the luxury of a large choice of types. Procedure parameters can only be 'LONG' or 'PTR TO TYPE'. This is not really a big limitation as we shall see in the later sections.

1.68 beginner.guide/ARRAY Type

'ARRAY' Type

=====

Quite often, the data used by a program needs to be ordered in some way, primarily so that it can be accessed easily. E provides a way to achieve such simple ordering: the 'ARRAY' type. This type (in its various forms) is common to most computer languages.

Tables of data
Accessing array data
Array pointers
Point to other elements

Array procedure parameters

1.69 beginner.guide/Tables of data

Tables of data

Data can be grouped together in many different ways, but probably the most common and straight-forward way is to make a table. In a table the data is ordered either vertically or horizontally, but the important thing is the relative positioning of the elements. The E view of this kind of ordered data is the 'ARRAY' type. An "array" is just a fixed sized collection of data in order. The size of an array is important and this is fixed when it is declared. The following illustrates array declarations:

```
DEF a[132]:ARRAY,
    table[21]:ARRAY OF LONG,
    ints[3]:ARRAY OF INT,
    objs[54]:ARRAY OF myobject
```

The size of the array is given in the square brackets ('[' and ']'). The type of the elements in the array defaults to 'CHAR', but this can be given explicitly using the 'OF' keyword and the type name. However, only 'LONG', 'INT', 'CHAR' and object types are allowed ('LONG' can hold pointer values so this isn't much of a limitation). Object types are described below (see OBJECT Type).

As mentioned above, procedure parameters cannot be arrays (see Procedure parameters). We will overcome this limitation soon (see Array procedure parameters).

1.70 beginner.guide/Accessing array data

Accessing array data

To access a particular element in an array you use square brackets again, this time specifying the "index" (or position) of the element you want. Indices start at zero for the first element of the array, one for the second element and, in general, (n-1) for the n-th element. This may seem strange at first, but it's the way most computer languages do it! We will see a reason why this makes sense soon (see Array pointers).

```
DEF a[10]:ARRAY

PROC main()
    DEF i
    FOR i:=0 TO 9
        a[i]:=i*i
```



```
ENDFOR
WriteF('The 7th element of the array a is \d\n', a[6])
a[a[2]]:=10
WriteF('The array is now:\n')
FOR i:=0 TO 9
  WriteF(' a[\d] = \d\n', i, a[i])
ENDFOR
ENDPROC
```

This should all seem very straight-forward although one of the lines looks a bit complicated. Try to work out what happens to the array after the assignment immediately following the first 'WriteF'. In this assignment the index comes from a value stored in the array itself! Be careful when doing complicated things like this, though: make sure you don't try to read data from or write data to elements beyond the end of the array. In our example there are only ten elements in the array 'a', so it wouldn't be sensible to talk about the eleventh element. The program could have checked that the value stored at 'a[2]' was a number between zero and nine before trying to access that array element, but it wasn't necessary in this case. Here's the output this example should generate:

```
The 7th element of the array a is 36
The array is now:
a[0] = 0
a[1] = 1
a[2] = 4
a[3] = 9
a[4] = 10
a[5] = 25
a[6] = 36
a[7] = 49
a[8] = 64
a[9] = 81
```

If you do try to write to a non-existent array element strange things can happen. This may be practically unnoticeable (like corrupting some other data), but if you're really unlucky you might crash your computer. The moral is: stay within the bounds of the array.

A short-hand for the first element of an array (i.e., the one with an index of zero) is to omit the index and write only the square brackets. Therefore, 'a[]' is the same as 'a[0]'.

1.71 beginner.guide/Array pointers

Array pointers

When you declare an array the address of the (beginning of the) array is given by the variable name without square brackets. Consider the following program:

```
DEF a[10]:ARRAY OF INT
```

```

PROC main()
  DEF ptr:PTR TO INT, i
  FOR i:=0 TO 9
    a[i]:=i
  ENDFOR
  ptr:=a
  ptr++
  ptr[]:=22
  FOR i:=0 TO 9
    WriteF('a[\d] is \d\n', i, a[i])
  ENDFOR
ENDPROC

```

Here's the output from it:

```

a[0] is 0
a[1] is 22
a[2] is 2
a[3] is 3
a[4] is 4
a[5] is 5
a[6] is 6
a[7] is 7
a[8] is 8
a[9] is 9

```

You should notice that the second element of the array has been changed using the pointer. The 'ptr++' statement increments the pointer 'ptr' to point to the next element of the array. It is important that 'ptr' is declared as 'PTR TO INT' since the array is an 'ARRAY OF INT'. The '[' is used to dereference the pointer and therefore 22 is stored in the second element of the array. In fact, the 'ptr' can be used in exactly the same way as an array, so 'ptr[1]' would be the next (or third element) of the array 'a' (after the 'ptr++' statement). Also, since 'ptr' points to the second element of 'a', negative values may legitimately be used as the index, and 'ptr[-1]' is the first element of 'a'.

In fact, the following declarations are identical except the first reserves an appropriate amount of memory for the array whereas the second relies on you having done this somewhere else in the program.

```
DEF a[20]:ARRAY OF INT
```

```
DEF a:PTR TO INT
```

The following diagram is similar to the diagrams given earlier (see Addresses). It is an illustration of an array, 'a', which was declared to be an array of twenty 'INT's.

```

+-----+
|Variable|
|  'a'   |
|-----|
| Address+-----*
+-----+
      \
      \

```

```

+-----+ +---\----+ +-----+      +-----+ +-----+
|Unknown| | a[0]  | | a[1]  |      | a[19]| |Unknown|
Memory: | +-----+ | +-----+ | +-----+ | ... | +-----+ | +-----+ |
        || XXX || || INT || || INT ||      || INT || || XXX ||
+=====+ +=====+ +=====+      +=====+ +=====+

```

As you can see, the variable 'a' is a pointer to the reserved chunk of memory which contains the array elements. Parts of memory that aren't between 'a[0]' and 'a[19]' are marked as 'Unknown' because they are not part of the array. This memory should therefore not be accessed using the array 'a'.

1.72 beginner.guide/Point to other elements

Point to other elements

We saw in the previous section how to increment a pointer so that it points to the next element in the array. Decrementing a pointer 'p' (i.e., making it point to the previous element) is done in a similar way, using the 'p--' statement which works in the same way as the 'p++' statement. In fact, 'p++' and 'p--' are really expressions which denote pointer values. 'p++' denotes the address stored in 'p' *before* it is incremented, and 'p--' denotes the address *after* 'p' is decremented. Therefore,

```

addr:=p
p++

```

does the same as

```

addr:=p++

```

And

```

p--
addr:=p

```

does the same as

```

addr:=p--

```

The reason why '++' and '--' should be used to increment and decrement a pointer is that values from different types occupy different numbers of memory locations. In fact, a single memory location is a "byte", and this is eight bits. Therefore, 'CHAR' values occupy a single byte, whereas 'LONG' values take up four bytes (32 bits). If 'p' were a pointer to 'CHAR' and it was pointing to an array (of 'CHAR') the 'p+1' memory location would contain the second element of the array (and 'p+2' the third, etc.). But if 'p' were a pointer to an array of 'LONG' the second element in the array would be at 'p+4' (and the third at 'p+8'). The locations 'p', 'p+1', 'p+2' and 'p+3' all make up the 'LONG' value at address 'p'. Having to remember things like this is a pain, and it's a lot less readable than using '++' or '--'. However, you must remember to

declare your pointer with the correct type in order for '++' and '--' to work correctly.

1.73 beginner.guide/Array procedure parameters

Array procedure parameters

Since we now know how to get the address of an array we can simulate passing an array as a procedure parameter by passing the address of the array. For example, the following program uses a procedure to fill in the first 'x' elements of an array with their index numbers.

```
DEF a[10]:ARRAY OF INT

PROC main()
  DEF i
  fillin(a, 10)
  FOR i:=0 TO 9
    WriteF('a[\d] is \d\n', i, a[i])
  ENDFOR
ENDPROC

PROC fillin(ptr:PTR TO INT, x)
  DEF i
  FOR i:=0 TO x-1
    ptr[]:=i
    ptr++
  ENDFOR
ENDPROC
```

Here's the output it should generate:

```
a[0] is 0
a[1] is 1
a[2] is 2
a[3] is 3
a[4] is 4
a[5] is 5
a[6] is 6
a[7] is 7
a[8] is 8
a[9] is 9
```

The array 'a' only has ten elements so we shouldn't fill in any more than the first ten elements. Therefore, in the example, the call to the procedure 'fillin' should not have a bigger number than ten as the second parameter. Also, we could treat 'ptr' more like an array (and not use '++'), but in this case using '++' is slightly better since we are assigning to each element in turn. The alternative definition of 'fillin' (without using '++') is:

```
PROC fillin2(ptr:PTR TO INT, x)
  DEF i
```

```

    FOR i:=0 TO x-1
        ptr[i]:=i
    ENDFOR
ENDPROC

```

Also, yet another version of 'fillin' uses the expression form of '++' and the horizontal form of the 'FOR' loop to give a really compact definition.

```

PROC fillin3(ptr:PTR TO INT, x)
    DEF i
    FOR i:=0 TO x-1 DO ptr[i]++:=i
ENDPROC

```

1.74 beginner.guide/OBJECT Type

'OBJECT' Type
=====

Objects are the E equivalent of C and Assembly structures, or Pascal records. They are like arrays except the elements are named not numbered, and the elements can be of different types. To find a particular element in an object you use a name instead of an index (number).

Example object
Element selection and element types
Amiga system objects

1.75 beginner.guide/Example object

Example object

We'll dive straight in with this first example, and define an object and use it. Object definitions are global and must be made before any procedure definitions.

```

OBJECT rec
    tag, check
    table[8]:ARRAY
    data:LONG
ENDOBJECT

PROC main()
    DEF a:rec
    a.tag:=1
    a.check:=a
    a.data:=a.tag+(10000*a.tag)
ENDPROC

```

This program doesn't visibly do anything so there isn't much point in compiling it. What it does do, however, is show how a typical object is defined and elements of an object are selected.

The object being defined in the example is 'rec', and its elements are defined just like variable declarations (but without a 'DEF'). There can be as many lines of element definitions as you like between the 'OBJECT' and 'ENDOBJECT' lines, and each line can contain any number of elements separated by commas. The elements of the 'rec' object are 'tag' and 'check' (which are 'LONG'), 'table' (which is an array of 'CHAR' with eight elements) and 'data' (which is also 'LONG'). Every variable of 'rec' object type will have space reserved for each of these elements. The declaration of the (local) variable 'a' therefore reserves enough memory for one 'rec' object.

1.76 beginner.guide/Element selection and element types

Element selection and element types

To select elements in an object 'obj' you use 'obj.name', where 'name' is one of the element names. In the example, the 'tag' element of the 'rec' object 'a' is selected by writing 'a.tag'. The other elements are selected in a similar way.

Just like an array declaration the address of an object 'obj' is stored in the variable 'obj', and any pointer of type 'PTR TO OBJECTNAME' can be used just like an object of type OBJECTNAME. Therefore, in the previous example 'a' is a 'PTR TO rec'.

As the example object shows, the elements of an object can have several different types. In fact, the elements can have any type, including object, pointer to object and array of object. The following example shows how to access some different typed elements.

```
OBJECT rec
  tag, check
  table[8]:ARRAY
  data:LONG
ENDOBJECT

OBJECT bigrec
  data:PTR TO LONG
  subrec:PTR TO rec
  rectable[22]:ARRAY OF rec
ENDOBJECT

PROC main()
  DEF r:rec, b:bigrec, rt:PTR TO rec
  r.table[:]="H"
  b.subrec:=r
  b.subrec.tag:=1
  b.subrec.data:=r.tag+(10000*b.subrec.tag)
  b.subrec.table[1]:="i"
```

```

    b.rectable[0].data:=r.tag
    b.rectable[0].table[0]:="A"
    rt:=b.rectable
    rt[].data++:=0
    rt[].table[]--:="B"
ENDPROC

```

The '++' and '--' operators apply to first thing in the selection (i.e., 'rt' in the *both* the last two assignments in the example above), and may only occur after all the selections. Notice that object selection and array indexing can be repeated as much as necessary (but only as the types of the elements allow). As a simple example, consider the third assignment:

```
b.subrec.tag:=1
```

This selects the 'subrec' element from the 'bigrec' object 'b', and then sets the 'tag' element of this 'rec' object to 1. Now, consider one of the later assignments:

```
b.rectable[0].table[0]:="A"
```

This selects the 'rectable' element from 'b', which is an array of 'rec' objects. The first element of this array is selected, and then the 'table' element of the 'rec' object is selected. Finally, the first character of the 'table' is set to the ASCII value of character 'A'.

As you can probably tell, it is important to give the elements of objects appropriate types if you want to do multiple selection in this way. However, this is not always possible or the best way of doing some things, so there is a way of giving a different type to pointers (this is called "explicit pointer typing"--see the 'Reference Manual' for more details).

Here's a quite simple example which uses an array of objects:

```

OBJECT rec
  tag, check
  table[8]:ARRAY
  data:LONG
ENDOBJECT

PROC main()
  DEF a[10]:ARRAY OF rec, p:PTR TO rec, i
  p:=a
  FOR i:=0 TO 9
    a[i].tag:=i
    p.check++:=i
  ENDFOR
  FOR i:=0 TO 9
    IF a[i].tag<>a[i].check
      WriteF('Whoops, a[\d] went wrong...\n', i)
    ENDIF
  ENDFOR
ENDPROC

```

If you think about it for long enough you'll see that 'a[0].tag' is the same as 'a.tag'. That's because 'a' is a pointer to the first element of

the array, and the elements of the array are objects. Therefore, 'a' is a pointer to an object (the first object in the array).

1.77 beginner.guide/Amiga system objects

Amiga system objects

There are many different Amiga system objects. For instance, there's one which contains the information needed to make a gadget (like the 'close' gadget on most windows), and one which contains all the information about a process or task. These objects are vitally important and so are supplied with E in the form of 'modules'. Each module is specific to a certain area of the Amiga system and contains object and other definitions. Modules are discussed in more detail later (see Modules).

1.78 beginner.guide/LIST and STRING Types

'LIST' and 'STRING' Types

=====

Arrays are common to many computer languages. However, they can be a bit of a pain because you always need to make sure you haven't run off the end of the array when you're writing to it. This is where the 'STRING' and 'LIST' types come in. 'STRING' is very much like 'ARRAY OF CHAR' and 'LIST' is like 'ARRAY OF LONG'. However, each has a set of E (built-in) functions which safely manipulate variables of these types without exceeding their bounds.

Normal strings and E-strings
String functions
Lists and E-lists
List functions
Complex types
Typed lists
Static data

1.79 beginner.guide/Normal strings and E-strings

Normal strings and E-strings

"Normal" strings are common to most programming languages. They are simply an array of characters, with the end of the string marked by a null character (ASCII zero). We've already met normal strings (see Strings).

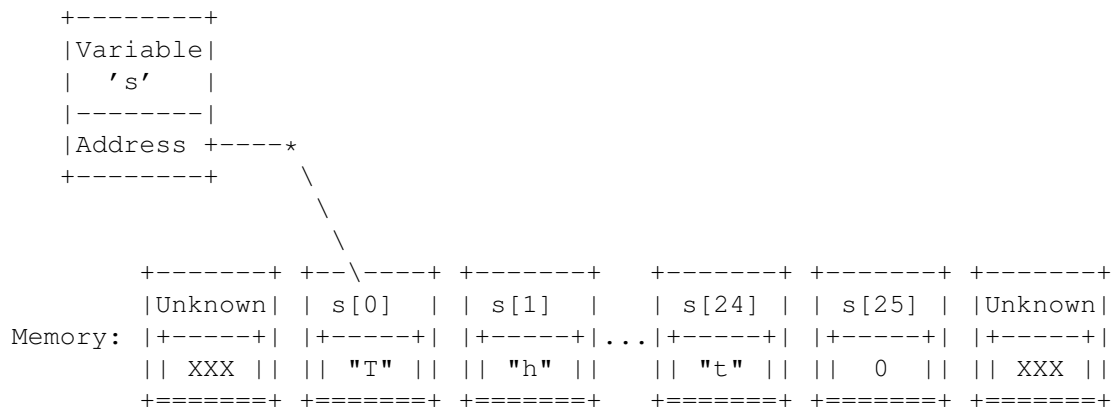
The ones we used were constant strings contained in ' characters, and they denote pointers to the memory where the string data is stored. Therefore, you can assign a string constant to a pointer (to 'CHAR'), and you've got an array with ready-filled elements, i.e., an initialised array.

```
DEF s:PTR TO CHAR
s:='This is a string constant'
/* Now s[] is T and s[2] is i */
```

Remember that 'LONG' is actually 'PTR TO CHAR' so this code is precisely the same as:

```
DEF s
s:='This is a string constant'
```

The following diagram illustrates the above assignment to 's'. The first two characters 's[0]' and 's[1]') are 'T' and 'h', and the last character (before the terminating null, or zero) is 't'. Memory marked as 'Unknown' is not part of the string constant.



"E-strings" are very similar to normal strings and, in fact, an E-string can be used wherever a normal string can. However, the reverse is not true, so if something requires an E-string you cannot use a normal string instead. The difference between a normal string and an E-string was hinted at in the introduction to this section: E-strings can be safely altered without exceeding their bounds. A normal string is just an array so you need to be careful not to exceed its bounds. However, an E-string knows what its bounds are, and so any of the string manipulation functions can alter them safely.

An E-string ('STRING' type) variable is declared as in the following example, with the maximum size of the E-string given just like an array declaration.

```
DEF s[30]:STRING
```

As with an array declaration, the variable 's' is actually a pointer to the string data. To initialise an E-string you need to use the function 'StrCopy' as we shall see.

1.80 beginner.guide/String functions

String functions

There are a number of useful built-in functions which manipulate strings. Remember that if an E-string can be used wherever a normal string can, but normal strings cannot be used where an E-string is required. If a parameter is marked as STRING then a normal or E-string can be passed as that parameter, but if it is marked as E-STRING then only an E-string may be used. Some of these functions have default arguments, which mean you don't need to specify some parameters in order to get the default values (see Default Arguments). (You can, of course, ignore the defaults and always give all parameters.)

`'String(MAXSIZE)'`

Allocates memory for an E-string of maximum size MAXSIZE and returns a pointer to the string data. It is used to make space for a new E-string, like a `'STRING'` declaration does. The following code fragments are practically equivalent:

```
DEF s[37]:STRING
```

```
DEF s:PTR TO CHAR
s:=String(37)
```

The slight difference is that there may not be enough memory left to hold the E-string when the `'String'` function is used. In that case the special value `'NIL'` (a constant) is returned. Your program *must* check that the value returned is not `'NIL'` before you use it as an E-string (or dereference it). The memory for the declaration version is allocated when the program is run, so your program won't run if there isn't enough memory. The `'String'` version is often called "dynamic" allocation because it happens only when the program is running; the declaration version has allocation done by the E compiler.

`'StrCmp (STRING1, STRING2, LENGTH=ALL)'`

Compares STRING1 with STRING2 (they can both be normal or E-strings). Returns `'TRUE'` if the first LENGTH characters of the strings match, and `'FALSE'` otherwise. The LENGTH defaults to the special constant `'ALL'` which means that the strings must agree on every character. For example, the following comparisons all return `'TRUE'`:

```
StrCmp('ABC', 'ABC')
StrCmp('ABC', 'ABC', ALL)
StrCmp('ABCd', 'ABC', 3)
StrCmp('ABCde', 'ABCxxjs', 3)
```

And the following return `'FALSE'` (notice the case of the letters):

```
StrCmp('ABC', 'ABc')
StrCmp('ABC', 'ABc', ALL)
StrCmp('ABCd', 'ABC', ALL)
```

`'StrCopy (E-STRING, STRING, LENGTH=ALL)'`

Copies the contents of `STRING` to `E-STRING`, and also returns a pointer to the resulting E-string (for convenience). Only `LENGTH` characters are copied from the source string, but the special constant `'ALL'` can be used to indicate that the whole of the source string is to be copied (and this is the default value for `LENGTH`). Remember that E-strings are safely manipulated, so the following code fragment results in `'s'` becoming `'More th'`, since its maximum size is (from its declaration) seven characters.

```
DEF s[7]:STRING
  StrCopy(s, 'More than seven characters', ALL)
```

A declaration using `'STRING'` (or `'ARRAY'`) reserves a small part of memory, and stores a pointer to this memory in the variable being declared. So to get data into this memory you need to copy it there, using `'StrCopy'`. If you're familiar with very high-level languages like BASIC you should take care, because you might think you can assign a string to an array or an E-string variable. In E (and languages like C and Assembly) you must explicitly copy data into arrays and E-strings. You should not do the following:

```
/* You don't want to do things like this! */
DEF s[80]:STRING
s:='This is a string constant'
```

This is fairly disastrous: it throws away the pointer to reserved memory that was stored in `'s'` and replaces it by a pointer to the string constant. `'s'` is then no longer an E-string, and *cannot* be repaired using `'SetStr'`. If you want `'s'` to contain the above string you must use `'StrCopy'`:

```
DEF s[80]:STRING
  StrCopy(s,'This is a string constant')
```

The moral is: remember when you are using pointers to data and when you need to copy data. Also, remember that assignment does not copy large arrays of data, it only copies pointers to data, so if you want to store some data in an `'ARRAY'` or `'STRING'` type variable you need to copy it there.

`'StrAdd(E-STRING,STRING,LENGTH=ALL)'`

This does the same as `'StrCopy'` but the source string is copied onto the end of the destination E-string. The following code fragment results in `'s'` becoming `'This is a string and a half'`.

```
DEF s[30]:STRING
  StrCopy(s, 'This is a string', ALL)
  StrAdd(s, ' and a half')
```

`'StrLen(STRING)'`

Returns the length of `STRING`. This assumes that the string is terminated by a null character (i.e., ASCII zero), which is true for any strings made from E-strings and string constants. However, you can make a string constant look short if you use the null character (the special sequence `'\0'`) in it. For instance, these calls all return three:

```
StrLen('abc')
StrLen('abc\0def')
```

In fact, most of the string functions assume strings are null-terminated, so you shouldn't use null characters in your strings unless you really know what you're doing.

For E-strings 'StrLen' is less efficient than the 'EstrLen' function.

'EstrLen(E-STRING)'

Returns the length of E-STRING (remember this can only be an E-string). This is much more efficient than 'StrLen' since E-strings know their length and it doesn't need to search the string for a null character.

'StrMax(E-STRING)'

Returns the maximum length of E-STRING. This not necessarily the current length of the E-string, rather it is the size used in the declaration with 'STRING' or the call to 'String'.

'RightStr(E-STRING1,E-STRING2,LENGTH)'

This is like 'StrCopy' but it copies the right-most characters from E-STRING2 to E-STRING1 and both strings must be E-strings. At most LENGTH characters are copied, and the special constant 'ALL' *cannot* be used (to copy all the string you should, of course, use 'StrCopy'). For instance, a value of one for LENGTH means the last character of E-STRING2 is copied to E-STRING1.

'MidStr(E-STRING,STRING,INDEX,LENGTH=ALL)'

Copies the contents of STRING starting at INDEX (which is an index just like an array index) to E-STRING. At most LENGTH characters are copied, and the special constant 'ALL' can be used if all the remaining characters in STRING should be copied (this is the default value for LENGTH). For example, the following two calls to 'MidStr' result in 's' becoming 'four':

```
DEF s[30]:STRING
MidStr(s, 'Just four',      5)
MidStr(s, 'Just four apples', 5, 4)
```

'InStr(STRING1,STRING2,STARTINDEX=0)'

Returns the index of the first occurrence of STRING2 in STRING1 starting at STARTINDEX (in STRING1). STARTINDEX defaults to zero. If STRING2 could not be found then -1 is returned.

'TrimStr(STRING)'

Returns the address of (i.e., a pointer to) the first non-whitespace character in STRING. For instance, the following code fragment results in 's' becoming '12345'.

```
DEF s:PTR TO CHAR
s:=TrimStr(' \n \t 12345')
```

'LowerStr(STRING)'

Converts all uppercase letters in STRING to lowercase. This change is made "in-place", i.e., the contents of the string are directly affected. The string is returned for convenience.

``UpperStr(String)``

Converts all lowercase letters in `String` to uppercase. Again, this change is made in-place and the string is returned for convenience.

