FORTRAN 77 4.0 Reference Manual

SunSoft
A Sun Microsystems, Inc. Business
2550 Garcia Avenue
Mountain View, CA 94043
U.S.A.

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Some of the material in this manual is based on the Bell Laboratories document entitled "A Portable Fortran 77 Compiler," by S. I. Feldman and P. J. Weinberger, dated August 1, 1978. Material on the I/O Library is derived from the paper entitled "Introduction to the f77 I/O Library," by David L. Wasley, University of California, Berkeley, California 94720. Further work was done at Sun Microsystems.

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Preface

This preface is organized into the following sections:

Purpose and Audience

This manual describes the language and routines of the FORTRAN 77 4.0 compiler from SunSoft.

This is a *reference* manual. Though it contains many examples, it is not a tutorial. Its function and purpose are solely to help you find features or routines, not to teach you FORTRAN 77, programming, or programming style.

This book is for scientists and engineers with the following background:

- Thorough knowledge and experience with FORTRAN 77 programming
- General knowledge and understanding of some operating system
- Particular knowledge of Solaris® or UNIX commands.

For help using the compiler, linker, debugger, the related utilities, or making or using libraries, refer to the *FORTRAN 77 4.0 User's Guide.*

How this Book is Organized

This book is organized as follows:

Related Manuals

The following documents are provided on-line or in hard copy, as indicated:

Title	Hard Copy	On-line
FORTRAN 77 4.0 User's Guide	X	X
FORTRAN 77 4.0 Reference Manual	X	X
Debugging a Program	X	X
Incremental Link Editor	X	X
Numerical Computation Guide	X	X
What Every Computer Scientist Should Know About Floating-Point Arithmetic		X
Installing SunSoft Developer Products on Solaris	X	X

Conventions in Text

We use the following conventions in this manual to display information.

- We show code listings examples in boxes:

```
   WRITE( *, * ) 'Hello world'
```

- The `plain Courier font` shows prompts and coding.
- In dialogs, the **`boldface Courier font`** shows text you type in:

```
demo% echo hello
hello
demo%
```

- *Italics* indicate general arguments or parameters that you replace with the appropriate input. Italics also indicate emphasis.
- For Solaris 2.x, the default shell is `sh`; the default prompt is the dollar sign (`$`). Most systems have distinct host names, and you can read some of our examples more easily if we use a symbol longer than a dollar sign. Where the `csh` shell is shown, we use `demo%` as the system prompt.
- The small clear triangle ∆ shows a blank space where that is significant:

```
 ∆∆36.001
```

- We generally tag nonstandard features with a small black diamond (♦). A program that uses a nonstandard feature does not conform to the ANSI X3.9-1978 standard, as described in American National Standard Programming Language FORTRAN, ANSI X3.9-1978, April 1978, American National Standards Institute, Inc., abbreviated as the FORTRAN Standard.
- We usually show FORTRAN 77 examples in tab format, not fixed columns. See Section 1.9, “Source Line Formats,” for details.
- We usually abbreviate FORTRAN 77 as `f77`.

Elements of FORTRAN 77 1

This chapter is organized into the following sections.

1.1 Operating Environments

Each release of `f77` is available *first* on SPARC systems under the Solaris 2.x operating environment. For information on other current platforms or operating environments, see the `/READMEs/fortran_77` file.

The previous major release was ported to Solaris™ 1.x and to Intel® 80386-compatible computers running Solaris 2.x for x86, and some features remain in this guide identified as being "*Solaris 1.x only*" or "*x86 only*," and sometimes "(*1.x only*)" or "(*x86*)".

1.2 Standards

This FORTRAN 77 compiler is an enhanced FORTRAN 77 development system. It conforms to the ANSI X3.9-1978 FORTRAN 77 standard and the corresponding International Standards Organization number is ISO 1539-1980. NIST (formerly GSA and NBS) validates it at appropriate intervals.

This compiler also conforms to the standards FIPS 69-1, BS 6832, and MIL-STD-1753. It provides an IEEE standard 754-1985 floating-point package.

On SPARC systems, it provides support for optimization exploiting features of SPARC V8, including the SuperSPARC™ implementation. These features are defined in the *SPARC Architecture Manual: Version 8*.

1.3 Extensions

This FORTRAN 77 compiler provides iMPact™ multiprocessor FORTRAN 77 and lint-like checking across routines for consistency of arguments, commons, parameters, and so forth.

Other extensions include recursion, pointers, double-precision complex, quadruple-precision real, quadruple-precision complex, and many VAX® and VMS® FORTRAN 77 5.0 extensions, including `NAMELIST`, `DO WHILE`, structures, records, unions, maps, and variable formats. Multiprocessor FORTRAN 77 includes automatic and explicit loop parallelization.

You can write FORTRAN 77 programs with many VMS extensions, so that these programs run with the same source code on both SPARC and VAX systems.

1.4 Basic Terms

Some of the FORTRAN 77 basic terms and concepts are:

- A *program* consists of one or more program units.
- A *program unit* is a sequence of statements, terminated by an `END`.
- A *statement* consists of zero or more key words, symbolic names, literal constants, statement labels, operators, and special characters.
- Each *key word*, *symbolic name*, *literal constant*, and *operator* consists of one or more characters from the FORTRAN 77 character set.

- A *character constant* can include any valid ASCII character.
- A *statement label* consists of 1 to 5 digits, with at least one nonzero.

1.5 Character Set

The character set consists of the following:

- Uppercase and lowercase letters, A – Z and a – z
- Numerals 0 – 9
- The special characters shown in the following table

Table 1-1 Special Characters

Character	Name	Character	Name
Space	Space	'	Apostrophe
Tab	Tab	"	Quote ♦
=	Equals	$	Dollar sign ♦
+	Plus	_	Underscore ♦
-	Minus	!	Exclamation point ♦
*	Asterisk	:	Colon
/	Slash	?	Question mark ♦
(	Left parenthesis	%	Percent ♦
)	Right parenthesis	&	Ampersand ♦
,	Comma	\	Backslash ♦
.	Period	<	Left angle bracket ♦
		>	Right angle bracket ♦

Note the following usage and restrictions:

- **Uppercase and lowercase**—The case is not significant in the key words of FORTRAN 77 statements or in symbolic names.

  The `-U` option of `f77` makes case significant in symbolic names. ♦

- **Control characters ♦**—Even though they are not in the character set, most control characters are allowed as data. The exceptions are: Control `A`, Control `B`, Control C, which are *not* allowed as data.

  While entering a character string, do not hold down the Control key and press the A, B, or C key. Even these characters can be entered other ways, such as with the `char()` function.

- **Special characters**—The following table shows the special characters that are used for punctuation:

Table 1-2 Special Character Usage

Character	Usage
Space	Ignored in statements, except as part of a character constant
Tab	Establish the line as a tab-format source line ♦
`=`	Assignment
`+`	Add, unary operator
`–`	Subtract, unary operator
`*`	Multiply, alternate returns, comments, exponentiation, `stdin`, `stdout`, list-directed I/O
`/`	Divide, delimit data, labeled commons, structures, end-of-record
`( )`	Enclose expressions, complex constants, equivalence groups, formats, argument lists, subscripts
`,`	Separator for data, expressions, complex constants, equivalence groups, formats, argument lists, subscripts
`.`	Radix point, delimiter for logical constants and operators, record fields
`'`	Quoted character literals
`"`	Quoted character literals, octal constants ♦
`$`	Delimit namelist input, edit descriptor, directives ♦
`!`	Comments ♦
`:`	Array declarators, substrings, edit descriptor
`%`	Special functions: `%REF`, `%VAL`, `%LOC` ♦
`&`	Continuation, alternate return, delimit namelist input; in column 1: establish the line as a tab-format source line ♦
`?`	Request names in namelist group ♦
`\`	Escape character ♦
`< >`	Enclose variable expressions in formats ♦

- **ASCII characters**—Any ASCII character is valid as literal data in a character string. ♦

  For the backslash (\) character, you may need to use an escape sequence or use the –xl compiler option. The backslash (\) is also called a reverse solidus, and the slash (/), a solidus. For the newline (\n) character, you must use an escape sequence. See also Table 2-5.

1.6 Symbolic Names

The items in the following table can have symbolic names:

Table 1-3 Items with Symbolic Names

Symbolic constants	Labeled commons
Variables	Namelist groups ♦
Arrays	Main programs
Structures ♦	Subroutines
Records ♦	Functions
Record fields ♦	Entry points

The following restrictions apply:

- Symbolic names can have from 1 to 32 characters. The standard is 6. ♦
- Symbolic names consist of letters, digits, the dollar sign ($), and the underscore character (_). $ and _ are not standard. ♦
- Symbolic names generally start with a letter—never with a digit or dollar sign ($). Names that start with an underscore (_) are allowed, ♦ but it is safer to reserve such names for the compiler.
- Uppercase and lowercase are not significant; the compiler converts them all to lowercase. The –U option on the f77 command line overrides this default, thereby preserving any uppercase used in your source file. ♦
- Example: These names are equivalent with the default in effect:

```
ATAD = 1.0E-6
Atad = 1.0e-6
```

Consistently separating words by spaces became a general custom about the tenth century A.D., and lasted until about 1957, when FORTRAN 77 abandoned the practice.

- The space character is not significant.

  Example: These names are equivalent:

```
IF ( X .LT. ATAD ) GO TO 9
IF ( X .LT. A TAD ) GO TO 9
IF(X.LT.ATAD)GOTO9
```

Here are some sample symbolic names:

Table 1-4 Sample Symbolic Names

Valid	**Invalid**	**Reason**
`X2`	`2X`	Starts with a digit.
`DELTA_TEMP`	`_DELTA_TEMP`	Starts with an _ (reserved for the compiler).
`Y$Dot`	`Y|Dot`	There is an invalid character `|`.

- In general, for any single program unit, different entities cannot have the same symbolic name. The exceptions are:
  - A variable or array can have the same name as a common block.
  - A field of a record can have the same name as a structure. ♦
  - A field of a record can have the same name as a field at a different level of the structure. ♦
- Throughout any program of more than one programming unit, no two of the following can have the same name:
  - Block data subprograms
  - Common blocks
  - Entry points
  - Function subprograms
  - Main program
  - Subroutines

1.7 Program

A program unit is a sequence of statements, terminated by an `END` statement. Every program unit is either a main program or a subprogram. If a program is to be executable, it must have a main program.

There are three types of subprograms: subroutines, functions, and block data subprograms. The subroutines and functions are called *procedures*, which are invoked from other procedures or from the main program. The block data subprograms are handled by the loader.

1.8 Statements

A statement consists of one or more key words, symbolic names, literal constants, and operators, with appropriate punctuation. In FORTRAN 77, no keywords are reserved in all contexts. Most statements begin with a keyword; the exceptions are the statement function and assignment statements.

Executable or Nonexecutable Statements

Every statement is either executable or nonexecutable. In general, if a statement specifies an action to be taken at runtime, it is executable. Otherwise, it is nonexecutable.

The nonexecutable statements specify attributes, such as type and size; determine arrangement or order; define initial data values; specify editing instructions; define statement functions; classify program units; and define entry points. In general, nonexecutable statements are completed before execution of the first executable statement.

FORTRAN 77 Statements

Table 1-5 FORTRAN 77 Statements

The asterisk (*) indicates an executable statement.

ACCEPT*	DOUBLE COMPLEX	GOTO (Assigned)*	PRINT*
ASSIGN*	DOUBLE PRECISION	GOTO (Unconditional)*	PRAGMA
Assignment*	ELSE*	IF (Arithmetic)*	PROGRAM
AUTOMATIC	ELSE IF*	IF (Block)*	REAL
BACKSPACE*	ENCODE*	IF (Logical)*	RECORD
BLOCK DATA	END*	IMPLICIT	RETURN*
BYTE	END DO*	INCLUDE	REWIND*
CALL*	END FILE*	INQUIRE*	SAVE
CHARACTER	END IF*	INTEGER	Statement Function
CLOSE*	END MAP	INTRINSIC	STATIC*
COMMON	END STRUCTURE	LOGICAL	STOP*
COMPLEX	END UNION	MAP	STRUCTURE
CONTINUE*	ENTRY	NAMELIST	SUBROUTINE*
DATA	EQUIVALENCE	OPEN*	TYPE
DECODE*	EXTERNAL	OPTIONS	UNION
DIMENSION	FORMAT	PARAMETER	VIRTUAL
DO*	FUNCTION	PAUSE*	VOLATILE
DO WHILE*	GOTO*	POINTER	WRITE*

1.9 Source Line Formats

A statement takes one or more lines; the first line is called the *initial line*; the subsequent lines are called the *continuation lines*.

You can format a source line in either of two ways:

- Standard fixed format
- Tab format ♦

Standard Fixed Format

The standard fixed format source lines are defined as follows:

- The first 72 columns of each line are scanned. See “Extended Lines,” page 9.
- The first five columns must be blank or contain a numeric label.
- Continuation lines are identified by a nonblank, nonzero in column 6.
- Short lines are padded to 72 characters.
- Long lines are truncated. See “Extended Lines,” below.

Tab-Format

The tab-format source lines are defined as follows: ♦

- A tab in any of columns 1 through 6, or an ampersand in column 1, establishes the line as a tab-format source line.
- If the tab is the first nonblank character, the text following the tab is scanned as if it started in column 7.
- A comment indicator or a statement number can precede the tab.
- Continuation lines are identified by an ampersand (&) in column 1, or a nonzero digit after the first tab.

Mixing Formats

You can format lines both ways in one program unit, but not in the same line.

Continuation Lines

The default maximum number of continuation lines is 99 ♦ (1 initial and 99 continuation). To change this number of lines, use the `-Nl`*n* option. ♦

Extended Lines

To **e**xtend the source line length to 132 characters, use the `–e` option.♦ Otherwise, by default, `f77` ignores any characters after column 72.

Example: Compile to allow extended lines:

```
demo% f77 -e prog.f
```

Padding

Padding is significant in lines such as the two in the following DATA statement:

```
C       1         2         3         4         5         6         7
C23456789012345678901234567890123456789012345678901234567890123456789012
      DATA SIXTYH/60H
     1                              /
```

Comments and Blank Lines

A line with a c, C, *, d, D, or ! in column one is a comment line, except that if the –xld option is set, then the lines starting with D or d are compiled as debug lines. The d, D, and ! are nonstandard. ♦

If you put an exclamation mark (!) in any column of the statement field, except within character literals, then everything after the ! on that line is a comment. ♦

A totally blank line is a comment line.

Example: c, C, d, D, *,!, and blank comments:

```
c   Start expression analyzer
    CHARACTER S, STACK*80
    COMMON /PRMS/ N, S, STACK
    …
*   Crack the expression:
    IF ( S .GE. '0' .AND. S .LE. '9' ) THEN ! EoL comment
        CALL PUSH ! Save on stack. EoL comment
d       PRINT *, S! Debug comment & EoL comment
    ELSE
        CALL TOLOWER ! To lowercase EoL comment
    END IF
D   PRINT *, N! Debug comment & EoL comment
    …
C   Finished
!   expression analyzer
```

Directives

A directive passes information to a compiler in a special form of comment. ♦ Directives are also called *compiler pragmas*. There are two kinds of directives:

- General directives
- Parallel directives

General Directives

The form of a general directive is one of the following:

- `C$PRAGMA` *id*
- `C$PRAGMA` *id* (*a* [, *a*] …) [, *id* (*a* [, *a*] …)] ,…
- `C$PRAGMA sun` *id*=

The variable *id* identifies the kind of directive; *a* is an argument.

Syntax

A directive has the following syntax:

- In column one, any of the comment-indicator characters `c`, `C`, `!`, or `*`
- In any column, the `!` comment-indicator character
- The next 7 characters are `$PRAGMA`, no blanks, any uppercase or lowercase

Rules and Restrictions

After the first eight characters, blanks are ignored, and uppercase and lowercase are equivalent, as in FORTRAN 77 text.

Because it is a comment, a directive cannot be continued, but you can have many `C$PRAGMA` lines, one after the other, as needed.

If a comment satisfies the above syntax, it is expected to contain one or more directives recognized by the compiler; if it does not, a warning is issued.

The `C()` *Directive*

The `C()` directive specifies that its arguments are external functions written in the C language. It is equivalent to an `EXTERNAL` declaration with the addition that the FORTRAN 77 compiler does not append an underscore to such names, as it ordinarily does with external names.

The `C()` directive for a particular function must appear before the first reference to that function in each subprogram that contains such a reference. The recommended usage is:

```
    EXTERNAL ABC, XYZ  !$PRAGMA C(ABC, XYZ)
```

The `unroll` *Directive*

The `unroll` directive requires that you specify `sun` after `C$PRAGMA`.

The `C$PRAGMA sun unroll=`*n* directive instructs the optimizer to unroll loops *n* times, where *n* is a positive integer. The choices are:

- If *n*=1, this directive orders the optimizer *not* to unroll any loops.
- If *n*>1, this directive suggests to the optimizer that it unroll loops *n* times.

If any loops are actually unrolled, then the executable file becomes larger.

Example: To unroll loops two times:

```
C$PRAGMA SUN UNROLL=2
```

Parallel Directives

A *parallel directive* is a special comment that directs the compiler to do something about parallelization. The following are the parallel directives:

- `DOALL`
- `DOSERIAL`
- `DOSERIAL*`

For syntax and other information on parallel directives, see the appendix on multiple processors in the *FORTRAN 77 4.0 User's Guide*.

Data Types and Data Items 2

This chapter is organized into the following sections:

2.1 Types

Any constant or constant expression usually represents typed data; the exceptions are the typeless constants. Any name of a variable, array, array element, substring, or function usually represents typed data.

The following items have data types:

Constant Expressions	External Functions
Variables	Statement Functions
Arrays	

These items do *not* have data types.

Main Programs	Common Blocks
Subroutines	Namelist Groups ♦
Block Data Subprograms	Structured Records ♦

Rules for Data Typing

The name determines the type; that is, the name of a datum or function determines its data type, explicitly or implicitly, according to the following rules of data typing;

- A symbolic name of a constant, variable, array, or function has only one data type for each program unit, except for generic functions.
- If you explicitly list a name in a type statement, then that determines the data type.
- If you do not explicitly list a name in a type statement, then the first letter of the name determines the data type implicitly.
- The default implicit typing rule is that if the first letter of the name is `I`, `J`, `K`, `L`, `M`, or `N`, then the data type is integer, otherwise it is real.
- You can change the default-implied types by using the `IMPLICIT` statement, even to the extent of turning off all implicit typing with the `IMPLICIT NONE` statement. You can also turn off all implicit typing by specifying the `–u` compiler flag on the command line; this is equivalent to beginning each program unit with the `IMPLICIT NONE` statement.

Array Elements

An array element has the same type as the array name.

Functions

Each intrinsic function has a specified type. An intrinsic function does not require an explicit type statement, but that is allowed. A generic function does not have a predetermined type; the type is determined by the type of the arguments, as shown in Chapter , “Intrinsic Functions.”

An external function can have its type specified in any of the following ways:

- Explicitly by putting its name in a type statement
- Explicitly in its `FUNCTION` statement, by preceding the word `FUNCTION` with the name of a data type
- Implicitly by its name, as with variables

Example: Explicitly by putting its name in a type statement:

```
     FUNCTION F ( X )
     INTEGER F, X
     F = X + 1
     RETURN
     END
```

Example: Explicitly in its `FUNCTION` statement:

```
     INTEGER FUNCTION F ( X )
     INTEGER X
     F = X + 1
     RETURN
     END
```

Example: Implicitly by its name, as with variables:

```
     FUNCTION NXT ( X )
     INTEGER X
     NXT = X + 1
     RETURN
     END
```

Implicit typing can affect the type of a function, either by default implicit typing or by an `IMPLICIT` statement. You must make the data type of the function be the same within the function subprogram as it is in the calling program unit. FORTRAN 77 does no type checking between program units.

Properties of Data Types

This section describes the data types, what each is for, the way storage is allocated for each of them, and the alignment of the different types. Storage and alignment are always given in bytes. Values that can fit into a single byte are byte-aligned.

BYTE ♦

The BYTE data type provides a data type that uses only one byte of storage. It is a logical data type, and has the synonym, LOGICAL*1.

A variable of type BYTE can hold any of the following:

- One character
- An integer between -128 and 127
- The logical values, .TRUE. or .FALSE.

If it is interpreted as a logical value, a value of 0 represents .FALSE., and any other value is interpreted as .TRUE.

f77 allows the BYTE type as an array index, just as it allows the REAL type, but it does not allow BYTE as a DO loop index (where it allows only INTEGER, REAL, and DOUBLE PRECISION). Wherever FORTRAN 77 makes an explicit check for INTEGER, it does not allow BYTE.

Examples:

```
      BYTE Bit3 / 8 /, C1 / 'W' /,
&          Counter / 0 /, Switch / .FALSE. /
```

A BYTE item occupies 1 byte of storage, and is aligned on 1-byte boundaries.

CHARACTER

The character data type, CHARACTER, which has the synonym, CHARACTER*1, holds one character.

The character is enclosed in apostrophes (') or quotes ("). ♦ Allowing quotes (") is nonstandard; if you compile with the –xl option, quotes mean something else, and you must use apostrophes to enclose a string.

The data of type CHARACTER is always unsigned.

A CHARACTER item occupies 1 byte (8 bits) of storage.

A CHARACTER item is aligned on 1-byte boundaries.

CHARACTER*n

The character string data type, CHARACTER**n*, where *n* > 0, holds a string of *n* characters.

A CHARACTER**n* data type occupies *n* bytes of storage.

A CHARACTER**n variable* is aligned on 1-byte boundaries.

Every character string *constant* is aligned on 2-byte boundaries. If it does not appear in a DATA statement, it is followed by a null character to ease communication with C routines.

COMPLEX

A complex datum is an approximation of a complex number. The complex data type, COMPLEX, which usually has the synonym COMPLEX*8, is a pair of REAL*4 values that represent a complex number. The first element represents the real part and the second represents the imaginary part.

The usual default size for a COMPLEX item (no size specified) is 8. If the –r8 compiler option is set, then the default size is 16; otherwise, it is 8.

COMPLEX is aligned on 4-byte boundaries, except if compiled on a Sun-4 or SPARC computer with the –f option, in which case it is aligned on 8-byte boundaries.

COMPLEX*8 ♦

The complex data type COMPLEX*8 is a synonym for COMPLEX, except that it always has a size of 8 bytes, independent of any compiler options.

COMPLEX*16 *(Double Complex)* ♦

The complex data type COMPLEX*16 is a synonym for DOUBLE COMPLEX, except that it always has a size of 16 bytes, independent of any compiler options.

COMPLEX*32 (*Quad Complex)* ♦

(*SPARC only*) The complex data type COMPLEX*32 is a quadruple-precision complex. It is a pair of REAL*16 elements, where each has a sign bit, a 15-bit exponent, and a 112-bit fraction. These REAL*16 elements in f77 conform to the IEEE standard.

The size for COMPLEX*32 is 32 bytes.

COMPLEX*32 is aligned on 4-byte boundaries, except if compiled on a Sun-4 or SPARC computer with the –f option, in which case it is aligned on 8-byte boundaries.

DOUBLE COMPLEX ♦

The complex data type, DOUBLE COMPLEX, which usually has the synonym, COMPLEX*16, is a pair of DOUBLE PRECISION (REAL*8) values that represents a complex number. The first element represents the real part; the second represents the imaginary part.

The default size for DOUBLE COMPLEX with no size specified is 16. If the –r8 compiler option is set, then the default size is 32; otherwise, it is 16.

COMPLEX*16 is aligned on 4-byte boundaries, except if compiled on a Sun-4 or SPARC computer with the –f option, in which case it is aligned on 8-byte boundaries.

DOUBLE PRECISION

A double-precision datum is an approximation of a real number. The double-precision data type, DOUBLE PRECISION, which has the synonym, REAL*8, holds one double-precision datum.

The default size for DOUBLE PRECISION with no size specified is 8. If the –r8 compiler option is set, then the default size is 16; otherwise, 8.

DOUBLE PRECISION is aligned on 4-byte boundaries.

A DOUBLE PRECISION element has a sign bit, an 11-bit exponent, and a 52-bit fraction. These DOUBLE PRECISION elements in f77 conform to the IEEE standard for double-precision floating-point data. The layout is shown in Appendix C, "Data Representations."

INTEGER

The integer data type, INTEGER, holds a signed integer.

The default size for INTEGER with no size specified is 4. However:

- If the –i2 compiler option is set, then the default size is 2; otherwise, it is 4.
- If the –r8 compiler option is set, then the default size is 8; otherwise, it is 4.
- If both the –i2 and –r8 options are set, then the results are unpredictable.
- If both the -r8 and -dbl options are set, then the default size is 8, and the values are 64 bits long. Thus, -dbl is the only way to set 64-bit integer values.

This data type is aligned on 4-byte boundaries, unless the –i2 option is set, in which case it is aligned on 2-byte boundaries.

INTEGER*2 ♦

The short integer data type, INTEGER*2, holds a signed integer. An expression involving only objects of type INTEGER*2 is of that type. Using this feature may have adverse performance implications, and we do not recommend it.

Generic functions return short or long integers depending on the default integer type. If a procedure is compiled with the –i2 flag, all integer constants that fit and all variables of type INTEGER (no explicit size) are of type INTEGER*2. If the precision of an integer-valued intrinsic function is not determined by the generic function rules, one is chosen that returns the prevailing length (INTEGER*2) when the –i2 command flag is in effect. When the –i2 option is in effect, the default length of LOGICAL quantities is 2 bytes.

Ordinary integers follow the FORTRAN 77 rules about occupying the same space as a REAL variable. They are assumed to be equivalent to the C type long int, and 1-byte integers are of C type short int. These short integer and logical quantities do not obey the standard rules for storage association.

An INTEGER*2 occupies 2 bytes.

INTEGER*2 is aligned on 2-byte boundaries.

INTEGER*4 ♦

The integer data type, INTEGER*4, holds a signed integer.

An INTEGER*4 occupies 4 bytes.

INTEGER*4 is aligned on 4-byte boundaries.

INTEGER*8 ♦

The integer data type, INTEGER*8, holds a signed 64-bit integer. It is allowed only if the -dbl option is set.

An INTEGER*8 occupies 8 bytes.

INTEGER*8 is aligned on 8-byte boundaries.

LOGICAL

The logical data type, LOGICAL, holds a logical value .TRUE. or .FALSE. The value 0 represents .FALSE.; any other value represents .TRUE.

The usual default size for an LOGICAL item with no size specified is 4. However:

- If the –i2 option is set, then the default size is 2; otherwise, it is 4.
- If the –r8 or -dbl option is set, then the default size is 8; otherwise, it is 4.
- If both the –i2 and –r8 options are set, then the results are unpredictable.

LOGICAL is aligned on 4-byte boundaries, unless the –i2 option is set, then it is aligned on 2-byte boundaries.

If the –i2 compiler flag is set, then LOGICAL (without any size specification) is the same as LOGICAL*2; otherwise, it is the same as LOGICAL*4.

LOGICAL*1 ♦

The one-byte logical data type, LOGICAL*1, which has the synonym, BYTE, can hold any of the following:

- One character
- An integer between -128 and 127
- The logical values .TRUE. or .FALSE.

The value is as defined for LOGICAL, but it can hold a character or small integer. An example:

```
    LOGICAL*1 Bit3 / 8 /, C1 / 'W' /,
&          Counter / 0 /, Switch / .FALSE. /
```

A LOGICAL*1 item occupies one byte of storage.

LOGICAL*1 is aligned on one-byte boundaries.

LOGICAL*2 ♦

The data type, LOGICAL*2, holds logical value .TRUE. or .FALSE. The value is defined as for LOGICAL.

A LOGICAL*2 occupies 2 bytes.

LOGICAL*2 is aligned on 2-byte boundaries.

LOGICAL*4 ♦

The logical data type, LOGICAL*4 holds a logical value .TRUE. or .FALSE. The value is defined as for LOGICAL.

A LOGICAL*4 occupies 4 bytes.

LOGICAL*4 is aligned on 4-byte boundaries.

LOGICAL*8 ♦

The logical data type, LOGICAL*8, holds the logical value .TRUE. or .FALSE. This data type is allowed only if the -dbl option is set. The value is defined the same way as for the LOGICAL data type.

A LOGICAL*8 occupies 8 bytes.

LOGICAL*8 is aligned on 8-byte boundaries.

REAL

A real datum is an approximation of a real number. The real data type, REAL, which usually has the synonym, REAL*4, holds one real datum.

The usual default size for a REAL item with no size specified is 4 bytes. If the –r8 option is set, then the default size is 8 bytes; otherwise, it is 4 bytes.

REAL is aligned on 4-byte boundaries, except if compiled on a Sun-4 or SPARC computer with the –f option, in which case it is aligned on 8-byte boundaries.

A REAL element has a sign bit, an 8-bit exponent, and a 23-bit fraction. These REAL elements in f77 conform to the IEEE standard.

REAL*4 ♦

The REAL*4 data type is a synonym for REAL, except that it always has a size of 4 bytes, independent of any compiler options.

REAL*8 *(Double-Precision Real)* ♦

The REAL*8, data type is a synonym for DOUBLE PRECISION, except that it always has a size of 8 bytes, independent of any compiler options.

REAL*16 *(Quad Real)* ♦

(*SPARC only*) The REAL*16 data type is a quadruple-precision real.

The size for a REAL*16 item is 16 bytes.

REAL*16 is aligned on 4-byte boundaries, except if compiled on a Sun-4 or SPARC computer with the –f option, in which case it is aligned on 8-byte boundaries.

A REAL*16 element has a sign bit, a 15-bit exponent, and a 112-bit fraction. These REAL*16 elements in f77 conform to the IEEE standard for extended precision.

Size and Alignment Summary

The size and alignment of types depends on various compiler options. This table summarizes the size and alignment, ignoring other aspects of types and options.

Table 2-1 Sizes and Alignments without `-dalign`, `–f`, `–i2`, `–r8`, or `-dbl`

FORTRAN 77 Type	Size (Bytes)	Alignment (Bytes)
BYTE	1	1
CHARACTER	1	1
CHARACTER*n	n	1
COMPLEX	8	4
COMPLEX*8	8	4
COMPLEX*16	16	4
DOUBLE COMPLEX	16	4
COMPLEX*32 (*SPARC only*)	32	4
REAL	4	4
REAL*4	4	4
REAL*8	8	4
DOUBLE PRECISION	8	4
REAL*16 (*SPARC only*)	16	4
INTEGER	4	4
INTEGER*4	4	4
INTEGER*2	2	2
LOGICAL	4	4
LOGICAL*4	4	4
LOGICAL*2	2	2
LOGICAL*1	1	1

Synonyms:
COMPLEX ≡ COMPLEX*8
INTEGER ≡ INTEGER*4
LOGICAL ≡ LOGICAL*4
REAL ≡ REAL*4
DOUBLE COMPLEX ≡ COMPLEX*16
DOUBLE PRECISION ≡ REAL*8

These are synonyms in the sense that COMPLEX is treated the same as COMPLEX*8; INTEGER is treated the same as INTEGER*4, and so forth.

REAL*16 is sometimes called quad real. COMPLEX*32 is sometimes called quad complex.

`-dalign` triggers the `-f` option.

Arrays and structures align according to their elements or fields. An array aligns the same as the array element. A structure aligns the same as the field with the widest alignment.

Changed synonyms:
INTEGER ≡ INTEGER*2
LOGICAL ≡ LOGICAL*2

Table 2-2 Sizes and Alignments Changed by `-i2`

FORTRAN 77 Type	**Size (Bytes)**	**Alignment (Bytes)**
`INTEGER`	2	2
`LOGICAL`	2	2

Do not use `–i2` with `–i4` or `–r8`.