``SetStr(E-String, Length)``

Sets the length of `E-String` to `Length`. E-strings know how long they are, so if you alter an E-string (without using an E-string function) and change its size you need to set its length using this function before you can use it as an E-string again. For instance, if you've used an E-string like an array (which you can do) and written characters to it directly you must set its length before you can treat it as anything other than an array/string:

```
DEF s[10]:STRING
s[0]:="a"      /* Remember that "a" is a character value. */
s[1]:="b"
s[2]:="c"
s[3]:="d"      /* At this point s is just an array of CHAR. */
SetStr(s, 4)  /* Now, s can be used as an E-string again. */
SetStr(s, 2)  /* s is a bit shorter, but still an E-string.*/
```

Notice that this function can be used to shorten an E-string (but you cannot lengthen it this way).

``Val(String, Address=NIL)``

What this function does is straight-forward but how you use it is a bit complicated. Basically, it converts `String` to a 'LONG' integer. Leading whitespace is ignored, and a leading '%' or '\$' means that the string denotes a binary or hexadecimal integer (in the same way they do for numeric constants). The decoded integer is returned as the regular return value (see Multiple Return Values). The number of characters of `String` that were read to make the integer is stored at `Address`, which is usually a variable address (from using '{VAR}'), and is returned as the first optional return value. If `Address` is the special constant 'NIL' (or zero) then this number is not stored (this is the default value for `Address`). You can use this number to calculate the position in the string which was not part of the integer in the string. If an integer could not be decoded from the string then zero is returned and zero is stored at `Address`.

Follow the comments in this example, and pay special attention to the use of the pointer 'p'.

```
DEF s[30]:STRING, value, chars, p:PTR TO CHAR
StrCopy(s, ' \t \n 10 \t $3F -%0101010')
value, chars:=Val('abcde 10 20') -> Two return values...
/* After the above line, value and chars will both be zero */
value:=Val(s, {chars})           -> Use address of chars
/* Now value will be 10, chars will be 7 */
p:=s+chars
/* p now points to the space after the 10 in s */
value, chars:=Val(p)
/* Now value will be $3F (63), chars will be 6 */
p:=p+chars
/* p now points to the space after the $3F in s */
value, chars:=Val(p)
```

```
/* Now value will be -%0101010 (-42), chars will be 10 */
```

Notice the two different ways of finding the number of characters read: a multiple-assignment and using the address of a variable.

There's a couple of other string functions ('ReadStr' and 'StringF') which will be discussed later (see Input and output functions).

1.81 beginner.guide/Lists and E-lists

Lists and E-lists

Lists are just like strings with 'LONG' elements rather than 'CHAR' elements (so they are very much like 'ARRAY OF LONG'). The list equivalent of an E-string is something called an "E-list". It has the same properties as an E-string, except the elements are 'LONG' (so could be pointers). Normal lists are most like string constants, except that the elements can be built from variables and so do not have to be constants. Just as strings are not true E-strings, (normal) lists are not true E-lists.

Lists are written using '[' and ']' to delimit comma separated elements. Like string constants a list returns the address of the memory which contains the elements.

For example the following code fragment:

```
DEF list:PTR TO LONG, number
number:=22
list:=[1,2,3,number]
```

is equivalent to:

```
DEF list[4]:ARRAY OF LONG, number
number:=22
list[0]:=1
list[1]:=2
list[2]:=3
list[3]:=number
```

Now, which of these two versions would you rather write? As you can see, lists are pretty useful for making your program easier to write and much easier to read.

E-list variables are like E-string variables and are declared in much the same way. The following code fragment declares 'lt' to be an E-list of maximum size 30. As ever, 'lt' is then a pointer (to 'LONG'), and it points to the memory allocated by the declaration.

```
DEF lt[30]:LIST
```

Lists are most useful for writing "tag lists", which are increasingly used in important Amiga system functions. A tag list is a list where the

elements are thought of in pairs. The first element of a pair is the tag, and the second is some data for that tag. See the 'Rom Kernel Reference Manual (Libraries)' for more details.

1.82 beginner.guide/List functions

List functions

There are a number of list functions which are very similar to the string functions (see String functions). Remember that E-lists are the list equivalents of E-strings, i.e., they can be altered and extended safely without exceeding their bounds. As with E-strings, E-lists are downwardly compatible with lists. Therefore, if a function requires a list as a parameter you can supply a list or an E-list. But if a function requires an E-list you cannot use a list in its place.

'List (MAXSIZE)'

Allocates memory for an E-list of maximum size MAXSIZE and returns a pointer to the list data. It is used to make space for a new E-list, like a 'LIST' declaration does. The following code fragments are (as with 'String') practically equivalent:

```
DEF lt[46]:LIST
```

```
DEF lt:PTR TO LONG
lt:=List(46)
```

Remember that you need to check that the return value from 'List' is not 'NIL' before you use it as an E-list.

'ListCmp (LIST1, LIST2, LENGTH=ALL)'

Compares LIST1 with LIST2 (they can both be normal or E-lists). Works just like 'StrCmp' does for E-strings, so, for example, the following comparisons all return 'TRUE':

```
ListCmp([1,2,3,4], [1,2,3,4])
ListCmp([1,2,3,4], [1,2,3,7], 3)
ListCmp([1,2,3,4,5], [1,2,3], 3)
```

'ListCopy (E-LIST, LIST, LENGTH=ALL)'

Works just like 'StrCopy', and the following example shows how to initialise an E-list:

```
DEF lt[7]:LIST, x
x:=4
ListCopy(lt, [1,2,3,x])
```

As with 'StrCopy', an E-list cannot be over-filled using 'ListCopy'.

'ListAdd (E-LIST, LIST, LENGTH=ALL)'

Works just like 'StrAdd', so this next code fragment results in the E-list 'lt' becoming the E-list version of '[1,2,3,4,5,6,7,8]'.

```

DEF lt[30]:LIST
ListCopy(lt, [1,2,3,4])
ListAdd(lt, [5,6,7,8])

`ListLen(LIST)`
  Works just like `StrLen`, returning the length of LIST. There is no
  E-list specific length function.

`ListMax(E-LIST)`
  Works just like `StrMax`, returning the maximum length of the E-LIST.

`SetList(E-LIST,LENGTH)`
  Works just like `SetStr`, setting the length of E-LIST to LENGTH.

`ListItem(LIST,INDEX)`
  Returns the element of LIST at INDEX. For example, if `lt` is an
  E-list then `ListItem(lt,n)` is the same as `lt[n]`. This function
  is most useful when the list is not an E-list. For example, the
  following two code fragments are equivalent:

      WriteF(ListItem(['Fred','Barney','Wilma','Betty'], name))

      DEF lt:PTR TO LONG
      lt:=['Fred','Barney','Wilma','Betty']
      WriteF(lt[name])

```

1.83 beginner.guide/Complex types

Complex types

In E the `'STRING'` and `'LIST'` types are called "complex" types. Complex typed variables can also be created using the `'String'` and `'List'` functions as we've seen in the previous sections.

1.84 beginner.guide/Typed lists

Typed lists

Normal lists contain `'LONG'` elements, so you can write initialised arrays of `'LONG'` elements. What about other kinds of array? Well, that's what "typed" lists are for. You specify the type of the elements of a list using `:TYPE` after the closing `]`. The allowable types are `'CHAR'`, `'INT'`, `'LONG'` and any object type. There is a subtle difference between a normal, `'LONG'` list and a typed list (even a `'LONG'` typed list): only normal lists can be used with the list functions (see List functions). For this reason, the term `'list'` tends to refer only to normal lists.

The following code fragment uses the object `'rec'` defined earlier (see

Example object) and gives a couple of examples of typed lists:

```
DEF ints:PTR TO INT, objects:PTR TO rec, p:PTR TO CHAR
ints:=[1,2,3,4]:INT
p:='fred'
objects:=[1,2,p,4,
          300,301,'barney',303]:rec
```

It is equivalent to:

```
DEF ints[4]:ARRAY OF INT, objects[2]:ARRAY OF rec, p:PTR TO CHAR
ints[0]:=1
ints[1]:=2
ints[2]:=3
ints[3]:=4
p:='fred'
objects[0].tag:=1
objects[0].check:=2
objects[0].table:=p
objects[0].data:=4
objects[1].table:='barney'
objects[1].tag:=300
objects[1].data:=303
objects[1].check:=301
```

The last group of assignments to 'objects[1]' have deliberately been shuffled in order to emphasise that the order of the elements in the **definition** of the object 'rec' is significant. Each of the elements of the list corresponds to an element in the object, and the order of elements in the list corresponds to the order in the object definition. In the example, the (object) list assignment line was broken after the end of the first object (the fourth element) to make it a bit more readable. The last object in the list need not be completely defined, so, for instance, the second line of the assignment could have contained only three elements.

1.85 beginner.guide/Static data

Static data

String constants (e.g., 'fred'), lists (e.g., '[1,2,3]') and typed lists (e.g., '[1,2,3]:INT') are "static" data. This means that the address of the (initialised) data is fixed when the program is run. Normally you don't need to worry about this, but, for instance, if you want to have a series of lists as initialised arrays you might be tempted to use some kind of loop:

```
PROC main()
  DEF i, a[10]:ARRAY OF LONG, p:PTR TO LONG
  FOR i:=0 TO 9
    a[i]:=[1, i, i*i]
    /* This assignment is probably not what you want! */
  ENDFOR
```

```

FOR i:=0 TO 9
  p:=a[i]
  WriteF('a[\d] is an array at address \d\n', i, p)
  WriteF('  and the second element is \d\n', p[1])
ENDFOR
ENDPROC

```

The array 'a' is an array of pointers to initialised arrays (which are all three elements long). But, as the comment suggests and the program shows, this probably doesn't do what was intended, since the list is static. That means the address of the list is fixed, so each element of 'a' gets the same address (i.e., the same array). Since 'i' is used in the list the contents of that part of memory varies slightly as the first 'FOR' loop is processed. But after this loop the contents remain fixed, and the second element of each of the ten arrays is always nine. This is an example of the output that will be generated (the '...' represents a number of similar lines):

```

a[0] is an array at address 4021144
  and the second element is 9
a[1] is an array at address 4021144
  and the second element is 9
...
a[9] is an array at address 4021144
  and the second element is 9

```

One solution is to use the dynamic typed-allocation statement 'NEW', which is described in detail in the 'Reference Manual'. Another solution is to use the function 'List' and copy the normal list into the new E-list using 'ListCopy':

```

PROC main()
  DEF i, a[10]:ARRAY OF LONG, p:PTR TO LONG
  FOR i:=0 TO 9
    a[i]:=List(3)
    /* Must check that the allocation succeeded before copying */
    IF a[i]<>NIL THEN ListCopy(a[i], [1, i, i*i], ALL)
  ENDFOR
  FOR i:=0 TO 9
    p:=a[i]
    IF p=NIL
      WriteF('Could not allocate memory for a[\d]\n', i)
    ELSE
      WriteF('a[\d] is an array at address \d\n', i, p)
      WriteF('  and the second element is \d\n', p[1])
    ENDIF
  ENDFOR
ENDPROC

```

The problem is not so bad with string constants, since the contents are fixed. However, if you alter the contents explicitly, you will need to take care not to run into the same problem, as this next example shows.

```

PROC main()
  DEF i, strings[10]:ARRAY OF LONG, s:PTR TO CHAR
  FOR i:=0 TO 9
    strings[i]:='Hello World\n'

```

```

        /* This assignment is probably not what you want! */
    ENDFOR
    s:=strings[4]
    s[5]:="X"
    FOR i:=0 TO 9
        WriteF('strings[\d] is ', i)
        WriteF(strings[i])
    ENDFOR
ENDPROC

```

This is an example of the output that will be generated (again, the '...' represents a number of similar lines)::

```

strings[0] is HelloXWorld
strings[1] is HelloXWorld
...
strings[9] is HelloXWorld

```

Again, the solution is to use dynamic allocation. The functions 'String' and 'StrCopy' should be used in the same way that 'List' and 'ListCopy' were used above.

1.86 beginner.guide/Linked Lists

Linked Lists
=====

E-lists and E-strings have a useful extension: they can be used to make "linked lists". These are like the lists we've seen already, except the list elements do not occupy a contiguous block of memory. Instead, each element has an extra piece of data: a pointer to the next element in the list. This means that each element can be anywhere in memory. (Normally, the next element of a list is in the next position in memory.) The end of a linked list has been reached when the pointer to the next element is the special value 'NIL' (a constant). You need to be very careful to check that the pointer is not 'NIL' because if it is and you dereference it the program will most definitely crash.

The elements of a linked list are E-lists or E-strings (i.e., the elements are complex typed). So, you can link E-lists to get a 'linked list of E-lists' (or, more simply, a 'list of lists'). Similarly, linking E-strings gives 'linked list of E-strings', or a 'list of strings'. You don't have to stick to these two kinds of linked lists, though: you can use a mixture of E-lists and E-strings in the same linked list. To link one complex typed element to another you use the 'Link' function and to find subsequent elements in a linked list you use the 'Next' or 'Forward' functions.

'Link(COMPLEX1,COMPLEX2)'

Links COMPLEX1 to COMPLEX2. Both must be an E-list or an E-string, with the exception that COMPLEX2 can be the special constant 'NIL' to indicate that COMPLEX1 is the end of the linked list. The value COMPLEX1 is returned by the function, which isn't always useful so, usually, calls to 'Link' will be used as statements rather than

functions. The effect of 'Link' is that COMPLEX1 will point to COMPLEX2 as the next element in the linked list (so COMPLEX1 is the "head" of the list, and COMPLEX2 is the "tail"). For both E-lists and E-strings the pointer to the next element is initially 'NIL', so you will only need to use 'Link' with a 'NIL' parameter when you want to make a linked list shorter (by losing the tail).

'Next (COMPLEX)'

Returns the pointer to the next element in the linked list. This may be the special constant 'NIL' if COMPLEX is the last element in the linked list. Be careful to check that the value isn't 'NIL' before you dereference it! Follow the comments in the example below:

```
DEF s[23]:STRING, t[7]:STRING, lt[41]:LIST, lnk
/* The next two lines set up the linked list "lnk" */
lnk:=Link(lt,t) /* lnk list starts at lt and is lt->t */
lnk:=Link(s,lt) /* Now it starts at s and is s->lt->t */
/* The next three lines follow the links in "lnk" */
lnk:=Next(lnk) /* Now it starts at lt and is lt->t */
lnk:=Next(lnk) /* Now it starts at t and is t */
lnk:=Next(lnk) /* Now lnk is NIL so the list has ended */
```

You may safely call 'Next' with a 'NIL' parameter, and in this case it will return 'NIL'.

'Forward (COMPLEX, EXPRESSION)'

Returns a pointer to the element which is EXPRESSION number of links down the linked list COMPLEX. If EXPRESSION represents the value one a pointer to the next element is returned (just like using 'Next'). If it's two a pointer to the element after that is returned.

If EXPRESSION represents a number which is greater than the number of links in the list the special value 'NIL' is returned.

Since the link in a linked list is a pointer to the next element you can only look through the list from beginning to end. Technically this is a "singly" linked list (a "doubly" linked list would also have a pointer to the previous element in the list, enabling backwards searching through the list).

Linked lists are useful for building lists that can grow quite large. This is because it's much better to have lots of small bits of memory than a large lump. However, you only need to worry about these things when you're playing with quite big lists (as a rough guide, ones with over 100,000 elements are big!).

1.87 beginner.guide/More About Statements and Expressions

More About Statements and Expressions

This chapter details various E statements and expressions that were not covered in Part One. It also completes some of the partial descriptions given in Part One.

Turning an Expression into a Statement
 Initialised Declarations
 Assignments
 More Expressions
 More Statements
 Quoted Expressions
 Assembly Statements

1.88 beginner.guide/Turning an Expression into a Statement

Turning an Expression into a Statement
 =====

The 'VOID' operator converts an expression to a statement. It does this by evaluating the expression and then throwing the result away. This may not seem very useful, but in fact we've done it a lot already. We didn't use 'VOID' explicitly because E does this automatically if it finds an expression where it was expecting a statement (normally when it is on a line by itself). Some of the expressions we've turned into statements were the procedure calls (to 'WriteF' and 'fred') and the use of '++'. Remember that all procedure calls denote values because they're really functions that, by default, return zero (see Functions).

For example, the following code fragments are equivalent:

```
VOID WriteF('Hello world\n')
VOID x++

WriteF('Hello world\n')
x++
```

Since E automatically uses 'VOID' it's a bit of a waste of time writing it in, although there may be occasions where you want to use it to make this voiding process more explicit (to the reader). The important thing is the fact that expressions can validly be used as statements in E.

1.89 beginner.guide/Initialised Declarations

Initialised Declarations
 =====

Some variables can be initialised using constants in their declarations. The variables you cannot initialise in this way are array and complex type variables (and procedure parameters, obviously). All the other kinds can be initialised, whether they are local or global. An "initialised declaration" looks very much like a constant definition, with the value following the variable name and a '=' character joining them. The following example illustrates initialised declarations:

```

SET ENGLISH, FRENCH, GERMAN, JAPANESE, RUSSIAN

CONST FREDLANGS=ENGLISH OR FRENCH OR GERMAN

DEF fredspeak=FREDLANGS,
    p=NIL:PTR TO LONG, q=0:PTR TO rec

PROC fred()
    DEF x=1, y=88
    /* Rest of procedure */
ENDPROC

```

Notice how the constant 'FREDLANGS' needs to be defined in order to initialise the declaration of 'fredspeak' to something mildly complicated. Also, notice the initialisation of the pointers 'p' and 'q', and the position of the type information.

Of course, if you want to initialise variables with anything more complicated than a constant you can use assignments at the start of the code. Generally, you should always initialise your variables (using either method) so that they are guaranteed to have a sensible value when you use them. Using the value of a variable that you haven't initialised in some way will probably get you in to a lot of trouble, because the value will just be some random value that happened to be in the memory used by the variable. There are rules for how E initialises some kinds of variables (see the 'Reference Manual', but it's wise to explicitly initialise even those, as (strangely enough!) this will make your program more readable.

1.90 beginner.guide/Assignments

Assignments
=====

We've already seen some assignments--these were assignment statements. Assignment expressions are similar except (as you've guessed) they can be used in expressions. This is because they return the value on the right-hand side of the assignment as well as performing the assignment. This is useful for efficiently checking that the value that's been assigned is sensible. For instance, the following code fragments are equivalent, but the first uses an assignment expression instead of a normal assignment statement.

```

IF (x:=y*z)=0
    WriteF('Error: y*z is zero (and x is zero)\n')
ELSE
    WriteF('OK: y*z is not zero (and x is y*z)\n')
ENDIF

x:=y*z
IF x=0
    WriteF('Error: y*z is zero (and x is zero)\n')
ELSE

```

```
    WriteF('OK: y*z is not zero (and x is y*z)\n')
ENDIF
```

You can easily tell the assignment expression: it's in parentheses and not on a line by itself. Notice the use of parentheses to group the assignment expression. Technically, the assignment operator has a very low precedence. Untechnically, it will take as much as it can of the right-hand side to form the value to be assigned, so you need to use parentheses to stop 'x' getting the value '((y*z)=0)' (which will be 'TRUE' or 'FALSE', i.e., -1 or zero).

Assignment expressions, however, don't allow as rich a left-hand side as assignment statements. The only thing allowed on the left-hand side of an assignment expression is a variable name, whereas the statement form allows:

```
VAR
VAR [ EXPRESSION ]
VAR . OBJ_ELEMENT_NAME
^ VAR
```

(With as many repetitions of object element selection and/or array indexing as the elements' types allow.) Each of these may end with '++' or '--'. Therefore, the following are all valid assignments (the last three use assignment expressions):

```
x:=2
x--:=1
x[a*b]:=rubble
x.apple++:=3
x[22].apple:=y*z
x[].banana.basket[6]:=3+full(9)
x[].pear--:=fred(2,4)

x.pear:=(y:=2)
x[y*z].table[1].orange:=(IF (y:=z)=2 THEN 77 ELSE 33)
WriteF('x is now \d\n', x:=1+(y:=(z:=fred(3,5)/2)*8))
```

You may be wondering what the '++' or '--' affect. Well, it's very simple: they only affect the VAR, which is 'x' in all of the examples above. Notice that 'x[].pear--' is the same as 'x.pear--', for the same reasons mentioned earlier (see Element selection and element types).

1.91 beginner.guide/More Expressions

More Expressions

```
=====
```

This section discusses side-effects, details two new operators ('BUT' and 'SIZEOF') and completes the description of the 'AND' and 'OR' operators.

Side-effects

BUT expression
 Bitwise AND and OR
 SIZEOF expression

1.92 beginner.guide/Side-effects

Side-effects

If evaluating an expression causes the contents of variables to change then that expression is said to have "side-effects". An assignment expression is a simple example of an expression with side-effects. Less obvious ones involve function calls with pointers to variables. Generally, expressions with side-effects should be avoided unless it is really obvious what is happening. This is because it can be difficult to find problems with your program's code if subtleties are buried in complicated expressions. On the other hand, side-effecting expressions are concise and often very elegant. They are also useful for **obfuscating** your code (i.e., making it difficult to understand--a form of copy protection!).

1.93 beginner.guide/BUT expression

'BUT' expression

'BUT' is used to sequence two expressions. 'EXP1 BUT EXP2' evaluates EXP1, and then evaluates and returns the value of EXP2. This may not seem very useful at first sight, but if the first expression is an assignment it allows for a more general assignment expression. For example, the following code fragments are equivalent:

```
fred((x:=12*3) BUT x+y)
```

```
x:=12*3
fred(x+y)
```

Notice that parentheses need to be used around the assignment expression (in the first fragment) for the reasons given earlier (see Assignments).

1.94 beginner.guide/Bitwise AND and OR

Bitwise 'AND' and 'OR'

As hinted in the earlier chapters, the operators 'AND' and 'OR' are not simply logical operators. In fact, they are both bit-wise operators,

where a "bit" is a binary digit (i.e., the zeroes or ones in the binary form of a number). So, to see how they work we should look at what happens to zeroes and ones:

x	y	x OR y	x AND y
1	1	1	1
1	0	1	0
0	1	1	0
0	0	0	0

Now, when you 'AND' or 'OR' two numbers the corresponding bits (binary digits) of the numbers are compared individually, according to the above table. So if 'x' were '%0111010' and 'y' were '%1010010' then 'x AND y' would be '%0010010' and 'x OR y' would be '%1111010':

%0111010	%0111010
AND	OR
%1010010	%1010010
-----	-----
%0010010	%1111010

The numbers (in binary form) are lined up above each other, just like you do additions with normal numbers (i.e., starting with the right-hand digits, and maybe padding with zeroes on the left-hand side). The two bits in each column are 'AND'-ed or 'OR'-ed to give the result below the dashed line.

So, how does this work for 'TRUE' and 'FALSE' and logic operations? Well, 'FALSE' is the number zero, so all the bits of 'FALSE' are zeroes, and 'TRUE' is -1, which has all 32 bits as ones (these numbers are 'LONG' so they are 32-bit quantities). So 'AND'-ing and 'OR'-ing these values always gives numbers which have all zero bits (i.e., 'FALSE') or all one bits (i.e., 'TRUE'), as appropriate. It's only when you start mixing numbers that aren't zero or -1 that you can muck up the logic. The non-zero numbers one and four are (by themselves) considered to be 'TRUE', but '4 AND 1' is '%100 AND %001' which is zero (i.e., 'FALSE'). So when you use 'AND' as the logical operator it's not strictly true that all non-zero numbers represent 'TRUE'. 'OR' does not give such problems so all non-zero numbers are treated as 'TRUE'. Run this example to see why you should be careful:

```

PROC main()
  test(TRUE,      'TRUE\t\t')
  test(FALSE,     'FALSE\t\t')
  test(1,         '1\t\t')
  test(4,         '4\t\t')
  test(TRUE OR TRUE, 'TRUE OR TRUE\t')
  test(TRUE AND TRUE, 'TRUE AND TRUE\t')
  test(1 OR 4,     '1 OR 4\t\t')
  test(1 AND 4,    '1 AND 4\t\t')
ENDPROC

PROC test(x, title)
  WriteF(title)
  WriteF(IF x THEN ' is TRUE\n' ELSE ' is FALSE\n')
ENDPROC

```

Here's the output that should be generated:

```
TRUE          is TRUE
FALSE         is FALSE
1             is TRUE
4             is TRUE
TRUE OR TRUE  is TRUE
TRUE AND TRUE is TRUE
1 OR 4        is TRUE
1 AND 4       is FALSE
```

So, 'AND' and 'OR' are primarily bit-wise operators, and they can be used as logical operators under most circumstances, with zero representing false and all other numbers representing true. Care must be taken when using 'AND' with some pairs of non-zero numbers, since the bit-wise 'AND' of such numbers does not always give a non-zero (or true) result.

1.95 beginner.guide/SIZEOF expression

'SIZEOF' expression

'SIZEOF' returns the size, in bytes, of an object or a built-in type (like 'LONG'). This can be useful for determining storage requirements. For instance, the following code fragment prints the size of the object 'rec':

```
OBJECT rec
  tag, check
  table[8]:ARRAY
  data:LONG
ENDOBJECT

PROC main()
  WriteF('Size of rec object is %d bytes\n', SIZEOF rec)
ENDPROC
```

You may think that 'SIZEOF' is unnecessary because you can easily calculate the size of an object just by looking at the sizes of the elements. Whilst this is generally true (it was for the 'rec' object), there is one thing to be careful about: alignment. This means that 'ARRAY', 'INT', 'LONG' and object typed elements must start at an even memory address. Normally this isn't a problem, but if you have an odd number of consecutive 'CHAR' typed elements or an odd sized 'ARRAY OF CHAR', an extra, "pad" byte is introduced into the object so that the following element is aligned properly. This pad byte can be considered part of an 'ARRAY OF CHAR', so in effect this means array sizes are rounded up to the nearest even number. Otherwise, pad bytes are just an unusable part of an object, and their presence means the object size is not quite what you'd expect. Try the following program:

```
OBJECT rec2
  tag, check
```

```

    table[7]:ARRAY
    data:LONG
ENDOBJECT

PROC main()
    WriteF('Size of rec2 object is %d bytes\n', sizeof rec2)
ENDPROC

```

The only difference between the 'rec' and 'rec2' objects is that the array size is seven in 'rec2'. If you run the program you'll see that the size of the object has not changed. We might just as well have declared the 'table' element to be a slightly bigger array (i.e., have eight elements).

1.96 beginner.guide/More Statements

More Statements
=====

This section details four new statements ('INC', 'DEC', 'JUMP' and 'LOOP') and describes the use of labelling.

INC and DEC statements
Labelling and the JUMP statement
LOOP block

1.97 beginner.guide/INC and DEC statements

'INC' and 'DEC' statements

'INC x' is the same as the statement 'x:=x+1'. However, because it doesn't do an addition it's a bit more efficient. Similarly, 'DEC x' is the same as 'x:=x-1'.

The observant reader may think that 'INC' and 'DEC' are the same as '++' and '--'. But there's one important difference: 'INC x' always increases 'x' by one, whereas 'x++' may increase 'x' by more than one depending on the type to which 'x' points. For example, if 'x' were a pointer to 'INT' then 'x++' would increase 'x' by two ('INT' is 16-bit, which is two bytes).

1.98 beginner.guide/Labelling and the JUMP statement

Labelling and the 'JUMP' statement

A "label" names a position in a program, and these names are global (they can be used in any procedure). The most common use of label is with the 'JUMP' statement, but you can also use labels to mark the position of some data (see Assembly Statements). To define a label you write a name followed by a colon immediately before the position you want to mark. This must be just before the beginning of a statement, either on the previous line (by itself) or the start of the same line.

The 'JUMP' statement makes execution continue from the position marked by a label. This position must be in the same procedure, but it can be, for instance, outside of a loop (and the 'JUMP' will then have terminated that loop). For example, the following code fragments are equivalent:

```
x:=1
y:=2
JUMP rubble
x:=9999
y:=1234
rubble:
z:=88

x:=1
y:=2
z:=88
```

As you can see the 'JUMP' statement has caused the second group of assignments to 'x' and 'y' to be skipped. A more useful example uses 'JUMP' to help terminate a loop:

```
x:=1
y:=2
WHILE x<10
  IF y<10
    WriteF('x is \d, y is \d\n', x, y)
  ELSE
    JUMP end
  ENDIF
  x:=x+2
  y:=y+2
ENDWHILE
end:
WriteF('Finished!\n')
```

This loop terminates if 'x' is not less than ten (the 'WHILE' check), or if 'y' is not less than ten (the 'JUMP' in the 'IF' block). This may seem pretty familiar, because it's practically the same as an example earlier (see WHILE loop). In fact, it's equivalent to:

```
x:=1
y:=2
WHILE (x<10) AND (y<10)
  WriteF('x is \d, y is \d\n', x, y)
  x:=x+2
  y:=y+2
ENDWHILE
WriteF('Finished!\n')
```

1.99 beginner.guide/LOOP block

'LOOP' block

A 'LOOP' block is a multi-line statement. It's the general form of loops like the 'WHILE' loop, and it builds a loop with no check. So, this kind of loop would normally never end. However, as we now know, you can terminate a 'LOOP' block using the 'JUMP' statement. As an example, the following two code fragments are equivalent:

```
x:=0
LOOP
  IF x<100
    WriteF('x is \d\n', x++)
  ELSE
    JUMP end
  ENDIF
ENDLOOP
end:
WriteF('Finished\n')

x:=0
WHILE x<100
  WriteF('x is \d\n', x++)
ENDWHILE
WriteF('Finished\n')
```

1.100 beginner.guide/Quoted Expressions

Quoted Expressions

=====

"Quoted expressions" are a powerful feature of the E language, and they require quite a bit of advanced knowledge. Basically, you can "quote" any expression by starting it with the back-quote character ` (be careful not to get it mixed up with the quote character ' which is used for strings). This quoting action does not evaluate the expression, instead the address of the code for the expression is returned. This address can be used just like any other address, so you can, for instance, store it in a variable and pass it to procedures. Of course, at some point you will use the address to execute the code and get the value of the expression.

The idea of quoted expressions was borrowed from the functional programming language Lisp. Also borrowed were some powerful functions which combine lists with quoted expressions to give very concise and readable statements.

Evaluation
 Quotable expressions
 Lists and quoted expressions

1.101 beginner.guide/Evaluation

Evaluation

When you've quoted an expression you have the address of the code which calculates the value of the expression. To evaluate the expression you pass this address to the 'Eval' function. So now we have a round-about way of calculating the value of an expression.

```
PROC main()
  DEF adr, x, y
  x:=0; y:=0
  adr:='1+(fred(x,1)*8)-y
  x:=2; y:=7
  WriteF('The value is \d\n', Eval(adr))
  x:=1; y:=100
  WriteF('The value is now \d\n', Eval(adr))
ENDPROC

PROC fred(a,b) RETURN (a+b)*a+20
```

This is the output that should be generated:

```
The value is 202
The value is now 77
```

This example shows a quite complicated expression being quoted. The address of the expression is stored in the variable 'adr', and the expression is evaluated using 'Eval' in the calls to 'WriteF'. The values of the variables 'x' and 'y' when the expression is quoted are irrelevant--only their values each time 'Eval' is used are significant. Therefore, when 'Eval' is used in the second call to 'WriteF' the values of 'x' and 'y' have changed so the resulting value is different.

Repeatedly evaluating the same expression is the most obvious use of quoted expressions. Another common use is when you want to do the same thing for a variety of different expressions. For example, if you wanted to discover the amount of time it takes to calculate the results of various expressions it would be best to use quoted expressions, something like this:

```
DEF x,y

PROC main()
  x:=999; y:=173
  time('x+y,      'Addition')
  time('x*y,      'Multiplication')
  time('fred(x),  'Procedure call')
ENDPROC
```

```

PROC time(exp, message)
  WriteF(message)
  /* Find current time */
  Eval(exp)
  /* Find new time and calculate difference, t */
  WriteF(': time taken \d\n', t)
ENDPROC

```

This is just the outline of a program--it's not complete so don't bother running it. The complete version is given as a worked example later (see Timing Expressions).

1.102 beginner.guide/Quotable expressions

Quotable expressions

There is no restriction on the kinds of expression you can quote, except that you need to be careful about variable scoping. If you use local variables in a quoted expression you can only 'Eval' it within the same procedure (so the variables are in scope). However, if you use only global variables you can 'Eval' it in any procedure. Therefore, if you are going to pass a quoted expression to a procedure and do something with it, you should use only global variables.

A word of warning: 'Eval' does not check to see if the address it's been given is really the address of an expression. You can therefore get in a real mess if you pass it, say, the address of a variable using '{VAR}'. You need to check all uses of things like 'Eval' yourself, because the E compiler lets you write things like 'Eval(x+9)', where you probably meant to write 'Eval('x+9)'. That's because you might want the address you pass to 'Eval' to be the result of complicated expressions. So you may have meant to pass 'x+9' as the parameter!

1.103 beginner.guide/Lists and quoted expressions

Lists and quoted expressions

There are several E built-in functions which use lists and quoted expressions in powerful ways. These functions are similar to functional programming constructs and, basically, they allow for very readable code, which otherwise would require iterative algorithms (i.e., loops).

```
'MapList(ADDRESS,LIST,E-LIST,QUOTED-EXP)'
```

The ADDRESS is the address of a variable (e.g., '{x}'), LIST is a list or E-list (the source), E-LIST is an E-list variable (the destination), and QUOTED-EXP is the address of an expression which involves the addressed variable (e.g., 'x+2'). The effect of the

function is to take, in turn, a value from LIST, store it at ADDRESS, evaluate the quoted expression and store the result in the destination list. The resulting list is also returned (for convenience).

For example:

```
MapList({y}, [1,2,3,a,99,1+c], lt, 'y*y)
```

results in 'lt' taking the value:

```
[1,4,9,a*a,9801,(1+c)*(1+c)]
```

Functional programmers would say that 'MapList' "mapped" the function (the quoted expression) across the (source) list.

'ForAll(ADDRESS,LIST,QUOTED-EXP)'

Works just like 'MapList' except that the resulting list is not stored. Instead, 'ForAll' returns 'TRUE' if every element of the resulting list is 'TRUE' (i.e., non-zero), and 'FALSE' otherwise. In this way it decides whether the quoted expression is 'TRUE' "for all" elements of the source list. For example, the following are 'TRUE':

```
ForAll({x}, [1,2,-13,8,0], 'x<10)
ForAll({x}, [1,2,-13,8,0], 'x<=8)
ForAll({x}, [1,2,-13,8,0], 'x>-20)
```

and these are 'FALSE':

```
ForAll({x}, [1,2,-13,8,0], 'x OR x)
ForAll({x}, [1,2,-13,8,0], 'x=2)
ForAll({x}, [1,2,-13,8,0], 'x<>2)
```

'Exists(ADDRESS,LIST,QUOTED-EXP)'

Works just like 'ForAll' except it returns 'TRUE' if the quoted expression is 'TRUE' (i.e., non-zero) for at least one of the source list elements and 'FALSE' otherwise. For example, the following are 'TRUE':

```
Exists({x}, [1,2,-13,8,0], 'x<10)
Exists({x}, [1,2,-13,8,0], 'x=2)
Exists({x}, [1,2,-13,8,0], 'x>0)
```

and these are 'FALSE':

```
Exists({x}, [1,2,-13,8,0], 'x<-20)
Exists({x}, [1,2,-13,8,0], 'x=4)
Exists({x}, [1,2,-13,8,0], 'x>8)
```

'SelectList(ADDRESS,LIST,E-LIST,QUOTED-EXP)'

Works just like 'MapList' except the QUOTED-EXP is used to decide which elements from LIST are copied to 'e-list'. Only the elements for which QUOTED-EXP evaluates to a non-zero (i.e., true) value are copied. The resulting list is also returned (for convenience).

For example:


```
SelectList({y}, [99,6,1,2,7,1,1,6,6], lt, 'y>5)

results in 'lt' taking the value:

[99,6,7,6,6]
```

1.104 beginner.guide/Assembly Statements

Assembly Statements
=====

The E language incorporates an assembler so you can write Assembly mnemonics as E statements. You can even write complete Assembly programs and compile them using the E compiler. More powerfully, you can use E variables as part of the mnemonics, so you can really mix Assembly statements with normal E statements.

This is not really the place to discuss Assembly programming, so if you plan to use this feature of E you should get yourself a good book, preferably on Amiga Assembly. Remember that the Amiga uses the Motorola 68000 CPU, so you need to learn the Assembly language for that CPU. More powerful and newer Amigas use more advanced CPUs (such as the 68020) which have extra mnemonics. Programs written using just 68000 CPU mnemonics will work on all Amigas.

If you don't know 68000 Assembly language you ought to skip this section and just bear in mind that E statements you don't recognise are probably Assembly mnemonics.

Assembly and the E language
Static memory
Things to watch out for

1.105 beginner.guide/Assembly and the E language

Assembly and the E language

You can reference E variables simply by using them in an operand. Follow the comments in the next example (the comments are on the same lines as the Assembly mnemonics, the other lines are normal E statements):

```
PROC main()
  DEF x
  x:=1
  MOVE.L x, D0 /* Copy the value in x to register D0 */
  ADD.L D0, D0 /* Double the value in D0 */
  MOVE.L D0, x /* Copy the value in D0 back to variable x */
  WriteF('x is now %d\n', x)
```

```
ENDPROC
```

Constants can also be referenced but you need to precede the constant with a `#`.

```
CONST APPLE=2
```

```
PROC main()
  DEF x
  MOVE.L #APPLE, D0 /* Copy the constant APPLE to register D0 */
  ADD.L D0, D0      /* Double the value in D0 */
  MOVE.L D0, x      /* Copy the value in D0 to variable x */
  WriteF('x is now %d\n', x)
ENDPROC
```

Labels and procedures can similarly be referenced, but these are PC-relative so you can only address them in this way. The following example illustrates this, but doesn't do anything useful:

```
PROC main()
  DEF x
  LEA main(PC), A0 /* Copy the address of main to register A0 */
  MOVE.L A0, x     /* Copy the value in A0 to variable x */
  WriteF('x is now %d\n', x)
ENDPROC
```

You can call Amiga system functions in the same way as you would normally in Assembly. You need to load the A6 register with the appropriate library base, load the other registers with appropriate data and then `JSR' to the system routine. This next example uses the E built-in variable `intuitionbase' and the Intuition library routine `DisplayBeep'. When you run it the screen flashes (or, with Workbench 2.1 and above, you might get a beep or a sampled sound, depending on your Workbench setup).

```
PROC main()
  MOVE.L #NIL, A0
  MOVE.L intuitionbase, A6
  JSR DisplayBeep(A6)
ENDPROC
```

1.106 beginner.guide/Static memory

Static memory

Assembly programs reserve static memory for things like strings using `DC' mnemonics. However, these aren't real mnemonics. They are, in fact, compiler directives and they can vary from compiler to compiler. The E versions are `LONG', `INT' and `CHAR' (the type names), which take a list of values, reserve the appropriate amount of static memory and fill in this memory with the supplied values. The `CHAR' form also allows a list of characters to be supplied more easily as a string. In this case, the string will automatically be aligned to an even memory location, although you are responsible for null-terminating it. You can also include a whole

file as static data using 'INCBIN' (and the file named using this statement must exist when the program is compiled). To get at the data you mark it with a label.

This next example is a bit contrived, but illustrates some static data:

```
PROC main()
    DEF x:PTR TO CHAR
    LEA datatable(PC), A0
    MOVE.L A0, x
    WriteF(x)
ENDPROC

datatable:
    CHAR 'Hello world\n', 0
moredata:
    LONG 1,5,-999,0;    INT -1,222
    INCBIN 'file.data'; CHAR 0,7,-8
```

The Assembly stuff to get the label address is not really necessary, so the example could have been just:

```
PROC main()
    WriteF({datatable})
ENDPROC

datatable:
    CHAR 'Hello world\n', 0
```

1.107 beginner.guide/Things to watch out for

Things to watch out for

There are a few things to be aware of when using Assembly with E:

- * All mnemonics and registers must be in uppercase, whilst, of course, E variables etc., follow the normal E rules.
- * Most standard Assemblers use ';' to mark the rest of the line as a comment. In E you use the normal '/*' and '*/' delimiters.
- * Registers A4 and A5 are used internally by E, so should not be messed with if you are mixing E and Assembly code. Other registers might also be used. Refer to the 'Reference Manual' for more details.
- * E function calls like 'WriteF' can affect registers. Refer to the 'Reference Manual' for more details.

1.108 beginner.guide/E Built-In Constants Variables and Functions

E Built-In Constants, Variables and Functions

This chapter describes the constants, variables and functions which are built-in to the E language. You can add more by using modules, but that's a more advanced topic (see Modules).

Built-In Constants
Built-In Variables
Built-In Functions

1.109 beginner.guide/Built-In Constants

Built-In Constants

=====

We've already met several built-in constants. Here's the complete list:

`'TRUE'`, `'FALSE'`

The boolean constants. As numbers, `'TRUE'` is -1 and `'FALSE'` is zero.

`'NIL'`

The bad pointer value. Several functions produce this value for a pointer if an error occurred. As a number, `'NIL'` is zero.

`'ALL'`

Used with string and list functions to indicate that all the string or list is to be used. As a number, `'ALL'` is -1.

`'GADGETSIZE'`

The minimum number of bytes required to hold all the data for one gadget. See Intuition support functions.

`'OLDFILE'`, `'NEWFILE'`

Used with `'Open'` to open an old or new file. See the `'AmigaDOS Manual'` for more details.

`'STRLEN'`

The length of the last string constant used. Remember that a string constant is something between `''` characters, so, for example, the following program prints the string `'s'` and then its length:

```
PROC main()
  DEF s:PTR TO CHAR, len
  s:='12345678'
  len:=STRLEN
  WriteF(s)
  WriteF('\nis \d characters long\n', len)
ENDPROC
```

1.110 beginner.guide/Built-In Variables

Built-In Variables

=====

The following variables are built-in to E and are called "system variables". They are global so can be accessed from any procedure.

`'arg'`

This is a string which contains the "command line" arguments passed your program when it was run (from the Shell or CLI). For instance, if your program were called `'fred'` and you ran it like this:

```
fred file.txt "a big file" another
```

then `'arg'` would be the string:

```
file.txt "a big file" another
```

If you have AmigaDOS 2.0 (or greater) you can use the system routine `'ReadArgs'` to parse the command line in a much more versatile way. There is a worked example on argument parsing in Part Three (see Argument Parsing).

`'wbmessage'`

This contains `'NIL'` if your program was started from the Shell/CLI, otherwise it's a pointer to the Workbench message which contains information about the icons selected when you started the program from Workbench. So, if you started the program from Workbench `'wbmessage'` will not be `'NIL'` and it will contain the Workbench arguments, but if you started the program from the Shell/CLI `'wbmessage'` will be `'NIL'` and the arguments will be in `'arg'` (or via `'ReadArgs'`). There is a worked example on argument parsing in Part Three (see Argument Parsing).

`'stdout', 'conout'`

These contain the standard output filehandle (which can be standard input, too). If your program was started from the Shell/CLI they will be filehandles on the Shell/CLI window. However, if your program was started from Workbench these will normally both be `'NIL'`. A call to `'WriteF'` will open an output window if they are `'NIL'`. See Input and output functions.

`'stdrast'`

The raster port used by E built-in graphics functions such as `'Box'` and `'Plot'`. This can be changed so that these functions draw on different screens etc. See Graphics functions.

`'dosbase', 'execbase', 'gfxbase', 'intuitionbase'`

These are pointers to the appropriate library base, and are initialised by the E startup code, i.e., the Dos, Exec, Graphics and Intuition libraries are all opened by E so you don't need to do it yourself. These libraries are also automatically closed by E, so you shouldn't close them yourself. However, you must explicitly open and close all other Amiga system libraries that you want to use. The other library base variables are defined in the accompanying module

(see Modules). Consult the 'Reference Manual' for details about the library base variable 'mathbase'.

1.111 beginner.guide/Built-In Functions

Built-In Functions =====

There are many built-in functions in E. We've already seen a lot of string and list functions, and we've used 'WriteF' for printing. The remaining functions are, generally, simplifications of complex Amiga system functions, or E versions of support functions found in languages like C and Pascal.

To understand the graphics and Intuition support functions completely you really need to get something like the 'Rom Kernel Reference Manual (Libraries)'. However, if you don't want to do anything too complicated you can just about get by.

Input and output functions
Intuition support functions
Graphics functions
Maths and logic functions
System support functions

1.112 beginner.guide/Input and output functions

Input and output functions -----

'WriteF(String,PARAM1,PARAM2,...)'

Writes a string to the standard output. If place-holders are used in the string then the appropriate number of parameters must be supplied after the string in the order they are to be printed as part of the string. So far we've only met the '\d' place-holder for decimal numbers. The complete list is:

Place-Holder	Parameter Type	Prints

\c	Number	Character
\d	Number	Decimal number
\h	Number	Hexadecimal number
\s	String	String

So to print a string you use the '\s' place-holder in the string and supply the string (e.g., a 'PTR TO CHAR') as a parameter. Try the following program (remember '\a' prints an apostrophe character):

```
PROC main()
```

```

DEF s[30]:STRING
StrCopy(s, 'Hello world', ALL)
WriteF('The third element of s is "%c"\n', s[2])
WriteF('or %d (decimal)\n',          s[2])
WriteF('or %h (hexadecimal)\n',      s[2])
WriteF('and s itself is %a\s\n',     s)
ENDPROC

```

This is the output it generates:

```

The third element of s is "l"
or 108 (decimal)
or 6C (hexadecimal)
and s itself is 'Hello world'

```

You can control how the parameter is formatted in the `'\d'`, `'\h'` and `'\s'` fields using another collection of special character sequences before the place-holder and size specifiers after it. If no size is specified the field will be as big as the data requires. A fixed field size can be specified using `'[NUMBER]'` after the place-holder. For strings you can also use the size specifier `'(MIN,MAX)'` which specifies the minimum and maximum sizes of the field. By default the data is right justified in the field and the left part of the field is filled, if necessary, with spaces. The following sequences before the place-holder can change this:

Sequence	Meaning
<code>\l</code>	Left justify in field
<code>\r</code>	Right justify in field
<code>\z</code>	Set fill character to "0"

See how these formatting controls affect this example:

```

PROC main()
DEF s[30]:STRING
StrCopy(s, 'Hello world', ALL)
WriteF('The third element of s is "%c"\n', s[2])
WriteF('or %d[4] (decimal)\n',          s[2])
WriteF('or %z\h[4] (hexadecimal)\n',    s[2])
WriteF('%a\s[5]\a are the first five elements of s \n', s)
WriteF('and s in a very big field %a\s[20]\a\n', s)
WriteF('and s left justified in it %a\l\s[20]\a\n', s)
ENDPROC

```

Here's the output it should generate:

```

The third element of s is "l"
or 108 (decimal)
or 006C (hexadecimal)
'Hello' are the first five elements of s
and s in a very big field '          Hello world'
and s left justified in it 'Hello world'

```

`'WriteF'` uses the standard output, and this file handle is stored in the variables `'stdout'` and `'conout'`. If your program is started from Workbench both variables will contain `'NIL'`. In this case, the first

call to `'WriteF'` will open a special output window and put the file handle in these variables. Actually, `'WriteF'` checks whether `'stdout'` contains a file handle and uses that if it is not `'NIL'`, and the file handle in `'conout'` is the one that will be closed by E when the program finishes. You can, therefore, open your own window and store the file handle in `'stdout'` so that all output goes to this window. If `'conout'` was originally `'NIL'` you can put this file handle here, too, and E will close it for you when the program terminates. Otherwise, you have to close the window yourself when you've finished with it.

`'StringF(E-STRING,STRING,ARG1,ARG2,...)'`

The same as `'WriteF'` except that the result is written to E-STRING instead of being printed. For example, the following code fragment sets `'s'` to `'00123 is a'` (since the E-string is not long enough for the whole string):

```
DEF s[10]:STRING
StringF(s, '\z\d[5] is a number', 123)
```

`'Out(FILEHANDLE,CHAR)'`

Outputs a single character, CHAR, to the file or console window denoted by FILEHANDLE. For instance, FILEHANDLE could be `'stdout'`, in which case the character is written to the standard output. (You need to make sure `'stdout'` is not `'NIL'`, and you can do this by using a `'WriteF('')` call.)

`'Inp(FILEHANDLE)'`

Reads and returns a single character from FILEHANDLE. If -1 is returned then the end of the file (EOF) was reached, or there was an error.