Changed synonyms:
COMPLEX ≡ COMPLEX*16
INTEGER ≡ *INTEGER*8*
LOGICAL ≡ *LOGICAL*8*
REAL ≡ REAL*8
DOUBLE PRECISION ≡ REAL*16
DOUBLE COMPLEX ≡ COMPLEX*32

Table 2-3 Sizes and Alignments Changed by `-r8` or `-dbl` (*SPARC only*)

FORTRAN 77 Type	**Size (Bytes)**	**Alignment (Bytes)**
`COMPLEX`	16	4
`DOUBLE COMPLEX`	32	4
`REAL`	8	4
`DOUBLE PRECISION`	16	4
`INTEGER`	8	4
`LOGICAL`	8	4

Do not use `–r8` with `–i2`.

With `-dbl` or `-r8`, `INTEGER` and `LOGICAL` are allocated the larger space indicated above. This is done to maintain the FORTRAN 77 requirement that an integer item and a real item have the same amount of storage. However, with `-r8` 8 bytes are allocated but only 4-byte arithmetic is done. With `-dbl`, 8 bytes are allocated and full 8-byte arithmetic is done. In all other ways, `-dbl` and `-r8` produce the same results.

Table 2-4 Sizes and Alignments Changed by `-dalign` or `-f` (*SPARC only*)

FORTRAN 77 Type	Size (Bytes)	Alignment (Bytes)
`COMPLEX*8`	8	8
`COMPLEX*16`	16	8
`DOUBLE COMPLEX`	16	8
`COMPLEX*32` *(SPARC only)*	32	8
`REAL*8`	8	8
`REAL*16` *(SPARC only)*	16	8

`-dalign` triggers the `-f` option.

2.2 Constants

A *constant* is a datum whose value cannot change throughout the program unit. The form of the string representing a constant determines the value and data type of the constant.

There are three general kinds of constants:

- Arithmetic
- Logical
- Character

Blank characters within an arithmetic or logical constant do not affect the value of the constant. Within character constants, they do affect the value.

Here are the different kinds of arithmetic constants:

Typed Constants	Typeless Constants
Complex	Binary
Double complex	Octal
Double precision	Hexadecimal
Integer	Hollerith
Real	

A *signed constant* is an arithmetic constant with a leading plus or minus sign. An *unsigned constant* is an arithmetic constant without a leading sign.

For integer, real, and double-precision data, zero is neither positive nor negative. The value of a signed zero is the same as that of an unsigned zero.

Character Constants

A character-string constant is a string of characters enclosed in apostrophes or quotes. The apostrophes are standard; the quotes are not. ♦

If you compile with the `-xl` option, then the quotes mean something else, and you must use apostrophes to enclose a string.

To include an apostrophe in an apostrophe-delimited string, repeat it. To include a quote in a quote-delimited string, repeat it. Examples:

```
'abc'      "abc"
'ain''t'   "in vi type ""h9Y"
```

If a string begins with one kind of delimiter, the other kind can be embedded within it without using the repeated quote or backslash escapes. See Table 2-5.

Example: Character constants:

```
"abc"   "abc"
"ain't" 'in vi type "h9Y'
```

Null Characters ♦

Each character string constant appearing outside a DATA statement is followed by a null character to ease communication with C routines. You can make character string *constants* consisting of no characters, but only as arguments being passed to a subprogram. Such zero length character string constants are not FORTRAN 77 standard.

Example: Null character string:

```
demo% cat NulChr.f
       write(*,*) 'a', '', 'b'
       stop
       end
demo% f77 NulChr.f
NulChr.f:
 MAIN:
demo% a.out
ab
demo%
```

However, if you put such a null character constant into a character variable, the variable will contain a blank, and have a length of at least 1 byte.

Example: Length of null character string:

```
demo% cat NulVar.f
       character*1 x / 'a' /, y / '' /, z / 'c' /
       write(*,*) x, y, z
       write(*,*) len( y )
       end
demo% f77 NulVar.f
NulVar.f:
 MAIN:
demo% a.out
a c
  1
demo%
```

Escape Sequences ♦

For compatibility with C usage, the following backslash escapes are recognized. If you include the escape sequence in a character string, then you get the indicated character.

Table 2-5 Backslash Escape Sequences

Escape Sequence	Character
`\n`	Newline
`\r`	Carriage return
`\t`	Tab
`\b`	Backspace
`\f`	Form feed
`\v`	Vertical tab
`\0`	Null
`\'`	Apostrophe, which does not terminate a string
`\"`	Quotation mark, which does not terminate a string
`\\`	\
`\x`	*x*, where *x* is any other character

If you compile with the `-xl` option, then the backslash character (\) is treated as an ordinary character. That is, with the `-xl` option, you cannot use these escape sequences to get special characters.

Technically, the escape sequences are not nonstandard, but are implementation-defined.

Complex Constants

A complex constant is an ordered pair of real or integer constants. The constants are separated by a comma, and the pair is enclosed in parentheses. The first constant is the real part, and the second is the imaginary part. A complex constant, `COMPLEX*8`, uses 8 bytes of storage.

Example: Complex constants:

```
( 9.01, .603 )
( +1.0, -2.0 )
( +1.0, -2 )
( 1, 2 )
( 4.51, )        Invalid —need second part
```

COMPLEX*16 *Constants*

A *double-complex* constant, COMPLEX*16, is an ordered pair of real or integer constants, where one of the constants is REAL*8, and the other is INTEGER, REAL*4, or REAL*8. ♦

The constants are separated by a comma, and the pair is enclosed in parentheses. The first constant is the real part, and the second is the imaginary part. A double-complex constant, COMPLEX*16, uses 16 bytes of storage.

Example: Double-complex constants:

```
( 9.01D6, .603 )
( +1.0, -2.0D0 )
( 1D0, 2 )
( 4.51D6, )            Invalid—need second part
( +1.0, -2.0 )         Not DOUBLE COMPLEX—need a REAL*8
```

COMPLEX*32 *(Quad Complex) Constants*

(*SPARC only*) A quad complex constant ♦ is an ordered pair of real or integer constants, where one of the constants is REAL*16, and the other is INTEGER, REAL*4, REAL*8, or REAL*16. ♦

The constants are separated by a comma, and the pair is enclosed in parentheses. The first constant is the real part, and the second is the imaginary part. A quad complex constant, COMPLEX*32 ♦, uses 32 bytes of storage.

Example: Quad complex constants (*SPARC only*):

```
( 9.01Q6, .603 )
( +1.0, -2.0Q0 )
( 1Q0, 2 )
( 3.3Q-4932, 9 )
( 1, 1.1Q+4932 )
( 4.51Q6, )                 Invalid—need second part
( +1.0, -2.0 )              Not quad complex —need a REAL*16
```

Integer Constants

An integer constant consists of an optional plus or minus sign, followed by a string of decimal digits.

Restrictions

No other characters are allowed except, of course, a space.

If no sign is present, the constant is assumed to be nonnegative.

The value must be in the range (-2147483648, 2147483647).

If the `-dbl` option is set, then the value must be in the range (-9223372036854775808,9223372036854775807).

Example: Integer constants:

```
-2147483648
-2147483649                 Invalid—too small, error message
-10
0
+199
29002
2.71828                     Not INTEGE—decimal point not allowed
1E6                         Not INTEGER—E not allowed
29,002                      Invalid—comma not allowed, error message
2147483647
2147483648                  Invalid— too large, error message
```

Alternate Octal Notation ♦

You can also specify integer constants with the following alternate octal notation. Precede an integer string with a double quote (") and compile with the `–xl` option. These are octal constants of type `INTEGER`.

Example: The following two statements are equivalent:

```
    JCOUNT = ICOUNT + "703
    JCOUNT = ICOUNT + 451
```

You can also specify *typeless* constants as binary, octal, hexadecimal, or Hollerith. See “Typeless Constants (Binary, Octal, Hexadecimal)” on page 35.

Long Integers ♦

If the `-dbl` option is used, then the range of integer constants is changed from (-21474836, 21474836) to (-9223372036854775808, 9223372036854775807). The integer constant is stored or passed as an 8-byte integer, data type `INTEGER*8`.

Short Integers ♦

If a constant argument is in the range (-32768, 32767), it is usually widened to a 4-byte integer, data type `INTEGER*4`; but if the `–i2` option is set, then it is stored or passed as a 2-byte integer, data type `INTEGER*2`.

Logical Constants

A logical constant is either the logical value true or false. The only logical constants are `.TRUE.` and `.FALSE.`; no others are possible. The period delimiters are necessary.

A logical constant takes 4 bytes of storage. If it is an actual argument, it is passed as 4 bytes, unless the `–i2` option is set, in which case it is passed as 2.

Real Constants

A real constant is an approximation of a real number. It can be positive, negative, or zero. It has a decimal point or an exponent. If no sign is present, the constant is assumed to be nonnegative.

Real constants, `REAL*4`, use 4 bytes of storage.

Basic Real Constant

A *basic real constant* consists of an optional plus or minus sign, followed by an integer part, followed by a decimal point, followed by a fractional part.

The integer part and the fractional part are each strings of digits, and you can omit either of these parts, but not both.

Example: Basic real constants:

```
+82.
-32.
90.
98.5
```

Real Exponent

A *real exponent* consists of the letter `E`, followed by an optional plus or minus sign, followed by an integer.

Example: Real exponents:

```
E+12
E-3
E6
```

Real Constant

A *real constant* has one of these forms:

- Basic real constant
- Basic real constant followed by a real exponent
- Integer constant followed by a real exponent

A real exponent denotes a power of ten. The value of a real constant is the product of that power of ten and the constant that precedes the E.

Example: Real constants:

`-32.`	
`-32.18`	
`1.6E-9`	
`7E3`	
`1.6E12`	
`$1.0E2.0`	*Invalid— $ not allowed, error message*
`82`	*Not* REAL*—need decimal point or exponent*
`29,002.0`	*Invalid —comma not allowed, error message*
`1.6E39`	*Invalid—too large, machine infinity is used*
`1.6E-39`	*Invalid —too small, some precision is lost*

The restrictions are:

- Other than the optional plus or minus sign, a decimal point, the digits 0 through 9, and the letter E, no other characters are allowed.
- The magnitude of a normalized single-precision floating-point value must be in the approximate range (1.175494E-38, 3.402823E+38).

REAL*8 *(Double-Precision Real) Constants*

A double-precision constant is an approximation of a real number. It can be positive, negative, or zero. If no sign is present, the constant is assumed to be nonnegative. A double-precision constant has a double-precision exponent and an optional decimal point. Double-precision constants, REAL*8, use 8 bytes of storage. The REAL*8 notation is nonstandard. ♦

Double-Precision Exponent

A *double-precision exponent* consists of the letter D, followed by an optional plus or minus sign, followed by an integer.

A double-precision exponent denotes a power of 10. The value of a double-precision constant is the product of that power of 10 and the constant that precedes the D. The form and interpretation are the same as for a real exponent, except that a D is used instead of an E.

Examples of double-precision constants are:

`1.6D-9`	
`7D3`	
`$1.0D2.0`	*Invalid* —`$` *not allowed, error message*
`82`	*Not* `DOUBLE PRECISION`*—need decimal point or exponent*
`29,002.0D0`	*Invalid—comma not allowed, error message*
`1.8D308`	*Invalid—too large, machine infinity is used*
`1.0D-324`	*Invalid—too small, some precision is lost*

The restrictions are:

- Other than the optional plus or minus sign, a decimal point, the digits 0 through 9, a blank, and the letter `D`. No other characters are allowed.
- The magnitude of an IEEE normalized double-precision floating-point value must be in the approximate range (2.225074D-308, 1.797693D+308).

`REAL*16` *(Quad Real) Constants*

(*SPARC only*) A quadruple-precision constant is a *basic real constant (*see the start of the section, “Real Constants” on page 32), or an integer constant, such that it is followed by a quadruple-precision exponent. ♦

A *quadruple-precision exponent* consists of the letter `Q`, followed by an optional plus or minus sign, followed by an integer.

A quadruple-precision constant can be positive, negative, or zero. If no sign is present, the constant is assumed to be nonnegative.

Example: Quadruple-precision constants (*SPARC only*):

`1.6Q-9`	
`7Q3`	
`3.3Q-4932`	
`1.1Q+4932`	
`$1.0Q2.0`	*Invalid—*`$` *not allowed, error message*
`82`	*Not* `quad`*—need exponent*
`29,002.0Q0`	*Invalid—comma not allowed, error message*
`1.6Q5000`	*Invalid—too large, machine infinity is used*
`1.6Q-5000`	*Invalid—too small, some precision is lost*

The form and interpretation are the same as for a real constant, except that a Q is used instead of an E.

The restrictions are:

- Other than the optional plus or minus sign, a decimal point, the digits 0 through 9, a blank, and the letter Q. No other characters are allowed.
- The magnitude of an IEEE normalized quadruple-precision floating-point value must be in the approximate range (3.362Q-4932, 1.20Q+4932).
- It occupies 16 bytes of storage.
- Each such datum is aligned on 4-byte boundaries.

Typeless Constants (Binary, Octal, Hexadecimal)

Typeless numeric constants are so named because their expressions assume data types based on how they are used. ♦

These constants are not converted before use. However, in f77, they must be distinguished from character strings.

The general form is to enclose a string of appropriate digits in apostrophes and prefix it with the letter B, O, X, or Z. The B is for binary, the O is for octal, and the X or Z are for hexadecimal.

Example: Binary, octal, and hexadecimal constants, DATA and PARAMETER:

```
    PARAMETER ( P1 = Z'1F' )
    INTEGER*2 N1, N2, N3, N4
    DATA N1 /B'0011111'/, N2/O'37'/, N3/X'1f'/, N4/Z'1f'/
    WRITE ( *, 1 ) N1, N2, N3, N4, P1
1   FORMAT ( 1X, O4, O4, Z4, Z4, Z4 )
    END
```

Note the edit descriptors in FORMAT statements: O for octal, and Z for hexadecimal. Each of the above integer constants has the value 31 decimal.

Example: Binary, octal, and hexadecimal, other than in DATA and PARAMETER:

```
INTEGER*4  M, ICOUNT/1/, JCOUNT
REAL*4  TEMP
M = ICOUNT + B'0001000'
JCOUNT = ICOUNT + O'777'
TEMP = X'FFF99A'
WRITE(*,*) M, JCOUNT, TEMP
END
```

In the above example, the context defines B'0001000' and O'777' as INTEGER*4 and X'FFF99A' as REAL*4. For a real number, using IEEE floating-point, a given bit pattern yields the same value on different architectures.

The above statements are treated as the following:

```
M = ICOUNT + 8
JCOUNT = ICOUNT + 511
TEMP = 2.35076E-38
```

Control Characters

You can enter control characters with typeless constants, although the CHAR function is standard, and this way is not.

Example: Control characters with typeless constants:

```
CHARACTER BELL, ETX / X'03' /
PARAMETER ( BELL = X'07' )
```

Alternate Notation for Typeless Constants

For compatibility with other versions of FORTRAN 77, the following alternate notation is allowed for octal and hexadecimal notation. This alternate does not work for binary, nor does it work in DATA or PARAMETER statements.

For an octal notation, enclose a string of octal digits in apostrophes and append the letter O.

Example: Octal alternate notation for typeless constants:

```
'37'O
37'O            Invalid—missing initial apostrophe
'37'            Not numeric— missing letter O
'397'O          Invalid—invalid digit
```

For hexadecimals, enclose a string of hex digits in apostrophes and *append* the letter X.

Example: Hex alternate notation for typeless constants:

```
'ab'X
3fff'X
'1f'X
'1fX            Invalid—missing trailing apostrophe
'3f'            Not numeric— missing X
'3g7'X          Invalid—invalid digit g
```

Here are the rules and restrictions for binary, octal, and hexadecimal constants:

- These constants are for use anywhere numeric constants are allowed.
- These constants are typeless. They are stored in the variables without any conversion to match the type of the variable, but they are stored in the appropriate part of the receiving field—low end, high end.
- If the receiving data type has *more* digits than are specified in the constant, zeros are *filled on the left*.
- If the receiving data type has *fewer* digits than are specified in the constant, digits are *truncated on the left*. If nonzero digits are lost, an error message is displayed.
- Specified leading zeros are ignored.
- You can specify up to 8 bytes of data for any one constant—at least that's all that are used.
- If a typeless constant is an actual argument, it has no data type, but it is *always* 4 bytes that are passed.
- For binary constants, each digit must be 0 or 1.

- For octal constants, each digit must be in the range 0 to 7.
- For hexadecimal constants, each digit must be in the range 0 to 9 or in the range A to F, or a to f.
- Outside of DATA statements, such constants are treated as the type required by the context. If a typeless constant is used with a binary operator, it gets the data type of the other operand (8.0 + '37'O).
- In DATA statements, such constants are treated as typeless binary, hexadecimal, or octal constants.

Hollerith Constants ♦

A Hollerith constant consists of an unsigned, nonzero, integer constant, followed by the letter H, followed by a string of printable characters where the integer constant designates the number of characters in the string, including any spaces and tabs.

A Hollerith constant occupies 1 byte of storage for each character.

A Hollerith constant is aligned on 2-byte boundaries.

The FORTRAN 77 standard does not have this old Hollerith notation, although the standard recommends implementing the Hollerith feature to improve compatibility with old programs.

Hollerith data can be used in place of character-string constants. They can also be used in IF tests, and to initialize noncharacter variables in DATA statements and assignment statements, though none of these are recommended, and none are standard. These are typeless constants.

Example: Typeless constants:

```
    CHARACTER C*1, CODE*2
    INTEGER TAG*2
    DATA TAG / 2Hok /
    CODE = 2Hno
    IF ( C .EQ. 1HZ ) CALL PUNT
```

The rules and restrictions on Hollerith constants are:

- The number of characters has no practical limit.
- The characters can continue over to a continuation line, but that gets tricky. Short standard fixed format lines are padded on the right with blanks up to 72 columns, but short tab-format lines stop at the newline.
- If a Hollerith constant is used with a binary operator, it gets the data type of the other operand.
- If you assign a Hollerith constant to a variable, and the length of the constant is less than the length of the data type of the variable, then spaces (ASCII 32) are appended on the right.

  If the length of a Hollerith constant or variable is greater than the length of the data type of the variable, then characters are truncated on the right.
- If a Hollerith constant is used as an actual argument, it is passed as a 4-byte item.
- If a Hollerith constant is used, and the context does not determine the data type, then `INTEGER*4` is used.

2.3 Variables

A *variable* is a symbolic name paired with a storage location. A variable has a name, a value, and a type. Whatever datum is stored in the location is the value of the variable. This does not include arrays, array elements, records, or record fields, so this definition is more restrictive than the usual usage of the word “variable.”

You can specify the type of a variable in a type statement. If the type is not explicitly specified in a type statement, it is implied by the first letter of the variable name: either by the usual default implied typing, or by any implied typing of `IMPLICIT` statements. See Section 2.1, “Types,” for more details on the rules for data typing.

At any given time during the execution of a program, a variable is either *defined* or *undefined*. If a variable has a predictable value, it is defined; otherwise, it is undefined. A previously defined variable may become undefined, as when a subprogram is exited.

You can define a variable with an assignment statement, an input statement, or a `DATA` statement. If a variable is assigned a value in a `DATA` statement, then it is initially defined.

Two variables are associated if each is associated with the same storage location. You can associate variables by use of `EQUIVALENCE`, `COMMON`, or `MAP` statements. Actual and dummy arguments can also associate variables.

2.4 Arrays

An *array* is a named collection of elements of the same type. It is a nonempty sequence of data and occupies a group of contiguous storage locations. An array has a name, a set of elements, and a type.

An *array name* is a symbolic name for the whole sequence of data.

An *array element* is one member of the sequence of data. Each storage location holds one element of the array.

An *array element name* is an array name qualified by a subscript. See “Array Subscripts,” on page 14 for details.

You can declare an array in any of the following statements:

- `DIMENSION` statement
- `COMMON` statement
- *Type* statements: `BYTE`, `CHARACTER`, `INTEGER`, `REAL`, and so forth

Array Declarators

An *array declarator* specifies the name and properties of an array.

The syntax of an array declarator is:

```
a ( d [, d ] … )
```

where:

- *a* is the name of the array
- *d* is a dimension declarator

A dimension declarator has the form:

`[` *dl*`:]` *du*

where:

- *dl* is the lower dimension bound
- *du* is the upper dimension bound

The number of dimensions in an array is the number of dimension declarators. The minimum number of dimensions is one; the maximum is seven. For an assumed-size array, the last dimension can be an asterisk.

The *lower bound* indicates the first element of the dimension, and the *upper bound* indicates the last element of the dimension. In a one-dimensional array, these are the first and last elements of the array.

Example: Array declarator, lower and upper bounds:

```
REAL V(-5:5)
```

In the above example, `V` is an array of real numbers, with 1 dimension and 11 elements. The first element is `V(-5)`; the last element is `V(5)`.

Example: Default lower bound of 1:

```
REAL V(1000)
```

In the above example, `V` is an array of real numbers, with 1 dimension and 1000 elements. The first element is `V(1)`; the last element is `V(1000)`.

Example: Arrays can have as many as 7 dimensions:

```
REAL TAO(2,2,3,4,5,6,10)
```

Example: Lower bounds other than one:

```
REAL A(3:5, 7, 3:5), B(0:2)
```

Example: Character arrays:

```
    CHARACTER M(3,4)*7, V(9)*4
```

The array M has 12 elements, each of which consists of 7 characters.

The array V has 9 elements, each of which consists of 4 characters.

The following restrictions on bounds apply:

- Both the upper and the lower bounds can be negative, zero, or positive.
- The upper bound must be greater than or equal to the lower bound.
- If only one bound is specified, it is the upper, and the lower is one.
- In assumed-size arrays, the upper bound of the last dimension is an asterisk.
- Each bound is an integer expression, and each operand of the expression is a constant, a dummy argument, or a variable in a common block. No array references or user-defined functions are allowed.

Adjustable Arrays

An *adjustable array* is an array which is a dummy argument, and which has one or more of its dimensions or bounds as integer variables that are either themselves dummy arguments, or are in a common block.

You can declare adjustable arrays in the usual DIMENSION, COMMON, or type statements. In f77, you can also declare adjustable arrays in a RECORD statement, if that RECORD statement is not inside a structure declaration block.

Example: Adjustable array bounds with arguments, and variables in common;

```
    SUBROUTINE POPUP ( A, B, N )
    COMMON / DEFS / M, L, K
    REAL A(3:5, 7, M:N), B(N+1:2*N)
```

The restrictions are:

- The size of an adjustable array cannot exceed the size of the corresponding actual argument.

- In the first caller of the call sequence, the corresponding array must be dimensioned with constants.

Assumed-Size Arrays

An *assumed-size array* is an array that is a dummy argument, and which has an asterisk as the upper bound of the last dimension.

You can declare assumed-size arrays in the usual `DIMENSION`, `COMMON`, or type statements.

In `f77,` the following extensions are allowed:

- You can declare assumed-size arrays in a `RECORD` statement, if that `RECORD` statement is not inside a structure declaration block.
- You can use an assumed-size array as a unit identifier for an internal file in an I/O statement.
- You can use an assumed-size array as a runtime format specifier in an I/O statement.

Example: Assumed-size with the upper bound of the last dimension an asterisk:

```
    SUBROUTINE PULLDOWN ( A, B, C )
      INTEGER A(5, *), B(*), C(0:1, (mI2:*) ea
```

An assumed-size array cannot be used in an I/O list.

Array Names with No Subscripts

An array name with no subscripts indicates the entire array. It can appear in any of the following statements:

- `COMMON`
- `DATA`
- I/O statements
- `NAMELIST`
- `RECORD` statements
- `SAVE`
- Type statements

In an EQUIVALENCE statement, the array name without subscripts indicates the first element of the array.

Array Subscripts

An *array element name* is an array name qualified by a subscript.

Form of a Subscript

A subscript is a parenthesized list of subscript expressions. There must be one subscript expression for each dimension of the array.

The form of a subscript is:

(*s* [, *s*] …)

where *s* is a subscript expression. The parentheses are part of the subscript.

Example: Declare a two-by-three array with the declarator:

```
REAL M(2,3)
```

With the above declaration, you can assign a value to a particular element, as follows:

```
M(1,2) = 0.0
```

The above code assigns 0.0 to the element in row 1, column 2, of array M.

Subscript Expressions

Subscript expressions have the following properties and restrictions:

- A subscript expression is an integer, real, or byte expression. According to the FORTRAN 77 Standard, it must be an integer expression.
- A subscript expression can contain array element references and function references.
- Evaluation of a function reference must not alter the value of any other subscript expression within the same subscript.

- Each subscript expression is an index into the appropriate dimension of the array.
- Each subscript expression must be within the bounds for the appropriate dimension of the array.
- A subscript of the form (*L1*, ..., *Ln*), where each *Li* is the *lower* bound of the respective dimension, references the first element of the array.
- A subscript of the form (*U1*, ..., *Un*), where each *Ui* is the *upper* bound of the respective dimension, references the last element of the array.
- Array element A(n) is not necessarily the n^{th} element of array A:

```
REAL V(-1:8)
V(2) = 0.0
```

In the above example, the fourth element of V is set to zero.

Subscript expressions cannot exceed the range of INTEGER*4. It is not controlled, but if the subscript expression is not in the range (-2147483648, 2147483647), then the results are unpredictable.

Array Ordering

Array elements are usually considered as being arranged with the first subscript as the row number and the second subscript as the column number. For example:

```
INTEGER*4 A(3,2)
```

The elements of A are usually mentally arranged like this in 3 rows and 2 columns:

A(1,1)	A(1,2)
A(2,1)	A(2,2)
A(3,1)	A(3,2)

Array elements are *stored* in column-major order.

Example: For the array A, they are located in memory as follows:

A(1,1)	A(2,1)	A(3,1)	A(1,2)	A(2,2)	A(3,2)

The inner (leftmost) subscript changes more rapidly.

2.5 Substrings

A character datum is a sequence of one or more characters. A character *substring* is a contiguous portion of a character variable or of a character array element or of a character field of a structured record.

A *substring name* can be in either of the following two forms:

v([*e1*] : [*e2*])

a(*s* [, *s*] …) ([*e1*] : [*e2*])

where:

v	Character variable name
a(*s* [, *s*] …)	Character array element name
e1	Leftmost character position of the substring
e2	Rightmost character position of the substring

Both *e1* and *e2* are integer expressions. They cannot exceed the range of INTEGER*4. If the expression is not in the range (-2147483648, 2147483647), then the results are unpredictable.

Example: The string with initial character from the *I*th character of *S* and with the last character from the *L*th character of *S*:

```
S(I:L)
```

In the above example, there are *L-I+1* characters in the substring.

The following string has an initial character from the *M*th character of the array element `A(J,K)`, with the last character from the *N*th character of that element.

```
A(J,K)(M:N)
```

In the above example, there are *N-M+1* characters in the substring.

Here are the rules and restrictions for substrings:

- Character positions within a substring are numbered from left to right.
- The first character position is numbered 1, not 0.
- The initial and last character positions must be integer expressions.
- If the *first* expression is omitted, it is 1.
- If the *second* expression is omitted, it is the declared length.
- The result is undefined unless $0 < I \le L \le$ *the declared length*, where *I* is the *initial* position, and *L* is the *last* position.
- Substrings can be used on the left and right sides of assignments and as procedure actual arguments.
- Substrings must not be overlapping. `ASTR(2:4) = ASTR(3:5)` is illegal.

Examples: Substrings—the value of the element in column 2, row 3 is `e23`:

```
demo% cat sub.f
    character v*8 / 'abcdefgh' /,
&           m(2,3)*3 / 'e11', 'e21',
&           'e12', 'e22',
&           'e13', 'e23' /
    print *, v(3:5)
    print *, v(1:)
    print *, v(:8)
    print *, v(:)
    print *, m(1,1)
    print *, m(2,1)
    print *, m(1,2)
    print *, m(2,2)
    print *, m(1,3)
    print *, m(2,3)
    print *, m(1,3)(2:3)
    end
demo% f77 sub.f
sub.f:
 MAIN:
demo% a.out
 cde
 abcdefgh
 abcdefgh
 abcdefgh
 e11
 e21
 e12
 e22
 e13
 e23
 13
demo%
```

2.6 Structures

A *structure* is a generalization of an array. ♦

Just as an array is a collection of elements of the same type, a structure is a collection of elements that are not necessarily of the same type.

As elements of arrays are referenced by using numeric subscripts, so elements of structures are referenced by using element (or field) names.

The structure declaration defines the form of a *record* by specifying the name, type, size, and order of the *fields* that constitute the record. Once a structure is defined and named, it can be used in RECORD statements, as explained in the following subsections.

Syntax

The structure declaration has the following syntax:

```
STRUCTURE [/structure-name/] [field-list]
     field-declaration
    [field-declaration]
    . . .
    [field-declaration]
END STRUCTURE
```

structure-name	Name of the structure
field-list	List of fields of the specified structure
field-declaration	Defines a field of the record. *field-declaration* is defined in the next section.

Field Declaration

Each field declaration can be one of the following:

- A substructure—either another structure declaration, or a record that has been previously defined
- A *union* declaration, which is described later
- A FORTRAN 77 type declaration

Example: A STRUCTURE declaration:

```
    STRUCTURE /PRODUCT/
        INTEGER*4 ID
        CHARACTER*16 NAME
        CHARACTER*8 MODEL
        REAL*4 COST
        REAL*4 PRICE
    END STRUCTURE
```

In the above example, a *structure* named PRODUCT is defined to consist of the five fields ID, NAME, MODEL, COST, and PRICE. For an example with a *field-list*, see “Structure within a Structure” on page 54.

Rules and Restrictions for Structures

Note the following:

- The name is enclosed in slashes, and is optional only in nested structures.
- If slashes are present, a name must be present.
- You can specify the *field-list* within nested structures only.
- There must be at least one *field-declaration*.
- Each *structure-name* must be unique among structures, although you can use structure names for fields in other structures or as variable names.
- The only statements allowed between the STRUCTURE statement and the END STRUCTURE statement are *field-declaration* statements and PARAMETER statements. A PARAMETER statement inside a structure declaration block is equivalent to one outside.

Rules and Restrictions for Fields

Fields that are type declarations use the identical syntax of normal FORTRAN 77 type statements. All f77 types are allowed, subject to the following rules and restrictions:

- Any dimensioning needed must be in the type statement. The DIMENSION statement has no effect on field names.

- You can specify the pseudo-name `%FILL` for a field name. `%FILL` is provided for compatibility with other versions of FORTRAN 77. It is not needed in `f77` because the alignment problems are taken care of for you. It may be a useful feature if you want to make one or more fields that you cannot reference in some particular subroutine. The only thing that `%FILL` does is provide a field of the specified size and type, and preclude referencing it.
- You must explicitly type all field names. The `IMPLICIT` statement does not apply to statements in a `STRUCTURE` declaration, nor do the implicit `I,J,K,L,M,N` rules apply.
- You cannot use arrays with adjustable or assumed size in field declarations, nor can you include passed-length `CHARACTER` declarations.

In a structure declaration, the offset of field *n* is the offset of the preceding field, plus the length of the preceding field, possibly corrected for any adjustments made to maintain alignment. See Appendix C, "Data Representations," for a summary of storage allocation.

Record Declaration

The `RECORD` statement declares variables to be records with a specified structure, or declares arrays to be arrays of such records.

The syntax of a `RECORD` statement is:

`RECORD` */structure-name/ record-list*
    `[,`*/structure-name/ record-list*`]`
    …
    `[,`*/structure-name/ record-list*`]`	

structure-name	Name of a previously declared structure
record-list	List of variables, arrays, or arrays with dimensioning and index ranges, separated by commas.

Example: A `RECORD` that uses the previous `STRUCTURE` example:

```
RECORD /PRODUCT/ CURRENT, PRIOR, NEXT, LINE(10)
```

Each of the three variables, CURRENT, PRIOR, and NEXT, is a record which has the PRODUCT structure; LINE is an array of 10 such records.