`'ReadStr(FILEHANDLE,E-STRING)'`

Reads a whole string from FILEHANDLE and returns -1 if EOF was reached or an error occurred. Characters are read up to a linefeed or the size of the string, whichever is sooner. Therefore, the resulting string may be only a partial line. If -1 is returned then EOF was reached or an error occurred, and in either case the string so far is still valid. So, you still need to check the string even if -1 is returned. (This will most commonly happen with files that do not end with a linefeed.) The string will be empty (i.e., of zero length) if nothing more had been read from the file when the error or EOF happened.

This next little program reads continually from the `'stdout'` window until an error occurs or the user types `'quit'`. It echoes the lines that it reads in uppercase. If you type a line longer than ten characters you'll see it reads it in more than one go. Because of the way normal console windows work, you need to type a return before a line gets read by the program (but this allows you to edit the line before the program sees it). Notice the use of `'WriteF('')` to ensure that `'stdout'` is a console window, even if the program is started from Workbench.

```
PROC main()
  DEF s[10]:STRING
  WriteF('')
```



```

    WHILE ReadStr(stdout, s)<>-1
      UpperStr(s)
      IF StrCmp(s, 'QUIT', ALL) THEN JUMP end
      WriteF('Read: \a\s\a\n', s)
    ENDWHILE
  end:
  WriteF('Finished\n')
ENDPROC

```

'FileLength(String)'

Returns the length of the file named in STRING, or -1 if the file doesn't exist or an error occurred. Notice that you don't need to 'Open' the file or have a filehandle, you just supply the filename.

'SetStdOut(FILEHANDLE)'

Returns the value of 'stdout' before setting it to FILEHANDLE. Therefore, the following code fragments are equivalent:

```
oldstdout:=SetStdOut(newstdout)
```

```
oldstdout:=stdout
stdout:=newstdout
```

1.113 beginner.guide/Intuition support functions

Intuition support functions

The functions in this section are simplified versions of Amiga system functions (in the Intuition library, as the title suggests). To make best use of them you are probably going to need something like the 'Rom Kernel Reference Manual (Libraries)', especially if you want to understand the Amiga specific things like IDCMP and raster ports.

The descriptions given here vary slightly in style from the previous descriptions. All function parameters can be expressions which represent numbers or addresses, as appropriate. Because many of the functions take several parameters they have been named in (fairly descriptively) so they can be more easily referenced.

'OpenW(X,Y,WID,HGT,IDCMP,WFLGS,TITLE,SCRN,SFLGS,GADS)'

Opens and returns a pointer to a window with the supplied properties. If for some reason the window could not be opened 'NIL' is returned.

X, Y

The position on the screen where the window will appear.

WID, HGT

The width and height of the window.

IDCMP, WFLGS

The IDCMP and window specific flags.

TITLE

The window title (a string) which appears on the title bar of the window.

SCRN, SFLGS

The screen on which the window should open. If SFLGS is 1 the window will be opened on Workbench, and SCRAN is ignored (so it can be 'NIL'). If SFLGS is '\$F' (i.e., 15) the window will open on the custom screen pointed to by SCRAN (which must then be valid). See 'OpenS' to see how to open a custom screen and get a screen pointer.

GADS

A pointer to a gadget list, or 'NIL' if you don't want any gadgets. These are not the standard window gadgets, since they are specified using the window flags. A gadget list can be created using the 'Gadget' function.

There's not enough space to describe all the fine details about windows and IDCMP (see the 'Rom Kernel Reference Manual (Libraries)' for complete details), but a brief description in terms of flags might be useful. Here's a small table of common IDCMP flags:

IDCMP Flag	Value
-----	-----
IDCMP_NEWSIZE	\$2
IDCMP_MOUSEMOVE	\$10
IDCMP_GADGETDOWN	\$20
IDCMP_GADGETUP	\$40
IDCMP_MENUPICK	\$100
IDCMP_CLOSEWINDOW	\$200
IDCMP_RAWKEY	\$400
IDCMP_DISKINSERTED	\$8000
IDCMP_DISKREMOVED	\$10000

Here's a table of useful window flags:

Window Flag	Value
-----	-----
WFLG_SIZEGADGET	\$1
WFLG_DRAGBAR	\$2
WFLG_DEPTHGADGET	\$4
WFLG_CLOSEGADGET	\$8
WFLG_SIZEBRIGHT	\$10
WFLG_SIZEBBOTTOM	\$20
WFLG_SMART_REFRESH	0
WFLG_SIMPLE_REFRESH	\$40
WFLG_SUPER_BITMAP	\$80
WFLG_BACKDROP	\$100
WFLG_REPORTMOUSE	\$200
WFLG_GIMMEZEROZERO	\$400
WFLG_BORDERLESS	\$800
WFLG_ACTIVATE	\$1000

All these flags are defined in the module 'intuition/intuition', so if you use that module you can use the constants rather than having to write the less descriptive value (see Modules). Of course, you can always define your own constants for the values that you use.

You use the flags by 'OR'-ing the ones you want together, in similar way to using sets (see Sets). However, you should supply only IDCMP flags as part of the IDCMP parameter, and you should supply only window flags as part of the WFLGS parameter. So, to get IDCMP messages when a disk is inserted and when the close gadget is clicked you specify both of the flags 'IDCMP_DISKINSERTED' and 'IDCMP_CLOSEWINDOW' for the IDCMP parameter, either by 'OR'-ing the constants or (less readably) by using the calculated value '\$8200'.

Some of the window flags require some of IDCMP flags to be used as well, if an effect is to be complete. For example, if you want your window to have a close gadget (a standard window gadget) you need to use 'WFLG_CLOSEGADGET' as one of the window flags. If you want that gadget to be useful then you need to get an IDCMP message when the gadget is clicked. You therefore need to use 'IDCMP_CLOSEWINDOW' as one of the IDCMP flags. So the full effect requires both a window and an IDCMP flag (a gadget is pretty useless if you can't tell when it's been clicked). The worked example in Part Three illustrates how to use these flags in this way (see Gadgets).

If you only want to output text to a window (and maybe do some input from a window), it may be better to use a "console" window. These provide a text based input and output window, and are opened using the Dos library function 'Open' with the appropriate 'CON:' file name. See the 'AmigaDOS Manual' for more details about console windows.

'CloseW(WINPTR)'

Closes the window which is pointed to by WINPTR. It's safe to give 'NIL' for WINPTR, but in this case, of course, no window will be closed! The window pointer is usually a pointer returned by a matching call to 'OpenW'. You *must* remember to close any windows you may have opened before terminating your program.

'OpenS(WID,HGT,DEPTH,SCRNRES,TITLE)'

Opens and returns a pointer to a custom screen with the supplied properties. If for some reason the screen could not be opened 'NIL' is returned.

WID, HGT

The width and height of the screen.

DEPTH

The depth of the screen, i.e., the number of bit-planes. This can be a number in the range 1-8 for AGA machines, or 1-6 for pre-AGA machines. A screen with depth 3 will be able to show 2 to the power 3 (i.e., 8) different colours, since it will have 2 to the power 3 different pens (or colour registers) available. You set the colours of pens using the Amiga system function 'SetRGB32' for AGA machines or 'SetRGB4' for pre-AGA machines. See the 'Rom Kernel Reference Manual (Libraries)' for more details.

SCRNRES

The screen resolution flags.

TITLE

The screen title (a string) which appears on the title bar of the screen.

The screen resolution flags control the screen mode. The following (common) values are taken from the module 'graphics/view' (see Modules). You can, if you want, define your own constants for the values that you use. Either way it's best to use descriptive constants rather than directly using the values.

Mode Flag	Value
-----	-----
V_LACE	\$4
V_SUPERHIRES	\$20
V_PFBA	\$40
V_EXTRA_HALFBRITE	\$80
V_DUALPF	\$400
V_HAM	\$800
V_HIRES	\$8000

So, to get a hires, interlaced screen you specify both of the flags 'V_HIRES' and 'V_LACE', either by 'OR'-ing the constants or (less readably) by using calculated value '\$8004'. There is a worked example using this function in Part Three (see Screens).

`'CloseS(SCRNPTR)'`

Closes the screen which is pointed to by SCRNPTR. It's safe to give 'NIL' for SCRNPTR, but in this case, of course, no screen will be closed! The screen pointer is usually a pointer returned by a matching call to 'OpenS'. You *must* remember to close any screens you may have opened before terminating your program. Also, you *must* close all windows that you opened on your screen before you can close the screen.

`'Gadget(BUF, GLIST, ID, FLAGS, X, Y, WIDTH, TEXT)'`

Creates a new gadget with the supplied properties and returns a pointer to the next position in the (memory) buffer which can be used for a gadget.

BUF

This is the memory buffer, i.e., a chunk of allocated memory. The best way of allocating this memory is to declare an array of size 'N*GADGETSIZE', where N is the number of gadgets which are going to be created. The first call to 'Gadget' will use the array as the buffer, and subsequent calls use the result of the previous call as the buffer (since this function returns the next free position in the buffer).

GLIST

This is a pointer to the gadget list that is being created, i.e., the array used as the buffer. When you create the first gadget in the list using an array 'a', this parameter should be 'NIL'. For all other gadgets in the list this parameter should be the array 'a'.

ID

A number which identifies the gadget. It is best to give a unique number for each gadget, that way you can easily identify

them. This number is the only way you can identify which gadget has been clicked.

FLAGS

The type of gadget to be created. Zero represents a normal gadget, one a boolean gadget (a toggle) and three a boolean that starts selected.

X, Y

The position of the gadget, relative to the top, left-hand corner of the window.

WIDTH

The width of the gadget (in pixels, not characters).

TEXT

The text (a string) which will be centred in the gadget, so the WIDTH must be big enough to hold this text.

Once a gadget list has been created by possibly several calls to this function the list can be passed as the GADS parameter to 'OpenW'. There is a worked example using this function in Part Three (see Gadgets).

'Mouse()'

Returns the state of the mouse buttons (including the middle mouse button if you have a three-button mouse). This is a set of flags, and the individual flag values are:

Button Pressed	Value
-----	-----
Left	%001
Middle	%010
Right	%100

So, if this function returns '%001' you know the left button is being pressed, and if it returns '%110' you know the middle and right buttons are both being pressed.

'MouseX(WINPTR)'

Returns the X coordinate of the mouse pointer, relative to the window pointed to by WINPTR.

'MouseY(WINPTR)'

Returns the Y coordinate of the mouse pointer, relative to the window pointed to by WINPTR.

The three mouse functions are not strictly the proper way to do things. It is suggested you use these functions only for small tests or demo-like programs. The proper way of getting mouse details is to use the appropriate IDCMP flags for your window, wait for events and decode the information.

'WaitIMessage(WINPTR)'

This function waits for a message from Intuition for the window pointed to by WINPTR and returns the class of the message (which is an IDCMP flag). If you did not specify any IDCMP flags when the

window was opened, or the specified messages could never happen (e.g., you asked only for gadget messages and you have no gadgets), then this function may wait forever. When you've got a message you can use the 'MsgXXX' functions to get some more information about the message. See the 'Rom Kernel Reference Manual (Libraries)' for more details on Intuition and IDCMP. There is a worked example using this function in Part Three (see IDCMP Messages).

This function is basically equivalent to the following function, except that the 'MsgXXX' functions can also access the message data held in the variables 'code', 'qual' and 'iaddr'.

```
PROC waitmessage(win:PTR TO window)
  DEF port,msg:PTR TO intuimessage,class,code,qual,iaddr
  port:=win.userport
  IF (msg:=GetMsg(port))=NIL
    REPEAT
      WaitPort(port)
    UNTIL (msg:=GetMsg(port))<>NIL
  ENDIF
  class:=msg.class
  code:=msg.code
  qual:=msg.qualifier
  iaddr:=msg.iaddress
  ReplyMsg(msg)
ENDPROC class
```

'MsgCode()'

Returns the 'code' part of the message returned by 'WaitIMessage'.

'MsgIaddr()'

Returns the 'iaddr' part of the message returned by 'WaitIMessage'. There is a worked example using this function in Part Three (see IDCMP Messages).

'MsgQualifier()'

Returns the 'qual' part of the message returned by 'WaitIMessage'.

1.114 beginner.guide/Graphics functions

Graphics functions

The functions in this section use the standard raster port, the address of which is held in the variable 'stdrast'. Most of the time you don't need to worry about this because the E functions which open windows and screens set up this variable (see Intuition support functions). So, by default, these functions affect the last window or screen opened. When you close a window or screen, 'stdrast' becomes 'NIL' and calls to these functions have no effect. There is a worked example using these functions in Part Three (see Graphics).

The descriptions in this section follow the same style as the previous section.

`'Plot(X,Y,PEN)'`

Plots a single point (X,Y) in the specified pen colour. The position is relative to the top, left-hand corner of the window or screen that is the current raster port (normally the last screen or window to be opened). The range of pen values available depend on the screen setup, but are at best 0-255 on AGA machines and 0-31 on pre-AGA machines. As a guide, the background colour is usually pen zero, and the main foreground colour is pen one. You set the colours of pens using the Amiga system function `'SetRGB32'` for AGA machines or `'SetRGB4'` for pre-AGA machines. See the `'Rom Kernel Reference Manual (Libraries)'` for more details.

`'Line(X1,Y1,X2,Y2,PEN)'`

Draws the line (X1,Y1) to (X2,Y2) in the specified pen colour.

`'Box(X1,Y1,X2,Y2,PEN)'`

Draws the (filled) box with vertices (X1,Y1), (X2,Y1), (X1,Y2) and (X2,Y2) in the specified pen colour.

`'Colour(FORE-PEN,BACK-PEN)'`

Sets the foreground and background pen colours. As mentioned above, the background colour is normally pen zero and the main foreground is pen one. You can change these defaults with this function.

`'TextF(X,Y,FORMAT-STRING,ARG1,ARG2,...)'`

This works just like `'WriteF'` except the resulting string is written starting at point (X,Y). Also, don't use any line-feed, carriage return, tab or escape characters in the string--they don't behave like they do in `'WriteF'`.

`'SetStdRast(NEWRAST)'`

Returns the value of `'stdrast'` before setting it to the new value. The following code fragments are equivalent:

```
oldstdrast:=SetStdRast(newstdrast)
```

```
oldstdrast:=stdrast
stdrast:=newstdrast
```

`'SetTopaz(SIZE)'`

Sets the text font for the current raster port to Topaz at the specified size.

1.115 beginner.guide/Maths and logic functions

Maths and logic functions

We've already seen the standard arithmetic operators. The addition, `'+'`, and subtraction, `'-'`, operators use full 32-bit integers, but, for efficiency, multiplication, `'*'`, and division, `'/'`, use restricted values. You can only use `'*'` to multiply 16-bit integers, and the result will be a 32-bit integer. Similarly, you can only use `'/'` to divide a 32-bit

integer by a 16-bit integer, and the result will be a 16-bit integer. The restrictions do not affect most calculations, but if you really need to use all 32-bit integers (and you can cope with overflows etc.) you can use the 'Mul' and 'Div' functions. 'Mul(a,b)' corresponds to 'a*b', and 'Div(a,b)' corresponds to 'a/b'.

We've also met the logic operators 'AND' and 'OR', which we know are really bit-wise operators. You can also use the functions 'And' and 'Or' to do exactly the same as 'AND' and 'OR' (respectively). So, for instance, 'And(a,b)' is the same as 'a AND b'. The reason for these functions is because there are 'Not' and 'Eor' (bit-wise) functions, too (and there aren't operators for these). 'Not(a)' swaps one and zero bits, so, for instance, 'Not(TRUE)' is 'FALSE' and 'Not(FALSE)' is 'TRUE'. 'Eor(a,b)' is the exclusive version of 'Or' and does almost the same, except that 'Eor(1,1)' is 0 whereas 'Or(1,1)' is 1 (and this extends to all the bits). So, basically, 'Eor' tells you which bits are different, or, logically, if the truth values are different. Therefore, 'Eor(TRUE,TRUE)' is 'FALSE' and 'Eor(TRUE,FALSE)' is 'TRUE'.

There's a collection of other functions related to maths, logic or numbers in general:

'Abs(EXPRESSION)'

Returns the absolute value of EXPRESSION. The absolute value of a number is that number made positive if necessary. So, 'Abs(9)' is 9, and 'Abs(-9)' is also 9.

'Even(EXPRESSION)'

Returns 'TRUE' if EXPRESSION represents an even number, and 'FALSE' otherwise. Obviously, a number is either odd or even!

'Odd(EXPRESSION)'

Returns 'TRUE' if EXPRESSION represents an odd number, and 'FALSE' otherwise.

'Mod(EXP1,EXP2)'

Returns the 16-bit remainder (or modulus) of the division of the 32-bit EXP1 by the 16-bit EXP2. For example, 'Mod(26,7)' is 5 (since $26 = (7 \times 3) + 5$).

'Rnd(EXPRESSION)'

Returns a random number in the range 0 to (n-1), where EXPRESSION represents the value n. These numbers are pseudo-random, so although you appear to get a random value from each call, the sequence of numbers you get will probably be the same each time you run your program. Before you use 'Rnd' for the first time in your program you should call it with a negative number. This decides the starting point for the pseudo-random numbers.

'RndQ(EXPRESSION)'

Returns a random 32-bit value, based on the seed EXPRESSION. This function is quicker than 'Rnd', but returns values in the 32-bit range, not a specified range. The seed value is used to select different sequences of pseudo-random numbers, and the first call to 'RndQ' should use a large value for the seed.

'Shl(EXP1,EXP2)'

Returns the value represented by EXP1 shifted EXP2 bits to the left. For example, `'Shl(%0001110,2)'` is `'%0111000'` and `'Shl(%0001011,3)'` is `'%1011000'`. Shifting a number one bit to the left is generally the same as multiplying it by two (although this isn't true when you shift large positive or large negative values).

`'Shr(EXP1,EXP2)'`

Returns the value represented by EXP1 shifted EXP2 bits to the right. For example, `'Shr(%0001110,2)'` is `'%0000011'` and `'Shr(%1011010,3)'` is `'%0001011'`. Shifting a number one bit to the right is generally the same as dividing it by two.

`'Long(ADDR), Int(ADDR), Char(ADDR)'`

Returns the 'LONG', 'INT' or 'CHAR' value at the address ADDR. These functions should be used only when setting up a pointer and dereferencing it in the normal way would make your program cluttered and less readable. Use of functions like these is often called "peeking" memory (especially in dialects of the BASIC language).

`'PutLong(ADDR,EXP), PutInt(ADDR,EXP), PutChar(ADDR,EXP)'`

Writes the 'LONG', 'INT' or 'CHAR' value represented by EXP to the address ADDR. Again, these functions should be used only when really necessary. Use of functions like these is often called "poking" memory.

1.116 beginner.guide/System support functions

System support functions

`'New(EXPRESSION)'`

Returns a pointer to a newly allocated chunk of memory, which is EXPRESSION number of bytes. If the memory could not be allocated 'NIL' is returned. The memory is initialised to zero in each byte, and taken from any available store (Fast or Chip memory, in that order of preference). When you've finished with this memory you can use 'Dispose' to free it for use elsewhere in your program. You don't have to 'Dispose' with memory you allocated with 'New' because your program will automatically free it when it terminates. This is **not** true for memory allocated using the normal Amiga system routines.

`'Dispose(ADDRESS)'`

Used to free memory allocated with 'New'.

`'DisposeLink(COMPLEX)'`

Used to free the memory allocated 'String' (see String functions) and 'List' (see List functions). Again, you should rarely need to use this function because the memory is automatically freed when the program terminates.

`'CleanUp(EXPRESSION)'`

Terminates the program at this point, and does the normal things an E program does when it finishes. The value denoted by EXPRESSION is

returned as the error code for the program. It is the replacement for the AmigaDOS 'Exit' routine which should **never** be used in an E program. This is the only safe way of terminating a program, other than reaching the (logical) end of the 'main' procedure (which is by far the most common way!).

'CtrlC()'

Returns 'TRUE' if control-C has been pressed since the last call, and 'FALSE' otherwise. This is only sensible for programs started from the Shell/CLI.

'FreeStack()'

Returns the current amount of free stack space for the program. Only complicated programs need worry about things like stack. Recursion is the main thing that eats a lot of stack space.

'KickVersion(EXPRESSION)'

Returns 'TRUE' if your Kickstart revision is at least that given by EXPRESSION, and 'FALSE' otherwise. For instance, 'KickVersion(37)' checks whether you're running with Kickstart version 37 or greater (i.e., AmigaDOS 2.04 and above).

1.117 beginner.guide/Modules

Modules

A "module" is the E equivalent of a C header file and an Assembly include file. It can contain various object and constant definitions, and also library function offsets and library base variables. This information is necessary for the correct use of a library.

Using Modules

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Using Modules

=====

To use the definitions in a particular module you use the 'MODULE' statement at the beginning of your program (before the first procedure definition). You follow the 'MODULE' keyword by a comma-separated list of strings, each of which is the filename (or path if necessary) of a module without the '.m' extension (every module file ends with '.m'). The filenames (and paths) are all

relative to the logical volume 'Emodules:', which is set-up using an 'assign' as described in the 'Reference Manual'. For instance, the statement:

```
MODULE 'fred', 'dir/barney'
```

will try to load the files 'Emodules:fred.m' and 'Emodules:dir/barney.m'. If it can't find these files or they aren't proper modules the E compiler will complain.

All the definitions in the modules included in this way are available to every procedure in the program. To see what a module contains you can use the 'showmodule' program that comes with the Amiga E distribution.

1.119 beginner.guide/Amiga System Modules

Amiga System Modules

=====

Amiga E comes with the standard Amiga system include files as E modules. The AmigaDOS 2.04 modules are supplied with E version 2.1, and the AmigaDOS 3.0 modules are supplied with E version 3.0. However, modules are much more useful in E version 3.0 (see Code Modules). If you want to use any of the standard Amiga libraries properly you will need to investigate the modules for that library. The top-level '.m' files in 'Emodules:' contain the library function offsets, and those in directories in 'Emodules:' contain constant and object definitions for the appropriate library. For instance, the module 'asl' (i.e., the file 'Emodules:asl.m') contains the ASL library function offsets and 'libraries/asl' contains the ASL library constants and objects.

If you are going to use, say, the ASL library then you need to open the library using the 'OpenLibrary' function (an Amiga system function) before you can use any of the library functions. You also need to define the library function offsets by using the 'MODULE' statement. However, the DOS, Exec, Graphics and Intuition libraries don't need to be opened and their function offsets are built in to E. That's why you won't find, for example, a 'dos.m' file in 'Emodules:'. The constants and objects for these libraries still need to be included via modules (they are not built in to E).

1.120 beginner.guide/Non-Standard Modules

Non-Standard Modules

=====

Several non-standard library modules are also supplied with Amiga E. To make your own modules you need the 'pragma2module' and 'iconvert' programs. These convert standard format C header files and Assembly include files to modules. The C header file should contain pragmas for function offsets,

and the Assembly include file should contain constant and structure definitions (the Assembly structures will be converted to objects). However, unless you're trying to do really advanced things you probably don't need to worry about any of this!

1.121 beginner.guide/Example Module Use

Example Module Use
=====

The gadget example program in Part Three shows how to use constants from the module 'intuition/intuition' (see Gadgets), and the IDCMP example program shows the object 'gadget' from that module being used (see IDCMP Messages). The following program uses the modules for the Reqtools library, which is not a standard Amiga system library but a commonly used one, and the appropriate modules are supplied with Amiga E. To run this program, you will, of course, need the 'reqtools.library' in 'Libs:'.

```
MODULE 'reqtools'

PROC main()
  DEF col
  IF (reqtoolsbase:=OpenLibrary('reqtools.library',37))<>NIL
    IF (col:=RtPaletteRequestA('Select a colour', 0,0))<>-1
      RtEZRequestA('You picked colour \'d',
                  'I did|I can\'at remember',0,[col],0)
    ENDIF
    CloseLibrary(reqtoolsbase)
  ELSE
    WriteF('Could not open reqtools.library, version 37+\n')
  ENDIF
ENDPROC
```

The 'reqtoolsbase' variable is the library base variable for the Reqtools library. This is defined in the module 'reqtools' and you *must* store the result of the 'OpenLibrary' call in this variable if you are going to use any of the functions from the Reqtools library. (You can find out which variable to use for other libraries by running the 'showmodule' program on the library module for the library.) The two functions the program uses are 'RtPaletteRequestA' and 'RtEZRequestA'. Without the inclusion of the 'reqtools' module and the setting up of the 'reqtoolsbase' variable you would not be able to use these functions. In fact, if you didn't have the 'MODULE' line you wouldn't even be able to compile the program because the compiler wouldn't know where the functions came from and would complain bitterly.

Notice that the Reqtools library is closed before the program terminates (if it had been successfully opened). This is always necessary: if you succeed in opening a library you *must* close it when you're finished with it.

1.122 beginner.guide/Code Modules

Code Modules

=====

You can also make modules containing procedure definitions and some global variables. These can be extremely useful. This section briefly outlines their construction and use. For in-depth details see the 'Reference Manual'.

Code modules can be made by using the E compiler as you would to make an executable, except you put the statement 'OPT MODULE' at the start of the code. Also, all definitions that are to be accessed from outside the module need to be marked with the 'EXPORT' keyword. Alternatively, all definitions can be exported using 'OPT EXPORT' at the start of the code. You include the definitions from this module (and use the exported ones) in your program using 'MODULE' in the normal way.

The following code is an example of a small module:

```
OPT MODULE

EXPORT CONST MAX_LEN=20

EXPORT OBJECT fullname
    firstname, surname
ENDOBJECT

EXPORT PROC printname(p:PTR TO fullname)
    IF short(p.surname)
        WriteF('Hello, \s \s\n', p.firstname, p.surname)
    ELSE
        WriteF('Gosh, you have a long name\n')
    ENDIF
ENDPROC

PROC short(s)
    RETURN StrLen(s)<MAX_LEN
ENDPROC
```

Everything is exported except the 'short' procedure. Therefore, this can be accessed only in the module. In fact, the 'printname' procedure uses it (rather artificially) to check the length of the 'surname'. It's not of much use or interest apart from in the module, so that's why it isn't exported. In effect, we've hidden the fact that 'printname' uses 'short' from the user of the module.

Assuming the above code was compiled to module 'mymods/name', here's how it could be used:

```
MODULE 'mymods/name'

PROC main()
    DEF fred:fullname, bigname:PTR TO fullname
    fred.firstname:='Fred'
    fred.surname:='Flintstone'
```

```

    printname(fred)
    bigname:=['Peter', 'Extremelybiglongprehistoricname']:fullname
    printname(bigname)
ENDPROC

```

Global variables in a module are a bit more problematic than the other kinds of definitions. You cannot initialise them in the declaration or make them reserve chunks memory. So you can't have 'ARRAY', 'OBJECT', 'STRING' or 'LIST' declarations. However, you can have pointers so this isn't a big problem. The reason for this limitation is that exported global variables with the same name in a module and the main program are taken to be the same variable, and the values are shared. So you can have an array declaration in the main program:

```
DEF a[80]:ARRAY OF INT
```

and the appropriate pointer declaration in the module:

```
EXPORT DEF a:PTR TO INT
```

The array from the main program can then be accessed in the module! For this reason you also need to be pretty careful about the names of your exported variables so you don't get unwanted sharing. Global variables which are not exported are private to the module, so will not clash with variables in the main program or other modules.

1.123 beginner.guide/Exception Handling

Exception Handling

Often your program has to check the results of functions and do different things if errors have occurred. For instance, if you try to open a window (using 'OpenW'), you may get a 'NIL' pointer returned which shows that the window could not be opened for some reason. In this case you normally can't continue with the program, so you must tidy up and terminate. Tidying up can sometimes involve closing windows, screens and libraries, so sometimes your error cases can make your program cluttered and messy. This is where exceptions come in--an "exception" is simply an error case, and exception handling is dealing with error cases. The exception handling in E neatly separates error specific code from the real code of your program.

```

Procedures with Exception Handlers
Raising an Exception
Automatic Exceptions
Raise within an Exception Handler

```

1.124 beginner.guide/Procedures with Exception Handlers

Procedures with Exception Handlers

=====

A procedure with an exception handler looks like this:

```
PROC fred(params...) HANDLE
  /* Main, real code */
EXCEPT
  /* Error handling code */
ENDPROC
```

This is very similar to a normal procedure, apart from the 'HANDLE' and 'EXCEPT' keywords. The 'HANDLE' keyword means the procedure is going to have an exception handler, and the 'EXCEPT' keyword marks the end of the normal code and the start of the exception handling code. The procedure works just as normal, executing the code in the part before the 'EXCEPT', but when an error happens you can pass control to the exception handler (i.e., the code after the 'EXCEPT' is executed).

1.125 beginner.guide/Raising an Exception

Raising an Exception

=====

When an error occurs (and you want to handle it), you "raise" an exception using the 'Raise' function. You call this function with a number which identifies the kind of error that occurred. The code in the exception handler is responsible for decoding the number and then doing the appropriate thing.

When 'Raise' is called it immediately stops the execution of the current procedure code and passes control to the exception handler of most recent procedure which has a handler (which may be the current procedure). This is a bit complicated, but you can stick to raising exceptions and handling them in the same procedure, as in the next example:

```
CONST BIG_AMOUNT = 100000

ENUM ERR_MEM

PROC main() HANDLE
  DEF block
  block:=New(BIG_AMOUNT)
  IF block=NIL THEN Raise(ERR_MEM)
  WriteF('Got enough memory\n')
EXCEPT
  IF exception=ERR_MEM
    WriteF('Not enough memory\n')
  ELSE
    WriteF('Unknown exception\n')
  ENDIF
ENDPROC
```

This uses an exception handler to print a message saying there wasn't enough memory if the call to 'New' returns 'NIL'. The parameter to 'Raise' is stored in the special variable 'exception' in the exception handler part of the code, so if 'Raise' is called with a number other than 'ERR_MEM' a message saying "Unknown exception" will be printed.

Try running this program with a really large 'BIG_AMOUNT' constant, so that the 'New' can't allocate the memory. Notice that the "Got enough memory" is not printed if 'Raise' is called. That's because the execution of the normal procedure code stops when 'Raise' is called, and control passes to the appropriate exception handler. When the end of the exception handler is reached the procedure is finished, and in this case the program terminates because the procedure was the 'main' procedure.

An enumeration (using 'ENUM') is a good way of getting different constants for various exceptions. It's always a good idea to use constants for the parameter to 'Raise' and in the exception handler, because it makes everything a lot more readable: 'Raise(ERR_MEM)' is much clearer than 'Raise(0)'.

So, what happens if you call 'Raise' in a procedure without an exception handler? Well, this is where the real power of the handling mechanism comes to light. In this case, control passes to the exception handler of the most "recent" procedure with a handler. If none are found then the program terminates. "Recent" means one of the procedures involved in calling your procedure. So, if the procedure 'fred' calls 'barney', then when 'barney' is being executed 'fred' is a recent procedure. Because the 'main' procedure is where the program starts it is a recent procedure for every other procedure in the program. This means, in practice:

- * If you define 'fred' to be a procedure with an exception handler then any procedures called by 'fred' will have their exceptions handled by the handler in 'fred' if they don't have their own handler.
- * If you define 'main' to be a procedure with an exception handler then any exceptions that are raised will always be dealt with by some exception handling code (i.e., the handler of 'main' or some other procedure).

Here's a more complicated example:

```
ENUM FRED, BARNEY

PROC main()
  WriteF('Hello from main\n')
  fred()
  barney()
  WriteF('Goodbye from main\n')
ENDPROC

PROC fred() HANDLE
  WriteF(' Hello from fred\n')
  Raise(FRED)
  WriteF(' Goodbye from fred\n')
EXCEPT
  WriteF(' Handler fred: \d\n', exception)
```

```

ENDPROC

PROC barney()
  WriteF(' Hello from barney\n')
  Raise(BARNEY)
  WriteF(' Goodbye from barney\n')
ENDPROC

```

When you run this program you get the following output:

```

Hello from main
Hello from fred
Handler fred: 0
Hello from barney

```

This is because the 'fred' procedure is terminated by the 'Raise(FRED)' call, and the whole program is terminated by the 'Raise(BARNEY)' call (since 'barney' and 'main' do not have handlers).

Now try this:

```

ENUM FRED, BARNEY

PROC main()
  WriteF('Hello from main\n')
  fred()
  WriteF('Goodbye from main\n')
ENDPROC

PROC fred() HANDLE
  WriteF(' Hello from fred\n')
  barney()
  Raise(FRED)
  WriteF(' Goodbye from fred\n')
EXCEPT
  WriteF(' Handler fred: \d\n', exception)
ENDPROC

PROC barney()
  WriteF(' Hello from barney\n')
  Raise(BARNEY)
  WriteF(' Goodbye from barney\n')
ENDPROC

```

When you run this you get the following output:

```

Hello from main
Hello from fred
Hello from barney
Handler fred: 1
Goodbye from main

```

Now the 'fred' procedure calls 'barney', so 'main' and 'fred' are recent procedures when 'Raise(BARNEY)' is executed, and therefore the 'fred' exception handler is called. When this handler finishes the call to 'fred' in 'main' is finished, so the 'main' procedure is completed and we see the 'Goodbye' message. In the previous program the 'Raise(BARNEY)'

call did not get handled and the whole program terminated at that point.

1.126 beginner.guide/Automatic Exceptions

Automatic Exceptions
=====

In the previous section we saw any example of raising an exception when a call to 'New' returned 'NIL'. We can re-write this example to use "automatic" exception raising:

```
CONST BIG_AMOUNT = 100000

ENUM ERR_MEM

RAISE ERR_MEM IF New()=NIL

PROC main() HANDLE
  DEF block
  block:=New(BIG_AMOUNT)
  WriteF('Got enough memory\n')
EXCEPT
  IF exception=ERR_MEM
    WriteF('Not enough memory\n')
  ELSE
    WriteF('Unknown exception\n')
  ENDIF
ENDPROC
```

The only difference is the removal of the 'IF' which checked the value of 'block', and the addition of a 'RAISE' part. This 'RAISE' part means that whenever the 'New' function is called in the program, the exception 'ERR_MEM' will be raised if it returns 'NIL' (i.e., the exception 'ERR_MEM' is automatically raised). This unclutters the program by removing a lot of error checking 'IF' statements.

The precise form of the 'RAISE' part is:

```
RAISE EXCEPTION IF FUNCTION() COMPARE VALUE ,
  EXCEPTION2 IF FUNCTION2() COMPARE2 VALUE2 ,
  ...
```

The EXCEPTION is a constant (or number) which represents the exception to be raised, FUNCTION is the E built-in or system function to be automatically checked, VALUE is the return value to be checked against, and COMPARE is the method of checking (i.e., '=', '<>', '<', '<=', '>' or '>='). This mechanism only exists for built-in or library functions because they would otherwise have no way of raising exceptions. The procedures you define yourself can, of course, use 'Raise' to raise exceptions in a much more flexible way.

1.127 beginner.guide/Raise within an Exception Handler

'Raise' within an Exception Handler

=====

If you call 'Raise' within an exception handler then control passes to the next most recent handler. In this way you can write procedures which have handlers that perform local tidying up. By using 'Raise' at the end of the handler code you can invoke the next layer of tidying up.

As an example we'll use the Amiga system functions 'AllocMem' and 'FreeMem' which are like the built-in function 'New' and 'Dispose', but the memory allocated by 'AllocMem' *must* be deallocated (using 'FreeMem') when it's finished with, before the end of the program.

```
CONST SMALL=100, BIG=123456789

ENUM ERR_MEM

RAISE ERR_MEM IF AllocMem()=NIL

PROC main()
  allocate()
ENDPROC

PROC allocate() HANDLE
  DEF mem=NIL
  mem:=AllocMem(SMALL, 0)
  morealloc()
  FreeMem(mem, SMALL)
EXCEPT
  IF mem THEN FreeMem(mem, SMALL)
  WriteF('Handler: deallocating "allocate" local memory\n')
ENDPROC

PROC morealloc() HANDLE
  DEF more=NIL, andmore=NIL
  more:=AllocMem(SMALL, 0)
  andmore:=AllocMem(BIG, 0)
  WriteF('Allocated all the memory!\n')
  FreeMem(andmore, BIG)
  FreeMem(more, SMALL)
EXCEPT
  IF andmore THEN FreeMem(andmore, BIG)
  IF more THEN FreeMem(more, SMALL)
  WriteF('Handler: deallocating "morealloc" local memory\n')
  Raise(ERR_MEM)
ENDPROC
```

The calls to 'AllocMem' are automatically checked, and if 'NIL' is returned the exception 'ERR_MEM' is raised. The handler in the 'allocate' procedure checks to see if it needs to free the memory pointed to by 'mem', and the handler in the 'morealloc' checks 'andmore' and 'more'. At the end of the 'morealloc' handler is the call 'Raise(ERR_MEM)'. This passes control to the exception handler of the 'allocate' procedure, since 'allocate' called 'morealloc'.

There's a couple of subtle points to notice about this example. Firstly, the memory variables are all initialised to 'NIL'. This is because the automatic exception raising on 'AllocMem' will result in the variables not being assigned if the call returns 'NIL' (i.e., the exception is raised before the assignment takes place). Of course, if 'AllocMem' does not return 'NIL' the assignments work as normal.

Secondly, the 'IF' statements in the handlers check the memory pointer variables do not contain 'NIL' by using their values as truth values. Since 'NIL' is actually zero, a non-'NIL' pointer will be non-zero, i.e., true in the 'IF' check. This shorthand is often used, and so you should be aware of it.

There is an example, in Part Three, of how to use an exception handler to make a program more readable (see Screens). There are a number of other features of E's exception handling mechanism that are not discussed here (such as 'Throw'). See the 'Reference Manual' for more in-depth details.

1.128 beginner.guide/Floating-Point Numbers

Floating-Point Numbers

"Floating-point" or "real" numbers can be used to represent very small fractions and very large numbers. However, unlike a 'LONG' which can hold every integer in a certain range (see Variable types), floating-point numbers have limited "accuracy". Using floating-point arithmetic in E is quite complicated, so you may wish to skip this chapter until you really need to use them.

Floating-Point Values
 Floating-Point Calculations
 Floating-Point Functions
 Accuracy and Range

1.129 beginner.guide/Floating-Point Values

Floating-Point Values

=====

Floating-point values in E are written just like you might expect and are stored in 'LONG' variables:

```
DEF x
x:=3.75
x:=-0.0000367
x:=275.0
```

You must remember to use a decimal point (without any spaces around it) in the number if you want it to be considered a floating-point number. At present you can't express every floating-point value in this way; the compiler may complain that the value does not fit in 32-bits if you try to use more than about nine digits in a single number. You can, of course, use the various floating-point maths functions (see Floating-Point Functions) to calculate any value you want.

1.130 beginner.guide/Floating-Point Calculations

Floating-Point Calculations

=====

Since a floating-point number is stored in a 'LONG' variable it would normally be interpreted as an integer, and this interpretation will generally not give a number anything like the intended floating-point number. To use floating-point numbers in expressions you must use the (rather complicated) floating-point conversion operator, which is the '!' character. This converts expressions and the normal maths and comparison operators to and from floating-point.

All expressions are, by default, integer expressions. That is, they represent 'LONG' values, rather than floating-point values. The first time a '!' occurs in an expression the value of the expression so far is converted to floating-point and all the operators and variables after this point are considered floating-point. The next time it occurs the (floating-point) value of the expression so far is converted to an integer, and the following operators and variables become are considered integer again. You can use '!' as often as necessary within an expression. Parts of an expression in parentheses are treated as separate expressions, so are, by default, integer expressions (this, of course, includes function call arguments).

The integer/floating-point conversions are not simple. They involve rounding and bounding, and conversion, for example, from integer to floating-point and back again will generally not result in the original integer value.

Here's a few commented examples, where 'f' always holds a floating-point number, and 'i' and 'j' always hold integers:

```
DEF f, i, j
i:=1
f:=i! -> i converted to floating-point (1.0)
f:=6.2
i:=!f! -> the expression f is floating-point,
        -> then converted to integer (6)
f:=!f*f -> the whole expression is floating-point,
        -> and f is squared (6.2*6.2)
f:=!f*(i!) -> the whole expression is floating-point,
            -> i is converted to floating-point and
            -> multiplied by f
j:=!f/(i!)! -> the whole division is floating-point,
```

```

        -> with the result converted to integer
j:=!f!/i -> floating-point f is converted to integer
        -> and is (integer) divided by i
IF !f<230.0 THEN RETURN 0 -> floating-point comparison <
IF !f>(i!) THEN RETURN 0 -> i converted to floating-point,
        -> then compared to f

```

The last two assignments to 'j' do roughly the same thing, although the first allows for greater accuracy since it uses floating-point division and will round the result (rather than truncating the fraction like the integer division would).

1.131 beginner.guide/Floating-Point Functions

Floating-Point Functions
=====

There are a number of built-in, floating-point functions which compute some of the less common mathematical functions, such as the various trigonometric functions. There are also functions for formatting floating-point numbers to E-strings (so that they can be printed) and for decoding floating-point numbers from strings. See the 'Reference Manual' for more details about these and other functions.

1.132 beginner.guide/Accuracy and Range

Accuracy and Range
=====

A floating-point number is just another 32-bit value, so can be stored in 'LONG' variables. It's just the interpretation of the 32-bits which makes them different. A floating-point number can range from numbers as small as 1.3E-38 to numbers as large as 3.4E+38 (that's very small and very large if you don't understand the scientific notation!). However, not every number in this range can "accurately" be represented, since the number of significant digits is roughly eight.

Accuracy is an important consideration when trying to compare two floating-point numbers and when combining floating-point values after dividing them. It is usually best to check that a floating-point value is in a small range of values, rather than just a particular value. And when combining values, allow for a small amount of error due to rounding etc. See the 'Reference Manual' for more details about the implementation of floating-point numbers.

1.133 beginner.guide/Recursion

Recursion

A "recursive" function is very much like a function which uses a loop. Basically, a "recursive" function calls itself (usually after some manipulation of data) rather than iterating a bit of code using a loop. There are also recursive types, which are objects with elements which have the object type (in E these would be pointers to objects). We've already seen a recursive type: linked lists, where each element in the list contains a pointer to the next element (see Linked Lists).

Recursive definitions are normally much more understandable than an equivalent iterative definition, and it's usually easier to use recursive functions to manipulate this data from a recursive type. However, recursion is by no means a simple topic. Read on at your own peril!

Factorial Example
Mutual Recursion
Binary Trees
Stack (and Crashing)
Stack and Exceptions

1.134 beginner.guide/Factorial Example

Factorial Example

=====

The normal example for a recursive definition is the factorial function, so let's not be different. In school mathematics the symbol ' $!$ ' is used after a number to denote the factorial of that number (and only positive integers have factorials). $n!$ is n -factorial, which is defined as follows:

$$n! = n * (n-1) * (n-2) * \dots * 1 \quad (\text{for } n \geq 1)$$

So, $4!$ is $4*3*2*1$, which is 24. And, $5!$ is $5*4*3*2*1$, which is 120.

Here's the iterative definition of a factorial function (we'll 'Raise' an exception if the number is not positive, but you can safely leave this check out if you are sure the function will be called only with positive numbers):

```
PROC fact_iter(n)
  DEF i, result=1
  IF n<=0 THEN Raise("FACT")
  FOR i:=1 TO n
    result:=result*i
  ENDFOR
ENDPROC result
```

We've used a 'FOR' loop to generate the numbers one to 'n' (the parameter to the 'fact_iter'), and 'result' holds the intermediate and final results.

The final result is returned, so check that `'fact_iter(4)'` returns 24 and `'fact_iter(5)'` returns 120 using a `'main'` procedure something like this:

```
PROC main()
  WriteF('4! is \d\n5! is\d\n', fact_iter(4), fact_iter(5))
ENDPROC
```

If you're really observant you might have noticed that $5! = 5 \cdot 4!$, and, in general, $n! = n \cdot (n-1)!$. This is our first glimpse of a recursive definition--we can define the factorial function in terms of itself. The real definition of factorial is (the reason why this is the real definition is because the `'...'` in the previous definition is not sufficiently precise for a mathematical definition):

```
1! = 1
n! = n * (n-1)!    (for n > 1)
```

Notice that there are now two cases to consider. The first case is called the "base" case and gives an easily calculated value (i.e., no recursion is used). The second case is the "recursive" case and gives a definition in terms of a number nearer the base case (i.e., $(n-1)$ is nearer 1 than n , for $n > 1$). The normal problem people get into when using recursion is they forget the base case. Without the base case the definition is meaningless. Without a base case in a recursive program the machine is likely to crash! (See Stack (and Crashing).)

We can now define the recursive version of the `'fact_iter'` function (again, we'll use a `'Raise'` if the number parameter is not positive):

```
PROC fact_rec(n)
  IF n=1
    RETURN 1
  ELSEIF n>=2
    RETURN n*fact_rec(n-1)
  ELSE
    Raise("FACT")
  ENDIF
ENDPROC
```

Notice how this looks just like the mathematical definition, and is nice and compact. We can even make a one-line function definition (if we omit the check on the parameter being positive):

```
PROC fact_rec2(n) RETURN IF n=1 THEN 1 ELSE n*fact_rec2(n-1)
```

You might be tempted to omit the base case and write something like this:

```
/* Don't do this! */
PROC fact_bad(n) RETURN n*fact_bad(n-1)
```

The problem is the recursion will never end. The function `'fact_bad'` will be called with every number from `'n'` to zero and then all the negative integers. A value will never be returned, and the machine will crash after a while. The precise reason why it will crash is given later (see Stack (and Crashing)).

1.135 beginner.guide/Mutual Recursion

Mutual Recursion

=====

In the previous section we saw the function 'fact_rec' which called itself. If you have two functions, 'fun1' and 'fun2', and 'fun1' calls 'fun2', and 'fun2' calls 'fun1', then this pair of functions are "mutually" recursive. This extends to any amount of functions linked in this way.

This is a rather contrived example of a pair of mutually recursive functions.

```
PROC f(n)
  IF n=1
    RETURN 1
  ELSEIF n>=2
    RETURN n*g(n-1)
  ELSE
    Raise("F")
  ENDIF
ENDPROC

PROC g(n)
  IF n=1
    RETURN 2*1
  ELSEIF n>=2
    RETURN 2*n*f(n-1)
  ELSE
    Raise("G")
  ENDIF
ENDPROC
```

Both functions are very similar to the 'fact_rec' function, but 'g' returns double the normal values. The overall effect is that every other value in long version of the multiplication is doubled. So, 'f(n)' computes $n \cdot (2 \cdot (n-1)) \cdot (n-2) \cdot (2 \cdot (n-3)) \cdot \dots \cdot 2$ which probably isn't all that interesting.

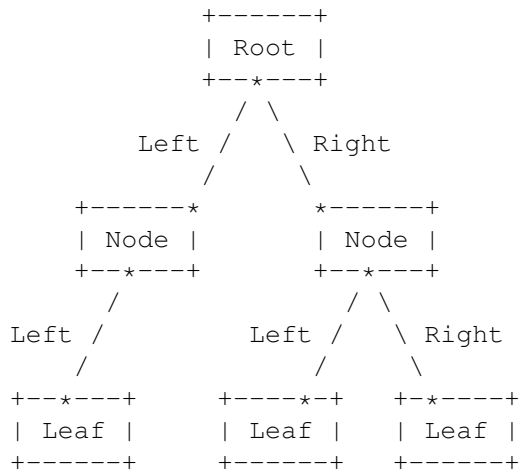
1.136 beginner.guide/Binary Trees

Binary Trees

=====

This is an example of a recursive type and the effect it has on functions which manipulate this type of data. A "binary tree" is like a linked list, but instead of each element containing only one link to another element there are two links in each element of a binary tree (which point to smaller trees called "branches"). The first link points to the left branch and the second points to the right branch. Each element of the tree is called a "node" and there are two kinds of special node: the start point, called the "root" of the tree (like the head of a

list), and the nodes which do not have left or right branches (i.e., 'NIL' pointers for both links), called "leaves". Every node of the tree contains some kind of data (just as the linked lists contained an E-string or E-list in each element). The following diagram illustrates a small tree.



Notice that a node might have only one branch (it doesn't have to have both the left and the right). Also, the leaves on the example were all at the same level, but this doesn't have to be the case. Any of the leaves could easily have been a node which had a lot of nodes branching off it.

So, how can a tree structure like this be written as an E object? Well, the general outline is this:

```

OBJECT tree
  data
  left, right
ENDOBJECT

```

The 'left' and 'right' elements are 'LONG' values, so can be used to store pointers to the left and right branches (which will be 'tree' objects, too). The 'data' element is some data for each node. This could equally well be a pointer, an 'ARRAY' or a number of different data elements.