Note the following rules and restrictions for records:

- Each record is allocated separately in memory.
- Initially, records have undefined values, unless explicitly initialized.
- Records, record fields, record arrays, and record-array elements are allowed as arguments and dummy arguments. When you pass records as arguments, their fields must match in type, order, and dimension. The record declarations in the calling and called procedures must match. Within a union declaration, the order of the map fields is not relevant. See “Unions and Maps” on page 56.
- Record fields are not allowed in COMMON statements.
- Records and record fields are not allowed in DATA, EQUIVALENCE, or NAMELIST statements. Record fields are not allowed in SAVE statements.

Record and Field Reference

You can refer to a whole record, or to an individual field in a record, and since structures can be nested, a field can itself be a structure, so you can refer to fields within fields, within fields, and so forth.

The syntax of record and field reference is:

record-name[.*field-name*] … [.*field-name*]	
record-name	Name of a previously defined record variable
field-name	Name of a field in the record immediately to the left.

Example: References that are based on structure and records of the above two examples:

```
    …
    RECORD /PRODUCT/ CURRENT, PRIOR, NEXT, LINE(10)
    …
    CURRENT = NEXT
    LINE(1) = CURRENT
    WRITE ( 9 ) CURRENT
    NEXT.ID = 82
```

In the above example:

- The first assignment statement copies one whole record (all five fields) to another record.
- The second assignment statement copies a whole record into the first element of an array of records.
- The `WRITE` statement writes a whole record.
- The last statement sets the `ID` of one record to 82.

Example: Structure and record declarations, record and field assignments:

```
demo% cat str1.f
* str1.f Simple structure
    STRUCTURE / S /
        INTEGER*4 I
        REAL*4 R
    END STRUCTURE
    RECORD / S / R1, R2
    R1.I = 82
    R1.R = 2.7182818
    R2 = R1
    WRITE ( *, * ) R2.I, R2.R
    STOP
    END
demo% f77 -silent str1.f
demo% a.out
82 2.718280
demo%
```

Substructure Declaration

A structure can have a field that is also a structure. Such a field is called a *substructure*. You can declare a substructure in one of two ways:

- A RECORD declaration within a structure declaration
- A structure declaration within a structure declaration (nesting)

Record within a Structure

A nested structure declaration is one that is contained within either a structure declaration or a union declaration. You can use a previously defined record within a structure declaration.

Example: Define structure SALE using previously defined record PRODUCT:

```
STRUCTURE /SALE/
   CHARACTER*32  BUYER
   INTEGER*2  QUANTITY
   RECORD /PRODUCT/  ITEM
END STRUCTURE
```

In the above example, the structure SALE contains three fields. BUYER, QUANTITY, and ITEM, where ITEM is a record with the structure, /PRODUCT/.

Structure within a Structure

You can nest a declaration within a declaration.

Example: If /PRODUCT/ is *not* declared previously, then you can declare it within the declaration of SALE:

```
STRUCTURE /SALE/
    CHARACTER*32  BUYER
    INTEGER*2  QUANTITY
    STRUCTURE /PRODUCT/ ITEM
        INTEGER*4  ID
        CHARACTER*16  NAME
        CHARACTER*8  MODEL
        REAL*4  COST
        REAL*4  PRICE
    END STRUCTURE
END STRUCTURE
```

Here, the structure SALE still contains the same three fields as in the prior example: BUYER, QUANTITY, and ITEM. The field ITEM is an example of a *field-list* (in this case, a single-element list), as defined under “Structure Declaration.”

The size and complexity of the various structures determine which style of substructure declaration is best to use in a given situation.

Field Reference in Substructures

You can refer to fields within substructures.

Example: Refer to fields of substructures (PRODUCT and SALE, from the previous examples, are defined in the current program unit):

```
…
RECORD /SALE/ JAPAN
…
N = JAPAN.QUANTITY
I = JAPAN.ITEM.ID
…
```

Rules and Restrictions for Substructures

Note the following:

- You must define at least one field name for any substructure.
- No two fields at the same nesting level can have the same name. Fields at different levels of a structure can have the same name; however, doing so might be questionable programming practice.
- You can use the pseudo-name, `%FILL`, to align fields in a record, and create an unnamed empty field.
- You must not include a structure as a substructure of itself, at any level of nesting.

Unions and Maps

A *union* declaration defines groups of fields that share memory at runtime.

Syntaxes

The syntax of a union declaration is:

```
UNION
     map-declaration
     map-declaration
    [map-declaration]
    …
    [map-declaration]
END UNION
```

The syntax of a map declaration is as follows.

```
MAP
     field-declaration
    [field-declaration]
    …
    [field-declaration]
END MAP
```

Fields in a Map

Each *field-declaration* in a *map* declaration can be one of the following:

- Structure declaration
- Record
- Union declaration
- Declaration of a typed data field

A *map* declaration defines alternate groups of fields in a union. During execution, one map at a time is associated with a shared storage location. When you reference a field in a map, the fields in any previous map become undefined and are succeeded by the fields in the map of the newly referenced field. The amount of memory used by a union is that of its biggest map.

Example: Declare the structure /STUDENT/ to contain either NAME, CLASS, and MAJOR—or NAME, CLASS, CREDITS, and GRAD_DATE:

```
STRUCTURE /STUDENT/
    CHARACTER*32  NAME
    INTEGER*2  CLASS
    UNION
        MAP
            CHARACTER*16 MAJOR
        END MAP
        MAP
            INTEGER*2  CREDITS
            CHARACTER*8  GRAD_DATE
        END MAP
    END UNION
END STRUCTURE
```

If you define the variable PERSON to have the structure /STUDENT/ from the above example, then PERSON.MAJOR references a field from the first map, and PERSON.CREDITS references a field from the second map. If the variables of the second map field are initialized, and then the program references the variable PERSON.MAJOR, the first map becomes active, and the variables of the second map become undefined.

2.7 Pointers

The POINTER statement establishes pairs of variables and pointers. ♦
Each pointer contains the address of its paired variable.

Syntax Rules

The POINTER statement has the following syntax:

```
POINTER ( p1, v1 ) [, ( p2, v2 ) … ]
```

where:

- *v1*, *v2* are pointer-based variables.
- *p1*, *p2* are the corresponding pointers.

A *pointer-based variable* is a variable paired with a pointer in a POINTER statement. A pointer-based variable is usually just called a *based variable*. The *pointer* is the integer variable that contains the address.

Example: A simple POINTER statement:

```
POINTER ( P, V )
```

Here, V is a pointer-based variable, and P is its associated pointer.

Usage of Pointers

Normal use of pointer-based variables involves the following steps. The first two steps can be in either order.

1. **Define the pairing of the pointer-based variable and the pointer in a POINTER statement.**
2. **Define the type of the pointer-based variable.**
   The pointer itself is integer type, but in general, it is safer if you *not* list it in an INTEGER statement.

3. **Set the pointer to the address of an area of memory that has the appropriate size and type.**
   You do *not* normally do anything else explicitly with the pointer.

4. **Reference the pointer-based variable.**
   Just use the pointer-based variable in normal FORTRAN 77 statements—the address of that variable is always from its associated pointer.

Address and Memory

No storage for the variable is allocated when a pointer-based variable is defined, so you must provide an address of a variable of the appropriate type and size, and assign the address to a pointer, usually with the normal assignment statement or data statement.

See Table 6-9 on page 327.

Address by `LOC()` *Function*

You can obtain the address from the intrinsic function `LOC()`.

Example: Use the `LOC()` function to get an address:

```
* ptr1.f: Assign an address via LOC()
    POINTER ( P, V )
    CHARACTER A*12, V*12
    DATA A / 'ABCDEFGHIJKL' /
    P = LOC( A )
    PRINT *, V(5:5)
    END
```

In the above example, the `CHARACTER` statement allocates 12 bytes of storage for `A`, but *no* storage for `V`. It merely specifies the type of `V` because `V` is a pointer-based variable, then assign the address of `A` to `P`, so now any use of `V` will refer to `A` by the pointer `P`. The program prints an `E`.

Memory and Address by `MALLOC()` *Function*

The function `MALLOC()` allocates an area of memory and returns the address of the start of that area. The argument to the function is an integer specifying the amount of memory to be allocated, in bytes. If successful, it returns a pointer to the first item of the region; otherwise, it returns an integer 0. The region of memory is not initialized in any way.

Example: Memory allocation for pointers, by `MALLOC`:

```
    COMPLEX Z
    REAL X, Y
    POINTER ( P1, X ), ( P2, Y ), ( P3, Z )
    …
    P1 = MALLOC ( 10000 )
    …
```

In the above example, we get 10,000 bytes of memory from `MALLOC()` and assign the address of that block of memory to the pointer `P1`.

Deallocation of Memory by `FREE()` *Function*

The subroutine `FREE()` deallocates a region of memory previously allocated by `MALLOC()`. The argument given to `FREE()` must be a pointer previously returned by `MALLOC()`, but not already given to `FREE()`. The memory is returned to the memory manager, making it unavailable to the programmer.

Example: Deallocate via `FREE`:

```
    POINTER ( P1, X ), ( P2, Y ), ( P3, Z )
    …
    P1 = MALLOC ( 10000 )
    …
    CALL FREE ( P1 )
    …
```

In the above example, after getting memory via `MALLOC()`, and after some other instructions, probably using that chunk of memory, we direct `FREE()` to return those same 10,000 bytes to the memory manager.

Restrictions

The pointers are of type integer, and are automatically typed that way by the compiler. You must *not* type them yourself.

A pointer-based variable cannot itself be a pointer.

The pointer-based variables can be of any type, including structures.

No storage is allocated when such a pointer-based variable is declared, even if there is a size specification in the type statement.

You cannot use a pointer-based variable as a dummy argument or in `COMMON`, `EQUIVALENCE`, `DATA`, or `NAMELIST` statements.

The dimension expressions for pointer-based variables must be constant expressions in main programs. In subroutines and functions, the same rules apply for pointer-based array variables as for dummy arguments—the expression can contain dummy arguments and variables in common. Any variables in the expressions must be defined with an integer value at the time the subroutine or function is called.

Address expressions cannot exceed the range of `INTEGER*4.` If the expression is not in the range (-2147483648, 2147483647), then the results are unpredictable.

Optimization and Pointers

Pointers have the annoying side effect of reducing the assumptions that the global optimizer can make. For one thing, compare the following:

- Without pointers, if you call a subroutine or function, the optimizer knows that the call will change only variables in common or those passed as arguments to that call.
- With pointers, this is no longer valid, since a routine can take the address of an argument and save it in a pointer in common for use in a subsequent call to itself or to another routine.

Therefore, the optimizer must assume that a variable passed as an argument in a subroutine or function call can be changed by any other call. Such an unrestricted use of pointers would degrade optimization for the vast majority of programs that do *not* use pointers.

General Guidelines

There are two alternatives for optimization with pointers.

- Do not use pointers with optimization level `-O4`.
- Use a pointer only to identify the location of the data for calculations and pass the pointer to a subprogram. Almost anything else you do to the pointer can yield incorrect results.

The second choice also has a suboption: localize pointers to one routine and do not optimize it, but do optimize the routines that do the calculations. If you put the calling the routines on different files, you can optimize one and not optimize the other.

Example: A relatively “safe” kind of coding with `-O3` or `-O4`:

```
REAL A, B, V(100,100) !  Within this programming unit,
POINTER ( P, V )      !  do nothing else with P
P = MALLOC(10000)     !  other than getting the address and passing it.
…
CALL CALC ( P, A )
...
END

SUBROUTINE CALC ( ARRAY, X )
...
RETURN
END
```

If you want to optimize only `CALC` at level `-O4`, then use no pointers in `CALC`.

Some Problematic Code Practices

Any of the following coding practices, and many others, could cause problems with an optimization level of `-O3` or `-O4`:

- A program unit does arithmetic with the pointer.
- A subprogram saves the address of any of its arguments between calls.
- A function returns the address of any of its arguments, although it can return the value of a pointer argument.

- A variable is referenced through a pointer, but the address of the variable is not explicitly taken with the `LOC()` or `MALLOC()` functions.

Example: One kind of code that could cause trouble with `-O3` or `-O4`:

```
COMMON A, B, C
POINTER ( P, V )
P = LOC(A) + 4    ! ←Possible problems if optimized
…
```

The compiler assumes that a reference through `P` may change `A`, but not `B`; this assumption could produce incorrect code.

Expressions 3

An *expression* is a combination of one or more operands, zero or more operators, and zero or more pairs of parentheses.

This chapter is organized into the following sections:

3.1 Expressions, Operators, and Operands

There are three kinds of expressions:

- An *arithmetic expression* evaluates to a single arithmetic value.
- A *character expression* evaluates to a single value of type character.
- A *logical* or *relational expression* evaluates to a single logical value.

The *operators* indicate what action or operation to perform.

The *operands* indicate what items to apply the action to. An operand can be any of the following kinds of data items:

- Constant
- Variable
- Array element
- Function
- Substring
- Structured record field (if it evaluates to a scalar data item)

3.2 Arithmetic Expressions

An *arithmetic expression* evaluates to a single arithmetic value, and its operands have the following types. ♦ indicates a nonstandard feature.

- `BYTE` ♦
- `COMPLEX`
- `COMPLEX*32` *(SPARC only)* ♦
- `DOUBLE COMPLEX` ♦
- `DOUBLE PRECISION`
- `INTEGER`
- `LOGICAL`
- `REAL`
- `REAL*16` *(SPARC only)* ♦

The operators for an *arithmetic expression* are any of the following:

Table 3-1 Arithmetic Operators

Operator	**Meaning**
`**`	Exponentiation
`*`	Multiplication
`/`	Division
`-`	Subtraction or Unary Minus
`+`	Addition or Unary Plus

If `BYTE` or `LOGICAL` operands are combined with arithmetic operators, they are interpreted as integer data.

Each of these operators is a *binary* operator in an expression of the form:

a ⊕ *b*

where *a* and *b* are operands, and ⊕ is any one of the `**`, `*`, `/`, `-`, or `+` operators.

Examples: Binary operators:

```
A-Z
X*B
```

The operators `+` and `-` are *unary* operators in an expression of the form:

⊕ *b*

where *b* is an operand, and ⊕ is either of the `-` or + operators.

Examples: Unary operators:

```
-Z
+B
```

Basic Arithmetic Expressions

Each arithmetic operator is shown in its basic expression in the following table:

Table 3-2 Arithmetic Expressions

Expression	**Meaning**
`a ** z`	Raise `a` to the power `z`
`a / z`	Divide `a` by `z`
`a * z`	Multiply `a` by `z`
`a - z`	Subtract `z` from `a`
`-z`	Negate `z`
`a + z`	Add `z` to `a`
`+z`	Same as `z`

In the absence of parentheses, if there is more than one operator in an expression, then the operators are applied in the order of precedence. With one exception, if the operators are of equal precedence, they are applied left to right.

Table 3-3 Arithmetic Operator Precedence

Operator	Precedence
`**`	First
`* /`	Second
`+ -`	Last

For the left-to-right rule, the one exception is shown by the following example:

```
F ** S ** Z
```

The above is evaluated as:

```
F ** (S ** Z)
```

`f77` allows two successive operators. ♦

Example: Two successive operators:

```
    X ** -A * Z
```

The above expression is evaluated as follows:

```
    X ** (-(A * Z))
```

In the above example, the compiler starts to evaluate the `**`, but it needs to know what power to raise `X` to; so it looks at the rest of the expression and must choose between `-` and `*`. It first does the `*`, then the `-`, then the `**`.

Some early releases of this FORTRAN 77 incorrectly interpreted `X**-A*Z` as `(X**(-A))*Z`. Current releases correctly interpret `X**-A*Z`” as “`X**(-(A*Z))`, which is compatible with VMS FORTRAN.

Example: Two successive operators:

```
demo% cat twoops.f
    REAL X / 2.0 /, A / 1.0 /, Z / -3.0 /
    PRINT *, "X**-A*Z = ", X ** -A*Z
    PRINT *, "X**(-(A*Z)) = ", X ** (-(A*Z))
    PRINT *, "(X**(-A))*Z = ", (X ** (-A))*Z
    PRINT *, "X**-2 = ", X ** -2 !{same in both}
    END
demo% f77old twoops.f                          (Use old)
twoops.f:
 MAIN:
demo% a.out
X**-A*Z      = -1.50000
X**(-(A*Z))  = 8.00000
(X**(-A))*Z  = -1.50000
X**-2        = 0.250000
demo% f77new -silent twoops.f         {Use new}
demo% a.out
X**-A*Z      = 8.00000
X**(-(A*Z))  = 8.00000
(X**(-A))*Z  = -1.50000
X**-2        = 0.250000
demo%
```

Mixed Mode

If both operands have the same type, then the resulting value has that type. If operands have different types, then the weaker of two types is promoted to the stronger type, where the weaker type is the one with less precision or fewer storage units. The ranking is summarized in the following table:

Data Type	Rank
BYTE or LOGICAL*1	1 (Weakest)
LOGICAL*2	2
LOGICAL*4	3
INTEGER*2	4
INTEGER*4	5
INTEGER*8	6
LOGICAL*8	6
REAL*4 (REAL)	6
REAL*8 (DOUBLE PRECISION)	7
REAL*16 (QUAD PRECISION) *(SPARC only)*	8
COMPLEX*8 (COMPLEX)	9
COMPLEX*16 (DOUBLE COMPLEX)	10
COMPLEX*32 (QUAD COMPLEX) *(SPARC only)*	11 (Strongest)

Note – REAL*4, INTEGER*8, and LOGICAL*8 are of the same rank, but they can be the results of different pairs of operands. For example, INTEGER*8 results if you combine INTEGER*8 and any of the types between 1-5. Likewise, REAL*4 results if one of the operands is REAL*4, and the other is any of the types between 1-5. LOGICAL*8 dictates only the 8-byte size of the result.

Example of mixed mode: If R is real, and I is integer, then the expression:

```
    R * I
```

has the type real, because first I is promoted to real, and then the multiplication is performed.

Rules

Note these rules for the data type of an expression:

- If there is more than one operator in an expression, then the type of the last operation performed becomes the type of the final value of the expression.
- Integer operators apply to only integer operands.

  Example: An expression that evaluates to zero:

```
    2/3 + 3/4
```

- When an INTEGER*8 operand is mixed with REAL*4 operands, the result is REAL*8.

  There is one extension to this: a logical or byte operand in an arithmetic context is used as an integer.

- Real operators apply to only real operands, or to combinations of byte, logical, integer, and real operands. An integer operand mixed with a real operand is promoted to real; the fractional part of the new real number is zero. For example, if R is real, and I is integer, then R+I is real. However, (2/3)*4.0 is 0.
- Double precision operators apply to only double precision operands, and any operand of lower precision is promoted to double precision. The new least significant bits of the new double precision number are set to zero. Promoting a real operand does not increase the accuracy of the operand.
- Complex operators apply to only complex operands. Any integer operands are promoted to real, and they are then used as the real part of a complex operand, with the imaginary part set to zero.
- Numeric operations are allowed on logical variables. ♦ You can use a logical value any place where the FORTRAN 77 Standard requires a numeric value. The numeric can be integer, real, complex, double precision, double complex, or real*16 *(SPARC only)*. The compiler implicitly converts the logical to the appropriate numeric. Logical operations are allowed on integers, bytes, and characters. If you use these features, your program may not be portable.

Example: Some combinations of both `integer` and `logical` types:

```
    COMPLEX  C1 / ( 1.0, 2.0 ) /
    INTEGER*2 I1, I2, I3
    LOGICAL L1, L2, L3, L4, L5
    REAL R1 / 1.0 /
    DATA I1 / 8 /, I2 / 'W' /, I3 / 0 /
    DATA L1/.TRUE./, L2/.TRUE./, L3/.TRUE./, L4/.TRUE./,
&        L5/.TRUE./
    L1 = L1 + 1
    I2 = .NOT. I2
    L2 = I1 .AND. I3
    L3 = I1 .OR. I2
    L4 = L4 + C1
    L5 = L5 + R1
```

Resultant Type

For integer operands with a logical operator, the operation is done bit by bit. The result is an integer.

If the operands are mixed integer and logical, then the logicals are converted to integers, and the result is an integer.

Arithmetic Assignment

The arithmetic assignment statement assigns a value to a variable, array element, or record field. The syntax is:

```
    v = e
```

e	Arithmetic expression, a character constant, or a logical expression
v	Numeric variable, array element, or record field

Assigning logicals to numerics is allowed, but nonstandard, and may not be portable. The resultant data type is, of course, the data type of *v*. ♦

Execution of an arithmetic assignment statement causes the evaluation of the expression *e*, and conversion to the type of *v* (if types differ), and assignment of *v* with the resulting value typed according to the table below.

Character constants can be assigned to variables of type integer or real. Such a constant can be a Hollerith constant or a string in apostrophes or quotes. The characters are transferred to the variables without any conversion of data. This practice is nonstandard and may not be portable. ♦

Type of *v*	**Type of *e***
`INTEGER*2`, `INTEGER*4`, or `INTEGER*8`	`INT(`*e*`)`
`REAL`	`REAL(`*e*`)`
`REAL*8`	`DBLE(`*e*`)`
`REAL*16` *(SPARC only)*	`QREAL(`*e*`)` *(SPARC only)*
`DOUBLE PRECISION`	`DBLE(`*e*`)`
`COMPLEX*8`	`CMPLX(`*e*`)`
`COMPLEX*16`	`DCMPLX(`*e*`)`
`COMPLEX*32` *(SPARC only)*	`QCMPLX(`*e*`)` *(SPARC only)*

Note – Some types of *e* depend on whether or not you compile with the `-r8` option. See the *FORTRAN 77 4.0 User's Guide* for a description of `-r8`.

Example: Arithmetic assignment:

```
INTEGER I2*2, J2*2, I4*4
LOGICAL L1, L2
REAL R4*4, R16*16 ! (The *16 is for SPARC only)
DOUBLE PRECISION DP
COMPLEX C8, C16*16
J2 = 29002
I2 = J2
I4 = (I2 * 2) + 1
DP = 6.4D0
QP = 9.8Q1
R4 = DP
R16 = QP
C8 = R1
C8 = ( 3.0, 5.0 )
I2 = C8
C16 = C8
C8 = L1
R4 = L2
```

3.3 Character Expressions

A *character expression* is an expression whose operands have the character type. It evaluates to a single value of type character, with a size of one or more characters. The only character operator is the concatenation operator, `//`.

Expression	**Meaning**
a // *z*	Concatenate *a* with *z*.

The result of *concatenating* two strings is a third string that contains the characters of the left operand followed immediately by the characters of the right operand. The value of a concatenation operation `a//z` is a character string whose value is the value of `a` concatenated on the right with the value of `z`, and whose length is the sum of the lengths of `a` and `z`.

The operands can be any of the following kinds of data items:

- Character constant
- Character variable
- Character array element
- Character function
- Substring
- Structured record field (if it evaluates to a scalar character data item)

Examples: Character expressions, assuming `C`, `S`, and `R.C` are characters:

```
'wxy'
'AB' // 'wxy'
C
C // S
C(4:7)
R.C
```

Note the following exceptions:

- **Control characters ♦**—One way to enter control characters is to hold down the Control key and press another key. Most control characters can be entered this way, but not Control-A, Control-B, Control-C, or Control-J.

  Example: A valid way to enter a Control-C:

```
CHARACTER etx
etx = CHAR(3)
```

- **Multiple byte characters ♦**—Multiple byte characters, such as Kanji, are allowed in comments and strings.

Character String Assignment

The form of the character string assignment is:

v = *e*	
e	Expression giving the value to be assigned
v	Variable, array element, substring, or character record field

The meaning of character assignment is to copy characters from the right to the left side.

Execution of a character assignment statement causes evaluation of the character expression and assignment of the resulting value to *v*.

- If *e* is longer than *v*, characters on the right are truncated.
- If *e* is shorter than *v*, blank characters are padded on the right.

Example: The following program below displays `joined`ΔΔ:

```
      CHARACTER A*4, B*2, C*8
      A = 'join'
      B = 'ed'
      C = A // B
      PRINT *, C
      END
```

Also, this program displays the `equal` string:

```
      IF ( ('ab' // 'cd') .EQ. 'abcd' ) PRINT *, 'equal'
      END
```

Example: Character assignment:

```
CHARACTER BELL*1, C2*2, C3*3, C5*5, C6*6
REAL Z
C2 = 'z'
C3 = 'uvwxyz'
C5 = 'vwxyz'
C5(1:2) = 'AB'
C6 = C5 // C2
I = 'abcd'
Z = 'wxyz'
BELL = CHAR(7)   ! Control Character (^G)
```

The results are:

C2	gets	'zΔ'	A trailing blank
C3	gets	'uvw'	
C5	gets	'ABxyz'	
C6	gets	'ABxyzz'	That is, the 'z' from C2
I	gets	'abcd'	
Z	gets	'wxyz'	
BELL	gets	07 hex	Control-G, a bell

Example 4: A Hollerith assignment: ♦

```
CHARACTER S*4
INTEGER I2*2, I4*4
REAL R
S = 4Hwxyz
I2 = 2Hyz
I4 = 4Hwxyz
R = 4Hwxyz
```

Rules of Assignment

Here are the rules for character assignments:

- If the left side is longer than the right, it is padded with trailing blanks.
- If the left side is shorter than the right, trailing characters are discarded.
- The left and right sides of a character assignment can share storage. ♦

Example: The following program displays `abcefggh`: ♦

```
      CHARACTER S*8
      S = 'abcdefgh'
      S(4:6) = S(5:7)
      WRITE(*,*) S
      END
```

3.4 Logical Expressions

A *logical expression* is a sequence of one or more logical operands and logical operators. It evaluates to a single logical value. The operators can be any of the following.

Table 3-4 Logical Operators

Operator	Standard Name
`.AND.`	Logical conjunction
`.OR.`	Logical disjunction (inclusive `OR`)
`.NEQV.`	Logical nonequivalence
`.XOR.`	Logical exclusive `OR`
`.EQV.`	Logical equivalence
`.NOT.`	Logical negation

The period delimiters are necessary.

Two logical operators cannot appear consecutively, unless the *second* one is the `.NOT.` operator.

Logical operators are evaluated according to the following precedence:

Table 3-5 Logical Operator Precedence

Operator	Precedence
`.NOT.`	Highest
`.AND.`	
`.OR.`	
`.NEQV.,.XOR., .EQV.`	Lowest

If the logical operators are of equal precedence, they are evaluated left to right.

If the logical operators appear along with the various other operators in a logical expression, the precedence is as follows.

Table 3-6 Operator Precedence

Operator	Precedence
Arithmetic	Highest
Character	
Relational	
Logical	Lowest

The following table shows the meanings of simple expressions:

Table 3-7 Logical Expressions and Their Meanings

Expression	Meaning
`X .AND. Y`	Both `X` and `Y` are true.
`X .OR. Y`	Either `X` or `Y`, or both, are true.
`X .NEQV. Y`	`X` and `Y` are not both true and not both false.
`X .XOR. Y`	Either `X` or `Y` is true, but not both.
`X .EQV. Y`	`X` and `Y` are both true or both false.
`.NOT. X`	Logical negation.

This is the syntax for the assignment of the value of a logical expression to a logical variable:

```
v = e
```

where:

e	A logical expression, an integer between –128 and 127, or a single character constant
v	A logical variable, array element, or record field

Execution of a logical assignment statement causes evaluation of the logical expression *e* and assignment of the resulting value to *v*. If *e* is a logical expression, rather than an integer between -128 and 127, or a single character constant, then *e* must have a value of either true or false.

Logical expressions of any size can be assigned to logical variables of any size.

Assigning numerics to logicals is allowed. This practice is nonstandard, however, and is not portable. ♦

Example: A logical assignment:

```
    LOGICAL B1*1, B2*1
    LOGICAL L3, L4
    B2 = B1
    B1 = L3
    L4 = .TRUE.
```

3.5 Relational Operator

A *relational operator* compares two arithmetic expressions, or two character expressions, and evaluates to a single logical value. The operators can be any of the following:

Table 3-8 Relational Operators

Operator	Meaning
`.LT.`	Less than
`.LE.`	Less than or equal
`.EQ.`	Equal
`.NE.`	Not equal
`.GT.`	Greater than
`.GE.`	Greater than or equal

The period delimiters are necessary.

All relational operators have equal precedence. Character and arithmetic operators have higher precedence than relational operators.

For a relational expression, first each of the two operands is evaluated, and then the two values are compared. If the specified relationship holds, then the value is true; otherwise, it is false.

Example: Relational operators:

```
NODE .GE. 0
X .LT. Y
U*V .GT. U-V
M+N .GT. U-V     Mixed mode: integer M+N is promoted to real
STR1 .LT. STR2  where STR1 and STR2 are type character
S .EQ. 'a'       where S is type character
```

For character relational expressions:

- “Less than” means “precedes in the ASCII collating sequence.”
- If one operand is shorter than the other, the shorter one is padded on the right with blanks to the length of the longer.

3.6 Constant Expressions

A *constant expression* is made up of explicit constants and parameters and the FORTRAN 77 operators. Each operand is either itself another constant expression, a constant, a symbolic name of a constant, or one of the intrinsic functions, such as the following:

```
LOC, CHAR
IAND, IOR, IEOR, ISHFT
AND, OR, NOT, XOR, LSHIFT, RSHIFT, LGE, LGT, LLE, LLT
MIN, MAX, ABS, MOD, ICHAR, ANINT, NINT, DIM
DPROD, CMPLX, CONJG, AIMAG
INT, IFIX
```

The functions, `IAND`, `IOR`, `IEOR`, and `ISHFT`, are also available, or you can use the corresponding `AND`, `OR`, `XOR`, `LSHIFT`, or `RSHIFT`.

Examples: Constant expressions:

```
    PARAMETER (L=29002), (P=3.14159), (C='along the ')
    PARAMETER ( I=L*2, V=4.0*P/3.0, S=C//'riverrun' )
    PARAMETER ( M=MIN(I,L), IA=ICHAR('A') )
    PARAMETER ( Q=6.4Q6, D=2.3D9 )
    K = 66 * 80
    VOLUME = V*10**3
    DO I = 1, 20*3
```

There are a few restrictions on constant expressions:

- Constant expressions are permitted wherever a constant is allowed, except they are *not* allowed in DATA or standard FORMAT statements.
- Constant expressions are permitted in variable format expressions. ♦
- Exponentiation to a floating-point power is not allowed; a warning is issued.

  Example: Exponentiation to a floating-point power is not allowed:

```
demo% cat ConstExpr.f
       parameter (T=2.0*(3.0**2.5))
       write(*,*) t
       end
demo% f77 ConstExpr.f
ConstExpr.f:
 MAIN:
"ConstExpr.f", line 1: Warning:
        parameter t set to a nonconstant
demo% a.out
    31.1769
demo%
```

3.7 Record Assignment

The general form of record assignment is: ♦

```
    v = e
```

where

e	A record or record field
v	A record or record field

Both *e* and *v* must have the same structure. That is, each must have the same number of fields, and corresponding fields must be of the same type and size.

Example: A record assignment and a record-field assignment:

```
STRUCTURE /PRODUCT/
    INTEGER*4 ID
    CHARACTER*16 NAME
    CHARACTER*8 MODEL
    REAL*4 COST
    REAL*4 PRICE
END STRUCTURE
RECORD /PRODUCT/ CURRENT, PRIOR, NEXT, LINE(10)
…
CURRENT = NEXT
LINE(1) = CURRENT
WRITE ( 9 ) CURRENT
NEXT.ID = 82
```

In the above example, the first assignment statement copies one whole record (all five fields) to another record; the second assignment statement copies a whole record into the first element of an array of records; the `WRITE` statement writes a whole record; and the last statement sets the `ID` of one record to 82.

3.8 Evaluation of Expressions

The following restrictions apply to all arithmetic, character, relational, and logical expressions:

- If you reference any one of these items in an expression, variable, array element, character substring, record field, pointer, or function, then that item must be defined at the time the reference is executed.
- An integer operand must be defined with an integer value, and not with a statement label value by an `ASSIGN` statement.

- All the characters of a substring that are referenced must be defined at the time the reference is executed.
- The execution of a function reference must not alter the value of any other entity within the same statement.
- The execution of a function reference must not alter the value of any entity in common that affects the value of any other function reference in the same statement.

Statements 4

This chapter describes the FORTRAN 77 statements. The nonstandard statements are indicated with a small black diamond (♦).

4.1 ACCEPT

The ACCEPT ♦ statement reads from standard input.

Syntax

ACCEPT *f* [, *iolist*]	
ACCEPT *grname*	
f	Format identifier
iolist	List of variables, substrings, arrays, and records
grname	Name of the namelist group

Description

`ACCEPT` *f* `[,`*iolist*`]` is equivalent to `READ` *f* `[,`*iolist*`]` and is for compatibility with older versions of FORTRAN 77. An example of list-directed input:

```
    REAL VECTOR(10)
    ACCEPT *, NODE, VECTOR
```

4.2 ASSIGN

The `ASSIGN` statement assigns a statement label to a variable.

Syntax

ASSIGN *s* TO *i*	
s	Statement label
i	Integer variable

Description

The label *s* is the label of an executable statement or a `FORMAT` statement.

The statement label must be the label of a statement that is defined in the same program unit as the `ASSIGN` statement.

The integer variable *i*, once assigned a statement label, can be reassigned the same statement label, a different label, or an integer.

Once a variable is defined as a statement label, you can reference in:

- An assigned `GO TO` statement
- An input/output statement, as a format identifier

Restrictions

Define a variable with a statement label *before* you reference it as a label.

i must be `INTEGER*4` or `INTEGER*8`, not `INTEGER*2`.

While *i* is defined with a statement label value, do *no* arithmetic with *i*.

Examples

Example 1: Assign the statement number of an executable statement:

```
    ASSIGN 9 TO K
    GO TO K
    …
9   WRITE (*,*) 'Assigned ', K, ' to K'
```

In the above example, the output shows the address, not 9.

Example 2: Assign the statement number of a format statement:

```
    INTEGER PHORMAT
2   FORMAT ( A80 )
    ASSIGN 2 TO PHORMAT
    …
    WRITE ( *, PHORMAT ) 'Assigned a FORMAT statement no.'
```

4.3 Assignment

The assignment statement assigns a value to a variable, substring, array element, record, or record field.

Syntax

v = e	
e	Expression giving the value to be assigned
v	Variable, substring, array element, record, or record field

Description

The value can be a constant or the result of an expression. The kinds of assignment statements: are arithmetic, logical, character, and record assignments.

Arithmetic Assignment

v is of numeric type and is the name of a variable, array element, or record field.

e is an arithmetic expression, a character constant, or a logical expression. Assigning logicals to numerics is nonstandard, and may not be portable; the resultant data type is, of course, the data type of *v*. ♦

Execution of an arithmetic assignment statement causes the evaluation of the expression *e*, and conversion to the type of *v* (if types differ), and assignment of *v* with the resulting value typed according to the following table.

Table 4-1 Arithmetic Assignment Conversion Rules

Type of *v*	**Type of *e***
INTEGER*2, INTEGER*4, or INTEGER*8	INT(*e*)
REAL	REAL(*e*)
REAL*8	REAL*8
REAL*16 *(SPARC only)*	QREAL(*e*) *(SPARC only)*
DOUBLE PRECISION	DBLE(*e*)
COMPLEX*8	CMPLX(*e*)
COMPLEX*16	DCMPLX(*e*)
COMPLEX*32 *(SPARC only)*	QCMPLX(*e*) *(SPARC only)*

Note – Some types of *e* depend on whether or not you compile with the `-r8` option. See the *FORTRAN 77 4.0 User's Guide* for a description of `-r8`.

Example: An assignment statement:

```
    REAL A, B
    DOUBLE PRECISION V
    V = A * B
```

The above code is compiled exactly as if it were the following:

```
    REAL A, B
    DOUBLE PRECISION V
    V = DBLE( A * B )
```

Logical Assignment

v is the name of a variable, array element, or record field of type logical.

e is a logical expression, or an integer between -128 and 127, or a single character constant.

Execution of a logical assignment statement causes evaluation of the logical expression *e* and assignment of the resulting value to *v*. If *e* is a logical expression (rather than an integer between -128 and 127, or a single character constant), then *e* must have a value of either true or false.

Logical expressions of any size can be assigned to logical variables of any size. The section on the `LOGICAL` statement provides more details on the size of logical variables.

Character Assignment

The constant can be a Hollerith constant or a string of characters delimited by apostrophes (`'`) or quotes (`"`). The character string *cannot* include the control characters Control-A, Control-B, or Control-C; that is, you cannot hold down the Control key and press the A, B, or C keys. If you need those control characters, use the `char()` function.

If you use quotes to delimit a character constant, then you cannot compile with the `-xl` option, because, in that case, a quote introduces an octal constant. The characters are transferred to the variables without any conversion of data, and may not be portable.

Character expressions which include the `//` operator can be assigned only to items of type `CHARACTER`. Here, the *v* is the name of a variable, substring, array element, or record field of type `CHARACTER`; *e* is a character expression.

Execution of a character assignment statement causes evaluation of the character expression and assignment of the resulting value to *v*. If the length of *e* is more than that of *v*, characters on the right are truncated. If the length of *e* is less than that of *v*, blank characters are padded on the right.

Record Assignment

v and *e* are each a record or record field. ♦

The *e* and *v* must have the same structure. They have the same structure if any of the following occur:

- Both *e* and *v* are fields with the same elementary data type.
- Both *e* and *v* are records with the same number of fields such that corresponding fields are the same elementary data type.
- Both *e* and *v* are records with the same number of fields such that corresponding fields are substructures with the same structure as defined in 2, above.

The sections on the `RECORD` and `STRUCTURE` statements have more details on the structure of records.

Examples

Example 1: Arithmetic assignment:

```
INTEGER I2*2, J2*2, I4*4
REAL R1, QP*16              ! (The *16 is for SPARC only)
DOUBLE PRECISION DP
COMPLEX C8, C16*16, QC*32 ! (The *32 is for SPARC only)
J2 = 29002
I2 = J2
I4 = (I2 * 2) + 1
DP = 6.4D9
QP = 6.4Q9
R1 = DP
C8 = R1
C8 = ( 3.0, 5.0 )
I2 = C8
C16 = C8
C32 = C8
```

Example 2: Logical assignment:

```
LOGICAL B1*1, B2*1
LOGICAL L3, L4
L4 = .TRUE.
B1 = L4
B2 = B1
```

Example 3: Hollerith assignment:

```
CHARACTER S*4
INTEGER I2*2, I4*4
REAL R
S = 4Hwxyz
I2 = 2Hyz
I4 = 4Hwxyz
R = 4Hwxyz
```

Example 4: Character assignment:

```
CHARACTER BELL*1, C2*2, C3*3, C5*5, C6*6
REAL Z
C2 = 'z'
C3 = 'uvwxyz'
C5 = 'vwxyz'
C5(1:2) = 'AB'
C6 = C5 // C2
BELL = CHAR(7)    ! Control Character (^G)
```

The results of the above are:

C2	gets	'zΔ'	*That is, a trailing blank*
C3	gets	'uvw'	
C5	gets	'ABxyz'	
C6	gets	'ABxyzz'	*That is, an extra* z *left over from* C5
BELL	gets	07 hex	*That is, Control-G, a bell*

Example 5: Record assignment and record field assignment:

```
STRUCTURE /PRODUCT/
    INTEGER*4 ID
    CHARACTER*16 NAME
    CHARACTER*8 MODEL
    REAL*4 COST
    REAL*4 PRICE
END STRUCTURE
RECORD /PRODUCT/ CURRENT, PRIOR, NEXT, LINE(10)
…
CURRENT = NEXT        ! Record to record
LINE(1) = CURRENT     ! Record to array element
WRITE ( 9 ) CURRENT ! Write whole record
NEXT.ID = 82          ! Assign a value to a field
```

4.4 AUTOMATIC

The AUTOMATIC ♦ statement makes each recursive invocation of the subprogram have its own copy of the specified items. It also makes the specified items become undefined outside the subprogram when the subprogram exits through a RETURN statement.

Syntax

AUTOMATIC *vlist*	
vlist	List of variables and arrays

Description

For automatic variables, there is one copy for each invocation of the procedure. To avoid local variables becoming undefined between invocations, f77 classifies every variable as either static or automatic with all *local* variables being static by default. For other than the default, you can declare variables as static or automatic in a STATIC ♦, AUTOMATIC ♦, or IMPLICIT statement. Compare with -stackvar option in the *FORTRAN 77 4.0 User's Guide*.

One usage of AUTOMATIC is to declare all automatic at the start of a function.

Example: Recursive function with implicit automatic:

```
      INTEGER FUNCTION NFCTRL( I )
      IMPLICIT AUTOMATIC (A-Z)
      ...
      RETURN
      END
```

Local variables and arrays are static by default, so in general, there is no need to use SAVE. You can still use SAVE to ensure portability. Also, SAVE is safer if you leave a subprogram by some way other than a RETURN.

Restrictions

Automatic variables and arrays cannot appear in DATA or SAVE statements.

Arguments and function values cannot appear in DATA, RECORD, STATIC, or SAVE statements because f77 always makes them automatic.

Examples

Example: Some other uses of AUTOMATIC:

```
      AUTOMATIC A, B, C
      REAL P, D, Q
      AUTOMATIC P, D, Q
      IMPLICIT AUTOMATIC (X-Z)
```

Example: Structures are unpredictable if AUTOMATIC:

```
demo% cat autostru.f
      AUTOMATIC X
      STRUCTURE /ABC/
        INTEGER I
      END STRUCTURE
      RECORD /ABC/ X        ! X is automatic. It cannot be a structure.
      X.I = 1
      PRINT '(I2)', X.I
      END
demo% f77 -silent autostru.f
demo% a.out
*** TERMINATING a.out
*** Received signal 10 (SIGBUS)
Bus Error (core dumped)
demo%
```

Note – An automatic structure sometimes works; sometimes, it core dumps.

Restrictions

An AUTOMATIC statement and a type statement cannot be combined to make an AUTOMATIC *type* statement. For example, the statement:

```
    AUTOMATIC REAL X
```

does *not* declare the variable X to be both AUTOMATIC and REAL; it declares the variable REALX to be AUTOMATIC.

4.5 BACKSPACE

The BACKSPACE statement positions the specified file to just before the preceding record.

Syntax

BACKSPACE *u*	
BACKSPACE([UNIT=] *u* [, IOSTAT= *ios*] [, ERR= *s*])	
u	Unit identifier of the external unit connected to the file
ios	I/O status specifier, integer variable, or an integer array element
s	Error specifier: *s* must be the label of an executable statement in the same program unit in which the BACKSPACE statement occurs. Program control is transferred to the label in case of an error during the execution of the BACKSPACE statement.

Description

BACKSPACE in a terminal file has no effect.

u must be connected for *sequential* access. Execution of a BACKSPACE statement on a direct-access file is not defined in the FORTRAN 77 Standard, and is unpredictable. We do not recommend using a BACKSPACE statement on a *direct-access* file or an *append access* file.

Execution of the BACKSPACE statement modifies the file position, as follows:

Prior to Execution	**After Execution**
Beginning of the file	Remains unchanged
Beyond the endfile record	Before the endfile record
Beginning of the previous record	Start of the same record

Examples

Example 1: Simple backspace:

```
    BACKSPACE 2
    LUNIT = 2
    BACKSPACE LUNIT
```

Example 2: Backspace with error trap:

```
    INTEGER CODE
    BACKSPACE ( 2, IOSTAT=CODE, ERR=9 )
    …
9   WRITE (*,*) 'Error during BACKSPACE'
    STOP
```

4.6 BLOCK DATA

The BLOCK DATA statement identifies a subprogram that initializes variables and arrays in labeled common blocks.

Syntax

BLOCK DATA [*name*]	
name	Symbolic *name* of the block data subprogram in which the BLOCK DATA statement appears. This parameter is optional. It is a global name.

Description

A block data subprogram can contain as many labeled common blocks and data initializations as desired.

The BLOCK DATA statement must be the first statement in a block data subprogram.

The only other statements that can appear in a block data subprogram are:

- COMMON
- DATA
- DIMENSION
- END
- EQUIVALENCE
- IMPLICIT
- PARAMETER
- RECORD
- SAVE
- STRUCTURE
- Type statements

Only an entity defined in a labeled common block can be initially defined in a block data subprogram.

If an entity in a labeled common block is initially defined, all entities having storage units in the common block storage sequence must be specified, even if they are not all initially defined.

Restrictions

Only one unnamed block data subprogram can appear in the executable program.

The same labeled common block cannot be specified in more than one block data subprogram in the same executable program.

The optional parameter *name* must not be the same as the name of an external procedure, main program, common block, or other block data subprogram in the same executable program. The name must not be the same as any local name in the subprogram.

Example

```
      BLOCK DATA INIT
      COMMON /RANGE/ X0, X1
      DATA X0, X1 / 2.0, 6.0 /
      END
```

4.7 BYTE

The BYTE ♦ statement specifies the type to be 1-byte integer. It optionally specifies array dimensions and initializes with values.

Syntax

BYTE *v* [/*c*/] …	
v	Name of a symbolic constant, variable, array, array declarator, function, or dummy function
c	List of constants for the immediately preceding name

Description

This is a synonym for LOGICAL*1. A BYTE type item can hold the logical values .TRUE., .FALSE., one character, or an integer between –128 and 127.

Example

```
      BYTE BIT3 / 8 /, C1 / 'W' /,
&          COUNTER /0/, M /127/, SWITCH / .FALSE. /
```

4.8 CALL

The CALL statement branches to the specified subroutine, executes the subroutine, and returns to the calling program after finishing the subroutine.

Syntax

CALL *sub* [([*ar* [, *ar*] …])]	
sub	Name of the subroutine to be called
ar	Actual argument to be passed to the subroutine

Description

Arguments are separated by commas.

The FORTRAN 77 Standard requires that actual arguments in a CALL statement must agree in order, number, and type with the corresponding formal arguments of the referenced subroutine. The compiler checks this only when the -XlistE option is on.

Recursion is allowed. A subprogram can call itself directly, or indirectly by calling another subprogram that in turns calls this subroutine. Such recursion is nonstandard. ♦

An actual argument, *ar*, must be one of the following:

- An expression
- An intrinsic function permitted to be passed as an argument; for a list of the intrinsics that cannot be actual arguments, see Table 4-3.
- An external function name
- A subroutine name

- An alternate return specifier, `*` or `&`, followed by a statement number. The `&` is nonstandard. ♦

The simplest expressions, and most frequently used, include such constructs as:

- Constant
- Variable name
- Array name
- Formal argument, if the `CALL` statement is inside a subroutine
- Record name

If a subroutine has no arguments, then a `CALL` statement that references that subroutine must not have any actual arguments. A pair of empty matching parentheses can follow the subroutine name.

Execution of the `CALL` statement proceeds as follows:

1. **All expressions (arguments) are evaluated.**
2. **All actual arguments are associated with the corresponding formal arguments, and the body of the subroutine is executed.**
3. **Normally, the control is transferred back to the statement following the** `CALL` **statement upon executing a** `RETURN` **statement or an** `END` **statement in the subroutine. If an alternate return in the form of** `RETURN` ***n*** **is executed, then control is transferred to the statement specified by the** ***n*** **alternate return specifier in the** `CALL` **statement.**

Examples

Example 1: Character string:

```
    CHARACTER *25 TEXT
    TEXT = 'Some kind of major screwup'
    CALL OOPS ( TEXT )
    END
    SUBROUTINE OOPS ( S )
    CHARACTER S*(*)
    WRITE (*,*) S
    END
```

Example 2: Alternate return:

```
      CALL RANK ( N, *8, *9 )
      WRITE (*,*) 'OK - Normal Return'
      STOP
 8    WRITE (*,*) 'Minor - 1st alternate return'
      STOP
 9    WRITE (*,*) 'Major - 2nd alternate return'
      STOP
      END

      SUBROUTINE RANK ( N, *, * )
      IF ( N .EQ. 0 ) RETURN
      IF ( N .EQ. 1 ) RETURN 1
      RETURN 2
      END
```

Example 3: Another form of alternate return; the & is nonstandard: ♦

```
      CALL RANK ( N, &8, &9 )
```

Example 4: Array, array element, and variable:

```
      REAL M(100,100), Q(2,2), Y
      CALL SBRX ( M, Q(1,2), Y )
      …
      END
      SUBROUTINE SBRX ( A, D, E )
      REAL A(100,100), D, E
      …
      RETURN
      END
```

In this example, the real array `M` matches the real array, `A`, and the real array element `Q(1,2)` matches the real variable, `D`.

Example 5: A structured record and field; the record is nonstandard: ♦

```
STRUCTURE /PRODUCT/
    INTEGER*4 ID
    CHARACTER*16 NAME
    CHARACTER*8 MODEL
    REAL*4 COST
    REAL*4 PRICE
END STRUCTURE
RECORD /PRODUCT/ CURRENT, PRIOR
CALL SBRX ( CURRENT, PRIOR.ID )
…
END
SUBROUTINE SBRX ( NEW, K )
STRUCTURE /PRODUCT/
    INTEGER*4 ID
    CHARACTER*16 NAME
    CHARACTER*8 MODEL
    REAL*4 COST
    REAL*4 PRICE
END STRUCTURE
RECORD /PRODUCT/ NEW
…
RETURN
END
```

In the above example, the record `NEW` matches the record `CURRENT`, and the integer variable, `K`, matches the record field, `PRIOR.OLD`.

4.9 CHARACTER

The `CHARACTER` statement specifies the type of a symbolic constant, variable, array, function, or dummy function to be character.

Optionally, it initializes any of the items with values and specifies array dimensions.

Syntax

CHARACTER [* *len* [,]] *v* [* *len* /*c*/]] …	
v	Name of a symbolic constant, variable, array, array declarator, function, or dummy function
len	Length in characters of the symbolic constant, variable, array element, or function
c	List of constants for the immediately preceding name

Description

Each character occupies 8 bits of storage, aligned on a character boundary. Character arrays and common blocks containing character variables are packed in an array of character variables. The first character of one element follows the last character of the preceding element, without holes.

The length, *len* must be greater than 0. If *len* is omitted, it is assumed equal to 1.

For local and common character variables, symbolic constants, dummy arguments, or function names, *len* can be an integer constant, or a parenthesized integer constant expression.

For dummy arguments or function names, *len* can have another form: a parenthesized asterisk, that is, `CHARACTER*(*)`, which denotes that the function name length is defined in referencing the program unit, and the dummy argument has the length of the actual argument.

For symbolic constants, *len* can also be a parenthesized asterisk, which indicates that the name is defined as having the length of the constant. This is shown in Example 5 in the next section.

The list *c* of constants can be used only for a variable, array, or array declarator. There can be only one constant for the immediately preceding variable, and one constant for each element of the immediately preceding array.

Examples

Example 1: Character strings and arrays of character strings:

```
CHARACTER*17 A, B(3,4), V(9)
CHARACTER*(6+3) C
```

The above code is exactly equivalent to the following:

```
CHARACTER A*17, B(3,4)*17, V(9)*17
CHARACTER C*(6+3)
```

Both of the above two examples are equivalent to the nonstandard variation: ♦

```
CHARACTER A*17, B*17(3,4), V*17(9)! nonstandard
```

There are no null (zero-length) character-string variables. A one-byte character string assigned a null constant has the length zero.

Example 2: No null character-string variables:

```
CHARACTER S*1
S = ''
```

During execution of the assignment statement, the variable `S` is precleared to blank, and then zero characters are moved into `S`, so `S` contains one blank; because of the declaration, the intrinsic function `LEN(S)` will return a length of `1`. You cannot declare a size of less than 1, so this is the smallest length string variable you can get.

Example 3: Dummy argument character string with constant length:

```
SUBROUTINE SCHLEP ( A )
CHARACTER A*32
```

Example 4: Dummy argument character string with length the same as corresponding actual argument:

```
    SUBROUTINE SCHLEP ( A )
    CHARACTER A*(*)
    …
```

Example 5: Symbolic constant with parenthesized asterisk:

```
    CHARACTER *(*) INODE
    PARAMETER ( INODE = 'Warning: INODE clobbered!' )
```

The intrinsic function `LEN(INODE)` returns the actual declared length of a character string. This is mainly for use with `CHAR*(*)` dummy arguments.

Example 6: The `LEN` intrinsic function:

```
      CHARACTER A*17
      A = "xyz"
      PRINT *, LEN( A )
      END
```

The above program displays `17`, not `3`.

4.10 CLOSE

The `CLOSE` statement disconnects a file from a unit.

Syntax

CLOSE([UNIT=] *u* [, STATUS= *sta*] [, IOSTAT= *ios*] [, ERR= *s*])	
u	Unit identifier for an external unit. If UNIT= is not used, then *u* must be first.
sta	Determines the disposition of the file—*sta* is a character expression whose value, when trailing blanks are removed, can be KEEP or DELETE. The default value for the status specifier is KEEP. For temporary (scratch) files, *sta* is forced to DELETE always. For other files besides scratch files, the default *sta* is KEEP.
ios	I/O status specifier—*ios* must be an integer variable or an integer array element.
s	Error specifier—*s* must be the label of an executable statement in the same program containing the CLOSE statement. The program control is transferred to this statement in case an error occurs while executing the CLOSE statement.

Description

For tape, it is more reliable to use the TOPEN() routines.

The options can be specified in any order.

The DISP= and DISPOSE= options are allowable alternates for STATUS=, with a warning, if the -ansi flag is set.

Execution of CLOSE proceeds as follows:

1. **The specified unit is disconnected.**
2. **If *sta* is DELETE, the file connected to the specified unit is deleted.**
3. **If an IOSTAT argument is specified, *ios* is set to zero if no error was encountered; otherwise, it is set to a positive value.**

Comments

All open files are closed with default *sta* at normal program termination. Regardless of the specified *sta*, scratch files, when closed, are always deleted.

Execution of a CLOSE statement specifying a unit that does not exist, or a unit that has no file connected to it, has no effect.

Execution of a CLOSE statement specifying a unit zero (standard error) is not allowed, but you can reopen it to some other file.

The unit or file disconnected by the execution of a CLOSE statement can be connected again to the same, or a different, file or unit.

Examples

Example 1: Close and keep:

```
    CLOSE ( 2, STATUS='KEEP')
```

Example 2: Close and delete:

```
    CLOSE ( 2, STATUS='DELETE', IOSTAT=I )
```

Example 3: Close and delete a scratch file even though the status is KEEP:

```
    OPEN ( 2, STATUS='SCRATCH')
    …
    CLOSE ( 2, STATUS='KEEP', IOSTAT=I )
```

4.11 COMMON

The COMMON statement defines a block of main memory storage so that different program units can share the same data without using arguments.

Syntax

COMMON [/[*cb*]/] *nlist* [[,]/[*cb*] / *nlist*] …	
cb	Common block name
nlist	List of variable names, array names, and array declarators

Description

If the common block name is omitted, then blank common block is assumed.

Any common block name including blank common can appear more than once in COMMON statements in the same program unit. The list *nlist* following each successive appearance of the same common block name is treated as a continuation of the list for that common block name.

The size of a common block is the sum of the sizes of all the entities in the common block, plus space for alignment.

Within a program, all common blocks in different program units that have the same name must be of the same size. However, blank common blocks within a program are not required to be of the same size.

Restrictions

Formal argument names and function names cannot appear in a COMMON statement.

An EQUIVALENCE statement must not cause the storage sequences of two different common blocks in the same program unit to be associated. See Example 2.

An EQUIVALENCE statement must not cause a common block to be extended on the left-hand side. See Example 4.

Examples

Example 1: Unlabeled common and labeled common:

```
DIMENSION V(100)
COMMON V, M
COMMON / LIMITS / I, J
…
```

In the above example, V and M are in the unlabeled common block; I and J are defined in the named common block, LIMITS.

Example 2: You cannot associate storage of two different common blocks in the same program unit:

```
COMMON /X/ A
COMMON /Y/ B
EQUIVALENCE ( A, B)  ! ← Not allowed
```

Example 3: An EQUIVALENCE statement can extend a common block on the right-hand side:

```
DIMENSION A(5)
COMMON /X/ B
EQUIVALENCE ( B, A)
```

Example 4: An EQUIVALENCE statement must not cause a common block to be extended on the left-hand side:

```
COMMON /X/ A
REAL B(2)
EQUIVALENCE ( A, B(2))  ! ← Not allowed
```

4.12 COMPLEX

The COMPLEX statement specifies the type of a symbolic constant, variable, array, function, or dummy function to be complex, optionally specifies array dimensions and size, and initializes with values.

Syntax

COMPLEX [**len*[,]] v [* *len* [/*c*/]] [, v [* *len* [/*c*/]] …	
v	Name of a symbolic constant, variable, array, array declarator, function, or dummy function
len	Either 8, 16, or 32, the length in bytes of the symbolic constant, variable, array element, or function (32 is *SPARC only*)
c	List of constants for the immediately preceding name

Description

The declarations can be: COMPLEX, COMPLEX*8, COMPLEX*16, or COMPLEX*32.

COMPLEX

For a declaration such as COMPLEX W, the variable W is usually two REAL*4 elements contiguous in memory, if no size options are set, interpreted as a complex number. Details are in “Default Size,” the next subsection.

COMPLEX*8 ♦

For a declaration such as COMPLEX*8 W, the variable W is always two REAL*4 elements contiguous in memory, interpreted as a complex number.

COMPLEX*16 ♦

For a declaration such as COMPLEX*16 W, W is always two REAL*8 elements contiguous in memory, interpreted as a double-width complex number.

COMPLEX*32 ♦

(SPARC only) For a declaration such as `COMPLEX*32 W`, the variable `W` is always two `REAL*16` elements contiguous in memory, interpreted as a quadruple-width complex number.

Default Size

If you specify the size as 8, 16, or 32, `COMPLEX*8`, `COMPLEX*16`, `COMPLEX*32`, you get what you specify; if you do *not* specify the size, you get the default size. (`*32` is for *SPARC only*.)

The default size, for a declaration such as `COMPLEX Z`, depends on `–r8`:

- If the `–r8` option is on the `f77` command line, then the compiler allocates 16 bytes, and does 16-byte arithmetic.

  If `–r8` is *not* on the command line, the compiler allocates 8 bytes.

  Similarly, for a declaration such as `DOUBLE COMPLEX Z`, the default size depends on the `–r8` option.

- If `–r8` or `-dbl` is on the `f77` command line, then the compiler allocates 32 bytes, and does 32-byte arithmetic (*SPARC only*).

  If `–r8` or `-dbl` is *not* on the command line, the compiler allocates 16 bytes.

- If you put both `–i2` and `–r8` on the `f77` command line, the results are unpredictable.

Specifying the size is nonstandard. ♦

There is a double-complex version of each complex built-in function. Generally, the specific function names begin with `Z` or `CD` instead of `C`, except for the two functions `DIMAG` and `DREAL`, which return a real value.

There are specific complex functions for quad precision *(SPARC only)*. In general, where there is a specific `REAL` a corresponding `COMPLEX` with a `C` prefix, and a corresponding `COMPLEX DOUBLE` with a `CD` prefix, there is also a quad-precision `COMPLEX` function with a `CQ` prefix. Examples are: `SIN()`, `CSIN()`, `CDSIN()`, `CQSIN()`.

Examples

Example 1: Complex scalars. Styles. Each of these statements is equivalent to the others. (Don't use all three statements in the same program unit—you cannot declare anything more than once in the same program unit.)

```
    COMPLEX U, V
    COMPLEX*8 U, V
    COMPLEX U*8, V*8
```

Example 2: Initialize complex scalars:

```
    COMPLEX U / (1, 9.0) /, V / (4.0, 5 ) /
```

A complex constant is a pair of numbers, either integers or reals.

Example 3: Double complex, some initialization:

```
    COMPLEX R*16, V*16
    COMPLEX U*16 / (1.0D0, 9 ) /, V*16 / (4.0, 5.0D0) /
    COMPLEX*16 X / (1.0D0, 9.0) /, Y / (4.0D0, 5 ) /
```

A double-complex constant is a pair of numbers, and at least one number of the pair must be double precision.

Example 4: Quadruple complex, some initialization *(SPARC only)*:

```
    COMPLEX R*32, V*32
    COMPLEX U*32 / (1.0Q0, 9 ) /, V*32 / (4.0, 5.0Q0) /
    COMPLEX*32 X / (1.0Q0, 9.0) /, Y / (4.0Q0, 5 ) /
```

A quadruple complex constant is a pair of numbers, and at least one number of the pair must be quadruple precision.

Example 5: Complex arrays, all of which are nonstandard:

```
    COMPLEX R*16(5), S(5)*16 ! (SPARC only)
    COMPLEX U*32(5), V(5)*32 ! (SPARC only)
    COMPLEX X*8(5), Y(5)*8
```

4.13 CONTINUE

The CONTINUE statement is a “do-nothing” statement.

Syntax

[*label*] CONTINUE	
label	Executable statement number

Description

The CONTINUE statement is often used as a place to hang a statement label, usually it is the end of a DO loop.

The CONTINUE statement is used primarily as a convenient point for placing a statement label, particularly as the terminal statement in a DO loop. Execution of a CONTINUE statement has no effect.

If the CONTINUE statement is used as the terminal statement of a DO loop, the next statement executed depends on the DO loop exit condition.

Example

```
      DIMENSION U(100)
      S = 0.0
      DO 1 J = 1, 100
         S = S + U(J)
         IF ( S .GE. 1000000 ) GO TO 2
1     CONTINUE
      STOP
2     CONTINUE
      …
```

4.14 DATA

The DATA statement initializes variables, substrings, arrays, and array elements.

Syntax

DATA *nlist* / *clist* / [[,] *nlist* / *clist* /] …	
nlist	List of variables, arrays, array elements, substrings, and implied DO lists separated by commas
clist	List of the form: c [, *c*] …
c	One of the forms: *c* or *r**c*, and *c* is a constant or the symbolic name of a constant.
r	Nonzero, unsigned integer constant or the symbolic name of such constant

Description

All initially defined items are defined with the specified values when an executable program begins running.

*r***c* is equivalent to *r* successive occurrences of the constant *c*.

A DATA statement is a nonexecutable statement, and must appear after all specification statements, but it can be interspersed with statement functions and executable statements.

Taking into account the repeat factor, the number of constants in *clist* must be equal to the number of items in the *nlist*. The appearance of an array in *nlist* is equivalent to specifying a list of all elements in that array. Array elements can be indexed by constant subscripts only.

Normal type conversion takes place for each noncharacter member of the clist.

Character Constants in the DATA *Statement*

If the length of a character item in *nlist* is greater than the length of the corresponding constant in *clist*, it is padded with blank characters on the right.

If the length of a character item in *nlist* is less than that of the corresponding constant in *clist*, the additional rightmost characters are ignored.

If the constant in *clist* is of integer type and the item of *nlist* is of character type, they must conform to the following rules:

- The character item must have a length of one character.
- The constant must be of type integer and have a value in the range 0 through 255. For ^A, ^B, ^C, do not hold down the Control key and press A, B, or C; use the CHAR intrinsic function.

If the constant of *clist* is a character constant or a Hollerith constant, and the item of *nlist* is of type INTEGER, then the number of characters that can be assigned is 2 or 4 for INTEGER*2 and INTEGER*4 respectively. If the character constant or the Hollerith constant has fewer characters than the capacity of the item, the constant is extended on the right with spaces. If the character or the Hollerith constant contains more characters than can be stored, the constant is truncated on the right.

Implied DO *Lists*

An *nlist* can specify an implied DO list for initialization of array elements.