So, what use can be made of such a tree? Well, a common use is for holding a sorted collection of data that needs to be able to have elements added quickly. As an example, the data at each node could be an integer, so a tree of this kind could hold a sorted set of integers. To make the tree sorted, constraints must be placed on the left and right branches of a node. The left branch should contain only nodes with data that is *less* than the parent node's data, and, similarly, the right branch should contain only nodes with data that is *greater*. Nodes with the same data could be included in one of the branches, but for our example we'll disallow them. We are now ready to write some functions to manipulate our tree.

The first function is one which starts off a new set of integers (i.e., begins a new tree). This should take an integer as a parameter and return a pointer to the root node of new tree (with the integer as that node's data).

```

PROC new_set(int)
  DEF root:PTR TO tree
  IF (root:=New(SIZEOF tree))=NIL
    Raise("MEM")
  ELSE
    root.data:=int
  ENDIF
ENDPROC root

```

The memory for the new tree element must be allocated dynamically using 'New'. Since 'New' clears the memory it allocates all elements of the new object will be zero. In particular, the 'left' and 'right' pointers will be 'NIL', so the root node will also be a leaf. If the 'New' fails an exception is raised; otherwise the data is set to the supplied value and a pointer to the root node is returned.

To add a new integer to such a set we need to find the appropriate position to insert it and set the left and right branches correctly. This is because if the integer is new to the set it will be added as a new leaf, and so one of the existing nodes will change its left or right branch.

```

PROC add(i, set:PTR TO tree)
  IF set=NIL
    RETURN new_set(i)
  ELSE
    IF i<set.data
      set.left:=add(i, set.left)
    ELSEIF i>set.data
      set.right:=add(i, set.right)
    ENDIF
    RETURN set
  ENDIF
ENDPROC

```

This function returns a pointer to the set to which it added the integer. If this set was initially empty a new set is created; otherwise the original pointer is returned. The appropriate branches are corrected as the search progresses. Only the last assignment to the left or right branch is significant (all others do not change the value of the pointer), since it is this assignment that adds the new leaf. Here's an iterative version of this function:

```

PROC add_iter(i, set:PTR TO tree)
  DEF node:PTR TO tree
  IF set=NIL
    RETURN new_set(i)
  ELSE
    node:=set
    LOOP
      IF i<node.data
        IF node.left=NIL
          node.left:=new_set(i)
          RETURN set
        ELSE
          node:=node.left
        ENDIF
      ENDIF
    ENDIF
  ENDIF

```

```

        ELSEIF i>node.data
            IF node.right=NIL
                node.right:=new_set(i)
                RETURN set
            ELSE
                node:=node.right
            ENDIF
        ELSE
            RETURN set
        ENDIF
    ENDLOOP
ENDIF
ENDPROC

```

As you can see, it's quite a bit messier. Recursive functions work well with manipulation of recursive types.

Another really neat example is printing the contents of the set. It's deceptively simple:

```

PROC show(set:PTR TO tree)
    IF set<>NIL
        show(set.left)
        WriteF('\d ', set.data)
        show(set.right)
    ENDIF
ENDPROC

```

The integers in the nodes will get printed in order (providing they were added using the 'add' function). The left-hand nodes contain the smallest elements so the data they contain is printed first, followed by the data at the current node, and then that in the right-hand nodes. Try writing an iterative version of this function if you fancy a really tough problem.

Putting everything together, here's a 'main' procedure which can be used to test the above functions:

```

PROC main()
    DEF s, i, j
    Rnd(-999999) /* Initialise seed */
    s:=new_set(10) /* Initialise set s to contain the number 10 */
    WriteF('Input:\n')
    FOR i:=1 TO 50 /* Generate 50 random numbers and add them to set s */
        j:=Rnd(100)
        add(j, s)
        WriteF('\d ', j)
    ENDFOR
    WriteF('\nOutput:\n')
    show(s) /* Show the contents of the (sorted) set s */
    WriteF('\n')
ENDPROC

```

1.137 beginner.guide/Stack (and Crashing)

Stack (and Crashing)

=====

When you call a procedure you use up a bit of the program's "stack". The stack is used to keep track of procedures in a program which haven't finished, and real problems can arise when the stack space runs out. Normally, the amount of stack available to each program is sufficient, since the E compiler handles all the fiddly bits quite well. However, programs which use a lot of recursion can quite easily run out of stack.

For example, the `'fact_rec(10)'` will need enough stack for ten calls of `'fact_rec'`, nine of which are recursively called. This is because each call does not finish until the return value has been computed, so all recursive calls up to `'fact_rec(1)'` need to be kept on the stack until `'fact_rec(1)'` returns one. Then each procedure will be taken off the stack as they finish. If you try to compute `'fact_rec(40000)'`, not only will this take a long time, but it will probably run out of stack space. When it does run out of stack, the machine will probably crash or do other weird things. The iterative version, `'fact_iter'` does not have these problems, since it only takes one procedure call to calculate a factorial using this function.

If there is the possibility of running out of stack space you can use the `'FreeStack'` (built-in) function call (see System support functions). This returns the amount of free stack space. If it drops below about 1KB then you might like to stop the recursion or whatever else is using up the stack. Also, you can specify amount of stack your program gets (and override what the compiler might decide is appropriate) using the `'OPT STACK'` option. See the `'Reference Manual'` for more details on E's stack organisation.

1.138 beginner.guide/Stack and Exceptions

Stack and Exceptions

=====

The concept `'recent'` used earlier is connected with the stack (see Raising an Exception). A recent procedure is one which is on the stack, the most recent being the current procedure. So, when `'Raise'` is called it looks through the stack until it finds a procedure with an exception handler. That handler will then be used, and all procedures before the selected one on the stack are taken off the stack.

Therefore, a recursive function with an exception handler can use `'Raise'` in the handler to call the handler in the previous (recursive) call of the function. So anything that has been recursively allocated can be `'recursively'` deallocated by exception handlers. This is a very powerful and important feature of exception handlers.

1.139 beginner.guide/Introduction to the Examples

Introduction to the Examples

In this part we shall go through some slightly larger examples than those in the previous parts. However, none of them are too big, so they should still be easy to understand. The note-worthy parts of each example are described, and you may even find the odd comment in the code. Large, complicated programs benefit hugely from the odd well-placed and descriptive comment. This fact can't be stressed enough.

Almost all the examples should run on a standard Amiga. The timing example will give better results on an A4000/040, though, and AmigaDOS 2.0 (and above) is really worth getting for the new, friendly system functions. The 'ReadArgs' example can only hint at the power of the newer system functions.

1.140 beginner.guide/Timing Expressions

Timing Expressions

You may recall the outline of a timing procedure in Part Two (see Evaluation). This chapter gives the complete version of this example. The information missing from the outline was how to determine the system time and use this to calculate the time taken by calls to 'Eval'. So the things to notice about this example are:

- * Use of the Amiga system function 'DateStamp' (from 'dos.library'). (You really need the 'Rom Kernel Reference Manuals' and the 'AmigaDOS Manual' to understand the system functions.)
 - * Use of the module 'dos/dos' to include the definitions of the object 'datestamp' and the constant 'TICKS_PER_SECOND'. (There are fifty ticks per second.)
 - * Use of the 'repeat' procedure to do 'Eval' a decent number of times for each expression (so that some time is taken up by the calls!).
 - * The timing of the evaluation of 0, to calculate the overhead of the procedure calls and loop. This value is stored in the variable 'offset' the first time the 'test' procedure is called. The expression 0 should take a negligible amount of time, so the number of ticks timed is actually the time taken by the procedure calls and loop calculations. Subtracting this time from the other times gives a fair view of how long the expressions take, relative to one another. (Thanks to Wouter for this offset idea.)
 - * Use of 'Forbid' and 'Permit' to turn off multi-tasking temporarily, making the CPU calculate only the expressions (rather than dealing with screen output, other programs, etc.).
-

* Use of 'CtrlC' and 'CleanUp' to allow the user to stop the program if it gets too boring...

Also supplied are some example outputs. The first was from an A1200 with 2MB Chip RAM and 4MB Fast RAM. The second was from an A500Plus with 2MB Chip RAM. Both used the constant 'LOTS_OF_TIMES' as 500,000, but you might need to increase this number to compare, for instance, an A4000/040 to an A4000/030. However, 500,000 gives a pretty long wait for results on the A500.

```

MODULE 'dos/dos'

CONST TICKS_PER_MINUTE=TICKS_PER_SECOND*60, LOTS_OF_TIMES=500000

DEF x, y, offset

PROC main()
  x:=9999
  y:=1717
  test('x+y,      'Addition')
  test('y-x,      'Subtraction')
  test('x*y,      'Multiplication')
  test('x/y,      'Division')
  test('x OR y,   'Bitwise OR')
  test('x AND y,  'Bitwise AND')
  test('x=y,      'Equality')
  test('x<y,      'Less than')
  test('x<=y,     'Less than or equal')
  test('y:=1,     'Assignment of 1')
  test('y:=x,     'Assignment of x')
  test('y++,      'Increment')
  test('IF FALSE THEN y ELSE x, 'IF FALSE')
  test('IF TRUE THEN y ELSE x,  'IF TRUE')
  test('IF x THEN y ELSE x,     'IF x')
  test('fred(2), 'fred(2)')
ENDPROC

PROC fred(n)
  DEF i
  i:=n+x
ENDPROC

/* Repeat evaluation of an expression */
PROC repeat(exp)
  DEF i
  FOR i:=0 TO LOTS_OF_TIMES
    Eval(exp) /* Evaluate the expresssion */
  ENDFOR
ENDPROC

/* Time an expression, and set-up offset if not done already */
PROC test(exp, message)
  DEF t
  IF offset=0 THEN offset:=time('0) /* Calculate offset */
  t:=time(exp)
  WriteF('\s:t\d ticks\n', message, t-offset)
ENDPROC

```

```
/* Time the repeated calls, and calculate number of ticks */
PROC time(x)
  DEF ds1:datestamp, ds2:datestamp
  Forbid()
  DateStamp(ds1)
  repeat(x)
  DateStamp(ds2)
  Permit()
  IF CtrlC() THEN CleanUp(1)
ENDPROC ((ds2.minute-ds1.minute)*TICKS_PER_MINUTE)+ds2.tick-ds1.tick
```

Here's the output from the A1200:

```
Addition:      21 ticks
Subtraction:    22 ticks
Multiplication: 64 ticks
Division:       131 ticks
Bitwise OR:     21 ticks
Bitwise AND:    21 ticks
Equality:       43 ticks
Less than:      43 ticks
Less than or equal: 66 ticks
Assignment of l: 7 ticks
Assignment of x: 18 ticks
Increment:      23 ticks
IF FALSE:       39 ticks
IF TRUE:        38 ticks
IF x: 43 ticks
fred(2):        96 ticks
```

Compare this to the output from the A500Plus:

```
Addition:      116 ticks
Subtraction:    115 ticks
Multiplication: 293 ticks
Division:       633 ticks
Bitwise OR:     116 ticks
Bitwise AND:    116 ticks
Equality:       160 ticks
Less than:      160 ticks
Less than or equal: 160 ticks
Assignment of l: 60 ticks
Assignment of x: 102 ticks
Increment:      133 ticks
IF FALSE:       116 ticks
IF TRUE:        160 ticks
IF x: 189 ticks
fred(2):        511 ticks
```

Evidence, if it were needed, that the A1200 is roughly five times faster than an A500, and that's not using the special 68020 CPU instructions!

1.141 beginner.guide/Argument Parsing

Argument Parsing

There are two examples in this chapter. One is for any AmigaDOS and the other is for AmigaDOS 2.0 and above. They both illustrate how to parse the arguments to your program. If your program is started from the Shell/CLI the arguments follow the command name on the command line, but if it was started from Workbench (i.e., you double-clicked on an icon for the program) then the arguments are those icons that were also selected at that time (see your Workbench manual for more details).

Any AmigaDOS

AmigaDOS 2.0 (and above)

1.142 beginner.guide/Any AmigaDOS

Any AmigaDOS

=====

This first example works with any AmigaDOS. The first thing that is done is the assignment of 'wbmessage' to a correctly typed pointer. At the same time we can check to see if it is 'NIL' (i.e., whether the program was started from Workbench or not). If it was not started from Workbench the arguments in 'arg' are printed. Otherwise we need to use the fact that 'wbmessage' is really a pointer to a 'wbstartup' object (defined in module 'workbench/startup'), so we can get at the argument list. Then for each argument in the list we need to check the lock supplied with the argument. If it's a proper lock it will be a lock on the directory containing the argument file. The name in the argument is just a filename, not a complete path, so to read the file we need to change the current directory to the lock directory. Once we've got a valid lock and we've changed directory to there, we can find the length of the file (using 'FileLength') and print it. If there was no lock or the file did not exist, the name of the file and an appropriate error message is printed.

```
MODULE 'workbench/startup'
```

```
PROC main()
```

```
  DEF startup:PTR TO wbstartup, args:PTR TO wbarg, i, oldlock, len
```

```
  IF (startup:=wbmessage)=NIL
```

```
    WriteF('Started from Shell/CLI\n  Arguments: "\s"\n', arg)
```

```
  ELSE
```

```
    WriteF('Started from Workbench\n')
```

```
    args:=startup.arglist
```

```
    FOR i:=1 to startup.numargs /* Loop through the arguments */
```

```
      IF args[i].lock=NIL
```

```
        WriteF('  Argument \d: "\s" (no lock)\n', i, args[i].name)
```

```
      ELSE
```

```
        oldlock:=CurrentDir(args[i].lock)
```

```

len:=FileLength(args[].name) /* Do something with file */
IF len=-1
    WriteF('  Argument \d: "\s" (file does not exist)\n',
          i, args[].name)
ELSE
    WriteF('  Argument \d: "\s", file length is \d bytes\n',
          i, args[].name, len)
ENDIF
CurrentDir(oldlock) /* Important: restore current dir */
ENDIF
args++
ENDFOR
ENDIF
ENDPROC

```

When you run this program you'll notice a slight difference between 'arg' and the Workbench message: 'arg' does not contain the program name, just the arguments, whereas the first argument in the Workbench argument list is the program. You can simply ignore the first Workbench argument in the list if you want.

1.143 beginner.guide/AmigaDOS 2.0 (and above)

AmigaDOS 2.0 (and above)
 =====

This second program can be used as the Shell/CLI part of the previous program to provide much better command line parsing. It can only be used with AmigaDOS 2.0 and above (i.e., 'OSVERSION' which is 37 or more). The template 'FILE/M' used with 'ReadArgs' gives command line parsing similar to C's 'argv' array. The template can be much more interesting than this, but for more details you need the 'AmigaDOS Manual'.

```

OPT OSVERSION=37

PROC main()
    DEF templ, rdargs, args=NIL:PTR TO LONG, i
    IF wbmessage=NIL
        WriteF('Started from Shell/CLI\n')
        templ:='FILE/M'
        rdargs:=ReadArgs(templ,{args},NIL)
        IF rdargs
            IF args
                i:=0
                WHILE args[i] /* Loop through arguments */
                    WriteF('  Argument \d: "\s"\n', i, args[i])
                    i++
                ENDWHILE
            ENDIF
            FreeArgs(rdargs)
        ENDIF
    ENDIF
ENDPROC

```

As you can see the result of the 'ReadArgs' call with this template is an array of filenames. The special quoting of filenames is dealt with correctly (i.e., when you use " around a filename that contains spaces). You need to do all this kind of work yourself if you use the 'arg' method.

1.144 beginner.guide/Gadgets IDCMP and Graphics

Gadgets, IDCMP and Graphics

There are three examples in this chapter. The first shows how to open a window and put some gadgets on it. The second shows how to decipher Intuition messages that arrive via IDCMP. The third draws things with the graphics functions.

Gadgets
IDCMP Messages
Graphics
Screens

1.145 beginner.guide/Gadgets

Gadgets
=====

The following program illustrates how to create a gadget list and use it:

```
MODULE 'intuition/intuition'

CONST GADGETBUFSIZE = 4 * GADGETSIZE

PROC main()
  DEF buf[GADGETBUFSIZE]:ARRAY, next, wptr
  next:=Gadget(buf, NIL, 1, 0, 10, 30, 50, 'Hello')
  next:=Gadget(next, buf, 2, 3, 70, 30, 50, 'World')
  next:=Gadget(next, buf, 3, 1, 10, 50, 50, 'from')
  next:=Gadget(next, buf, 4, 0, 70, 50, 70, 'gadgets')
  wptr:=OpenW(20,50,200,100, 0, WFLG_ACTIVATE,
             'Gadgets in a window',NIL,1,buf)
  IF wptr      /* Check to see we opened a window */
    Delay(500) /* Wait a bit */
    CloseW(wptr) /* Close the window */
  ELSE
    WriteF('Error -- could not open window!')
  ENDIF
ENDPROC
```

Four gadgets are created using an appropriately sized array as the buffer.

These gadgets are passed to 'OpenW' (the last parameter). If the window could be opened a small delay is used so that the window is visible before the program closes it and terminates. 'Delay' is an Amiga system function from the DOS library, and 'Delay(n)' waits n/50 seconds. Therefore, the window stays up for 10 seconds, which is enough time to play with the gadgets and see what the different types are. The next example will show a better way of deciding when to terminate the program (using the standard close gadget).

1.146 beginner.guide/IDCMP Messages

IDCMP Messages

=====

This next program shows how to use 'WaitIMessage' with a gadget.

```
MODULE 'intuition/intuition'

CONST GADGETBUFSIZE = GADGETSIZE, OURGADGET = 1

PROC main()
  DEF buf[GADGETBUFSIZE]:ARRAY, wptr, class, gad:PTR TO gadget
  Gadget(buf, NIL, OURGADGET, 1, 10, 30, 100, 'Press Me')
  wptr:=OpenW(20,50,200,100,
    IDCMP_CLOSEWINDOW OR IDCMP_GADGETUP,
    WFLG_CLOSEGADGET OR WFLG_ACTIVATE,
    'Gadget message window',NIL,1,buf)
  IF wptr
    /* Check to see we opened a window */
    WHILE (class:=WaitIMessage(wptr))<>IDCMP_CLOSEWINDOW
      gad:=MsgIaddr() /* Our gadget clicked? */
      IF (class=IDCMP_GADGETUP) AND (gad.userdata=OURGADGET)
        TextF(10,60,
          IF gad.flags=0 THEN 'Gadget off ' ELSE 'Gadget on ')
      ENDIF
    ENDWHILE
    CloseW(wptr) /* Close the window */
  ELSE
    WriteF('Error -- could not open window!')
  ENDIF
ENDPROC
```

The gadget reports its state when you click on it, using the 'TextF' function (see Graphics functions). The only way to quit the program is using the close gadget of the window. The 'gadget' object is defined in the module 'intuition/intuition' and the 'iaddr' part of the IDCMP message is a pointer to our gadget if the message was a gadget message. The 'userdata' element of the gadget identifies the gadget that was clicked, and the 'flags' element is zero if the boolean gadget is off (unselected) or non-zero if the boolean gadget is on (selected).

1.147 beginner.guide/Graphics

Graphics

=====

The following program illustrates how to use the various graphics functions.

```
MODULE 'intuition/intuition'

PROC main()
  DEF wptr, i
  wptr:=OpenW(20,50,200,100,IDCMP_CLOSEWINDOW,
              WFLG_CLOSEGADGET OR WFLG_ACTIVATE,
              'Graphics demo window',NIL,1,NIL)
  IF wptr /* Check to see we opened a window */
    Colour(1,3)
    TextF(20,30,'Hello World')
    SetTopaz(11)
    TextF(20,60,'Hello World')
    FOR i:=10 TO 150 STEP 8 /* Plot a few points */
      Plot(i,40,2)
    ENDFOR
    Line(160,40,160,70,3)
    Line(160,70,170,40,2)
    Box(10,75,160,85,1)
    WHILE WaitIMessage(wptr)<>IDCMP_CLOSEWINDOW
    ENDWHILE
    CloseW(wptr)
  ELSE
    WriteF('Error -- could not open window!\n')
  ENDIF
ENDPROC
```

First of all a small window is opened with a close gadget and activated (so it is the selected window). Clicks on the close gadget will be reported via IDCMP, and this is the only way to quit the program. The graphics functions are used as follows:

- * 'Colour' is used to set the foreground colour to pen one and the background colour to pen three. This will make the text nicely highlighted.
 - * Text is output in the standard font.
 - * The font is set to Topaz 11.
 - * More text is output (probably now in a different font).
 - * The 'FOR' loop plots a dotted line in pen two.
 - * A vertical line in pen three is drawn.
 - * A diagonal line in pen two is drawn. This and the previous line together produce a vee shape.
-

* A filled box is drawn in pen one.

1.148 beginner.guide/Screens

Screens
=====

This next example uses parts of the previous example, but also opens a custom screen. Basically, it draws coloured lines and boxes in a big window opened on a 16 colour, high resolution screen.

```
MODULE 'intuition/intuition', 'graphics/view'

PROC main()
  DEF sptr=NIL, wptr=NIL, i
  sptr:=OpenS(640,200,4,V_HIRES,'Screen demo')
  IF sptr
    wptr:=OpenW(0,20,640,180,IDCMP_CLOSEWINDOW,
               WFLG_CLOSEGADGET OR WFLG_ACTIVATE,
               'Graphics demo window',sptr,$F,NIL)
    IF wptr
      TextF(20,20,'Hello World')
      FOR i:=0 TO 15 /* Draw a line and box in each colour */
        Line(20,30,620,30+(7*i),i)
        Box(10+(40*i),140,30+(40*i),170,1)
        Box(11+(40*i),141,29+(40*i),169,i)
      ENDFOR
      WHILE WaitIMessage(wptr)<>IDCMP_CLOSEWINDOW
      ENDWHILE
      WriteF('Program finished successfully\n')
    ELSE
      WriteF('Could not open window\n')
    ENDIF
  ELSE
    WriteF('Could not open screen\n')
  ENDIF
  IF wptr THEN CloseW(wptr)
  IF sptr THEN CloseS(sptr)
ENDPROC
```

As you can see, the error-checking 'IF' blocks can make the program hard to read. Here's the same example written with an exception handler:

```
MODULE 'intuition/intuition', 'graphics/view'

ENUM NO_ERR, WIN, SCRN

RAISE WIN IF OpenW()=NIL,
      SCRN IF OpenS()=NIL

PROC main() HANDLE
  DEF sptr=NIL, wptr=NIL, i
  sptr:=OpenS(640,200,4,V_HIRES,'Screen demo')
  wptr:=OpenW(0,20,640,180,IDCMP_CLOSEWINDOW,
```

```

                WFLG_CLOSEGADGET OR WFLG_ACTIVATE,
                'Graphics demo window', sptr, $F, NIL)
    TextF(20, 20, 'Hello World')
    FOR i:=0 TO 15 /* Draw a line and box in each colour */
        Line(20, 30, 620, 30+(7*i), i)
        Box(10+(40*i), 140, 30+(40*i), 170, 1)
        Box(11+(40*i), 141, 29+(40*i), 169, i)
    ENDFOR
    WHILE WaitIMessage(wptr) <> IDCMP_CLOSEWINDOW
    ENDWHILE
    Raise(NO_ERR)
EXCEPT
    IF wptr THEN CloseW(wptr)
    IF sptr THEN CloseS(sptr)
    SELECT exception
    CASE NO_ERR
        WriteF('Program finished successfully\n')
    CASE WIN
        WriteF('Could not open window\n')
    CASE SCRNL
        WriteF('Could not open screen\n')
    ENDSELECT
ENDPROC

```

It's much easier to see what's going on here. The real part of the program (the bit before the 'EXCEPT') is no longer cluttered with error checking, and it's easy to see what happens if an error occurs. Notice that if the program successfully finishes it still has to close the screen and window properly, so it's often sensible to raise a dummy exception (like 'NO_ERR') and deal with all the tidying up in the handler.