The form of an implied DO list is:

(dlist, iv=m1, m2 [,*m3*])	
dlist	List of array element names and implied DO lists
iv	Integer variable, called the implied DO variable

m1	Integer constant expression specifying the initial value of *iv*
m2	Integer constant expression specifying the limit value of *iv*
m3	Integer constant expression specifying the increment value of *iv*. If *m3* is omitted, then a default value of 1 is assumed.

The range of an implied DO loop is *dlist*. The iteration count for the implied DO is computed from *m1*, *m2*, and *m3*, and it must be positive.

Variables

Variables can also be initialized in type statements. This is an extension of the FORTRAN 77 Standard. Examples are given under each of the individual type statements and under the general *type* statement. ♦

Examples

Example 1: Character, integer, and real scalars. Real arrays:

```
      CHARACTER TTL*16
      REAL VEC(5), PAIR(2)
      DATA TTL / 'Arbitrary Titles' /,
&          M / 9 /, N / 0 /,
&          PAIR(1) / 9.0 /,
&          VEC / 3*9.0, 0.1, 0.9 /
      …
```

Example 2: Arrays—implied DO:

```
      REAL R(3,2), S(4,4)
      DATA ( S(I,I), I=1,4) / 4*1.0 /,
&         (( R(I,J), J=1,3), I=1,2) / 6*1.0 /
      …
```

Example 3: Mixing an integer and a character:

```
CHARACTER CR*1
INTEGER I*2, N*4
DATA I / 'oy' /, N / 4Hs12t /, CR / 13 /
…
```

4.15 DECODE/ENCODE

ENCODE writes to a character variable, array, or array element. ♦ DECODE reads from a character variable, array, or array element. ♦ Data is edited according to the format identifier.

Similar functionality can be accomplished, using internal files with formatted sequential WRITE statements and READ statements. ENCODE and DECODE are not in the FORTRAN 77 Standard, and are provided for compatibility with older versions of FORTRAN 77.

Syntax

ENCODE(*size*, *f*, *buf* [, IOSTAT= *ios*] [, ERR= *s*]) [*iolist*]	
DECODE(*size*, *f*, *buf* [, IOSTAT= *ios*] [, ERR= *s*]) [*iolist*]	
size	Number of characters to be translated, an integer expression
f	Format identifier, either the label of a FORMAT statement, or a character expression specifying the format string, or an asterisk.
buf	Variable, array, or array element
ios	I/O status specifier, *ios* must be an integer variable or an integer array element.
s	The error specifier (statement label) *s* must be the label of executable statement in the same program unit in which the ENCODE and DECODE statement occurs.
iolist	List of input/output items.

Description

The entities in the I/O list must be one of the following:

- Variables
- Substrings
- Arrays
- Array elements
- Record fields

A simple unsubscripted array name specifies all of the elements of the array in memory storage order, with the leftmost subscript increasing more rapidly.

Execution proceeds as follows:

1. The `ENCODE` statement translates the list items to character form according to the format identifier, and stores the characters in *buf*. A `WRITE` operation on internal files does the same.

2. The `DECODE` statement translates the character data in *buf* to internal (binary) form according to the format identifier, and stores the items in the list. A `READ` statement does the same.

3. If *buf* is an array, its elements are processed in the order of subscript progression, with the leftmost subscript increasing more rapidly.

4. The number of characters that an `ENCODE` or a `DECODE` statement can process depends on the data type of *buf*. For example, an `INTEGER*2` array can contain two characters per element, so that the maximum number of characters is twice the number of elements in that array. A character variable or character array element can contain characters equal in number to its length. A character array can contain characters equal in number to the length of each element multiplied by the number of elements.

5. The interaction between the format identifier and the I/O list is the same as for a formatted I/O statement.

Example

A program using DECODE/ENCODE:

```
CHARACTER S*6 / '987654' /, T*6
INTEGER V(3)*4
DECODE( 6, '(3I2)', S ) V
WRITE( *, '(3I3)') V
ENCODE( 6, '(3I2)', T ) V(3), V(2), V(1)
PRINT *, T
END
```

The above program has this output:

```
 98 76 54
547698
```

The DECODE reads the characters of S as 3 integers, and stores them into V(1), V(2), and V(3).

The ENCODE statement writes the values V(3), V(2), and V(1) into T as characters; T then contains '547698'.

4.16 DIMENSION

The DIMENSION statement specifies the number of dimensions for an array, including the number of elements in each dimension.

Optionally, the DIMENSION statement initializes items with values.

Syntax

DIMENSION *a* (*d*) [,*a* (*d*)] …	
a	Name of an array
d	Specifies the dimensions of the array. It is a list of 1 to 7 declarators separated by commas.

Description

This section contains descriptions for the dimension declarator and the arrays.

Dimension Declarator

The lower and upper limits of each dimension are designated by a dimension declarator. The form of a dimension declarator is:

```
[ dd1 :] dd2
```

dd1 and *dd2* are dimension bound expressions specifying the lower- and upper-bound values. They can be arithmetic expressions of type integer or real. They can be formed using constants, symbolic constants, formal arguments, or variables defined in the COMMON statement. Array references and references to user-defined functions cannot be used in the dimension bound expression. *dd2* can also be an asterisk. If *dd1* is not specified, a value of one is assumed. The value of *dd1* must be less than or equal to *dd2*.

Nonconstant dimension-bound expressions can be used in a subprogram to define adjustable arrays, but not in a main program.

Noninteger dimension bound expressions are converted to integers before use. Any fractional part is truncated.

Adjustable Array

If the dimension declarator is an arithmetic expression that contains formal arguments or variables defined in the COMMON statement, then the array is called an adjustable array. In such cases, the dimension is equal to the initial value of the argument upon entry into the subprogram.

Assumed-Size Array

The array is called an assumed-size array when the dimension declarator contains an asterisk. In such cases, the upper bound of that dimension is not stipulated. An asterisk can only appear for formal arrays and as the upper bound of the last dimension in an array declarator.

Examples

Example 1: Arrays in a main program:

```
DIMENSION M(4,4), V(1000)
…
END
```

In the above example, M is specified as an array of dimensions 4 ×4 and V is specified as an array of dimension 1000.

Example 2: An adjustable array in a subroutine:

```
SUBROUTINE INV( M, N )
DIMENSION M( N, N )
…
END
```

In the above example, the formal arguments are an array, M, and a variable N. M is specified to be a square array of dimensions N× N.

Example 3: Lower and upper bounds:

```
DIMENSION HELIO (-3:3, 4, 3:9)
…
END
```

In the above example, HELIO is a 3-dimensional array. The first element is HELIO(-3,1,3) and the last element is HELIO(3,4,9).

Example 4: Dummy array with lower and upper bounds:

```
      SUBROUTINE ENHANCE( A, NLO, NHI )
      DIMENSION A(NLO : NHI)
      …
      END
```

Example 5: Noninteger bounds:

```
      PARAMETER ( LO = 1, HI = 9.3 )
      DIMENSION A(HI, HI*3 + LO )
      …
      END
```

In the above example, A is an array of dimension 9×28.

Example 6: Adjustable array with noninteger bounds:

```
      SUBROUTINE ENHANCE( A, X, Y )
      DIMENSION A(X : Y)
      …
      END
```

4.17 DO

The DO statement repeatedly executes a set of statements.

Syntax

DO *s* [,] *loop-control*
  or
DO *loop-control* ♦

s is a statement number.

The form of *loop-control* is:

variable = *e1*, *e2* [, *e3*]	
variable	Variable of type integer, real, or double precision.
e1, *e2*, *e3*	Expressions of type integer, real or double precision, specifying initial, limit, and increment values respectively.

Description

The `DO` statement contains the following constructs.

Labeled `DO` Loop

A labeled `DO` loop consists of the following:

- `DO` statement
- Set of executable statements called a block
- Terminal statement, usually a `CONTINUE` statement

Terminal Statement

The statement identified by *s* is called the *terminal statement*. It must follow the `DO` statement in the sequence of statements within the same program unit as the `DO` statement.

The terminal statement should *not* be one of the following statements:

- Unconditional `GO TO`
- Assigned `GO TO`
- Arithmetic `IF`
- Block `IF`
- `ELSE IF`
- `ELSE`
- `END IF`
- `RETURN`
- `STOP`
- `END DO`

If the terminal statement is a logical IF statement, it can contain any executable statement, *except:*

- DO
- DO WHILE
- Block IF
- ELSE IF
- ELSE
- END IF
- END
- Logical IF statement

DO *Loop Range*

The range of a DO loop consists of all of the executable statements that appear following the DO statement, up to and including the terminal statement.

If a DO statement appears within the range of another DO loop, its range must be entirely contained within the range of the outer DO loop. More than one labeled DO loop can have the same terminal statement.

If a DO statement appears within an IF, ELSE IF, or ELSE block, the range of the associated DO loop must be contained entirely within that block.

If a block IF statement appears within the range of a DO loop, the corresponding END IF statement must also appear within the range of that DO loop.

Block DO *Loop* ♦

A block DO loop consists of:

- DO statement
- Set of executable statements called a block
- Terminal statement, an END DO statement

This loop is nonstandard.

Execution proceeds as follows:

1. **The expressions *e1*, *e2*, and *e3* are evaluated. If *e3* is not present, its value is assumed to be one.**

2. **The DO variable is initialized with the value of *e1*.**
3. **The iteration count is established as the value of the expression:**

   ```
   MAX (INT ((e2 - e1 + e3) / e3 ), 0)
   ```

   The iteration count is zero if either of the following is true:
   - *e1* > *e2* and *e3* > zero.
   - *e1* < *e2* and *e3* < zero.

   If the `–onetrip` compile time option is specified, then the iteration count is never less than one.
4. **The iteration count is tested, and, if it is greater than zero, the range of the DO loop is executed.**

Terminal Statement Processing

After the terminal statement of a DO loop is executed, the following steps are performed:

1. **The value of the DO variable, if any, is incremented by the value of *e3* that was computed when the DO statement was executed.**
2. **The iteration count is decreased by one.**
3. **The iteration count is tested, and if it is greater than zero, the statements in the range of the DO loop are executed again.**

Restrictions

The DO variable must not be modified in any way within the range of the DO loop.

You must not jump into the range of a DO loop from outside its range.

Comments

In some cases, the DO variable can overflow as a result of an increment that is performed prior to testing it against the final value. When this happens, your program has an error, and neither the compiler nor the runtime system detects it. In this situation, though the DO variable wraps around, the loop can terminate properly.

If there is a jump into the range of a DO loop from outside its range, a warning is issued, but execution continues anyway.

When the jump is from outside to the terminal statement that is CONTINUE, and this statement is the terminal statement of several nested DO loops, then the most inner DO loop is always executed.

Examples

Example 1: Nested DO loops:

```
    N = 0
    DO 210 I = 1, 10
       J = I
       DO 200 K = 5, 1
          L = K
          N = N + 1
200    CONTINUE
210 CONTINUE
    WRITE(*,*)'I =',I, ', J =',J, ', K =',K, ', N =',N, ', L =',L
    END
demo% f77 -silent DoNest1.f
"DoNest1.f", line 4: Warning: DO range never executed
demo% a.out
I =  11, J =  10, K =  5, N =  0, L =  0
demo%
```

The inner loop is not executed, and at the WRITE, L is undefined. Here L is shown as 0, but that is implementation-dependent; do not rely on it.

Example 2: The program `DoNest2.f` (`DO` variable always defined):

```
INTEGER COUNT, OUTER
COUNT = 0
DO OUTER = 1, 5
    NOUT = OUTER
    DO INNER = 1, 3
        NIN = INNER
        COUNT = COUNT+1
    END DO
END DO
WRITE(*,*) OUTER, NOUT, INNER, NIN, COUNT
END
```

The above program prints out:

```
6 5 4 3 15
```

4.18 DO WHILE

The `DO WHILE` ♦ statement repeatedly executes a set of statements while the specified condition is true.

Syntax

`DO [ s [,]] WHILE (e)`	
s	Label of an executable statement
e	Logical expression

Description

Execution proceeds as follows:

1. **The specified expression is evaluated.**
2. **If the value of the expression is true, the statements in the range of the `DO WHILE` loop are executed.**

3. If the value of the expression is false, control is transferred to the statement following the `DO WHILE` loop.

Terminal Statement

If *s* is specified, the statement identified by it is called the terminal statement, and it must follow the `DO WHILE` statement. The terminal statement must *not* be one of the following statements:

- Unconditional `GO TO`
- Assigned `GO TO`
- Arithmetic `IF`
- Block `IF ELSE IF`
- `ELSE`
- `END IF`
- `RETURN`
- `STOP`
- `END`
- `DO`
- `DO WHILE`

If the terminal statement is a logical `IF` statement, it can contain any executable statement, *except*:

- `DO`
- `DO WHILE`
- Block `IF`
- `ELSE IF`
- `ELSE`
- `END IF`
- `END`
- Logical `IF`

If *s* is not specified, the `DO WHILE` loop must end with an `END DO` statement.

`DO WHILE` *Loop Range*

The range of a `DO WHILE` loop consists of all the executable statements that appear following the `DO WHILE` statement, up to and including the terminal statement.

If a DO WHILE statement appears within the range of another DO WHILE loop, its range must be entirely contained within the range of the outer DO WHILE loop. More than one DO WHILE loop can have the same terminal statement.

If a DO WHILE statement appears within an IF, ELSE IF, or ELSE block, the range of the associated DO WHILE loop must be entirely within that block.

If a block IF statement appears within the range of a DO WHILE loop, the corresponding END IF statement must also appear within the range of that DO WHILE loop.

Terminal Statement Processing

After the terminal statement of a DO WHILE loop is executed, control is transferred back to the corresponding DO WHILE statement.

Restrictions

If you jump into the range of a DO WHILE loop from outside its range, then the results are unpredictable.

Comments

The variables used in the *e* can be modified in any way within the range of the DO WHILE loop.

Examples

Example 1: A DO WHILE *without* a statement number:

```
      INTEGER A(4,4), C, R
      …
      C = 4
      R = 1
      DO WHILE ( C .GT. R )
         A(C,R) = 1
         C = C - 1
      END DO
```

Example 2: A DO WHILE *with* a statement number:

```
       INTEGER A(4,4), C, R
       …
       DO 10 WHILE ( C .NE. R )
          A(C,R) = A(C,R) + 1
          C = C+1
    10 CONTINUE
```

4.19 DOUBLE COMPLEX

The DOUBLE COMPLEX ♦ statement specifies the type to be double complex. It optionally specifies array dimensions and size, and initializes with values.

Syntax

DOUBLE COMPLEX *v* [/*c*/] [, *v* [/*c*/] …	
v	Name of a symbolic constant, variable, array, array declarator, function, or dummy function
c	List of constants for the immediately preceding name

Description

The declaration can be: DOUBLE COMPLEX or COMPLEX*16.

DOUBLE COMPLEX ♦

For a declaration such as DOUBLE COMPLEX Z, the variable Z is usually two REAL*8 elements contiguous in memory, if no size options are set, interpreted as one double-width complex number. See the next subsection, "Default Size."

COMPLEX*16 ♦

For a declaration such as COMPLEX*16 Z, the variable Z is always two REAL*8 elements contiguous in memory, interpreted as one double-width complex number.

Default Size

If you explicitly specify the size as 16, COMPLEX*16, you get what you specify; if you *do not* specify the size, you get the default size. Default size, for such a declaration as DOUBLE COMPLEX Z, depends on –r8.

- If –r8 or -dbl is on the f77 command line, then the compiler allocates 32 bytes, and does 128-bit arithmetic (*SPARC only*).
- If –r8 or -dbl is *not* on the command line, then the compiler allocates 16 bytes, and does 64-bit arithmetic.
- If you put both –i2 and –r8 on the f77 command line, the results are unpredictable.

Comments

There is a double-complex version of each complex built-in function. Generally, the specific function names begin with Z or CD instead of C, except for the two functions, DIMAG and DREAL, which return a real value. Examples are: SIN(), CSIN(), CDSIN().

Example: Double-complex scalars and arrays:

```
    DOUBLE COMPLEX U, V
    DOUBLE COMPLEX W(3,6)
    COMPLEX*16 X, Y(5,5)
    COMPLEX  U*16(5), V(5)*16
```

4.20 DOUBLE PRECISION

The DOUBLE PRECISION statement specifies the type to be double precision, and optionally specifies array dimensions and initializes with values.

Syntax

DOUBLE PRECISION *v* [/*c*/] [, *v* [/*c*/] …	
v	Name of a symbolic constant, variable, array, array declarator, function, or dummy function
c	List of constants for the immediately preceding name

Description

The declaration can be: `DOUBLE PRECISION` or `REAL*8`.

DOUBLE PRECISION

For a declaration such as `DOUBLE PRECISION X`, the variable `X` is usually a `REAL*8` element in memory, interpreted as one double-width real number. See the next subsection, "Default Size."

REAL*8 ♦

For a declaration such as `REAL*8 X`, the variable `X` is always an element of type `REAL*8` in memory, interpreted as a double-width real number.

Default Size

If you explicitly specify the size as 8, `REAL*8`, you get what you specify; if you do *not* specify the size, you get the default size.

The default size for a declaration such as `DOUBLE PRECISION X` depends on the `–r8` option, as follows:

- If `–r8` is on the `f77` command line, then the compiler allocates 16 bytes, and does 128-bit arithmetic (*SPARC only*).
- If `–r8` is *not* on the command line, then the compiler allocates 8 bytes, and does 64-bit arithmetic.
- If you put both `–i2` and `–r8` on the `f77` command line, the results are unpredictable.

Example

Example: Double-precision scalars and arrays:

```
      DOUBLE PRECISION R, S
      DOUBLE PRECISION T(3,6)
      REAL*8 U(3,6)
      REAL V*8(6), W(6)*8
```

4.21 ELSE

The ELSE statement indicates the beginning of an ELSE block.

Syntax

```
IF ( e ) THEN
...
ELSE
...
END IF
```

e	Logical expression

Description

Execution of an ELSE statement has no effect on the program.

An ELSE block consists of all the executable statements following the ELSE statements, up to but not including the next END IF statement at the same IF level as the ELSE statement. See Section 4.40, “IF (Block),” for more details.

An ELSE block can be empty.

Restrictions

You cannot jump into an ELSE block from outside the ELSE block.

The statement label, if any, of an ELSE statement cannot be referenced by any statement.

A matching END IF statement of the same IF level as the ELSE must appear before any ELSE IF or ELSE statement at the same IF level.

Examples

Example 1: ELSE:

```
CHARACTER S
…
IF ( S .GE. '0' .AND. S .LE. '9' ) THEN
   CALL PUSH
ELSE
   CALL TOLOWER
END IF
…
```

Example 2: An invalid ELSE IF where an END IF is expected:

```
IF ( K .GT. 5 ) THEN
   N = 1
ELSE
   N = 0
ELSE IF ( K .EQ. 5 ) THEN ←Incorrect
…
```

4.22 ELSE IF

The ELSE IF provides a multiple alternative decision structure.

Syntax

`IF (` *e1* `) THEN`
 	
`ELSE IF (` *e2* `) THEN`
 	
`END IF…`	

e1 and *e2*	Logical expressions

Description

You can make a series of independent tests, and each test can have its own sequence of statements.

An `ELSE IF` block consists of all the executable statements following the `ELSE IF` statement up to, but not including, the next `ELSE IF`, `ELSE`, or `END IF` statement at the same `IF` level as the `ELSE IF` statement.

An `ELSE IF` block can be empty.

Execution of the `ELSE IF` proceeds as follows:

1. ***e* is evaluated.**

2. **If *e* is true, execution continues with the first statement of the `ELSE IF` block. If *e* is true and the `ELSE IF` block is empty, control is transferred to the next `END IF` statement at the same `IF` level as the `ELSE IF` statement.**

3. **If *e* is false, control is transferred to the next `ELSE IF`, `ELSE`, or `END IF` statement at the same `IF` level as the `ELSE IF` statement.**

Restrictions

You cannot jump into an `ELSE IF` block from outside the `ELSE IF` block.

The statement label, if any, of an `ELSE IF` statement cannot be referenced by any statement.

A matching `END IF` statement of the same `IF` level as the `ELSE IF` must appear before any `ELSE IF` or `ELSE` statement at the same `IF` level.

Example

Example: ELSE IF:

```
      READ (*,*) N
      IF ( N .LT. 0 ) THEN
           WRITE(*,*) 'N<0'
      ELSE IF ( N .EQ. 0) THEN
           WRITE(*,*) ’N=0’
      ELSE
           WRITE(*,*) ’N>0’
      END IF
```

4.23 ENCODE/DECODE

The ENCODE ♦ statement writes data from a list to memory.

Syntax

ENCODE(*size*, *f*, *buf* [, IOSTAT= *ios*] [, ERR= *s*]) [*iolist*]	
size	Number of characters to be translated
f	Format identifier
buf	Variable, array, or array element
ios	I/O status specifier
s	Error specifier (statement label)
iolist	List of I/O items, each a character variable, array, or array element

Description

ENCODE is provided for compatibility with older versions of FORTRAN 77. Similar functionality can be accomplished using internal files with a formatted sequential WRITE statement. ENCODE is not in the FORTRAN 77 Standard.

Data are edited according to the format identifier.

Example

```
    CHARACTER S*6, T*6
    INTEGER V(3)*4
    DATA S / '987654' /
    DECODE( 6, 1, S ) V
1   FORMAT( 3 I2 )
    ENCODE( 6, 1, T ) V(3), V(2), V(1)
```

The `DECODE` reads the characters of `S` as 3 integers, and stores them into `V(1)`, `V(2)`, and `V(3)`. The `ENCODE` statement writes the values `V(3)`, `V(2)`, and `V(1)`, into `T` as characters; `T` then contains `'547698'`.

See Section 4.15, "DECODE/ENCODE," for more details and a full example.

4.24 END

The `END` statement indicates the end of a program unit.

Syntax

```
END
```

Description

The `END` statement:

- Must be the last statement in the program unit.
- Must be the only statement in a line.
- Can have a label.

In a main program, an `END` statement terminates the execution of the program. In a function or subroutine, it has the effect of a `RETURN`. ♦

In the FORTRAN 77 Standard, the `END` statement cannot be continued, but `f77` allows this practice. ♦

No other statement, such as an `END IF` statement, can have an initial line that appears to be an `END` statement.

Example

Example: END:

```
      PROGRAM MAIN
      WRITE( *, * ) 'Very little'
      END
```

4.25 END DO

The END DO statement terminates a DO loop. ♦

Syntax

```
END DO
```

Description

The END DO statement is the delimiting statement of a Block DO statement. If the statement label is not specified in a DO statement, the corresponding terminating statement must be an END DO statement. You can branch to an END DO statement only from within the range of the DO loop that it terminates.

Examples

Example 1: A DO loop with a statement number:

```
      DO 10 N = 1, 100
          …
10    END DO
```

Example 2: A DO loop without statement number:

```
    DO N = 1, 100
       …
    END DO
```

4.26 END FILE

The END FILE statement writes an end-of-file record as the next record of the file connected to the specified unit.

Syntax

END FILE *u*	
END FILE ([UNIT=] *u* [, IOSTAT= *ios*] [, ERR= *s*])	
u	Unit identifier of an external unit connected to the file, The options can be specified in any order, but if UNIT= is omitted, then *u* must be first.
ios	I/O status specifier, an integer variable or an integer array element.
s	Error specifier, *s* must be the label of an executable statement in the same program in which the END FILE statement occurs. The program control is transferred to the label in the event of an error during the execution of the END FILE statement.

Description

If you are using the ENDFILE statement and other standard FORTRAN 77 I/O for tapes, we recommend that you use the TOPEN() routines instead, because they are more reliable.

Two endfile records signify the end-of-tape mark. When writing to a tape file, ENDFILE writes two endfile records, then the tape backspaces over the second one. If the file is closed at this point, both end-of-file and end-of-tape are marked. If more records are written at this point, either by continued write statements or by another program if you are using no-rewind magnetic tape, the first tape mark stands (endfile record), and is followed by another data file, then by more tape marks, and so on.

Restrictions

u must be connected for *sequential* access. Execution of an `END FILE` statement on a direct-access file is not defined in the FORTRAN 77 Standard, and is unpredictable. Do not use an `END FILE` statement on a direct-access file.

Examples

Example 1: Constants:

```
    END FILE 2
    END FILE ( 2 )
    END FILE ( UNIT=2 )
```

Example 2: Variables:

```
    LOGUNIT = 2
    END FILE LOGUNIT
    END FILE ( LOGUNIT )
    END FILE ( UNIT=LOGUNIT )
```

Example 3: Error trap:

```
    NOUT = 2
    END FILE ( UNIT=NOUT, IOSTAT=KODE, ERR=9)
    …
9   WRITE(*,*) 'Error at END FILE, on unit', NOUT
    STOP
```

4.27 END IF

The END IF statement ends the block IF that the IF began.

Syntax

```
END IF
```

Description

For each block IF statement there must be a corresponding END IF statement in the same program unit. An END IF statement matches if it is at the same IF level as the block IF statement.

Examples

Example 1: IF/END IF:

```
      IF ( N .GT. 0 )THEN
           N = N+1
      END IF
```

Example 2: IF/ELSE/END IF:

```
      IF ( N .EQ. 0 ) THEN
           N = N+1
      ELSE
           N = N-1
      END IF
```

4.28 END MAP

The END MAP ♦ statement terminates the MAP declaration.

Syntax

```
END MAP
```

Description

See Section 4.70, “UNION and MAP.”

Restrictions

The MAP statement must be within a UNION statement.

Example

```
    …
    MAP
       CHARACTER *16 MAJOR
    END MAP
    …
```

4.29 END STRUCTURE

The END STRUCTURE ♦ statement terminates the STRUCTURE statement.

Syntax

```
END STRUCTURE
```

Description

See Section 4.66, “STRUCTURE.”

Example

```
STRUCTURE /PROD/
    INTEGER*4       ID
    CHARACTER*16    NAME
    CHARACTER*8     MODEL
    REAL*4          COST
    REAL*4          PRICE
END STRUCTURE
```

4.30 END UNION

The END UNION ♦ statement terminates the UNION statement.

Syntax

```
END UNION
```

Description

See Section 4.70, “UNION and MAP.”

Example

```
    UNION
       MAP
          CHARACTER*16
       END MAP
       MAP
          INTEGER*2    CREDITS
          CHARACTER *8 GRAD_DATE
       END MAP
    END UNION
```

4.31 ENTRY

The ENTRY statement defines an alternate entry point within a subprogram.

Syntax

ENTRY *en* [([*fa* [, *fa*] …])]	
en	Symbolic name of an entry point in a function or subroutine subprogram
fa	Formal argument—it can be a variable name, array name, formal procedure name, or an asterisk specifying an alternate return label.

Description

Note these nuances for the ENTRY statement:

Procedure References by Entry Names

An ENTRY name used in a subroutine subprogram is treated like a subroutine and can be referenced with a CALL statement. Similarly, the ENTRY name used in a function subprogram is treated like a function and can be referenced as a function reference.

An entry name can be specified in an EXTERNAL statement and used as an actual argument. It cannot be used as a dummy argument.

Execution of an ENTRY subprogram (subroutine or function) begins with the first executable statement after the ENTRY statement.

The ENTRY statement is a nonexecutable statement.

The entry name cannot be used in the executable statements that physically precede the appearance of the entry name in an ENTRY statement.

Parameter Correspondence

The formal arguments of an ENTRY statement need not be the same in order, number, type, and name as those for FUNCTION, SUBROUTINE, and other ENTRY statements in the same subprogram. Each reference to a function, subroutine, or entry must use an actual argument list that agrees in order, number, type, and name with the dummy argument list in the corresponding FUNCTION, SUBROUTINE, or ENTRY statement.

Alternate return arguments in ENTRY statements can be specified by placing asterisks in the dummy argument list. Ampersands are valid alternates. ♦ ENTRY statements that specify alternate return arguments can be used only in subroutine subprograms, not functions.

Restrictions

An ENTRY statement cannot be used within a block IF construct or a DO loop.

If an ENTRY statement appears in a character function subprogram, it must be defined as type CHARACTER with the same length as that of a function subprogram.

Examples

Example 1: Multiple entry points in a subroutine:

```
      SUBROUTINE FINAGLE( A, B, C )
      INTEGER A, B
      CHARACTER C*4
      …
      RETURN

      ENTRY SCHLEP( A, B, C )
      …
      RETURN

      ENTRY SHMOOZ
      …
      RETURN
      END
```

In the above example, the subroutine FINAGLE has two alternate entries: the entry SCHLEP has an argument list; the entry SHMOOZ has no argument list.

Example 2: In the calling routine, you can call the above subroutine and entries as follows:

```
      INTEGER A, B
      CHARACTER C*4
      …
      CALL FINAGLE( A, B, C )
      …
      CALL SHMOOZ
      …
      CALL SCHLEP( A, B, C )
      …
```

In the above example, the order of the call statements need not match the order of the entry statements.

Example 3: Multiple entry points in a function:

```
      REAL FUNCTION F2 ( X )
      F2 = 2.0 * X
      RETURN

      ENTRY F3 ( X )
      F3 = 3.0 * X
      RETURN

      ENTRY FHALF ( X )
      FHALF = X / 2.0
      RETURN
      END
```

4.32 EQUIVALENCE

The EQUIVALENCE statement specifies that two or more variables or arrays in a program unit share the same memory.

Syntax

EQUIVALENCE (*nlist*) [, (*nlist*)] …	
nlist	List of variable names, array element names, array names, and character substring names separated by commas

Description

An EQUIVALENCE statement stipulates that the storage sequence of the entities whose names appear in the list *nlist* must have the same first memory location.

An EQUIVALENCE statement can cause association of entities other than specified in the *nlist*.

An array name, if present, refers to the first element of the array.

If an array element name appears in an EQUIVALENCE statement, the number of subscripts can be less than or equal to the number of dimensions specified in the array declarator for the array name.

Restrictions

In *nlist*, dummy arguments and functions are not permitted.

Subscripts of array elements must be integer constants greater than the lower bound and less than or equal to the upper bound.

EQUIVALENCE can associate automatic variables only with other automatic variables or undefined storage classes. These classes must be ones which are not in any of the COMMON, STATIC, SAVE, DATA, or dummy arguments.

An EQUIVALENCE statement can associate an element of type character with a noncharacter element. ♦

An EQUIVALENCE statement cannot specify that the same storage unit is to occur more than once in a storage sequence. For example, the following statement is not allowed:

```
DIMENSION A (2)
EQUIVALENCE (A(1),B), (A(2),B)
```

An EQUIVALENCE statement cannot specify that consecutive storage units are to be nonconsecutive. For example, the following statement is not allowed:

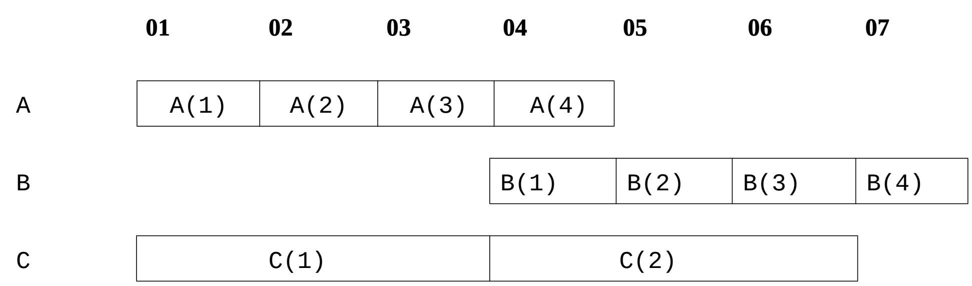
```
  REAL A (2)
DOUBLE PRECISION D (2)
  EQUIVALENCE (A(1), D(1)), (A(2), D(2))
```

When COMMON statements and EQUIVALENCE statements are used together, several additional rules can apply. For such rules, refer to the notes on the COMMON statement.

Example

```
    CHARACTER A*4, B*4, C(2)*3
    EQUIVALENCE (A,C(1)),(B,C(2))
```

The association of A, B, and C can be graphically illustrated as follows.



4.33 EXTERNAL

The EXTERNAL statement specifies procedures or dummy procedures as external, and allows their symbolic names to be used as actual arguments.

Syntax

EXTERNAL *proc* [, *proc*] …	
proc	Name of external procedure, dummy procedure, or block data routine.

Description

If an external procedure or a dummy procedure is an actual argument, it must be in an EXTERNAL statement in the same program unit.

If an intrinsic function name appears in an EXTERNAL statement, that name refers to some external subroutine or function. The corresponding intrinsic function is not available in the program unit.

Restrictions

A subroutine or function name can appear in only one of the EXTERNAL statements of a program unit.

A statement function name must not appear in an EXTERNAL statement.

Examples

Example 1: Use your own version of TAN:

```
      EXTERNAL TAN
      T = TAN( 45.0 )
      …
      END
      FUNCTION TAN( X )
      …
      RETURN
      END
```

Example 2: Pass a user-defined function name as an argument:

```
      REAL AREA, LOW, HIGH
      EXTERNAL FCN
      …
      CALL RUNGE ( FCN, LOW, HIGH, AREA )
      …
      END

      FUNCTION FCN( X )
      …
      RETURN
      END

      SUBROUTINE RUNGE ( F, X0, X1, A )
      …
      RETURN
      END
```

4.34 FORMAT

The FORMAT statement specifies the layout of the input or output records.

Syntax

label FORMAT (*f*)	
label	Statement number
f	Format specification list

The items in *f* have the form:

[*r*] *d*	
[*r*] (*f*)	
r	A repeat factor
d	An edit descriptor (repeatable or nonrepeatable). If *r* is present, then *d* must be repeatable.

The repeatable edit descriptors are:

I I*w* I*w.m* O O*w* O*w.m* Z Z*w* Z*w.m*	F F*w* F*w.m* A A*w* L L*w*	E E*w* E*w.m* E*w.m.e* E*w.m*E*e*	D D*w* D*w.m* D*w.m.e* D*w.m*E*e*	G G*w* G*w.m* G*w.m.e* G*w.m*E*e*

Here is a summary:

- I, O, Z are for integers (decimal, octal, hex)
- F, E, D, G are for reals (fixed-point, exponential, double, general)
- A is for characters
- L is for logicals

See the section,"Formatted I/O," in Chapter 5, "Input and Output," for full details of these edit descriptors.

Nonrepeatable Edit Descriptors

'*a1a2 … an*'	[*k*]R	*k* defaults to 10
"*a1a2 … an*"	[*k*]P	*k* defaults to 0
*n*H*a1a2 … an*	S	
$	SU	
/	SP	
:	SS	
B	T*n*	
BN	*n*T	
BZ	TL[*n*]	*n* defaults to 1
	TR[*n*]	*n* defaults to 1
	[*n*]X	*n* defaults to 1

Variable Format Expressions ♦

In general, any integer constant in a format can be replaced by an arbitrary expression enclosed in angle brackets:

```
1    FORMAT(  … < e > … )
```

The *n* in an *n*H… edit descriptor cannot be a variable format expression.

Description

The FORMAT statement includes the explicit editing directives to produce or use the layout of the record. It is used with formatted input/output statements and ENCODE/DECODE statements.

Repeat Factor

r must be a nonzero, unsigned, integer constant.

Repeatable Edit Descriptors

The descriptors I, O, Z, F, E, D, G, L, and A indicate the manner of editing and are repeatable.

w and *e* are nonzero, unsigned integer constants.

d and *m* are unsigned integer constants.

Nonrepeatable Edit Descriptors

The descriptors are the following:

("), ($), ('), (/), (:), B, BN, BZ, H, P, R, Q, S, SU, SP, SS, T, TL, TR, X

These descriptors indicate the manner of editing and are *not* repeatable:

- Each *ai* is any ASCII character.
- *n* is a nonzero, unsigned integer constant.
- *k* is an optionally signed integer constant.

Item Separator

Items in the format specification list are separated by commas. A comma can be omitted before or after the slash and colon edit descriptors, between a P edit descriptor, and the immediately following F, E, D, or G edit descriptors.

In some sense, the comma can be omitted anywhere the meaning is clear without it, but, other than those cases listed above, this is nonstandard. ◆

Restrictions

The FORMAT statement label cannot be used in a GO TO, IF-arithmetic, DO, or alternate return.

Warnings

For *constant* formats, invalid format strings cause warnings or error messages at compile time.

For formats in variables, invalid format strings cause warnings or error messages at runtime.

For variable format expressions, of the form <e>, invalid format strings cause warnings or error messages at compile time or runtime.

See Chapter 5, “Input and Output,” for more details and more examples.

Examples

Example 1: Some A, I, and F formats:

```
    READ( 2, 1 ) PART, ID, HEIGHT, WEIGHT
1   FORMAT( A8, 2X, I4, F8.2, F8.2 )
    WRITE( 9, 2 ) PART, ID, HEIGHT, WEIGHT
2   FORMAT( 'Part:', A8, ' Id:', I4, ' Height:', F8.2,
&          ' Weight:', F8.2 )
```

Example 2: Variable format expressions:

```
    DO 100 N = 1, 50
         …
1   FORMAT( 2X, F<N+1>.2 )
```

4.35 FUNCTION (External)

The FUNCTION statement identifies a program unit as a function subprogram.

Syntax

```
[ type ] FUNCTION  fun ( [ ar [, ar ] … ] )
```

type is one of the following:

BYTE ♦ CHARACTER CHARACTER*n CHARACTER*(*) COMPLEX COMPLEX*8 ♦ COMPLEX*16 ♦ COMPLEX*32 ♦ *(SPARC only)*	DOUBLE COMPLEX ♦ DOUBLE PRECISION INTEGER INTEGER*2 ♦ INTEGER*4 ♦ INTEGER*8 ♦ LOGICAL	LOGICAL*1 ♦ LOGICAL*2 ♦ LOGICAL*4 ♦ LOGICAL*8 ♦ REAL REAL*4 ♦ REAL*8 ♦ REAL*16 ♦ *(SPARC only)*
n (as in CHARACTER**n*)	Must be greater than zero	
fun	Symbolic name assigned to function	
ar	Formal argument name	

An alternate nonstandard syntax for length specifier is as follows: ♦

[*type*] FUNCTION *name* [* *m*]([*ar* [,*ar*] …])	
m	Unsigned, nonzero integer constant specifying length of the data type.

Description

Note the type, value, and formal arguments for a FUNCTION statement.

Type of Function

The function statement involves type, name, and formal arguments.

If *type* is not present in the FUNCTION statement, then the type of the function is determined by default and by any subsequent IMPLICIT or type statement. If *type* is present, then the function name cannot appear in other type statements.

Value of Function

The symbolic name of the function must appear as a variable name in the subprogram. The value of this variable, at the time of execution of the RETURN or END statement in the function subprogram, is the value of the function.

Formal Arguments

The list of arguments defines the number of formal arguments. The type of these formal arguments is defined by some combination of default, type statements, IMPLICIT statements, and DIMENSION statements.

The number of formal arguments must be the same as the number of actual arguments at the invocation of this function subprogram.

A function can assign values to formal arguments. These values are returned to the calling program when the RETURN or END statements are executed in the function subprogram.

Restrictions

Alternate return specifiers are not allowed in FUNCTION statements.

f77 provides recursive calls. A function or subroutine is called *recursively* if it calls itself directly. If it calls another function or subroutine, which in turn calls this function or subroutine before returning, then it is also called recursively.

Examples

Example 1: Character function:

```
CHARACTER*5 FUNCTION BOOL(ARG)
BOOL = 'TRUE'
IF (ARG .LE. 0) BOOL = 'FALSE'
RETURN
END
```

In the above example, BOOL is defined as a function of type CHARACTER with a length of 5 characters. This function when called returns the string, TRUE or FALSE, depending on the value of the variable, ARG.

Example 2: Real function:

```
FUNCTION SQR (A)
SQR = A*A
RETURN
END
```

In the above example, the function SQR is defined as function of type REAL by default, and returns the square of the number passed to it.

Example 3: Size of function, alternate syntax: ♦

```
 INTEGER FUNCTION FCN*2 ( A, B, C )
```

The above nonstandard form is treated as:

```
INTEGER*2 FUNCTION FCN ( A, B, C )
```

4.36 GO TO *(Assigned)*

The *assigned* GO TO statement branches to a statement label identified by the assigned label value of a variable.

Syntax

GO TO *i* [[,] (*s* [, *s*] …)]	
i	Integer variable name
s	Statement label of an executable statement

Description

Execution proceeds as follows:

1. **At the time an assigned `GO TO` statement is executed, the variable *i* must have been assigned the label value of an executable statement in the same program unit as the assigned `GO TO` statement.**
2. **If an assigned `GO TO` statement is executed, control transfers to a statement identified by *i*.**
3. **If a list of statement labels is present, the statement label assigned to *i* must be one of the labels in the list.**

Restrictions

i must be assigned by an `ASSIGN` statement in the same program unit as the `GO TO` statement.

i must be `INTEGER*4` or `INTEGER*8`, not `INTEGER*2`.

s must be in the same program unit as the `GO TO` statement.

The same statement label can appear more than once in a `GO TO` statement.

The statement you jump to must be *executable*, not `DATA`, `ENTRY`, `FORMAT`, or `INCLUDE`.

You cannot jump into a `DO`, `IF`, `ELSE IF`, or `ELSE` block from outside the block.

Example

Example: Assigned GO TO:

```
       ASSIGN 10 TO N
       …
       GO TO N ( 10, 20, 30, 40 )
       …
10     CONTINUE
       …
40     STOP
```

4.37 GO TO (Computed)

The *computed* GO TO statement selects one statement label from a list, depending on the value of an integer or real expression, and transfers control to the selected one.

Syntax

GO TO (*s* [, *s*] …) [,] *e*	
s	Statement label of an *executable* statement
e	Expression of type integer or real

Description

Execution proceeds as follows:

1. ***e* is evaluated first. It is converted to integer, if required.**
2. **If 1 ≤ *e* ≤ *n*, where *n* is the number of statement labels specified, then the e^{th} label is selected from the specified list and control is transferred to it.**
3. **If the value of *e* is outside the range, that is, *e* < 1 or *e* > *n*, then the computed GO TO statement serves as a CONTINUE statement.**

Restrictions

s must be in the same program unit as the GO TO statement.

The same statement label can appear more than once in a GO TO statement.

The statement you jump to must be *executable*, not DATA, ENTRY, FORMAT, or INCLUDE.

You cannot jump into a DO, IF, ELSE IF, or ELSE block from outside the block.

Example

Example: Computed GO TO:

```
    …
    GO TO ( 10, 20, 30, 40 ), N
    …
10  CONTINUE
    …
20  CONTINUE
    …
40  CONTINUE
```

In the above example:

- If N=1, then go to 10.
- If N=2, then go to 20.
- If N=3, then go to 30.
- If N=4, then go to 40.
- If N<1 or N>4, then fall through to 10.

4.38 GO TO (Unconditional)

The *unconditional* GO TO statement transfers control to a specified statement.

Syntax

GO TO *s*	
s	Statement label of an *executable* statement

Description

Execution of the GO TO statement transfers control to the statement labeled *s*.

Restrictions

s must be in the same program unit as the GO TO statement.

The statement you jump to must be executable, not a DATA, ENTRY, FORMAT, or INCLUDE statement.

You cannot jump into a DO, IF, ELSE IF, or ELSE block from outside the block.

Example

```
    A = 100.0
    B = 0.01
    GO TO 90
    …
90  CONTINUE
```

4.39 IF (Arithmetic)

The *arithmetic* IF statement branches to one of three specified statements, depending on the value of an arithmetic expression.

Syntax

IF (*e*) *s1*, *s2*, *s3*	
e	Arithmetic expression: integer, real, double precision, or quadruple precision
s1, s2, s3	Labels of *executable* statements

Description

The IF statement transfers control to the first, second, or third label if the value of the arithmetic expression is less than zero, equal to zero, or greater than zero, respectively.

The restrictions are:

- The *s1*, *s2*, *s3* must be in the same program unit as the IF statement.
- The same statement label can appear more than once in a IF statement.
- The statement you jump to must be *executable*, not DATA, ENTRY, FORMAT, or INCLUDE.
- You cannot jump into a DO, IF, ELSE IF, or ELSE block from outside the block.

Example

```
    N = 0
    IF ( N ) 10, 20, 30
```

Since the value of N is zero, control is transferred to statement label 20.

4.40 `IF` *(Block)*

The *block* `IF` statement executes one of two or more sequences of statements, depending on the value of a logical expression.

Syntax

```
IF ( e ) THEN
 …
END IF
```

e	A logical expression

Description

The *block* `IF` statement evaluates a logical expression and, if the logical expression is true, it executes a set of statements called the `IF` block. If the logical expression is false, control transfers to the next `ELSE`, `ELSE IF`, or `END IF` statement at the same `IF`-level.

`IF` *Level*

The `IF` level of a statement *S* is the value *n1–n2*, where *n1* is the number of block `IF` statements from the beginning of the program unit up to the end, including *S*; *n2* is the number of `END IF` statements in the program unit up to, but not including, *S*.

Example: In the following program, the `IF`-level of statement 9 is 2-1, or, 1:

```
    IF ( X .LT. 0.0 ) THEN
       MIN = NODE
    END IF
    …
9   IF ( Y .LT. 0.0 ) THEN
       MIN = NODE - 1
    END IF
```

The IF-level of every statement must be zero or positive. The IF-level of each block IF, ELSE IF, ELSE, and END IF statement must be positive. The IF-level of the END statement of each program unit must be zero.

IF *Block*

An IF block consists of all the executable statements following the block IF statement, up to, but not including, the next ELSE, ELSE IF, or END IF statement that has the same if level as the block IF statement. An IF block can be empty. In the following example, the two assignment statements form an IF block:

```
IF ( X .LT. Y ) THEN
   M = 0
   N = N+1
END IF
```

Execution proceeds as follows:

1. **The logical expression *e* is evaluated first. If *e* is true, execution continues with the first statement of the IF block.**
2. **If *e* is true and the IF block is empty, control is transferred to the next END IF statement with the same IF level as the block IF statement.**
3. **If *e* is false, control is transferred to the next ELSE IF, ELSE, or END IF statement with the same IF level as the block IF statement.**
4. **If the last statement of the IF block does not result in a branch to a label, control is transferred to the next END IF statement that has the same IF level as the block IF statement preceding the IF block.**

Restrictions

You cannot jump into an IF block from outside the IF block.

Examples

Example 1: IF-THEN-ELSE:

```
IF ( L ) THEN
    N=N+1
    CALL CALC
ELSE
    K=K+1
    CALL DISP
END IF
```

Example 2: IF-THEN-ELSE-IF with ELSE-IF:

```
IF ( C .EQ. 'a' ) THEN
    NA=NA+1
    CALL APPEND
ELSE IF ( C .EQ. 'b' ) THEN
    NB=NB+1
    CALL BEFORE
ELSE IF ( C .EQ. 'c' ) THEN
    NC=NC+1
    CALL CENTER
END IF
```

Example 3: Nested IF-THEN-ELSE:

```
IF ( PRESSURE .GT 1000.0 ) THEN
    IF ( N .LT. 0.0 ) THEN
        X = 0.0
        Y = 0.0
    ELSE
        Z = 0.0
    END IF
ELSE IF ( TEMPERATURE .GT. 547.0 ) THEN
    Z = 1.0
ELSE
    X = 1.0
    Y = 1.0
END IF
```

4.41 IF (Logical)

The *logical* IF statement executes one single statement, or does not execute it, depending on the value of a logical expression.

Syntax

IF (*e*) *st*	
e	Logical expression
st	Executable statement

Description

The *logical* IF statement evaluates a logical expression and executes the specified statement if the value of the logical expression is true. The specified statement is not executed if the value of the logical expression is false, and execution continues as though a CONTINUE statement had been executed.

st can be any *executable* statement, except a DO block, IF, ELSE IF, ELSE, END IF, END, or another logical IF statement.

Example

```
      IF ( VALUE .LE. ATAD ) CALL PUNT  ! Note that there is no THEN.
      IF ( TALLY .GE. 1000 ) RETURN
```

4.42 IMPLICIT

The `IMPLICIT` statement confirms or changes the default type of names.

Syntax

`IMPLICIT` *type* (*a* [, *a*] …) [, *type* (*a* [, *a*] …)]
or:
`IMPLICIT NONE`
or:
`IMPLICIT UNDEFINED(A-Z)` ◆

type is one of the following permitted types:

`BYTE` ◆
`CHARACTER`
`CHARACTER*`*n*
`CHARACTER*(*)`
`COMPLEX`
`COMPLEX*8` ◆
`COMPLEX*16` ◆
`COMPLEX*32` ◆ *(SPARC only)*
`DOUBLE COMPLEX` ◆
`DOUBLE PRECISION`
	`INTEGER`
	`INTEGER*2` ◆
	`INTEGER*4` ◆
	`INTEGER*8` ◆
	`LOGICAL`
	`LOGICAL*1` ◆
	`LOGICAL*2` ◆
	`LOGICAL*4` ◆
	`LOGICAL*8` ◆
		`REAL`
		`REAL*4` ◆
		`REAL*8` ◆
		`REAL*16` ◆ *(SPARC only)*
		`AUTOMATIC` ◆
		`STATIC` ◆

n must be greater than 0.		
a is either a single letter or a range of single letters in alphabetical order. A range of letters can be specified by the first and last letters of the range, separated by a minus sign.		

Description

The different uses for implicit typing and no implicit typing are described here.

Implicit Typing

The `IMPLICIT` statement can also indicate that no implicit typing rules apply in a program unit.

An IMPLICIT statement specifies a type and size for all user-defined names that begin with any letter, either a single letter or in a range of letters, appearing in the specification.

An IMPLICIT statement does not change the type of the intrinsic functions.

An IMPLICIT statement applies only to the program unit that contains it.

A program unit can contain more than one IMPLICIT statement.

IMPLICIT types for particular user names are overridden by a *type* statement.

No Implicit Typing

The second form of IMPLICIT specifies that no implicit typing should be done for user-defined names, and all user-defined names shall have their types declared explicitly.

If either IMPLICIT NONE or IMPLICIT UNDEFINED (A-Z) is specified, there cannot be any other IMPLICIT statement in the program unit.

Restrictions

IMPLICIT statements must precede all other specification statements.

The same letter can appear *more than once* as a single letter, or in a range of letters in all IMPLICIT statements of a program unit. ♦

The FORTRAN 77 Standard restricts this usage to *only once*. For f77, if a letter is used twice, each usage is declared in order. See Example 4.

Examples

Example 1: IMPLICIT: everything is integer:

```
      IMPLICIT INTEGER (A-Z)
      X = 3
      K = 1
      STRING = 0
```

Example 2: Complex if it starts with U, V, or W; character if it starts with C or S:

```
IMPLICIT COMPLEX (U,V,W), CHARACTER*4 (C,S)
U1 = ( 1.0, 3.0)
STRING = 'abcd'
I = 0
X = 0.0
```

Example 3: All items must be declared:

```
IMPLICIT NONE
CHARACTER STR*8
INTEGER N
REAL Y
N = 100
Y = 1.0E5
STR = 'Length'
```

In the above example, once IMPLICIT NONE is specified in the beginning. All the variables *must* be declared explicitly.

Example 4: A letter used twice: ♦

```
IMPLICIT INTEGER (A-Z)
IMPLICIT REAL (A-C)
C = 1.5E8
D = 9
```

In the above example, D through Z implies INTEGER, and A through C implies REAL.

4.43 INCLUDE

The INCLUDE ♦ statement inserts a file into the source program.

Syntax

INCLUDE '*file*' or: INCLUDE "*file*"	
file	Name of the file to be inserted

Description

The contents of the named file replace the INCLUDE statement.

Search Path

If the name referred to by the INCLUDE statement begins with the character /, then it is taken by f77 to mean the absolute path name of the INCLUDE file. Otherwise, f77 looks for the file in the following directories, in this order:

1. The directory that contains the source file with the INCLUDE statement
2. The directories that are named in the -I*loc* options
3. The current directory in which the f77 command was issued
4. The directories in the default list. This is different in Solaris 1.x and 2.x.

   The default list varies between Solaris 1.x and 2.x.

   For Solaris 2.x, if you installed into the *standard* directory, the default list is:

   /opt/SUNWspro/SC4.0/include/f77 /usr/include

   If you installed into *nonstandard* directory /*mydir*/, then it is:

   /*mydir*/SUNWspro/SC4.0/include/f77 /usr/include

For Solaris 1.x, if you installed in the *standard* directory, then the default list is:

```
/usr/lang/SC4.0/include/f77 /usr/include
```

If you installed into *nonstandard* directory /*mydir*/, then it is:

/*mydir*/`SC4.0/include/f77 /usr/include`

The release number, `SC4.0`, varies with the release of the set of compilers.

These `INCLUDE` statements can be nested ten deep.

Preprocessor `#include`

The paths and order searched for the `INCLUDE` statement are not the same as those searched for the preprocessor `#include` directive, described under `-I` in the *FORTRAN* 77 4.0 *User's Guide*. Files included by the preprocessor `#include` directive can contain `#defines` and the like; files included with the compiler `INCLUDE` statement must contain only FORTRAN 77 statements.

VMS Logical File Names in the `INCLUDE` *Statement*

`f77` interprets VMS logical file names on the `INCLUDE` statement if:

- The `-xl[d]` compiler option is set.
- The environment variable `LOGICALNAMEMAPPING` is there to define the mapping between the logical names and the UNIX path name.

  `f77` uses the following rules for the interpretation:
  - The environment variable should be set to a string with the syntax:

```
"lname1=path1; lname2=path2; … "
```

where each *lname* is a logical name and each *path1*, *path2*, and so forth is the path name of a directory (without a trailing `/`).

- All blanks are ignored when parsing this string. It strips any trailing `/[no]`*list* from the file name in the `INCLUDE` statement.
- Logical names in a file name are delimited by the first : in the VMS file name, so `f77` converts file names of the *lname1*`:`*file* form to the *path1*`/`*file* form.

- For logical names, uppercase and lowercase are significant. If a logical name is encountered on the `INCLUDE` statement which is not specified in the `LOGICALNAMEMAPPING`, the file name is used, unchanged.

Examples

Example 1: `INCLUDE`, simple case:

```
    INCLUDE 'stuff'
```

The above line is replaced by the contents of the file `stuff`.

Example 2: `INCLUDE`, search paths:

For the following conditions:

- Your source file has the line:

```
    INCLUDE 'ver1/const.h'
```

- Your current working directory is `/usr/ftn`.
- Your source file is `/usr/ftn/projA/myprg.f`.

In this example, `f77` seeks `const.h` in these directories, in the order shown.

For Solaris 2.x, If you installed into the *standard* directory, then `f77` searches these directories:

- `/usr/ftn/projA/ver1`
- `/usr/ftn/ver1`
- `/opt/SUNWspro/SC4.0/include/f77/ver1`
- `/usr/include`

If you installed into *nonstandard* directory */mydir*, it searches these directories:

- `/usr/ftn/projA/ver1`
- `/usr/ftn/ver1`
- */mydir*`/SUNWspro/SC4.0/include/f77/ver1`
- `usr/include`

For Solaris 1.x, if you installed into the *standard* directory, then `f77` searches these directories:

- `/usr/ftn/projA/ver1`
- `/usr/ftn/ver1`
- `/usr/lang/SC4.0/include/f77/ver1`
- `/usr/include`

If you installed into *nonstandard* directory /*mydir*/, it searches these directories:

- `/usr/ftn/projA/ver1`
- `/usr/ftn/ver1`
- /*mydir*/`SC4.0/include/f77/ver1`
- `/usr/include`

4.44 INQUIRE

The `INQUIRE` statement returns information about a unit or file.

Syntax

An inquire by *unit* has the general form:

`INQUIRE( [ UNIT=]` *u*`,` *slist* `)`

An inquire by *file* has the general form:

`INQUIRE( FILE=`*fn*`,` *slist* `)`	
fn	Name of the file being queried
u	Unit of the file being queried
slist	Specifier list

The `INQUIRE` *slist* can include one or more of the following, in any order:

- `ERR` = *s*
- `EXIST` = *ex*
- `OPENED` = *od*
- `NAMED` = *nmd*
- `ACCESS` = *acc*

- SEQUENTIAL = *seq*
- DIRECT = *dir*
- FORM = *fm*
- FORMATTED = *fmt*
- UNFORMATTED = *unf*
- NAME = *fn*
- BLANK = *blnk*
- IOSTAT = *ios*
- NUMBER = *num*
- RECL = *rcl*
- NEXTREC = *nr*

Description

You can determine such things about a file as whether it exists, is opened, or is connected for sequential I/O. That is, files have such attributes as name, existence (or nonexistence), and the ability to be connected in certain ways (FORMATTED, UNFORMATTED, SEQUENTIAL, or DIRECT).

You can inquire either by unit or by file, but not by both in the same INQUIRE statement.

In this system environment, the only way to discover what permissions you have for a file is to use the ACCESS(3F) function. The INQUIRE statement does not determine permissions.

The specifiers for INQUIRE are:

- FILE = *fn*—*n* is a character expression or * with the name of the file. Trailing blanks in the file name are ignored. If the file name is all blanks, that means the current *directory.* The file need not be connected to a unit in the current program.
- UNIT = *u*—*u* is an integer expression or * with the value of the unit. Exactly one of FILE or UNIT must be used.
- IOSTAT = *ios*—*ios* is as in the OPEN statement.
- ERR = *s*—*s* is a statement label of a statement to branch to if an error occurs during the execution of the INQUIRE statement.
- EXIST = *ex*—*ex* is a logical variable that is set to .TRUE. if the file or unit exists, and .FALSE. otherwise.

- `OPENED =` *od—od* is a logical variable that is set to `.TRUE.` if the file is connected to a unit or the unit is connected to a file, and `.FALSE.` otherwise.
- `NUMBER =` *num—num* is an integer variable that is assigned the number of the unit connected to the file, if any. If no file is connected, the variable is unchanged.
- `NAMED =` *nmd—nmd* is a logical variable that is assigned `.TRUE.` if the file has a name, `.FALSE.` otherwise.
- `NAME =` *fn—fn* is a character variable that is assigned the name of the file connected to the unit. If you do an inquire-by-unit, the name parameter is undefined, unless both the values of the `OPENED` and `NAMED` variables are both true. If you do an inquire by file, the name parameter is returned, even though the FORTRAN 77 Standard leaves it undefined.
- `ACCESS =` *acc—acc* is a character variable that is assigned the value `'SEQUENTIAL'` if the connection is for sequential I/O and `'DIRECT'` if the connection is for direct I/O. The value is undefined if there is no connection.
- `SEQUENTIAL =` *seq—seq* is a character variable that is assigned the value `'YES'` if the file could be connected for sequential I/O, `'NO'` if the file could not be connected for sequential I/O, and `'UNKNOWN'` if the system can't tell.
- `DIRECT =` *dir—dir* is a character variable that is assigned the value `'YES'` if the file could be connected for direct I/O, `'NO'` if the file could not be connected for direct I/O, and `'UNKNOWN'` if the system can't tell.
- `FORM =` *fm—fm* is a character variable which is assigned the value `'FORMATTED'` if the file is connected for formatted I/O and `'UNFORMATTED'` if the file is connected for unformatted I/O.
- `FORMATTED =` *fmt—fmt* is a character variable that is assigned the value `'YES'` if the file could be connected for formatted I/O, `'NO'` if the file could not be connected for formatted I/O, and `'UNKNOWN'` if the system cannot tell.
- `UNFORMATTED =` *unf—unf* is a character variable that is assigned the value `'YES'` if the file could be connected for unformatted I/O, `'NO'` if the file could not be connected for unformatted I/O, and `'UNKNOWN'` if the system cannot tell.

- `RECL = ` *rcl*—*rcl* is an integer variable that is assigned the record length of the records in the file if the file is connected for direct access. `f77` does not adjust the *rcl* returned by `INQUIRE`. The `OPEN` statement does such an adjustment if the `-xl[d]` option is set. For an explanation of `-xl[d]`, see the section, “Details of Features That Require -xl[d]” on page 437.
- `NEXTREC = ` *nr*— *nr* is an integer variable that is assigned one more than the number of the last record read from a file connected for direct access.
- `BLANK = ` *blnk*—*blnk* is a character variable that is assigned the value `'NULL'` if null blank control is in effect for the file connected for formatted I/O, and `'ZERO'` if blanks are being converted to zeros and the file is connected for formatted I/O.

Example: An `OPEN` statement in which declarations are omitted:

```
    OPEN( 1, FILE='/dev/console' )
```

For `f77,` this statement opens the console for formatted sequential I/O. An `INQUIRE` for either unit 1 or the file, `/dev/console`, reveals that the file:

- Exists
- Is connected to unit 1
- Has the name `/dev/console`
- Is opened for sequential I/O
- Could be connected for sequential I/O
- Cannot be connected for direct I/O, that is cannot seek
- Is connected for formatted I/O
- Can be connected for formatted I/O
- Cannot be connected for unformatted I/O, that is, cannot seek
- Has neither a record length nor a next record number
- Is ignoring blanks in numeric fields

The following table summarizes the INQUIRE options:

Table 4-2 INQUIRE Options Summary

Form: SPECIFIER = Variable

SPECIFIER	**Value of Variable**	**Data Type of Variable**
ACCESS	'DIRECT' 'SEQUENTIAL'	CHARACTER
BLANK	'NULL','ZERO'	CHARACTER
DIRECT *	'YES' 'NO' 'UNKNOWN'	CHARACTER
ERR	Statement number	INTEGER
EXIST	.TRUE., .FALSE.	LOGICAL
FORM	'FORMATTED' 'UNFORMATTED'	CHARACTER
FORMATTED *	'YES' 'NO' 'UNKNOWN'	CHARACTER
IOSTAT	Error number	INTEGER
NAME †	Name of the file	CHARACTER
NAMED †	.TRUE., .FALSE.	LOGICAL
NEXTREC	Next record number	INTEGER
NUMBER *	Unit number	INTEGER
OPENED	.TRUE., .FALSE.	LOGICAL
RECL	Record length	INTEGER
SEQUENTIAL *	'YES' 'NO' 'UNKNOWN'	CHARACTER
UNFORMATTED *	'YES' 'NO' 'UNKNOWN'	CHARACTER

The asterisk (*) indicates the returned value is undefined for inquire-by-unit in the FORTRAN 77 Standard, but is defined in f77.

The † indicates the returned value is undefined for inquire-by-file in the FORTRAN 77 Standard, but is defined in f77.

Also:

- If a file is scratch, then NAMED and NUMBER are not returned.
- If there is no file with the specified name, then these variables are not returned: DIRECT, FORMATTED, NAME, NAMED, SEQUENTIAL, and UNFORMATTED.
- If OPENED=.FALSE., then these variables are not returned: ACCESS, BLANK, FORM, NEXTREC, and RECL.
- If no file is connected to the specified unit, then these variables are not returned: ACCESS, BLANK, DIRECT, FORM, FORMATTED, NAME, NAMED, NEXTREC, NUMBER, RECL, SEQUENTIAL, and UNFORMATTED.
- If ACCESS='SEQUENTIAL', then these variables are not returned: RECL and NEXTREC.
- If FORM='UNFORMATTED', then BLANK is not returned.

Examples

Example 1: Inquire by *unit*:

```
      LOGICAL OK
      INQUIRE( UNIT=3, OPENED=OK )
      IF ( OK ) CALL GETSTD ( 3, STDS )
```

Example 2: Inquire by *unit*—omit the UNIT=:

```
      LOGICAL OK
      INQUIRE( 3, OPENED=OK )
      IF ( OK ) CALL GETSTD ( 3, STDS )
```

Example 3: Inquire by *file:*

```
      LOGICAL THERE
      INQUIRE( FILE='.profile', EXIST=THERE )
      IF ( THERE ) CALL GETPROFILE( FC, PROFILE )
```

Example 4: More than one answer:

```
    CHARACTER FN*32
    LOGICAL HASNAME, OK
    INQUIRE ( UNIT=3, OPENED=OK, NAMED=HASNAME, NAME=FN )
    IF ( OK .AND. HASNAME ) PRINT *, 'Filename="', FN, '"'
```

4.45 INTEGER

The INTEGER statement specifies the type to be integer for a symbolic constant, variable, array, function, or dummy function.