1.149 beginner.guide/Recursion Example

Recursion Example

This next example uses a pair of mutually recursive procedures to draw what is known as a dragon curve (a pretty, space-filling pattern).

```

MODULE 'intuition/intuition', 'graphics/view'

/* Screen size, use SIZEY=512 for a PAL screen */
CONST SIZEX=640, SIZEY=400

/* Exception values */
ENUM NO_ERR, WIN, SCRNL, STK, BRK

/* Directions (DIRECTIONS gives number of directions) */
ENUM NORTH, EAST, SOUTH, WEST, DIRECTIONS

RAISE WIN IF OpenW()=NIL,
        SCRNL IF OpenS()=NIL

/* Start off pointing WEST */

```

```

DEF state=WEST, x, y, t

/* Face left */
PROC left()
    state:=Mod(state-1+DIRECTIONS, DIRECTIONS)
ENDPROC

/* Move right, changing the state */
PROC right()
    state:=Mod(state+1, DIRECTIONS)
ENDPROC

/* Move in the direction we're facing */
PROC move()
    SELECT state
    CASE NORTH; draw(0,t)
    CASE EAST; draw(t,0)
    CASE SOUTH; draw(0,-t)
    CASE WEST; draw(-t,0)
    ENDSELECT
ENDPROC

/* Draw and move to specified relative position */
PROC draw(dx, dy)
    /* Check the line will be drawn within the window bounds */
    IF (x>=Abs(dx)) AND (x<=SIZEX-Abs(dx)) AND
        (y>=Abs(dy)) AND (y<=SIZEY-10-Abs(dy))
        Line(x, y, x+dx, y+dy, 2)
    ENDIF
    x:=x+dx
    y:=y+dy
ENDPROC

PROC main() HANDLE
    DEF sptr=NIL, wptr=NIL, i, m
    /* Read arguments: [m [t [x [y]]]] */
    /* so you can say: dragon 16 */
    /* or: dragon 16 1 */
    /* or: dragon 16 1 450 */
    /* or: dragon 16 1 450 100 */
    /* m is depth of dragon, t is length of lines */
    /* (x,y) is the start position */
    m:=Val(arg, {i})
    t:=Val(arg:=arg+i, {i})
    x:=Val(arg:=arg+i, {i})
    y:=Val(arg:=arg+i, {i})
    /* If m or t is zero use a more sensible default */
    IF m=0 THEN m:=5
    IF t=0 THEN t:=5
    sptr:=OpenS(SIZEX,SIZEY,4,V_HIRES OR V_LACE,'Dragon Curve Screen')
    wptr:=OpenW(0,10,SIZEX,SIZEY-10,
        IDCMP_CLOSEWINDOW,WFLG_CLOSEGADGET,
        'Dragon Curve Window',sptr,$F,NIL)
    /* Draw the dragon curve */
    dragon(m)
    WHILE WaitIMessage(wptr)<>IDCMP_CLOSEWINDOW
    ENDWHILE

```

```

        Raise(NO_ERR)
    EXCEPT
        IF wptr THEN CloseW(wptr)
        IF sptr THEN CloseS(sptr)
        SELECT exception
        CASE NO_ERR
            WriteF('Program finished successfully\n')
        CASE WIN
            WriteF('Could not open window\n')
        CASE SCRN
            WriteF('Could not open screen\n')
        CASE STK
            WriteF('Ran out of stack in recursion\n')
        CASE BRK
            WriteF('User aborted\n')
        ENDSELECT
    ENDPROC

/* Draw the dragon curve (with left) */
PROC dragon(m)
    /* Check stack and ctrl-C before recursing */
    IF FreeStack() < 1000 THEN Raise(STK)
    IF CtrlC() THEN Raise(BRK)
    IF m > 0
        dragon(m-1)
        left()
        nogard(m-1)
    ELSE
        move()
    ENDIF
ENDPROC

/* Draw the dragon curve (with right) */
PROC nogard(m)
    IF m > 0
        dragon(m-1)
        right()
        nogard(m-1)
    ELSE
        move()
    ENDIF
ENDPROC

```

If you write this to the file 'dragon.e' and compile it to the executable 'dragon' then some good things to try are:

```

dragon 5 9 300 100
dragon 10 4 250 250
dragon 11 3 250 250
dragon 15 1 300 100
dragon 16 1 400 150

```

If you want to understand how the program works you need to study the recursive parts. Here's an overview of the program, outlining the important aspects:

- * The constants 'SIZEX' and 'SIZEY' are the width and height

(respectively) of the custom screen (and window). As the comment suggests, change 'SIZEY' to 512 if you want a bigger screen and you have a PAL Amiga.

- * The 'state' variable holds the current direction (north, south, east or west).
- * The 'left' and 'right' procedures turn the current direction to the left and right (respectively) by using some modulo arithmetic trickery.
- * The 'move' procedure uses the 'draw' procedure to draw a line (of length 't') in the current direction from the current point (stored in 'x' and 'y').
- * The 'draw' procedure draws a line relative to the current point, but only if it fits within the boundaries of the window. The current point is moved to the end of the line (even if it isn't drawn).
- * The 'main' procedure reads the command line arguments into the variables 'm', 't', 'x' and 'y'. The depth/size of the dragon is given by 'm' (the first argument) and the length of each line making up the dragon is given by 't' (the second argument). The starting point is given by 'x' and 'y' (the final two arguments). The defaults are five for 'm' and 't', and zero for 'x' and 'y'.
- * The 'main' procedure also opens the screen and window, and sets the dragon drawing.
- * The 'dragon' and 'nogard' procedures are very similar, and these are responsible for creating the dragon curve by calling the 'left', 'right' and 'move' procedures.
- * The 'dragon' procedure contains a couple of checks to see if the user has pressed Control-C or if the program has run out of stack space, raising an appropriate exception if necessary. These exceptions are handled by the 'main' procedure.

Notice the use of 'Val' and the exception handling. Also, the important base case of the recursion is when 'm' reaches zero (or becomes negative, but that shouldn't happen). If you start off a big dragon and want to stop it you can press Control-C and the program tidies up nicely. If it has finished drawing you simply click the close gadget on the window.

1.150 beginner.guide/Common Problems

Common Problems

If you are new to programming or the Amiga E language then you might appreciate some help locating problems (or "bugs") in your programs. This Appendix details some of the most common mistakes people make.

Assignment and Copying
 Pointers and Memory Allocation
 String and List Misuse
 Initialising Data
 Freeing Resources
 Array and Object Element Selection
 Pointers and Dereferencing

1.151 beginner.guide/Assignment and Copying

Assignment and Copying

=====

This is probably the most common problem encountered by people who are used to languages like BASIC. Things like E-strings or arrays cannot be initialised using an assignment statement: data must be copied. This means that you shouldn't write this:

```

/* You probably don't want to do this */
DEF s[30]:STRING, a[25]:ARRAY OF INT
s:='Some text in a string'
a:=[1,-3,8,7]:INT

```

Instead you need to copy the string constant and array data, like this:

```

DEF s[30]:STRING, a[25]:ARRAY OF INT
StrCopy(s,'Some text in a string',ALL)
CopyMem([1,-3,8,7]:INT, a, 4*2)

```

The 'CopyMem' function is an Amiga system function from the Exec library. It does a byte-by-byte copy, something like this:

```

PROC copymem(src, dest, size)
  DEF i
  FOR i:=1 TO size DO dest[i++] := src[i++]
ENDPROC

```

Of course, you can use string constants and typed lists to give initialised arrays, but in this case you should be initialising an appropriately typed pointer. You must also be careful not to run into a static data problem (see Static data).

```

DEF s:PTR TO CHAR, a:PTR TO INT
s:='Some text in a string'
a:=[1,-3,8,7]:INT

```

1.152 beginner.guide/Pointers and Memory Allocation

Pointers and Memory Allocation

=====

Another common error is to declare a pointer (usually a pointer to an object) and then use it without the memory for the target data being allocated.

```
/* You don't want to do this */
DEF p:PTR TO object
p.element:=99
```

There are two ways of correcting this: either dynamically allocate the memory using 'New' or, more simply, let an appropriate declaration allocate it.

```
DEF p:PTR TO object
p:=New(SIZEOF object)

DEF p:object
p.element:=99
```

1.153 beginner.guide/String and List Misuse

String and List Misuse
=====

Some of the string functions can only be used with E-strings. Generally, these are the ones that might extend the string. If you use a normal string instead you can run into some serious (but subtle) problems. Commonly misused functions are 'ReadStr', 'MidStr' and 'RightStr'. Similar problems can arise by using a list when an E-list is required by a list function.

String constants and normal lists are static data, so you shouldn't try to alter their contents unless you know what you're doing (see Static data).

1.154 beginner.guide/Initialising Data

Initialising Data
=====

Probably one of the most common mistakes that even seasoned programmers make is to forget to initialise variables (especially pointers). The rules in the 'Reference Manual' state which declarations initialise variables to zero values, but it is often wise to make even these explicit (using initialised declarations). Variable initialisation becomes even more important when using automatic exceptions.

1.155 beginner.guide/Freeing Resources

Freeing Resources

=====

Unlike most Unix systems, the Amiga operating system requires the programmer to release or free any resources used by a program. In practice, this means that all windows, screens, libraries, etc., that are successfully opened must be closed before the program terminates. Amiga E provides some help, though: the four most commonly used libraries (Dos, Exec, Graphics and Intuition) are opened before the start of an E program and closed at the end (or when 'CleanUp' is called). Also, memory allocated using 'New', 'List' and 'String' is automatically freed at the end of a program.

1.156 beginner.guide/Array and Object Element Selection

Array and Object Element Selection

=====

Selection in E is sometimes slightly different than in other languages. See Element selection and element types.

Assignment expressions can also cause problems: they do not allow as rich a left-hand side as assignment statements. See Assignments.

1.157 beginner.guide/Pointers and Dereferencing

Pointers and Dereferencing

=====

C programmers may think that the '^VAR' and '{VAR}' expressions are the direct equivalent of C's '&VAR' and '*VAR' expressions. However, in E dereferencing is normally achieved using array and object element selection, and pointers to large amounts of data (like E-strings or objects) are made by declarations. This means that the '^VAR' and '{VAR}' expressions are rarely used, whilst 'VAR[]' is very common.

1.158 beginner.guide/Other Information

Other Information

This Appendix contains some useful, miscellaneous information.

Amiga E Versions
Further Reading
Amiga E Author
Guide Author

1.159 beginner.guide/Amiga E Versions

Amiga E Versions
=====

As I write, the current version of Amiga E is version 3.0, which is very new and full of new features. This edition of the Guide is based primarily on that version, but is a simple update of the first edition (which covered Amiga E v2.1b). I plan to properly update this Guide when I have become more familiar with the new features. I hope to include most of the missing bits, including some of the OOP mechanisms.

1.160 beginner.guide/Further Reading

Further Reading
=====

'Amiga E Language Reference'

Referred to as the 'Reference Manual' in this Guide. This is one of the documents that comes with the Amiga E package (docs/E.doc), and is essential reading since it was written by Wouter (the author of Amiga E). It contains a lot of extra information.

'Rom Kernel Reference Manual' (Addison-Wesley)

This is the official Commodore documentation on the Amiga system functions and is a must if you want to use these functions properly. At the time of writing the Third Edition is the most current and it covers the Amiga system functions up to Release 2 (i.e., AmigaDOS 2.04 and KickStart 37). Because there is so much information it comes in three separate volumes: 'Libraries', 'Includes and Autodocs', and 'Devices'. The 'Libraries' volume is probably the most useful as it contains many examples and a lot of tutorial material. However, the examples are written mainly in C (the remainder are in Assembly).

'The AmigaDOS Manual' (Bantam Books)

This is the companion to the 'Rom Kernel Reference Manual' and is the official Commodore book on AmigaDOS (both the AmigaDOS programs and the DOS library functions). Again, the Third Edition is the most current.

Example sources

Amiga E comes with a large collection of example programs. When you're familiar with the language you should be able to learn quite a bit from these. There are a lot of small, tutorial programs and a

few large, complicated programs.

1.161 beginner.guide/Amiga E Author

Amiga E Author
=====

In case you didn't know the author and creator of Amiga E is Wouter van Oortmerssen (or '\$#!'). You can reach him by normal mail at the following address:

Wouter van Oortmerssen ('\$#!')
Levendaal 87
2311 JG Leiden
HOLLAND

However, he much prefers to chat by E-mail, and you can reach him at the following addresses:

'Wouter@alf.let.uva.nl' (E-programming support)
'Wouter@mars.let.uva.nl' (personal)
'Oortmers@gene.fwi.uva.nl' (other)

Better still, if your problem or enquiry is of general interest to Amiga E users you may find it useful joining the Amiga E mailing list. Wouter regularly contributes to this list and there are a number of good programmers who are at hand to help or discuss problems. To join send a message to:

'amigae-request@bkhouse.cts.com'

Once you're subscribed, you will receive a copy of each message mailed to the list. You will also receive a message telling you how you can contribute (i.e., ask questions!).

1.162 beginner.guide/Guide Author

Guide Author
=====

This Guide was written by Jason Hulance, with a lot of help and guidance from Wouter. The original aim was to produce something that might be a useful introduction to Amiga E for beginners, so that the language could (rightly) become more widespread. The hidden agenda was to free Wouter from such a task so that he could concentrate his efforts on producing the 3.0 version of Amiga E.

You can reach me by normal mail most easily at the following (work) address:

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 OX1 4EH
 ENGLAND

Alternatively, you can find me on the Amiga E mailing list, or E-mail me directly at one of the following addresses:

'jason@fsel.com'
 'm88jrh@uk.ac.oxford.ecs'

If you have any changes or additions you'd like to see then I'd be very happy to consider them. Criticism of the text is also welcome, especially if you can suggest a better way of explaining things.

1.163 beginner.guide/E Language Index

E Language Index

This index should be used to find detailed information about the keywords, functions, variables and constants which are part of the Amiga E language. There is a separate index which deals with concepts etc. (see Main Index).

Symbol, close curly brace	Finding addresses (making pointers)
Symbol, double-quote	Numeric Constants
Symbol, open curly brace	Finding addresses (making pointers)
Symbol, !	Floating-Point Calculations
Symbol, \$	Numeric Constants
Symbol, %	Numeric Constants
Symbol, ' .. ' (string)	Normal strings and E-strings
Symbol, *	Mathematics
Symbol, +	Mathematics
Symbol, + (strings)	Statements
Symbol, ++	Point to other elements
Symbol, -	Mathematics
Symbol, --	Point to other elements
Symbol, ->	Comments
Symbol, /	Mathematics
Symbol, /* .. */	Comments
Symbol, :	Labelling and the JUMP statement
Symbol, :=	Assignment
Symbol, ;	Statements
Symbol, <	Logic and comparison
Symbol, <=	Logic and comparison
Symbol, <>	Logic and comparison
Symbol, =	Logic and comparison
Symbol, >	Logic and comparison
Symbol, >=	Logic and comparison

Symbol, [.. , ..] (list)	Lists and E-lists
Symbol, [.. , ..]:TYPE (typed list)	Typed lists
Symbol, [..] (array)	Tables of data
Symbol, [] (array)	Accessing array data
Symbol, \0	String Constants Special Character ↔
Sequences	
Symbol, \a	String Constants Special Character ↔
Sequences	
Symbol, \b	String Constants Special Character ↔
Sequences	
Symbol, \c	Input and output functions
Symbol, \d	Input and output functions
Symbol, \d	Changing the example
Symbol, \e	String Constants Special Character ↔
Sequences	
Symbol, \h	Input and output functions
Symbol, \l	Input and output functions
Symbol, \n	String Constants Special Character ↔
Sequences	
Symbol, \n	Strings
Symbol, \q	String Constants Special Character ↔
Sequences	
Symbol, \r	Input and output functions
Symbol, \s	Input and output functions
Symbol, \t	String Constants Special Character ↔
Sequences	
Symbol, \z	Input and output functions
Symbol, \\	String Constants Special Character ↔
Sequences	
Symbol, ^	Extracting data (dereferencing pointers)
Symbol, ` (backquote)	Quoted Expressions
Abs	Maths and logic functions
ALL	Built-In Constants
AND	Bitwise AND and OR
And	Maths and logic functions
arg	Built-In Variables
ARRAY	Tables of data
ARRAY OF TYPE	Tables of data
Box	Graphics functions
BUT	BUT expression
CASE	SELECT block
CASE	SELECT..OF block
CASE ..TO..	SELECT..OF block
CHAR	Static memory
Char	Maths and logic functions
CHAR	Indirect types
CleanUp	System support functions
CloseS	Intuition support functions
CloseW	Intuition support functions
Colour	Graphics functions
conout	Built-In Variables
CONST	Named Constants
CtrlC	System support functions
DEC	INC and DEC statements
DEF	Variable declaration
DEFAULT	SELECT..OF block
DEFAULT	SELECT block

Dispose	System support functions
DisposeLink	System support functions
Div	Maths and logic functions
DO, (FOR loop)	FOR loop
DO, (WHILE loop)	WHILE loop
dosbase	Built-In Variables
ELSE	IF block
ELSEIF	IF block
ENDFOR	FOR loop
ENDIF	IF block
ENDLOOP	LOOP block
ENDOBJECT	Example object
ENDPROC	Procedure Definition
ENDPROC VALUE	Functions
ENDSELECT	SELECT block
ENDSELECT	SELECT..OF block
ENDWHILE	WHILE loop
ENUM	Enumerations
Eor	Maths and logic functions
EstrLen	String functions
Eval	Evaluation
Even	Maths and logic functions
EXCEPT	Procedures with Exception Handlers
exception	Raising an Exception
execbase	Built-In Variables
Exists	Lists and quoted expressions
FALSE	Built-In Constants
FALSE	Logic and comparison
FileLength	Input and output functions
FOR	FOR loop
ForAll	Lists and quoted expressions
Forward	Linked Lists
FreeStack	System support functions
Gadget	Intuition support functions
GADGETSIZE	Built-In Constants
gfxbase	Built-In Variables
HANDLE	Procedures with Exception Handlers
IF	IF block
IF, (expression)	IF expression
INC	INC and DEC statements
INCBIN	Static memory
Inp	Input and output functions
InStr	String functions
Int	Maths and logic functions
INT	Indirect types
INT	Static memory
intuitionbase	Built-In Variables
IS	One-Line Functions
IS	One-Line Functions
JUMP	Labelling and the JUMP statement
KickVersion	System support functions
Line	Graphics functions
Link	Linked Lists
LIST	Lists and E-lists
List	List functions
ListAdd	List functions
ListCmp	List functions

ListCopy	List functions
ListItem	List functions
ListLen	List functions
ListMax	List functions
LONG	LONG Type
LONG	Static memory
Long	Maths and logic functions
LONG, preliminary	Variable types
LOOP	LOOP block
LowerStr	String functions
main	Procedures
MapList	Lists and quoted expressions
MidStr	String functions
Mod	Maths and logic functions
MODULE	Using Modules
Mouse	Intuition support functions
MouseX	Intuition support functions
MouseY	Intuition support functions
MsgCode	Intuition support functions
Mul	Maths and logic functions
New	System support functions
NEWFILE	Built-In Constants
Next	Linked Lists
NIL	Built-In Constants
Not	Maths and logic functions
OBJECT	Example object
Odd	Maths and logic functions
OLDFILE	Built-In Constants
OpenS	Intuition support functions
OpenW	Intuition support functions
Or	Maths and logic functions
OR	Bitwise AND and OR
Out	Input and output functions
Plot	Graphics functions
PROC	Procedure Definition
PTR TO TYPE	PTR Type
PutChar	Maths and logic functions
PutInt	Maths and logic functions
PutLong	Maths and logic functions
RAISE	Automatic Exceptions
Raise	Raising an Exception
ReadStr	Input and output functions
REPEAT	REPEAT..UNTIL loop
RETURN	Functions
RightStr	String functions
Rnd	Maths and logic functions
RndQ	Maths and logic functions
SELECT	SELECT..OF block
SELECT	SELECT block
SELECT..OF	SELECT..OF block
SelectList	Lists and quoted expressions
SET	Sets
SetList	List functions
SetStdOut	Input and output functions
SetStdRast	Graphics functions
SetStr	String functions
SetTopaz	Graphics functions

Shl	Maths and logic functions
Shr	Maths and logic functions
SIZEOF	SIZEOF expression
stdout	Built-In Variables
stdrast	Built-In Variables
STEP	FOR loop
StrAdd	String functions
StrCmp	String functions
StrCopy	String functions
STRING	Normal strings and E-strings
String	String functions
StringF	Input and output functions
StrLen	String functions
STRLEN	Built-In Constants
StrMax	String functions
TextF	Graphics functions
THEN	IF block
TO	FOR loop
TO, (CASE range)	SELECT..OF block
TO, (FOR loop)	FOR loop
TrimStr	String functions
TRUE	Built-In Constants
TRUE	Logic and comparison
UNTIL	REPEAT..UNTIL loop
UpperStr	String functions
Val	String functions
VOID	Turning an Expression into a Statement
WaitIMessage	Intuition support functions
wbmessage	Built-In Variables
WHILE	WHILE loop
WriteF	Input and output functions

1.164 beginner.guide/Main Index

Main Index

This index should be used to find detailed information about particular concepts. There is a separate index which deals with the keywords, variables, functions and constants which are part of Amiga E (see E Language Index).

A4 register	Things to watch out for
A5 register	Things to watch out for
Absolute value	Maths and logic functions
Access array outside bounds	Accessing array data
Accessing array data	Accessing array data
Accuracy of floating-point numbers	Accuracy and Range
Addition	Mathematics
Address	Addresses
Address	Memory addresses
Address, finding	Finding addresses (making pointers)
Algebra	Variables and Expressions
Alignment	SIZEOF expression

Allocating memory	System support functions
Allowable assignment left-hand sides	Assignments
Amiga E author	Amiga E Author
Amiga system module	Amiga System Modules
Amiga system objects	Amiga system objects
Analogy, pointers	Addresses
And	Maths and logic functions
AND, bit-wise	Bitwise AND and OR
AND-ing flags	Sets
Apostrophe	String Constants Special Character ↔
Sequences	
Append to a list	List functions
Append to an E-string	String functions
arg, using	Any AmigaDOS
Argument	Parameters
Argument parsing	Argument Parsing
Argument, default	Default Arguments
Array	Tables of data
Array and array pointer declaration	Array pointers
Array diagram	Array pointers
Array pointer, decrementing	Point to other elements
Array pointer, incrementing	Point to other elements
Array pointer, next element	Point to other elements
Array pointer, previous element	Point to other elements
Array size	Tables of data
Array, access outside bounds	Accessing array data
Array, accessing data	Accessing array data
Array, first element short-hand	Accessing array data
Array, initialised	Typed lists
Array, pointer	Array pointers
Array, procedure parameter	Array procedure parameters
ASCII character constant	Numeric Constants
Assembly and E constants	Assembly and the E language
Assembly and E variables	Assembly and the E language
Assembly and labels	Assembly and the E language
Assembly and procedures	Assembly and the E language
Assembly and static memory	Static memory
Assembly statements	Assembly Statements
Assembly, calling system functions	Assembly and the E language
Assembly, potential problems	Things to watch out for
Assignment expression	Assignments
Assignment versus copying	String functions
Assignment, :=	Assignment
Assignment, allowable left-hand sides	Assignments
Assignment, Emodules:	Using Modules
Assignment, multiple	Multiple Return Values
Automatic exceptions	Automatic Exceptions
Automatic voiding	Turning an Expression into a Statement
Background pen, setting colour	Graphics functions
Backslash	String Constants Special Character ↔
Sequences	
Base case	Factorial Example
Beginner's Guide author	Guide Author
Binary constant	Numeric Constants
Binary tree	Binary Trees
Bit shift left	Maths and logic functions
Bit shift right	Maths and logic functions

Bit-wise AND and OR	Bitwise AND and OR
Block, conditional	Conditional Block
Block, IF	IF block
Block, SELECT	SELECT block
Block, SELECT..OF	SELECT..OF block
Books, further reading	Further Reading
Box drawing	Graphics functions
Bracketing expressions	Precedence and grouping
Branch	Binary Trees
Breaking a string over several lines	Statements
Breaking statements over several lines	Statements
Bug, finding	Common Problems
Built-in constants	Built-In Constants
Built-in functions	Built-In Functions
Built-in functions, floating-point	Floating-Point Functions
Built-in functions, linked list	Linked Lists
Built-in functions, list and E-list	List functions
Built-in functions, string and E-string	String functions
Built-in variables	Built-In Variables
BUT expression	BUT expression
Buttons state	Intuition support functions
Calculating with floating-point numbers	Floating-Point Calculations
Calling a procedure	Procedure Execution
Calling a procedure	Procedures
Calling system functions from Assembly	Assembly and the E language
Carriage return	String Constants Special Character ↔
Sequences	
Case of characters in identifiers	Identifiers
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Case, recursive	Factorial Example
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Changing stderr	Graphics functions
Changing the value of a variable	Assignment
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Character, apostrophe	String Constants Special Character ↔
Sequences	
Character, backslash	String Constants Special Character ↔
Sequences	
Character, carriage return	String Constants Special Character ↔
Sequences	
Character, double quote	String Constants Special Character ↔
Sequences	
Character, escape	String Constants Special Character ↔
Sequences	
Character, linefeed	String Constants Special Character ↔
Sequences	
Character, null	String Constants Special Character ↔
Sequences	
Character, printing	Input and output functions
Character, read from a file	Input and output functions
Character, set	Sets
Character, tab	String Constants Special Character ↔
Sequences	
Character, write to file	Input and output functions
Choice, conditional block	Conditional Block
Clean-up, program termination	System support functions
Close screen	Intuition support functions

Close window	Intuition support functions
Code fragment	Conditional Block
Code modules	Code Modules
code part of Intuition message	Intuition support functions
Code, reuse	Style Reuse and Readability
Code, style	Style Reuse and Readability
Colour, setting foreground and background pen	Graphics functions
Command line argument parsing	Argument Parsing
Comment, nested	Comments
Comments	Comments
Common problems	Common Problems
Common use of pointers	Extracting data (dereferencing pointers)
Comparison of lists	List functions
Comparison of strings	String functions
Comparison operators	Logic and comparison
Compiler, ec	Compilation
Complex memory, deallocate	System support functions
Complex memory, free	System support functions
Complex types	Complex types
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Constant string	Normal strings and E-strings
Constant, binary	Numeric Constants
Constant, built-in	Built-In Constants
Constant, character	Numeric Constants
Constant, decimal	Numeric Constants
Constant, enumeration	Enumerations
Constant, hexadecimal	Numeric Constants
Constant, named	Named Constants
Constant, numeric	Numeric Constants
Constant, use in Assembly	Assembly and the E language
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Controlling program flow	Program Flow Control
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Convert include file to module	Non-Standard Modules
Convert pragma file to module	Non-Standard Modules
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Copy right-hand part of an E-string	String functions
Copying a list	List functions
Copying a string	String functions
Copying versus assignment	String functions
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Crash, running out of stack	Stack (and Crashing)
Create gadget	Intuition support functions
Cure for linefeed problem	Strings
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Data, input	The Simple Program
Data, manipulation	The Simple Program
Data, named	Variables and Expressions
Data, output	The Simple Program
Data, static	Static data
Data, storage	Variable types
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Deallocating memory	System support functions

Decimal constant	Numeric Constants
Decimal number, printing	Input and output functions
Decision, conditional block	Conditional Block
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Declaration, illegal	Indirect types
Declaration, initialised	Initialised Declarations
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Declaring a variable	Variable declaration
Decrementing a variable	INC and DEC statements
Decrementing array pointer	Point to other elements
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Default type	Default type
Definition of a procedure with parameters	Global and local variables
Dereferencing a pointer	Extracting data (dereferencing pointers)
Descoping a global variable	Global and local variables
Direct type	Indirect types
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Disposing memory	System support functions
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Division, 32-bit	Maths and logic functions
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Drawing, line	Graphics functions
Drawing, text	Graphics functions
Dynamic E-list allocation	List functions
Dynamic E-string allocation	String functions
E author	Amiga E Author
E-list	Lists and E-lists
E-list functions	List functions
E-list, append	List functions
E-list, comparison	List functions
E-list, copying	List functions
E-list, dynamic allocation	List functions
E-list, length	List functions
E-list, maximum length	List functions
E-list, setting the length	List functions
E-string	Normal strings and E-strings
E-string functions	String functions
E-string, append	String functions
E-string, comparison	String functions
E-string, copying	String functions
E-string, dynamic allocation	String functions
E-string, format text to	Input and output functions
E-string, length	String functions
E-string, lowercase	String functions
E-string, maximum length	String functions
E-string, middle copy	String functions
E-string, reading from a file	Input and output functions
E-string, right-hand copy	String functions
E-string, set length	String functions
E-string, trim leading whitespace	String functions
E-string, uppercase	String functions
Early termination of a function	Functions
ec compiler	Compilation

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Element types	Element selection and element types
Elements of a linked list	Linked Lists
Elements of an array	Accessing array data
Elements of an object	OBJECT Type
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Even number	Maths and logic functions
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Examples, altering	Tinkering with the example
Examples, tinkering	Tinkering with the example
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Exception handler in a procedure	Procedures with Exception Handlers
Exception handling	Exception Handling
Exception, automatic	Automatic Exceptions
Exception, raising	Raising an Exception
Exception, raising from a handler	Raise within an Exception Handler
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Exception, use of stack	Stack and Exceptions
Exclusive or	Maths and logic functions
Executing a procedure	Procedure Execution
Execution	Execution
Execution, jumping to a label	Labelling and the JUMP statement
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Expression	Variables and Expressions
Expression in parentheses	Precedence and grouping
Expression, assignment	Assignments
Expression, bad grouping	Precedence and grouping
Expression, bracketing	Precedence and grouping
Expression, BUT	BUT expression
Expression, conversion to a statement	Turning an Expression into a Statement
Expression, grouping	Precedence and grouping
Expression, IF	IF expression
Expression, quotable	Quotable expressions
Expression, quoted	Quoted Expressions
Expression, sequence	BUT expression
Expression, side-effects	Side-effects
Expression, timing example	Timing Expressions
Expression, voiding	Turning an Expression into a Statement
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Extracting numbers from a string	String functions
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Field formatting	Input and output functions
Field size	Input and output functions
Field, left-justify	Input and output functions
Field, right-justify	Input and output functions
Field, zero fill	Input and output functions
File length	Input and output functions
Filtering a list	Lists and quoted expressions
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Finding bugs	Common Problems
First element of an array	Accessing array data
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Flag, mouse button	Intuition support functions
Flag, OR-ing	Sets
Flag, screen resolution	Intuition support functions
Flag, set constant	Sets
Flag, window	Intuition support functions
Floating-point conversion operator	Floating-Point Calculations
Floating-point functions	Floating-Point Functions
Floating-point number	Floating-Point Numbers
Flow control	Program Flow Control
Following elements in a linked list	Linked Lists
Font, setting Topaz	Graphics functions
For all list elements	Lists and quoted expressions
FOR loop	FOR loop
Foreground pen, setting colour	Graphics functions
Format rules	Format and Layout
Format text to an E-string	Input and output functions
Forward through a linked list	Linked Lists
Fragment, code	Conditional Block
Free stack space	System support functions
Freeing complex memory	System support functions
Freeing memory	System support functions
Function	Procedures and Functions
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Function, early termination	Functions
Function, factorial	Factorial Example
Function, graphics	Graphics functions
Function, input	Input and output functions
Function, Intuition support	Intuition support functions
Function, logic	Maths and logic functions
Function, maths	Maths and logic functions
Function, one-line	One-Line Functions
Function, output	Input and output functions
Function, recursive	Recursion
Function, return value	Functions
Function, system support	System support functions
Functions, floating-point	Floating-Point Functions
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Functions, list and E-list	List functions
Functions, string and E-string	String functions
Further reading	Further Reading
Gadget and IDCMP example	IDCMP Messages
Gadget, create	Intuition support functions
Gadgets example	Gadgets
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Global variable	Global and local variables
Global variable, descoping	Global and local variables
Graphics example	Graphics
Graphics functions	Graphics functions
Grouping expressions	Precedence and grouping
Grouping, bad	Precedence and grouping
Guide author	Guide Author
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Handler raising an exception	Raise within an Exception Handler
Handler, recursive	Stack and Exceptions
Handling exceptions	Exception Handling
Head of a linked list	Linked Lists
Header file, convert to module	Non-Standard Modules
Hexadecimal constant	Numeric Constants
Hexadecimal number, printing	Input and output functions
Horizontal FOR loop	FOR loop
Horizontal function definition	One-Line Functions
Horizontal IF block	IF block
Horizontal WHILE loop	WHILE loop
iaddr part of Intuition message	Intuition support functions
IDCMP and gadget example	IDCMP Messages
IDCMP flags	Intuition support functions
IDCMP message, code part	Intuition support functions
IDCMP message, iaddr part	Intuition support functions
IDCMP message, qual part	Intuition support functions
IDCMP message, waiting for	Intuition support functions
Identifier	Identifiers
Identifier, case of characters	Identifiers
IF block	IF block
IF block, nested	IF block
IF block, overlapping conditions	IF block
IF expression	IF expression
Illegal declaration	Indirect types
Include file, convert to module	Non-Standard Modules
Incrementing a variable	INC and DEC statements
Incrementing array pointer	Point to other elements
Indentation	Spacing and Separators
Indirect type	Indirect types
Initialised array	Typed lists
Initialised declaration	Initialised Declarations
Inlining procedures	Style Reuse and Readability
Input a character	Input and output functions
Input a string	Input and output functions
Input functions	Input and output functions
Intuition message flags	Intuition support functions
Intuition message, code part	Intuition support functions
Intuition message, iaddr part	Intuition support functions
Intuition message, qual part	Intuition support functions
Intuition message, waiting for	Intuition support functions
Intuition support functions	Intuition support functions
Iteration	Loops
Jumping out of a loop	Labelling and the JUMP statement
Jumping to a label	Labelling and the JUMP statement
Kickstart version	System support functions
Label	Labelling and the JUMP statement
Label, use in Assembly	Assembly and the E language
Languages	Introduction to Amiga E
Layout rules	Format and Layout
Leaf	Binary Trees
Left shift	Maths and logic functions
Left-hand side of an assignment, allowable	Assignments
Left-justify field	Input and output functions
Length (maximum) of an E-list	List functions
Length (maximum) of an E-string	String functions
Length of a file	Input and output functions

Length of a list	List functions
Length of a string	String functions
Length of an E-list, setting	List functions
Length of an E-string	String functions
Length of an E-string, setting	String functions
Line drawing	Graphics functions
Linefeed	String Constants Special Character ↔
Sequences	
Linefeed problem	Execution
Linefeed problem, cure	Strings
Linefeed, \n	Strings
Linked list	Linked Lists
Linked list, doubly	Linked Lists
Linked list, elements	Linked Lists
Linked list, following elements	Linked Lists
Linked list, functions	Linked Lists
Linked list, head	Linked Lists
Linked list, linking	Linked Lists
Linked list, next element	Linked Lists
Linked list, singly	Linked Lists
Linking a linked list	Linked Lists
List	Lists and E-lists
List functions	List functions
List, append	List functions
List, comparison	List functions
List, copying	List functions
List, filtering	Lists and quoted expressions
List, for all elements	Lists and quoted expressions
List, length	List functions
List, linked	Linked Lists
List, mapping a quoted expression	Lists and quoted expressions
List, normal	Lists and E-lists
List, selecting an element	List functions
List, tag	Lists and E-lists
List, there exists an element	Lists and quoted expressions
List, typed	Typed lists
Lists and quoted expressions	Lists and quoted expressions
Local variable	Global and local variables
Local variable, same names	Global and local variables
Local variables in a quoted expression	Quotable expressions
Locate sub-string in a string	String functions
Location, memory	Memory addresses
Location, memory	Addresses
Logic	Logic and comparison
Logic functions	Maths and logic functions
Logic operators	Logic and comparison
Logic, and	Maths and logic functions
Logic, exclusive or	Maths and logic functions
Logic, not	Maths and logic functions
Logic, or	Maths and logic functions
LONG type	LONG Type
LONG type, definition	Indirect types
Loop	Loops
LOOP block	LOOP block
Loop check, REPEAT..UNTIL	REPEAT..UNTIL loop
Loop check, WHILE	WHILE loop
Loop termination	WHILE loop

Loop, FOR	FOR loop
Loop, general	LOOP block
Loop, LOOP	LOOP block
Loop, REPEAT..UNTIL	REPEAT..UNTIL loop
Loop, terminate by jumping to a label	Labelling and the JUMP statement
Loop, WHILE	WHILE loop
Lowercase a string	String functions
main procedure	Procedures
Making pointers	Finding addresses (making pointers)
Manipulation, safe	LIST and STRING Types
Mapping a quoted expression over a list	Lists and quoted expressions
Mathematical operators	Mathematics
Maths functions	Maths and logic functions
Maximum length of an E-list	List functions
Maximum length of an E-string	String functions
Memory address	Memory addresses
Memory address	Addresses
Memory, allocating	System support functions
Memory, deallocate	System support functions
Memory, deallocate complex	System support functions
Memory, free	System support functions
Memory, free complex	System support functions
Memory, reading	Maths and logic functions
Memory, writing	Maths and logic functions
Middle copy of a string	String functions
Mnemonics, Assembly	Assembly Statements
Module	Modules
Module, Amiga system	Amiga System Modules
Module, code	Code Modules
Module, convert from include, header or pragma file	Non-Standard Modules
Module, example use	Example Module Use
Module, non-standard	Non-Standard Modules
Module, using	Using Modules
Module, view contents	Using Modules
Modulus	Maths and logic functions
Mouse button flags	Intuition support functions
Mouse buttons state	Intuition support functions
Mouse x-coordinate	Intuition support functions
Mouse y-coordinate	Intuition support functions
Multiple return values	Multiple Return Values
Multiple-assignment	Multiple Return Values
Multiplication	Mathematics
Multiplication, 32-bit	Maths and logic functions
Mutual recursion	Mutual Recursion
Named constant	Named Constants
Named data	Variables and Expressions
Named elements	OBJECT Type
Names of local variables	Global and local variables
Nested comment	Comments
Nested IF blocks	IF block
Next element of a linked list	Linked Lists
Node	Binary Trees
Non-standard module	Non-Standard Modules
Normal list	Lists and E-lists
Normal list, selecting an element	List functions
Normal string	Normal strings and E-strings
Not	Maths and logic functions

Null character	String Constants Special Character ←
Sequences	
Number, even	Maths and logic functions
Number, extracting from a string	String functions
Number, floating-point	Floating-Point Numbers
Number, odd	Maths and logic functions
Number, printing	Input and output functions
Number, printing (simple)	Changing the example
Number, quick random	Maths and logic functions
Number, random	Maths and logic functions
Number, real	Floating-Point Numbers
Numbered elements of an array	Accessing array data
Numeric constant	Numeric Constants
Object	OBJECT Type
Object element types	Element selection and element types
Object pointer	Element selection and element types
Object selection, use of ++ and -	Element selection and element types
Object, Amiga system	Amiga system objects
Object, element selection	Element selection and element types
Object, named elements	OBJECT Type
Object, size	SIZEOF expression
Odd number	Maths and logic functions
One-line function	One-Line Functions
Open screen	Intuition support functions
Open window	Intuition support functions
Operator precedence	Precedence and grouping
Operators, comparison	Logic and comparison
Operators, logic	Logic and comparison
Operators, mathematical	Mathematics
Option, set constant	Sets
Optional return values	Multiple Return Values
Or	Maths and logic functions
OR, bit-wise	Bitwise AND and OR
Or, exclusive	Maths and logic functions
OR-ing flags	Sets
Output a character	Input and output functions
Output functions	Input and output functions
Output text	Input and output functions
Output window	Input and output functions
Overlapping conditions	IF block
Pad byte	SIZEOF expression
Parameter	Parameters
Parameter variable	Global and local variables
Parameter, default	Default Arguments
Parameter, procedure local variables	Global and local variables
Parentheses and expressions	Precedence and grouping
Parsing command line arguments	Argument Parsing
Peeking memory	Maths and logic functions
Pen, setting foreground and background colour	Graphics functions
Place-holder, decimal \d	Changing the example
Place-holder, field formatting	Input and output functions
Place-holder, field size	Input and output functions
Place-holders	Input and output functions
Plot a point	Graphics functions
Point, plot	Graphics functions
Pointer	PTR Type
Pointer (array) and array declaration	Array pointers

Pointer analogy	Addresses
Pointer diagram	Addresses
Pointer type	PTR Type
Pointer, array	Array pointers
Pointer, common use	Extracting data (dereferencing pointers)
Pointer, dereference	Extracting data (dereferencing pointers)
Pointer, making	Finding addresses (making pointers)
Pointer, object	Element selection and element types
Poking memory	Maths and logic functions
Potential problems using Assembly	Things to watch out for
Pragma file, convert to module	Non-Standard Modules
Precedence, operators	Precedence and grouping
Printing characters	Input and output functions
Printing decimal numbers	Input and output functions
Printing hexadecimal numbers	Input and output functions
Printing numbers	Changing the example
Printing strings	Input and output functions
Printing text	Input and output functions
Printing to an E-string	Input and output functions
Problems, common	Common Problems
Procedure	Procedures
Procedure argument	Parameters
Procedure parameter	Parameters
Procedure parameter local variables	Global and local variables
Procedure parameter types	Procedure parameters
Procedure parameter variable	Global and local variables
Procedure parameter, array	Array procedure parameters
Procedure parameter, default	Default Arguments
Procedure with parameters, definition	Global and local variables
Procedure, calling	Procedures
Procedure, calling	Procedure Execution
Procedure, definition	Procedure Definition
Procedure, early termination	Functions
Procedure, exception handler	Procedures with Exception Handlers
Procedure, execution	Procedure Execution
Procedure, inlining	Style Reuse and Readability
Procedure, recent	Raising an Exception
Procedure, return value	Functions
Procedure, reuse	Style Reuse and Readability
Procedure, running	Procedure Execution
Procedure, running	Procedures
Procedure, style	Style Reuse and Readability
Procedure, use in Assembly	Assembly and the E language
Program flow control	Program Flow Control
Program termination	System support functions
Program, finish	Procedures
Program, running	Execution
Program, start	Procedures
Pseudo-random number	Maths and logic functions
qual part of Intuition message	Intuition support functions
Quick random number	Maths and logic functions
Quotable expressions	Quotable expressions
Quoted expression	Quoted Expressions
Quoted expression, evaluation	Evaluation
Quoted expression, for all list elements	Lists and quoted expressions
Quoted expression, local variables	Quotable expressions
Quoted expression, mapping over a list	Lists and quoted expressions

Quoted expression, there exists a list element	Lists and quoted expressions
Quoted expressions and lists	Lists and quoted expressions
Raising an exception	Raising an Exception
Raising an exception from a handler	Raise within an Exception Handler
Random number	Maths and logic functions
Random number, quick	Maths and logic functions
Range of floating-point numbers	Accuracy and Range
ReadArgs, using	AmigaDOS 2.0 (and above)
Reading a character from a file	Input and output functions
Reading a string from a file	Input and output functions
Reading from memory	Maths and logic functions
Reading, further	Further Reading
Real number	Floating-Point Numbers
Recent procedure	Raising an Exception
Recursion	Recursion
Recursion example	Recursion Example
Recursion, mutual	Mutual Recursion
Recursive case	Factorial Example
Recursive exception handling	Stack and Exceptions
Recursive function	Recursion
Recursive type	Recursion
Registers, A4 and A5	Things to watch out for
Regular return value	Multiple Return Values
Remainder	Maths and logic functions
REPEAT..UNTIL loop	REPEAT..UNTIL loop
REPEAT..UNTIL loop check	REPEAT..UNTIL loop
REPEAT..UNTIL loop version of a FOR loop	REPEAT..UNTIL loop
Repeated execution	Loops
Resolution flags	Intuition support functions
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Return value, optional	Multiple Return Values
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Return values, multiple	Multiple Return Values
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Reusing procedures	Style Reuse and Readability
Revision, Kickstart	System support functions
Rewriting a FOR loop as a REPEAT..UNTIL loop	REPEAT..UNTIL loop
Rewriting a FOR loop as a WHILE loop	WHILE loop
Rewriting SELECT block as IF block	SELECT block
Rewriting SELECT..OF block as IF block	SELECT..OF block
Right shift	Maths and logic functions
Right-hand copy of an E-string	String functions
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Rules, format and layout	Format and Layout
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Safe manipulation	LIST and STRING Types
Same names of local variables	Global and local variables
Screen example, with handler	Screens
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Screen resolution flags	Intuition support functions
Screen, close	Intuition support functions
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Seed of a random sequence	Maths and logic functions
SELECT block	SELECT block
SELECT block, rewriting as IF block	SELECT block

SELECT..OF block	SELECT..OF block
SELECT..OF block, rewriting as IF block	SELECT..OF block
SELECT..OF block, speed versus size	SELECT..OF block
Selecting an element of a normal list	List functions
Selecting an element of an object	Element selection and element types
Selection, use of ++ and -	Element selection and element types
Separators	Spacing and Separators
Sequencing expressions	BUT expression
Sequential composition	Statements
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Set length of an E-string	String functions
Setting foreground and background pen colours	Graphics functions
Setting stdout	Input and output functions
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Setting the length of an E-list	List functions
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Shift left	Maths and logic functions
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Short-hand for first element of an array	Accessing array data
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Singly linked list	Linked Lists
Size of an array	Tables of data
Size of an object	SIZEOF expression
Size versus speed, SELECT..OF block	SELECT..OF block
Spacing	Spacing and Separators
Special character sequences	String Constants Special Character ←
Sequences	
Speed versus size, SELECT..OF block	SELECT..OF block
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Stack and crashing	Stack (and Crashing)
Stack and exceptions	Stack and Exceptions
Stack space, free	System support functions
Stack, avoiding crashes	Stack (and Crashing)
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Statement, Assembly	Assembly Statements
Statement, breaking	Statements
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Statement, several on one line	Statements
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Static data	Static data
Static data, potential problems	Static data
Static memory, use in Assembly	Static memory
stdout, setting	Input and output functions
stdrast, setting	Graphics functions
String	Normal strings and E-strings
String	Strings
String diagram	Normal strings and E-strings
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STRING type	Normal strings and E-strings
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String, breaking	Statements
String, comparison	String functions
String, constant	Normal strings and E-strings
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String, copying	String functions
String, find sub-string	String functions
String, length	String functions
String, lowercase	String functions
String, middle copy	String functions
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String, special character sequence	String Constants Special Character ↔
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String, splitting	Statements
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Structure	OBJECT Type
Sub-string location in a string	String functions
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System module	Amiga System Modules
System objects	Amiga system objects
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System variables	Built-In Variables
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Terminating loops	WHILE loop
Termination, program	System support functions
Test for control-C	System support functions
Test for even number	Maths and logic functions
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Text drawing	Graphics functions
Text, printing	Input and output functions
There exists a list element	Lists and quoted expressions
Timing expressions example	Timing Expressions
Tinkering	Tinkering with the example
Topaz, setting font	Graphics functions
Tree, binary	Binary Trees
Tree, branch	Binary Trees
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Trim leading whitespace from a string	String functions
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Turn an expression into a statement	Turning an Expression into a Statement
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Type, 32-bit	Default type
Type, 8-bit	Indirect types
Type, address	Addresses
Type, array	Tables of data
Type, complex	Complex types
Type, default	Default type
Type, direct	Indirect types
Type, E-list	Lists and E-lists

Type, indirect	Indirect types
Type, list	Lists and E-lists
Type, LONG	LONG Type
Type, LONG (definition)	Indirect types
Type, object	OBJECT Type
Type, object elements	Element selection and element types
Type, pointer	PTR Type
Type, procedure parameters	Procedure parameters
Type, recursive	Recursion
Type, STRING	Normal strings and E-strings
Type, variable declaration	Default type
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Using arg	Any AmigaDOS
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Using wbmessage	Any AmigaDOS
van Oortmerssen, Wouter	Amiga E Author
Variable	Variables and Expressions
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Variable, changing value	Assignment
Variable, declarating	Variable declaration
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Variable, global	Global and local variables
Variable, increment	INC and DEC statements
Variable, local	Global and local variables
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Variable, same global and local names	Global and local variables
Variable, same local names	Global and local variables
Variable, system	Built-In Variables
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Variable, use in Assembly statements	Assembly and the E language
Version, Kickstart	System support functions
Vertical FOR loop	FOR loop
Vertical IF block	IF block
Vertical WHILE loop	WHILE loop
View module contents	Using Modules
Voiding an expression	Turning an Expression into a Statement
Voiding, automatic	Turning an Expression into a Statement
Waiting for Intuition messages	Intuition support functions
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WHILE loop check	WHILE loop
WHILE loop version of a FOR loop	WHILE loop
Whitespace	Spacing and Separators
Whitespace, trim from a string	String functions
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Window, close	Intuition support functions
Window, open	Intuition support functions
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Wouter van Oortmerssen	Amiga E Author
Writing a character to file	Input and output functions
Writing to memory	Maths and logic functions
X-coordinate, mouse	Intuition support functions
Y-coordinate, mouse	Intuition support functions

Zero fill field

Input and output functions