Optionally, it specifies array dimensions and size and initializes with values.

Syntax

INTEGER [* *len*[,]] *v* [* *len* [/*c*/]] [, *v* [* *len* [/*c*/]] …	
v	Name of a symbolic constant, variable, array, array declarator, function, or dummy function
len	Either 2, 4, or 8, the length in bytes of the symbolic constant, variable, array element, or function. 8 is allowed only if -dbl is on. ♦
c	List of constants for the immediately preceding name

Description

If you specify the size as 2, 4, or 8, you get what you specify; if you do *not* specify the size, you get the default size.

Default Size

The default size depends on –i2 and –r8.

- If the –i2 option is on the f77 command line, then the default length is 2; otherwise, the default is 4.

- If the –r8 option is on the f77 command line, then the compiler allocates 8 bytes, but still performs only 4-byte arithmetic. This is done to satisfy the requirements of the FORTRAN 77 Standard that an integer and a real datum are allocated the same amount of storage.
- If the -dbl option is on, then the compiler allocates 8 bytes and performs 8-byte arithmetic as well.
- If you put both –i2 and –r8 on the f77 command line, the results are unpredictable.

Restrictions

Do not use INTEGER*8 variables or 8-byte constants or expressions when indexing arrays, otherwise, only 4 low-order bytes are taken into account. This action can cause unpredictable results in your program if the index value exceeds the range for 4-byte integers.

We recommend that you *not* use INTEGER*8 in your code, since the program will not compile if you omit -dbl. Instead, use INTEGER and compile with -dbl, which automatically converts INTEGER to 64-bit integers.

Examples

Example 1: Each of these integer scalars is equivalent to the others, if there is no –i2:

```
    INTEGER    U, V
    INTEGER*4  U, V
    INTEGER    U*4, V*4
```

Do not use all three lines in the same program unit—you cannot declare anything more than once in the same program unit.

Example 2: Initialize:

```
    INTEGER U / 1 /, V / 4 /, W*2 / 1 /, X*2 / 4 /
```

Example 3: Use any one of these lines for integer arrays; they are equivalent:

```
    INTEGER    U(9), V(9)
    INTEGER*4  U(9), V(9)
    INTEGER    U*4(9), V(9)*4
```

4.46 INTRINSIC

The INTRINSIC statement lists intrinsic functions that can be passed as actual arguments.

Syntax

INTRINSIC *fun* [, *fun*] …	
fun	Function name

Description

If the name of an intrinsic function is used as an actual argument, it must appear in an INTRINSIC statement in the same program unit.

Example: Intrinsic functions passed as actual arguments:

```
    INTRINSIC SIN, COS
    X = CALC ( SIN, COS )
```

Restrictions

A symbolic name must not appear in both an EXTERNAL and an INTRINSIC statement in the same program unit.

The *actual* argument must be a *specific* name. Most generic names are also specific, but a few are not: IMAG, LOG, and LOG10.

A symbolic name can appear *more than once* in an INTRINSIC statement. ♦ In the FORTRAN 77 Standard, a symbolic name can appear only *once* in an INTRINSIC statement.

Because they are in-line or generic, the following intrinsics *cannot* be passed as *actual* arguments:

Table 4-3 Intrinsics That Cannot Be Passed As Actual Arguments

LOC	IIQINT	QEXTD	MIN	LOG
AND	JIQINT	QFLOAT	MIN0	LOG10
IAND	IFIX	CMPLX	AMIN0	QREAL
IIAND	IIFIX	DCMPLX	AIMIN0	QCMPLX
JIAND	JIFIX	ICHAR	AJMIN0	SIZEOF
OR	IDINT	IACHAR	IMIN0	
IOR	IIDINT	ACHAR	JMIN0	
IIOR	JIDINT	CHAR	MIN1	
IEOR	FLOAT	MAX	AMIN1	
IIEOR	FLOATI	MAX0	DMIN1	
JIOR	FLOATJ	AMAX0	IMIN1	
JIEOR	DFLOAT	AIMAX0	JMIN1	
NOT	DFLOTI	AJMAX0	QMIN1	
INOT	DFLOTJ	IMAX0	IMAG	
JNOT	SNGL	JMAX0	EPBASE	
XOR	SNGLQ	MAX1	EPEMAX	
LSHIFT	REAL	AMAX1	EPEMIN	
RSHIFT	DREAL	DMAX1	EPHUGE	
INT	DBLE	IMAX1	EPMRSP	
IINT	DBLEQ	JMAX1	EPPREC	
JINT	QEXT	QMAX1	EPTINY	
IQINT				

4.47 LOGICAL

The `LOGICAL` statement specifies the type to be logical for a symbolic constant, variable, array, function, or dummy function.

Optionally, it specifies array dimensions and initializes with values.

Syntax

LOGICAL [*len[,]] v[* len [/c/]] [, v [* len [/c/]] …	
v	Name of a symbolic constant, variable, array, array declarator, function, or dummy function
len	Either 1, 2, 4, or 8, the length in bytes of the symbolic constant, variable, array element, or function. 8 is allowed only if `-dbl` is on. ♦
c	List of constants for the immediately preceding name

Description

If you specify the size as 1, 2, or 4, then you get what you specify; but if you do *not* specify the size, you get the default size.

Default Size

The default size depends on `–i2` and `–r8`:

- If the `–i2` option is on the `f77` command line, then the default length is 2; otherwise, the default is 4.
- If the `–r8` or `-dbl` option is on the `f77` command line, then the compiler allocates 8 bytes. If `-dbl` is specified, 8-byte arithmetic is done, otherwise only 4-byte arithmetic is performed. This is to satisfy the requirements of the FORTRAN 77 Standard that an integer and a real datum are allocated the same amount of storage.
- If you put both `–i2` and `–r8` on the `f77` command line, the results are unpredictable.

Examples

Example 1: Each of these statements is equivalent to the others, if there is no `-i2`:

```
    LOGICAL U, V
    LOGICAL*4 U, V
    LOGICAL U*4, V*4
```

Do not use all three statements in the same program unit—you cannot declare anything more than once in the same program unit.

Example 2: Initialize:

```
    LOGICAL U /.false./, V /0/, W*4 /.true./, X*4 /'z'/
```

4.48 MAP

The MAP ♦ declaration defines alternate groups of fields in a *union*.

Syntax

```
MAP
    field-declaration
…
    [field-declaration]
END MAP
```

Description

Each field declaration can be one of the following:

- Type declaration, which can include initial values
- Substructure—either another structure declaration, or a record that has been previously defined
- Union declaration—see Section 4.70, “UNION and MAP,” for more details

Example

Example: MAP:

```
    STRUCTURE /STUDENT/
        CHARACTER*32  NAME
        INTEGER*2  CLASS
        UNION
            MAP
                CHARACTER*16 MAJOR
            END MAP
            MAP
                INTEGER*2  CREDITS
                CHARACTER*8  GRAD_DATE
            END MAP
        END UNION
    END STRUCTURE
```

4.49 NAMELIST

The NAMELIST ♦ statement defines a list of variables or array names, and associates it with a unique group name.

Syntax

NAMELIST / *grname* / *namelist* [[,] / *grname* / *namelist*] …	
grname	Symbolic name of the group
namelist	List of variables and arrays

Description

The NAMELIST statement contains a group name and other items.

Group Name

The group name is used in the namelist-directed I/O statement to identify the list of variables or arrays that are to be read or written. This name is used by namelist-directed I/O statements instead of an input/output list. The group name must be unique, and identifies a list whose items can be read or written.

A group of variables can be defined through several `NAMELIST` statements with the same group name. Together, these definitions are taken as defining one `NAMELIST` group.

Namelist Items

The namelist items can be of any data type. The items in the namelist can be variables or arrays, and can appear in more than one namelist. Only the items specified in the namelist can be read or written in namelist-directed I/O, but it is not necessary to specify data in the input record for every item of the namelist.

The order of the items in the namelist controls the order in which the values are written in namelist-directed output. The items in the input record can be in any order.

Restrictions

Input data can assign values to the elements of arrays or to substrings of strings that appear in a namelist.

The following constructs *cannot* appear in a `NAMELIST` statement:

- Constants (parameters)
- Array elements
- Records and record fields
- Character substrings
- Dummy assumed-size arrays

See Chapter 5, "Input and Output," for more details on namelist.

Example

Example: The NAMELIST statement:

```
    CHARACTER*16 SAMPLE
    LOGICAL*4 NEW
    REAL*4 DELTA
    NAMELIST /CASE/ SAMPLE, NEW, DELTA
```

In this example, the group CASE has three variables: SAMPLE, NEW, and DELTA.

4.50 OPEN

The OPEN statement connects an existing external file to a unit, or creates a file and connects it to a unit, or changes some specifiers of the connection.

Syntax

OPEN(*KEYWORD1*=*value1*, *KEYWORD2*=*value2*, …)	
KEYWORDn	A valid keyword specifier, as listed below

Description

For tape, it is more reliable to use the TOPEN() routines. The OPEN statement determines the type of file named, whether the connection specified is legal for the file type (for instance, DIRECT access is illegal for tape and tty devices), and allocates buffers for the connection if the file is on tape or if the subparameter FILEOPT='BUFFER=*n*' is specified. Existing files are never truncated on opening. The options can be specified in any order.

Table 4-4 OPEN Keyword Specifier Summary

Standard Form	Alternate Form
[UNIT=] *u*	
FILE = *fin*	NAME = *fin*
ACCESS = *acc*	

Table 4-4 OPEN Keyword Specifier Summary *(Continued)*

Standard Form	Alternate Form
BLANK = *blnk*	
ERR = *s*	
FORM = *fm*	
IOSTAT = *ios*	
RECL = *rl*	RECORDSIZE = *rl*
STATUS = *sta*	TYPE = *sta*
FILEOPT = *fopt* ♦	
READONLY ♦	
ACTION = *act* ♦	

Details of the OPEN keyword specifier are listed in the following table.

Table 4-5 OPEN Keyword Specifier Details

[UNIT=] *u*	
	u is an integer expression or an asterisk (*) that specifies the unit number. *u* is required. If *u* is first in the parameter list, then UNIT= can be omitted.
FILE=*fin*	
	fin is a character expression or * naming the file to open. An OPEN statement need not specify a file name. If the file name is not specified, a default name is created.
	Reopen—If you open a unit that is already open without specifying a file name (or with the previous file name), FORTRAN 77 thinks you are reopening the file to change parameters. The file position is not changed. The only parameters you are allowed to change are BLANK (NULL or ZERO) and FORM (FORMATTED or PRINT). To change any other parameters, you must close, then reopen the file.
	Switch Files—If you open a unit that is already open, but you specify a different file name, it is as if you closed with the old file name before the open.
	Switch Units—If you open a file that is already open, but you specify a different unit, that is an error. This error is *not* detected by the ERR= option, however, and the program does *not* terminate abnormally.
	Scratch—If a file is opened with STATUS='SCRATCH', a temporary file is created and opened. See STATUS=*sta*.

Table 4-5 OPEN Keyword Specifier Details *(Continued)*

ACCESS=*acc*	
	The ACCESS=*acc* clause is optional. *acc* is a character expression. Possible values are: APPEND, DIRECT, or SEQUENTIAL. The default is SEQUENTIAL.
	If ACCESS='APPEND': SEQUENTIAL and FILEOPT='EOF' are assumed. This is for opening a file to append records to an existing sequential-access file. Only WRITE operations are allowed. This is an extension. ♦
	If ACCESS='DIRECT': RECL must also be given, since all I/O transfers are done in multiples of fixed-size records. Only directly accessible files are allowed; thus, tty, pipes, and magnetic tape are not allowed. If you build a file as sequential, then you cannot access it as direct. If FORM is not specified, unformatted transfer is assumed. If FORM='UNFORMATTED', the size of each transfer depends upon the data transferred.
	If ACCESS='SEQUENTIAL', RECL is ignored. ♦ The FORTRAN 77 Standard prohibits RECL for sequential access. No padding of records is done. If you build a file as direct, then you cannot access it as sequential. Files do not have to be randomly accessible, in the sense that tty, pipes, and tapes can be used. For tapes, we recommend the TOPEN() routines because they are more reliable. If FORM is not specified, formatted transfer is assumed. If FORM='FORMATTED', each record is terminated with a newline (\n) character; that is, each record actually has one extra character. If FORM='PRINT', the file acts like a FORM='FORMATTED' file, except for interpretation of the column-1 characters on the output (blank = single space, 0 = double space, 1 = form feed, and + = no advance). If FORM='UNFORMATTED', each record is preceded and terminated with an INTEGER*4 count, making each record 8 characters longer than normal. This convention is not shared with other languages, so it is useful only for communicating between FORTRAN 77 programs.
FORM=*fm*	
	The FORM=*fm* clause is optional. *fm* is a character expression. Possible values are 'FORMATTED', 'UNFORMATTED', or 'PRINT'. ♦ The default is 'FORMATTED'. This option interacts with ACCESS. 'PRINT' makes it a *print* file. See Chapter 5, “Input and Output,” for details.

Table 4-5 OPEN Keyword Specifier Details *(Continued)*

RECL=*rl*	
	The RECL=*rl* clause is required if ACCESS='DIRECT' and ignored otherwise.
	rl is an integer expression for the length in characters of each record of a file. *rl* must be positive.
	If the record length is unknown, you can use RECL=1; see "Direct Access I/O" on page 261.
	If -xl[d] is *not* set, *rl* is number of characters, and record length is *rl*.
	If -xl[d] is set, *rl* is number of words, and record length is *rl**4. ♦
	There are more details in the ACCESS='SEQUENTIAL' section, above.
	Each WRITE defines one record and each READ reads one record (unread characters are flushed).
	The default buffer size for tape is 64K characters. For tapes, we recommend the TOPEN() routines because they are more reliable.
ERR=*s*	
	The ERR=*s* clause is optional. *s* is a statement label of a statement to branch to if an error occurs during execution of the OPEN statement.
IOSTAT=*ios*	
	The IOSTAT=*ios* clause is optional. *ios* is an integer variable that receives the error status from an OPEN. After the execution of the OPEN, if no error condition exists, then *ios* is zero; otherwise, it is some positive number.
	If you want to avoid aborting the program when an error occurs on an OPEN, include ERR=*s* or IOSTAT=*ios*.
BLANK=*blnk*	
	The BLANK=*blnk* clause is optional, and is for formatted input only. The *blnk* is a character expression that indicates how blanks are treated. Possible values are 'ZERO' and 'NULL'.
	'ZERO'—Blanks are treated as zeroes.
	'NULL'—Blanks are ignored during numeric conversion. This is the default.
STATUS=*sta*	
	The STATUS=*sta* clause is optional. *sta* is a character expression. Possible values are: 'OLD', 'NEW', 'UNKNOWN', or 'SCRATCH'.
	'OLD'— The file already exists (nonexistence is an error). For example: STATUS='OLD'.
	'NEW' — The file doesn't exist (existence is an error). If 'FILE=*name*' is not specified, then a file named 'fort.*n*' is opened, where *n* is the specified logical unit.
	'UNKNOWN' — Existence is unknown. This is the default.

Table 4-5 OPEN Keyword Specifier Details *(Continued)*

STATUS=*sta* (*Continued*)	
	'SCRATCH' — For a file opened with STATUS='SCRATCH', a temporary file with a name of the form tmp.F*AAAxnnnnn* is opened. Any other STATUS specifier without an associated file name results in opening a file named 'fort.*n*', where *n* is the specified logical unit number. By default, a scratch file is deleted when closed or during normal termination. If the program aborts, then the file may not be deleted. To prevent deletion, CLOSE with STATUS='KEEP'. The FORTRAN 77 Standard prohibits opening a named file as scratch: if OPEN has a FILE=*name* option, then it cannot have a STATUS='SCRATCH' option. This FORTRAN 77 extends the standard by allowing opening named files as scratch. ♦ Such files are normally deleted when closed or at normal termination. TMPDIR: FORTRAN 77 programs normally put scratch files in the current working directory. If the TMPDIR environment variable is set to a writable directory, then the program puts scratch files there. ♦
FILEOPT=*fopt* ♦	
	The FILEOPT=*fopt* clause is optional. *fopt* is a character expression. Possible values are 'NOPAD', 'BUFFER=*n*', and 'EOF'.
	'NOPAD'—Do not extend records with blanks if you read past the end-of-record (formatted input only). That is, a *short* record causes an abort with an error message, rather than just filling with trailing blanks and continuing.
	'BUFFER=*n*'— This suboption is for disks. For tapes, we recommend the TOPEN() routines because they are more reliable. It sets the size in bytes of the I/O buffer to use. For writes, larger buffers yield faster I/O. For good performance, make the buffer a multiple of the largest record size. This size can be larger than the actual physical memory, and probably the best performance is obtained by making the record size equal to the entire file size. Larger buffer sizes can cause extra paging.
	'EOF'—Opens a file at end-of-file rather than at the beginning (useful for appending data to file), for example, FILEOPT='EOF'. Unlike ACCESS='APPEND', in this case, both READ and BACKSPACE are allowed.
READONLY ♦	
	The file is opened read-only.
ACTION = *act*	
	This specifier denotes file permissions. Possible values are: READ, WRITE, and READWRITE.
	If *act* is READ, it specifies that the file is opened read-only.
	If *act* is WRITE, it specifies that the file is opened write-only. You cannot execute a BACKSPACE statement on a write-only file.
	If *act* is READWRITE, it specifies that the file is opened with both read and write permissions.

Examples

Here are six examples.

Example 1: Open a file and connect it to unit 8—either of the following forms of the OPEN statement opens the file, projectA/data.test, and connects it to FORTRAN 77 unit 8:

```
      OPEN( UNIT=8, FILE='projectA/data.test' )
      OPEN( 8, FILE='projectA/data.test' )
```

In the above example, these properties are established by *default*: sequential access, formatted file, and (unwisely) no allowance for error during file open.

Example 2: Explicitly specify properties:

```
      OPEN( UNIT=8, FILE='projectA/data.test',
&           ACCESS='SEQUENTIAL', FORM='FORMATTED' )
```

Example 3: Either of these opens file, fort.8, and connects it to unit 8:

```
    OPEN( UNIT=8 )
    OPEN( 8 )
```

In the above example, you get sequential access, formatted file, and no allowance for error during file open. If the file, fort.8 does not exist before execution, it is created. The file remains after termination.

Example 4: Allowing for open errors:

```
    OPEN( UNIT=8, FILE='projectA/data.test', ERR=99 )
```

The above statement branches to 99 if an error occurs during OPEN.

Example 5: Allowing for variable-length records;

```
OPEN( 1, ACCESS='DIRECT', recl=1 )
```

For more information on variable-length records, see “Direct Access I/O” on page 261.

Example 6: Scratch file:

```
OPEN( 1, STATUS='SCRATCH' )
```

This statement opens a temporary file with a name, such as `tmp.FAAAa003zU`. The file is usually in the current working directory, or in `TMPDIR` if that environment variable is set.

4.51 OPTIONS

The `OPTIONS` ♦ statement overrides compiler command-line options.

Syntax

```
OPTIONS /qualifier [/qualifier ...]
```

Description

The following table shows the `OPTIONS` statement qualifiers:

Table 4-6 `OPTIONS` Statement Qualifiers

Qualifier	Action Taken
`/[NO]G_FLOATING`	None (not implemented)
`/[NO]I4`	Enables/Disables the `-i2` option
`/[NO]F77`	None (not implemented)
`/CHECK=ALL`	Enables the `-C` option
`/CHECK=[NO]OVERFLOW`	None (not implemented)
`/CHECK=[NO]BOUNDS`	Disables/Enables the `-C` option
`/CHECK=[NO]UNDERFLOW`	None (not implemented)

Table 4-6 OPTIONS Statement Qualifiers *(Continued)*

Qualifier	Action Taken
/CHECK=NONE	Disables the -C option
/NOCHECK	Disables the -C option
/[NO]EXTEND_SOURCE	Disables/enables the -e option

Restrictions

The OPTIONS statement must be the *first* statement in a program unit; it must be before the BLOCK DATA, FUNCTION, PROGRAM, and SUBROUTINE statements.

Options set by the OPTIONS statement override those of the command line.

Options set by the OPTIONS statement endure for that program unit only.

A qualifier can be abbreviated to four or more characters.

Uppercase or lowercase is not significant.

Example

For the following source, integer variables declared with no explicit size occupy 4 bytes rather than 2, with or without the –i2 option on the command line. This rule does *not* change the size of integer constants, only variables.

```
      OPTIONS /I4
      PROGRAM FFT
      …
      END
```

By way of contrast, if you use /NOI4, then all integer variables declared with no explicit size occupy 2 bytes rather than 4, with or without the –i2 option on the command line. However, integer constants occupy 2 bytes with –i2, and 4 bytes otherwise.

4.52 PARAMETER

The PARAMETER statement assigns a symbolic name to a constant.

Syntax

PARAMETER (p=*e* [, p=e] …)	
p	Symbolic name
e	Constant expression

An alternate syntax is allowed, if the -xl flag is set: ♦

```
PARAMETER p=e [, p=e ] …
```

In this alternate form, the type of the constant expression determines the type of the name; no conversion is done.

Description

e can be of any type and the type of symbolic name and the corresponding expression must match.

A symbolic name can be used to represent the real part, imaginary part, or both parts of a complex constant.

A constant expression is made up of explicit constants and parameters and the FORTRAN 77 operators. See Section 3.6, "Constant Expressions," for more details.

No structured records or record fields are allowed in a constant expression.

Exponentiation to a floating-point power is not allowed, and a warning is issued.

If the type of the data expression does not match the type of the symbolic name, then the type of the name must be specified by a type statement or IMPLICIT statement prior to its first appearance in a PARAMETER statement, otherwise conversion will be performed.

If a CHARACTER statement explicitly specifies the length for a symbolic name, then the constant in the PARAMETER statement can be no longer than that length. Longer constants are truncated, and a warning is issued. The CHARACTER statement must appear before the PARAMETER statement.

If a CHARACTER statement uses *(*) to specify the length for a symbolic name, then the data in the PARAMETER statement are used to determine the length of the symbolic constant. The CHARACTER statement must appear before the PARAMETER statement.

Any symbolic name of a constant that appears in an expression *e* must have been defined previously in the same or a different PARAMETER statement in the same program unit.

Restrictions

A symbolic constant must not be defined more than once in a program unit.

If a symbolic name appears in a PARAMETER statement, then it cannot represent anything else in that program unit.

A symbolic name cannot be used in a constant format specification, but it can be used in a variable format specification.

If you pass a parameter as an argument, and the subprogram tries to change it, you may get a runtime error.

Examples

Example 1: Some real, character, and logical parameters:

```
      CHARACTER HEADING*10
      LOGICAL T
      PARAMETER ( EPSILON=1.0E-6, PI=3.141593,
&              HEADING='IO Error #',
&              T=.TRUE. )
      …
```

Example 2: Let the compiler count the characters:

```
CHARACTER HEADING*(*)
PARAMETER ( HEADING='I/O Error Number' )
…
```

Example 3: The alternate syntax, if the `–xl` flag is set:

```
PARAMETER FLAG1 = .TRUE.
```

The above statement is treated as:

```
LOGICAL FLAG1
PARAMETER (FLAG1 = .TRUE.)
```

An ambiguous statement that could be interpreted as either a PARAMETER statement or an assignment statement is always taken to be the former, as long as either the `–xl` or `–xld` option is set.

Example: An ambiguous statement:

```
PARAMETER S = .TRUE.
```

With `-xl`, the above statement is a PARAMETER statement about the variable S.

```
PARAMETER S = .TRUE.
```

It is *not* an assignment statement about the variable PARAMETERS.

```
PARAMETERS = .TRUE.
```

4.53 PAUSE

The PAUSE statement suspends execution, and waits for you to type: go.

Syntax

PAUSE [*str*]	
str	String of not more than 5 digits or a character constant

Description

The PAUSE statement suspends program execution temporarily, and waits for acknowledgment. On acknowledgment, execution continues.

If the argument *string* is present, it is displayed on the screen (written to stdout), followed by the following message:

```
PAUSE. To resume execution, type: go
Any other input will terminate the program.
```

After you type: `go`, execution continues as if a `CONTINUE` statement is executed. See this example:

```
demo% cat p.f
       PRINT *, "Start"
       PAUSE 1
       PRINT *, "Ok"
       END
demo% f77 p.f
p.f:
 MAIN:
demo% a.out
Start
PAUSE: 1
To resume execution, type: go
Any other input will terminate the program.
go
Execution resumed after PAUSE.
Ok
demo%
```

If `stdin` is not a `tty` I/O device, `PAUSE` displays a message like this:

```
PAUSE: To resume execution, type: kill -15 pid
```

where *pid* is the process ID.

Example: `stdin` not a `tty` I/O device:

```
demo% a.out < mydatafile
PAUSE: To resume execution, type: kill -15 20537
demo%
```

For the above example, type the following command line at a shell prompt in some other window. The window displaying the message cannot accept command input.

```
demo% kill -15 20537
```

4.54 POINTER

The `POINTER` ♦ statement establishes pairs of variables and pointers.

Syntax

`POINTER ( p1, v1 ) [, ( p2, v2 ) … ]`	
v1, v2	Pointer-based variables
p1, p2	Corresponding pointers

Description

Each pointer contains the address of its paired variable.

A *pointer-based variable* is a variable paired with a pointer in a `POINTER` statement. A pointer-based variable is usually called just a *based variable*. The *pointer* is the integer variable that contains the address.

Usage

Normal use of pointer-based variables involves the following steps. The first two steps can be in either order.

1. **Define the pairing of the pointer-based variable and the pointer in a `POINTER` statement.**
2. **Define the type of the pointer-based variable.**
   The pointer itself is an integer type, but in general, it is safer if you *not* list it in an `INTEGER` statement.
3. **Set the pointer to the address of an area of memory that has the appropriate size and type.**
   You do *not* normally do anything else with the pointer explicitly.
4. **Reference the pointer-based variable.**
   Just use the pointer-based variable in normal FORTRAN 77 statements; the address of that variable is always taken from its associated pointer.

Address and Memory

No storage for the variable is allocated when a pointer-based variable is defined, so you must provide an address of a variable of the appropriate type and size, and assign the address to a pointer, usually with the normal assignment statement or data statement.

There are three procedures used to manage memory with pointers:

- `LOC`—You can obtain the address from the intrinsic function `LOC()`.
- `MALLOC`—You can obtain both the area of memory and the address from the function `MALLOC()`.
- `FREE`—You can *deallocate* a region of memory previously allocated by `MALLOC()` by using the subroutine `FREE()`.

Subroutine `FREE()`

The subroutine `FREE()` deallocates a region of memory previously allocated by `MALLOC()`. The argument given to `FREE()` must be a pointer previously returned by `MALLOC()`, but not already given to `FREE()`. The memory is returned to the memory manager, making it unavailable to the programmer.

Function `MALLOC()`

The function `MALLOC()` allocates an area of memory and returns the address of the start of that area. The argument to the function is an integer specifying the amount of memory to be allocated, in bytes. If successful, it returns a pointer to the first item of the region; otherwise, it returns an integer 0. The region of memory is not initialized in any way—assume it is garbage.

Optimization and Pointers

Pointers have the side effect of reducing the assumptions that the global optimizer can make.

Compare:

- Without pointers, if you call a subroutine or function, the optimizer knows that the call will change only variables in common or those passed as arguments to that call.

- With pointers, this is no longer valid, since a routine can take the address of an argument and save it in a pointer in common for use in a subsequent call to itself or to another routine.

Therefore, the optimizer must assume that a variable passed as an argument in a subroutine or function call can be changed by any other call. Such an unrestricted use of pointers would degrade optimization for the vast majority of programs that do *not* use pointers.

Restrictions

The pointers are of type integer and are automatically typed that way by the compiler. You must *not* type them yourself.

A pointer-based variable cannot itself be a pointer.

The pointer-based variables can be of any type, including structures.

No storage is allocated when such a pointer-based variable is defined, even if there is a size specification in the type statement.

You cannot use a pointer-based variable as a dummy argument or in `COMMON`, `EQUIVALENCE`, `DATA`, or `NAMELIST` statements.

The dimension expressions for pointer-based variables must be constant expressions in main programs. In subroutines and functions, the same rules apply for pointer-based array variables as for dummy arguments—the expression can contain dummy arguments and variables in common. Any variables in the expressions must be defined with an integer value at the time the subroutine or function is called.

This implementation of `POINTER` follows more along the line of Cray, not Fortran 90, although it does not follow Cray exactly.

The address cannot exceed the range of `INTEGER*4`. If the address expression is not in the range (-2147483648, 2147483647), then the results are unpredictable.

If you use an optimization level greater than `-O2`, you must write your programs with the following restrictions on the use of pointers:

- Subroutines and functions are not permitted to save the address of any of their arguments between calls.

- A function cannot return the address of any of its arguments, although it can return the value of a pointer argument.
- Only those variables whose addresses are explicitly taken with the LOC() or MALLOC() functions can be referenced through a pointer.

Example: One kind of code that could cause problems if you optimize at a level greater than -O2:

```
COMMON A, B, C
POINTER ( P, V )
P = LOC(A) + 4   ! ←Possible problems if optimized
…
```

The compiler assumes that a reference through P can change A, but not B; this assumption could produce incorrect code.

Examples

Example 1: A simple POINTER statement:

```
POINTER ( P, V )
```

Here, V is a pointer-based variable, and P is its associated pointer.

Example 2: Using the LOC() function to get an address:

```
* ptr1.f: Assign an address via LOC()
POINTER ( P, V )
CHARACTER A*12, V*12
DATA A / 'ABCDEFGHIJKL' /
P = LOC( A )
PRINT *, V(5:5)
END
```

In the above example, the CHARACTER statement allocates 12 bytes of storage for A, but *no* storage for V; it merely specifies the type of V because V is a pointer-based variable. You then assign the address of A to P, so now any use of V refers to A by the pointer P. The program prints an E.

Example 3: Memory allocation for pointers, by MALLOC:

```
POINTER ( P1, X ), ( P2, Y ), ( P3, Z )
…
P1 = MALLOC ( 36 )
…
CALL FREE ( P1 )
…
```

In the above example, you get 36 bytes of memory from MALLOC() and then, after some other instructions, probably using that chunk of memory, tell FREE() to return those same 36 bytes to the memory manager.

Example 4: Get the area of memory and its address:

```
POINTER ( P, V )
CHARACTER V*12, Z*1
P = MALLOC( 12 )
…
END
```

In the above example, you obtain 12 bytes of memory from the function MALLOC() and assign the address of that block of memory to the pointer P.

Example 5: Dynamic allocation of arrays:

```
PROGRAM UsePointers
REAL X
POINTER ( P, X )
…
READ ( *,* ) Nsize ! Get the size.
P = MALLOC( Nsize )! Allocate the memory.
…
CALL CALC ( X, Nsize )
…
END
SUBROUTINE CALC ( A, N )
REAL A(N)
…       ! Use the array of whatever size.
RETURN
END
```

This is a slightly more realistic example. The size might well be some large number, say, 10,000. Once that's allocated, the subroutines perform their tasks, not knowing that the array was dynamically allocated.

Example 6: One way to use pointers to make a linked list in `f77`:

Linked.f

```
    STRUCTURE /NodeType/
       INTEGER recnum
       CHARACTER*3 label
       INTEGER next
    END STRUCTURE
    RECORD /NodeType/ r, b
    POINTER (pr,r), (pb,b)
    pb = malloc(12)          ! Create the base record, b.
    pr = pb                  ! Make pr point to b.
    NodeNum = 1
    DO WHILE (NodeNum .LE. 4) ! Initialize/create records
        IF (NodeNum .NE. 1) pr = r.next
        CALL struct_creat(pr,NodeNum)
        NodeNum = NodeNum + 1
    END DO
    r.next = 0
    pr = pb                   ! Show all records.
    DO WHILE (pr .NE. 0)
        PRINT *, r.recnum, " ", r.label
        pr = r.next
    END DO
    END
    SUBROUTINE struct_creat(pr,Num)
    STRUCTURE /NodeType/
       INTEGER recnum
       CHARACTER*3 label
       INTEGER next
    END STRUCTURE

    RECORD /NodeType/ r
    POINTER (pr,r), (pb,b)
    CHARACTER v*3(4)/'aaa', 'bbb', 'ccc', 'ddd'/

    r.recnum = Num           ! Initialize current record.
    r.label = v(Num)
    pb = malloc(12)          ! Create next record.
    r.next = pb
    RETURN
    END
```

```
demo% f77 -silent Linked.f
"Linked.f", line 6: Warning: local variable "b" never used
"Linked.f", line 31: Warning: local variable "b" never used
demo% a.out
   1 aaa
   2 bbb
   3 ccc
   4 ddd
demo%
```

Remember:

- Do not optimize programs using pointers like this with `-O3`, `-O4`, or `-O5`.
- The warnings can be ignored.
- This is not the normal usage of pointers described at the start of this section.

4.55 PRINT

The `PRINT` statement writes from a list to `stdout`.

Syntax

`PRINT` *f* [, *iolist*]	
`PRINT` *grname*	
f	Format identifier
iolist	List of variables, substrings, arrays, records, …
grname	Name of the namelist group

Description

The `PRINT` statement accepts the following arguments.

Format Identifier

f is a format identifier and can be:

- An asterisk (*), which indicates list-directed I/O. See Section 5.6, "List-Directed I/O," for details.
- The label of a `FORMAT` statement that appears in the same program unit.
- An integer variable name that has been assigned the label of a `FORMAT` statement that appears in the same program unit.
- A character expression or integer array that specifies the format string. The integer array is nonstandard. ♦

Output List

iolist can be empty or can contain output items or implied `DO` lists. The output items must be one of the following:

- Variables
- Substrings
- Arrays
- Array elements
- Record fields
- Any other expression

A simple unsubscripted array name specifies all of the elements of the array in memory storage order, with the leftmost subscript increasing more rapidly.

Namelist-Directed `PRINT`

The second form of the `PRINT` statement is used to print the items of the specified namelist group. Here, *grname* is the name of a group previously defined by a `NAMELIST` statement.

Execution proceeds as follows:

1. **The format, if specified, is established.**
2. **If the output list is not empty, data is transferred from the list to standard output.**
   If a format is specified, data is edited accordingly.

3. In the second form of the PRINT statement, data is transferred from the items of the specified namelist group to standard output.

Restrictions

Output from an exception handler is unpredictable. If you make your own exception handler, do not do any FORTRAN 77 output from it. If you must do some, then call abort right after the output. Doing so reduces the relative risk of a program freeze. FORTRAN 77 I/O from an exception handler amounts to recursive I/O. See the next point.

Recursive I/O does not work reliably. If you list a function in an I/O list, and if that function does I/O, then during runtime, the execution may freeze, or some other unpredictable problem may occur. This risk exists independent of parallelization.

Example: Recursive I/O fails intermittently:

```
      PRINT *, x, f(x)     ! Not allowed, f() does I/O.
      END
      FUNCTION F(X)
      PRINT *, X
      RETURN
      END
```

Examples

Example 1: Formatted scalars:

```
      CHARACTER TEXT*16
      PRINT 1, NODE, TEXT
1     FORMAT ( I2, A16 )
```

Example 2: List-directed array:

```
      PRINT *, I, J, ( VECTOR(I), I = 1, 5 )
```

Example 3: Formatted array:

```
    INTEGER VECTOR(10)
    PRINT '( 12 I2 )', I, J, VECTOR
```

Example 4: Namelist:

```
    CHARACTER LABEL*16
    REAL QUANTITY
    INTEGER NODE
    NAMELIST /SUMMARY/ LABEL, QUANTITY, NODE
    PRINT SUMMARY
```

4.56 PROGRAM

The `PROGRAM` statement identifies the program unit as a main program.

Syntax

`PROGRAM` *pgm*	
pgm	Symbolic name of the main program

Description

For the loader, the main program is always named `MAIN`. The `PROGRAM` statement serves only the person who reads the program.

Restrictions

The `PROGRAM` statement can appear only as the first statement of the main program.

The name of the program *cannot* be:

- The same as that of an external procedure or common block
- `MAIN` (all uppercase), or a runtime error results

The name of the program can be the same as a local name in the main program.♦ The FORTRAN 77 Standard does not allow this practice.

Example

Example: A PROGRAM statement:

```
    PROGRAM US_ECONOMY
    NVARS = 2
    NEQS = 2
    …
```

4.57 READ

The READ statement reads data from a file or the keyboard to items in the list. If you use this statement for tapes, we recommend the TOPEN() routines instead, because they are more reliable.

Syntax

READ([UNIT=] *u* [, [FMT=] *f*] [, IOSTAT= *ios*] [, REC= *rn*] [, END= *s*] [, ERR= *s*]) *iolist*
READ *f* [, *iolist*]
READ([UNIT=] *u*, [NML=] *grname* [,IOSTAT=*ios*] [,END=*s*] [,ERR=*s*])
READ *grname*

An alternate to the UNIT=*u*, REC=*rn* form is as follows: ♦

```
READ( u 'rn … ) iolist
```

u	Unit identifier of the unit connected to the file
f	Format identifier
ios	I/O status specifier
rn	Record number to be read

s	Statement label for end of file processing
iolist	List of variables
grname	Name of a namelist group

The options can be specified in any order.

Description

The `READ` statement accepts the following arguments.

Unit Identifier

u is either an external unit identifier or an internal file identifier.

An external unit identifier must be one of these:

- A nonnegative integer expression
- An asterisk (`*`), identifying `stdin`, normally connected to the keyboard

If the optional characters `UNIT=` are omitted from the unit specifier, then *u* must be the first item in the list of specifiers.

Format Identifier

f is a format identifier and can be:

- An asterisk (`*`), indicating list-directed I/O. See Section 5.6, "List-Directed I/O," for details.
- A label of a `FORMAT` statement that appears in the same program unit
- An integer variable name that has been assigned the label of a `FORMAT` statement that appears in the same program unit
- A character expression or integer array specifying the format string. This is called a runtime format or a variable format. The integer array is nonstandard. ♦

If the optional characters, `FMT=`, are omitted from the format specifier, then *f* must appear as the second argument for a formatted read; otherwise, it must not appear at all.

Unformatted data transfer from internal files and terminal files is not allowed, hence, *f* must be present for such files.

List-directed data transfer from direct-access and internal files is allowed; hence, *f* can be an asterisk for such files. ♦

If a file is connected for formatted I/O, unformatted data transfer is not allowed, and vice versa.

I/O Status Specifier

ios must be an integer variable or an integer array element.

Record Number

rn must be a positive integer expression, and can be used for direct-access files only. *rn* can be specified for internal files. ♦

End-of-File Specifier

s must be the label of an executable statement in the same program unit in which the READ statement occurs.

The END=*s* and REC=*rn* specifiers can be present in the same READ statement. ♦

Error Specifier

s must be the label of an executable statement in the same program unit in which the READ statement occurs.

Input List

iolist can be empty or can contain input items or implied DO lists. The input items can be any of the following:

- Variables
- Substrings
- Arrays
- Array elements
- Record fields

A simple unsubscripted array name specifies all of the elements of the array in memory storage order, with the leftmost subscript increasing more rapidly.

Namelist-Directed READ

The third and fourth forms of the READ statement are used to read the items of the specified namelist group, and *grname* is the name of the group of variables previously defined in a NAMELIST statement.

Execution

Execution proceeds as follows:

1. **The file associated with the specified unit is determined.**
   The format, if specified, is established. The file is positioned appropriately prior to the data transfer.

2. **If the input list is not empty, data is transferred from the file to the corresponding items in the list.**
   The items are processed in order as long as the input list is not exhausted. The next specified item is determined and the value read is transmitted to it. Data editing in formatted READ is done according to the specified format.

3. **In the third and fourth forms of namelist-directed READ, the items of the specified namelist group are processed according to the rules of namelist-directed input.**

4. **The file is repositioned appropriately after data transfer.**

5. **If *ios* is specified and no error occurred, it is set to zero.**
   ios is set to a positive value, if an error or end of file was encountered.

6. **If *s* is specified and end of file was encountered, control is transferred to *s*.**

7. **If *s* is specified and an error occurs, control is transferred to *s*.**

There are two forms of READ:

READ *f* [, *iolist*]
READ ([NML=] *grname*)

The above two forms operate the same way as the others, except that reading from the *keyboard* is implied.

Execution has the following differences:

- When the input list is exhausted, the cursor is moved to the start of the line following the input. For an empty input list, the cursor is moved to the start of the line following the input.
- If an end-of-line, `CR`, or `NL` is reached before the input list is satisfied, input continues from the next line.
- If an end-of-file (Control-D) is received before the input list is satisfied, input stops, and unsatisfied items of the input list remain unchanged.

If *u* specifies an external unit that is not connected to a file, an implicit `OPEN` operation is performed which is equivalent to opening the file with the options in the following example:

```
      OPEN( u, FILE='FORT.u', STATUS='OLD',
&                  ACCESS='SEQUENTIAL', FORM=fmt )
```

The value of *fmt* is `'FORMATTED'` or `'UNFORMATTED'` accordingly, as the read is formatted or unformatted.

A simple unsubscripted array name specifies all of the elements of the array in memory storage order, with the leftmost subscript increasing more rapidly.

An attempt to read the record of a direct-access file that has not been written, causes all items in the input list to become undefined.

The record number count starts from one.

Namelist-directed input is permitted on sequential access files only.

Examples

Example 1: Formatted read, trap I/O errors, EOF, and I/O status:

```
   READ( 1, 2, ERR=8, END=9, IOSTAT=N ) X, Y
   …
8  WRITE( *, * ) 'I/O error # ', N, ', on 1'
   STOP
9  WRITE( *, * ) 'EoF on 1'
   RETURN
   END
```

Example 2: Direct, unformatted read, trap I/O errors, and I/O status:

```
   …
   READ( 1, REC=3, IOSTAT=N, ERR=8 ) V
   …
4  CONTINUE
   RETURN
8  WRITE( *, * ) 'I/O error # ', N, ', on 1'
   END
```

Example 3: List-directed read from keyboard:

```
   READ( *, * ) A, V
or
   READ *, A, V
```

Example 4: Formatted read from an internal file:

```
    CHARACTER CA*16 / 'abcdefghijklmnop' /, L*8, R*8
    READ( CA, 1 ) L, R
1   FORMAT( 2 A8 )
```

Example 5: Read an entire array:

```
   DIMENSION V(5)
   READ( 3, '(5F4.1)') V
```

Example 6: Namelist-directed read:

```
    CHARACTER SAMPLE*16
    LOGICAL NEW*4
    REAL DELTA*4
    NAMELIST /G/ SAMPLE, NEW, DELTA
    …
    READ( 1, G )
or
    READ( UNIT=1, NML=G )
or
    READ( 1, NML=G )
```

4.58 REAL

The REAL statement specifies the type of a symbolic constant, variable, array, function, or dummy function to be real, and optionally specifies array dimensions and size, and initializes with values.

Syntax

REAL [*len[,]] v[* len [/c/]] [, v [* len [/c/]] …	
v	Name of a variable, symbolic constant, array, array declarator, function, or dummy function
len	Either 4, 8, or 16 (*SPARC only*), the length in bytes of the symbolic constant, variable, array element, or function
c	List of constants for the immediately preceding name

Description

Following are descriptions for REAL, REAL*4, REAL*8, and REAL*16.

REAL

For a declaration such as REAL W, the variable W is usually a REAL*4 element in memory, interpreted as a real number. For more details, see the next section, “Default Size.”

REAL*4 ♦

For a declaration such as `REAL*4 W`, the variable `W` is always a `REAL*4` element in memory, interpreted as a single-width real number.

REAL*8 ♦

For a declaration such as `REAL*8 W`, the variable `W` is always a `REAL*8` element in memory, interpreted as a double-width real number.

REAL*16 ♦

(SPARC only) For a declaration such as `REAL*16 W`, the variable `W` is always an element of type `REAL*16` in memory, interpreted as a quadruple-width real.

Default Size

If you specify the size as 4, 8, or 16, you get what you specify; if you do *not* specify the size, you get the default size.

The default size for a declaration such as `REAL X`, depends on the `–r8` option:

- If `–r8` or `-dbl` is on the `f77` command line, then for declarations such as `REAL X`, the compiler allocates 8 bytes, and does 8-byte arithmetic. If `–r8` or `-dbl` is *not* on the `f77` command line, then the compiler allocates 4 bytes.
- If you put both `–i2` and `–r8` on the `f77` command line, the results are unpredictable.

Examples

Example 1: Simple real scalars—each of these statements is generally equivalent to the others, but the first is different if you compile with `-r8`:

```
      REAL U, V
      REAL*4 U, V
      REAL U*4, V*4
```

Do not use all three statements in the same program unit.

Example 2: Initialize scalars (REAL*16 *is for SPARC only*):

```
REAL U/ 1.0 /, V/ 4.3 /, D*8/ 1.0 /, Q*16/ 4.5 /
```

Example 3: Specify dimensions for some real arrays:

```
REAL A(10,100), V(10)
REAL X*4(10), Y(10)*4
```

Example 4: Initialize some arrays:

```
REAL A(10,100) / 1000 * 0.0 /, B(2,2) /  1.0, 2.0, 3.0, 4.0 /
```

Example 5: Double and quadruple precision (REAL*16 *is for SPARC only*):

```
REAL*8  R
REAL*16 Q
DOUBLE PRECISION D
```

In the above example, D and R are both double precision; Q is quadruple precision.

4.59 RECORD

The RECORD ♦ statement defines variables to have a specified structure, or arrays to be arrays of variables with such structures.

Syntax

RECORD /*struct-name*/ *record-list* [,/*struct-name*/ *record-list*]…	
struct-name	Name of a previously declared structure
record-list	List of variables, arrays, or array declarators

Description

A structure is a template for a record. The name of the structure is included in the STRUCTURE statement, and once a structure is thus defined and named, it can be used in a RECORD statement.

The record is a generalization of the variable or array: where a variable or array has a type, the record has a structure. Where all the elements of an array must be of the same type, the fields of a record can be of different types.

The RECORD line is part of an inherently multiline group of statements, and neither the RECORD line nor the END RECORD line has any indication of continuation. Do not put a nonblank in column six, nor an & in column one.

Restrictions

Each record is allocated separately in memory.

Initially, records have undefined values.

Records, record fields, record arrays, and record-array elements are allowed as arguments and dummy arguments. When you pass records as arguments, their fields must match in type, order, and dimension. The record declarations in the calling and called procedures must match.

Within a union declaration, the order of the map fields is not relevant.

Record fields are not allowed in COMMON statements.

Records and record fields are not allowed in DATA, EQUIVALENCE, NAMELIST, PARAMETER, AUTOMATIC, STATIC, or SAVE statements. To initialize records and record fields, use the STRUCTURE statement. See Section 4.66, “STRUCTURE.”

Example

Example 1: Declare some items to be records of a specified structure:

```
    STRUCTURE /PRODUCT/
       INTEGER*4 ID
       CHARACTER*16 NAME
       CHARACTER*8 MODEL
       REAL*4 COST
       REAL*4 PRICE
    END STRUCTURE
    RECORD /PRODUCT/ CURRENT, PRIOR, NEXT, LINE(10)
    …
```

Each of the three variables CURRENT, PRIOR, and NEXT is a record which has the PRODUCT structure, and LINE is an array of 10 such records.

Example 2: Define some fields of records, then use them:

```
    STRUCTURE /PRODUCT/
       INTEGER*4    ID
       CHARACTER*16 NAME
       CHARACTER*8  MODEL
       REAL*4       COST
       REAL*4       PRICE
    END STRUCTURE
    RECORD /PRODUCT/  CURRENT, PRIOR, NEXT, LINE(10)
    CURRENT.ID = 82
    PRIOR.NAME = "CacheBoard"
    NEXT.PRICE = 1000.00
    LINE(2).MODEL = "96K"
    PRINT 1, CURRENT.ID, PRIOR.NAME, NEXT.PRICE, LINE(2).MODEL
1   FORMAT(1X I5/1X A16/1X F8.2/1X A8)
    END
```

The above program produces the following output:

```
   82
CacheBoard
 1000.00
96K
```

4.60 RETURN

A RETURN statement returns control to the calling program unit.

Syntax

RETURN [*e*]	
e	Expression of type INTEGER or REAL

Description

Execution of a RETURN statement terminates the reference of a function or subroutine.

Execution of an END statement in a function or a subroutine is equivalent to the execution of a RETURN statement. ♦

The expression *e* is evaluated and converted to integer, if required. *e* defines the ordinal number of the *alternate return* label to be used. Alternate return labels are specified as asterisks (or ampersands) ♦ in the SUBROUTINE statement.

If *e* is not specified, or the value of *e* is less than one or greater than the number of asterisks or ampersands in the SUBROUTINE statement that contains the RETURN statement, control is returned normally to the statement following the CALL statement that invoked the subroutine.

If the value of *e* is between one and the number of asterisks (or ampersands) in the SUBROUTINE statement, control is returned to the statement identified by the e^{th} alternate. A RETURN statement can appear only in a function subprogram or subroutine.

Examples

Example 1: Standard return:

```
     CHARACTER*25 TEXT
     TEXT = "Some kind of minor catastrophe"
     …
     CALL OOPS ( TEXT )
     STOP
     END
     SUBROUTINE OOPS ( S )
     CHARACTER S* 32
     WRITE (*,*) S
     RETURN
     END
```

Example 2: Alternate return:

```
     CALL RANK ( N, *8, *9 )
     WRITE (*,*) 'OK - Normal Return'
     STOP
8    WRITE (*,*) 'Minor - 1st alternate return'
     STOP
9    WRITE (*,*) 'Major - 2nd alternate return'
     END
     SUBROUTINE RANK (N, *,*)
     IF ( N .EQ. 0 ) RETURN
     IF ( N .EQ. 1 ) RETURN 1
     RETURN 2
     END
```

4.61 REWIND

`REWIND` positions the file associated with the specified unit to its initial point.

If you use this statement for tapes, we recommend the `TOPEN()` routines instead, because they are more reliable.

Syntax

REWIND *u*	
REWIND ([UNIT=] *u* [, IOSTAT=*ios*] [, ERR= *s*])	
u	Unit identifier of an external unit connected to the file *u* must be connected for *sequential* access, or *append access*.
ios	I/O specifier, an integer variable or an integer array element
s	Error specifier: *s* must be the label of an executable statement in the same program in which this REWIND statement occurs. The program control is transferred to this label in case of an error during the execution of the REWIND statement.

Description

The options can be specified in any order.

Rewinding a unit not associated with any file has no effect. Likewise, REWIND in a terminal file has no effect either.

We do not recommend using a REWIND statement on a direct-access file, as the execution is not defined in the FORTRAN 77 Standard, and is unpredictable.

Examples

Example 1: Simple form of unit specifier:

```
    ENDFILE 3
    REWIND 3
    READ (3,'(I2)') I
    REWIND 3
    READ (3,'(I2)')I
```

Example 2: REWIND with the UNIT=*u* form of unit specifier and error trap:

```
    INTEGER  CODE
    …
    REWIND (UNIT = 3)
    REWIND (UNIT = 3, IOSTAT = CODE, ERR = 100)
    …
100 WRITE (*,*) 'error in rewinding'
    STOP
```

4.62 SAVE

The SAVE statement prevents items in a subprogram from becoming undefined after the RETURN or END statements are executed.

Syntax

SAVE [*v* [, *v*] …]	
v	Name of an array, variable, or common block (enclosed in slashes), occurring in a subprogram

Description

All variables to be saved are placed in an internal static area. All common blocks are saved by allocating a static area. Therefore, common block names specified in SAVE statements are just ignored.

A SAVE statement is optional in the main program and has no effect.

A SAVE with no list saves everything that can be saved.

SAVE/STATIC

Local variables and arrays are static by default, so in general, using these constructs eliminates the need for SAVE. You can still use SAVE to ensure portability.

Also, SAVE is safer if you leave a subprogram by some way other than a RETURN.

Restrictions

The following constructs must not appear in a SAVE statement:

- Variables or arrays in a common block
- Dummy argument names
- Record names
- Procedure names
- Automatic variables or arrays

Example

Example: A SAVE statement:

```
      SUBROUTINE FFT
      DIMENSION A(1000,1000), V(1000)
      SAVE A
      …
      RETURN
      END
```

4.63 Statement Function

A *statement function* statement is a function-like declaration, made in a single statement.

Syntax

fun ([*d* [, *d*] …]) = *e*	
fun	Name of statement function being defined
d	Statement function dummy argument
e	Expression. *e* can be any of the types arithmetic, logical, or character.

Description

If a statement function is referenced, the defined calculations are inserted.

Example: The following statement is a statement function:

```
ROOT( A, B, C ) = (-B + SQRT(B**2-4.0*A*C))/(2.0*A)
```

The statement function argument list indicates the order, number, and type of arguments for the statement function.

A statement function is referenced by using its name, along with its arguments, as an operand in an expression.

Execution proceeds as follows:

1. **If they are expressions, actual arguments are evaluated.**
2. **Actual arguments are associated with corresponding dummy arguments.**
3. **The expression *e*, the body of a statement function, is evaluated.**
4. **If the type of the above result is different from the type of the function name, then the result is converted.**
5. **Return the value.**

The resulting value is thus available to the expression that referenced the function.

Restrictions

Note these restrictions:

- A statement function must appear only after the specification statements and before the first executable statement of the program unit in which it is referenced.
- A statement function is not executed at the point where it is specified. It is executed, as any other, by the execution of a function reference in an expression.
- The type conformance between *fun* and *e* are the same as those for the assignment statement. The type of *fun* and *e* can be different, in which case *e* is converted to the type of *fun*.
- The actual arguments must agree in order, number, and type with corresponding dummy arguments.

- The same argument cannot be specified more than once in the argument list.
- The statement function must be referenced only in the program unit that contains it.
- The name of a statement function cannot be an actual argument. Nor can it appear in an EXTERNAL statement.
- The type of the argument is determined as if the statement function were a whole program unit in itself.
- Even if the name of a statement function argument is the same as that of another local variable, the reference is considered a dummy argument of the statement function, not the local variable of the same name.
- The length specification of a character statement function or its dummy argument of type CHARACTER must be an integer constant expression.
- A statement function cannot be invoked recursively.

Examples

Example 1: Arithmetic statement function:

```
PARAMETER ( PI=3.14159 )
REAL RADIUS, VOLUME
SPHERE ( R ) = 4.0 * PI * (R**3) / 3.0
READ *, RADIUS
VOLUME = SPHERE( RADIUS )
…
```

Example 2: Logical statement function:

```
LOGICAL OKFILE
INTEGER STATUS
OKFILE ( I ) = I .LT. 1
READ( *, *, IOSTAT=STATUS ) X, Y
IF ( OK FILE(STATUS) ) CALL CALC ( X, Y, A )
…
```

Example 3: Character statement function:

```
      CHARACTER FIRST*1, STR*16
      FIRST(S) = S(1:1)
      READ( *, * ) STR
      IF ( FIRST(STR) .LT. " " ) CALL CONTROL ( S, A )
      …
```

4.64 STATIC

The STATIC ♦ statement ensures that the specified items are stored in static memory.

Syntax

STATIC *list*	
list	List of variables and arrays

Description

To deal with the problem of local variables becoming undefined between invocations, f77 classifies every variable as either static or automatic, with all local variables being static by default.

For static variables, there is exactly one copy of each datum, and its value is retained between calls. You can also explicitly define variables as static or automatic in a STATIC or AUTOMATIC statement, or in any type statement or IMPLICIT statement.

Local variables and arrays are static by default, so in general, these constructs eliminate the need for SAVE. You can still use SAVE to ensure portability.

Also, SAVE is safer if you leave a subprogram by some way other than a RETURN.

Also note that:

- Arguments and function values are automatic.
- A STATIC statement and a *type* statement cannot be combined to make a STATIC *type* statement. For example, the statement:

```
      STATIC REAL X      !   Not what you might expect
```

does *not* declare the variable X to be both STATIC and REAL; it declares the variable REALX to be STATIC.

Example

```
    STATIC A, B, C
    REAL P, D, Q
    STATIC P, D, Q
    IMPLICIT STATIC (X-Z)
```

4.65 STOP

The STOP statement terminates execution of the program.

Syntax

STOP [[*str*]	
str	String of no more that 5 digits or a character constant

Description

The argument *str* is displayed when the program stops.

If *str* is not specified, no message is displayed.

Examples

Example 1: Integer:

```
stop 9
```

The above statement displays:

```
STOP: 9
```

Example 2: Character:

```
stop 'oyvay'
```

The above statement displays:

```
STOP: oyvay
```

Example 3: Nothing after the `stop`:

```
stop
```

The above statement displays nothing.

4.66 STRUCTURE

The `STRUCTURE` ♦ statement organizes data into structures.

Syntax

STRUCTURE [/*structure-name*/] [*field-list*] *field-declaration* [*field-declaration*] ... [*field-declaration*] END STRUCTURE	
structure-name	Name of the structure
field-list	List of fields of the specified structure
field-declaration	Field of the record

Each field declaration can be one of the following:

- A substructure—either another structure declaration, or a record that has been previously defined
- A union declaration
- A type declaration, which can include initial values

Description

A STRUCTURE statement defines a form for a record by specifying the name, type, size, and order of the fields that constitute the record. Optionally, it can specify the initial values.

A structure is a template for a record. The name of the structure is included in the STRUCTURE statement, and once a structure is thus defined and named, it can be used in a RECORD statement.

The record is a generalization of the variable or array—where a variable or array has a *type*, the record has a *structure*. Where all the elements of an array must be of the same type, the fields of a record can be of different types.

Restrictions

The name is enclosed in slashes and is optional in nested structures only.

If slashes are present, a name must be present.

You can specify the *field-list* within nested structures only.

There must be at least one *field-declaration*.

Each *structure-name* must be unique among structures, although you can use structure names for fields in other structures or as variable names.

The only statements allowed between the `STRUCTURE` statement and the `END STRUCTURE` statement are *field-declaration* statements and `PARAMETER` statements. A `PARAMETER` statement inside a structure declaration block is equivalent to one outside.

Restrictions for Fields

Fields that are type declarations use the identical syntax of normal FORTRAN 77 type statements, and all `f77` types are allowed, subject to the following rules and restrictions:

- Any dimensioning needed must be in the type statement. The `DIMENSION` statement has no effect on field names.
- You can specify the pseudonyme `%FILL` for a field name. The `%FILL` is provided for compatibility with other versions of FORTRAN 77. It is not needed in `f77` because the alignment problems are taken care of for you. It is a useful feature if you want to make one or more fields not referenceable in some particular subroutine. The only thing that `%FILL` does is provide a field of the specified size and type, and preclude referencing it.
- You must explicitly type all field names. The `IMPLICIT` statement does not apply to statements in a `STRUCTURE` declaration, nor do the implicit `I,J,K,L,M,N` rules apply.
- You cannot use arrays with adjustable or assumed size in field declarations, nor can you include passed-length `CHARACTER` declarations.

In a structure declaration, the offset of field *n* is the offset of the preceding field, plus the length of the preceding field, possibly corrected for any adjustments made to maintain alignment.

You can initialize a field that is a variable, array, substring, substructure, or union.

Examples

Example 1: A structure of five fields:

```
STRUCTURE /PRODUCT/
    INTEGER*4 ID/ 99 /
    CHARACTER*16 NAME
    CHARACTER*8 MODEL/ 'Z' /
    REAL*4 COST
    REAL*4 PRICE
END STRUCTURE
RECORD /PRODUCT/ CURRENT, PRIOR, NEXT, LINE(10)
```

In the above example, a structure named `PRODUCT` is defined to consist of the fields `ID`, `NAME`, `MODEL`, `COST`, and `PRICE`. Each of the three variables, `CURRENT`, `PRIOR`, and `NEXT`, is a record which has the `PRODUCT` structure, and `LINE` is an array of 10 such records. Every such record has its `ID` initially set to 99, and its `MODEL` initially set to `Z`.

Example 2: A structure of two fields:

```
STRUCTURE /VARLENSTR/
    INTEGER*4 NBYTES
    CHARACTER A*25
END STRUCTURE
RECORD /VARLENSTR/ VLS
VLS.NBYTES = 0
```

The above structure matches the one used by the `pc` Pascal compiler from SunSoft for varying length strings. The `25` is arbitrary.

4.67 SUBROUTINE

The SUBROUTINE statement identifies a named program unit as a subroutine, and specifies arguments for it.

Syntax

SUBROUTINE *sub* [([*fd* [, *fd*] …])]	
sub	Name of subroutine subprogram
d	Variable name, array name, record name, or dummy procedure name, an asterisk, or an ampersand

Description

A subroutine subprogram must have a SUBROUTINE statement as the first statement. A subroutine can have any other statements, except a BLOCK DATA, FUNCTION, PROGRAM, or another SUBROUTINE statement.

sub is the name of a subroutine and is a global name, and must not be the same as any other global name such as a common block name or a function name. Nor can it be the same as any local name in the same subroutine.

d is the dummy argument, and multiple dummy arguments are separated by commas. *d* can be one of the following:

- Variable name
- Array name
- Dummy procedure name
- Record name
- Asterisk (*) or an ampersand (&) ♦

The dummy arguments are local to the subroutine and must *not* appear in any of the following statements, except as a common block name:

- EQUIVALENCE
- PARAMETER
- SAVE
- STATIC
- AUTOMATIC
- INTRINSIC

- DATA
- COMMON

The actual arguments in the CALL statement that references a subroutine must agree with the corresponding formal arguments in the SUBROUTINE statement, in order, number, and type. An asterisk (or an ampersand) in the formal argument list denotes an alternate return label. A RETURN statement in this procedure can specify the ordinal number of the alternate return to be taken.

Examples

Example 1: A variable and array as parameters:

```
    SUBROUTINE SHR ( A, B )
    CHARACTER A*8
    REAL B(10,10)
    …
    RETURN
    END
```

Example 2: Standard alternate returns:

In this example, the RETURN 1 statement refers to the first alternate return label (first *). The RETURN 2 statement refers to the second alternate return label (second *) specified in the SUBROUTINE statement.

```
    PROGRAM TESTALT
    CALL RANK ( N, *8, *9 )
    WRITE (*,*) 'OK - Normal Return [n=0]'
    STOP
8   WRITE (*,*) 'Minor - 1st alternate return [n=1]'
    STOP
9   WRITE (*,*) 'Major - 2nd alternate return [n=2]'
    END
    SUBROUTINE RANK ( N, *, * )
    IF ( N .EQ. 0 ) RETURN
    IF ( N .EQ. 1 ) RETURN 1
    RETURN 2
    END
```

Example 3: Nonstandard alternate returns: ♦

```
     CALL SUB(…, &label, …)
```

is treated as:

```
     CALL SUB(…, *label, …)
```

4.68 TYPE

The TYPE ♦ statement writes to stdout.

Syntax

TYPE f [, *iolist*] or: TYPE *grname*	
f	Format identifier
iolist	List of output variables
grname	Name of the namelist group

Description

The TYPE statement is provided for compatibility with older versions of FORTRAN 77, and is equivalent to the following:

- PRINT *f* [, *iolist*]
- PRINT *grname*
- WRITE(*, *f*) [*iolist*]
- WRITE(*,*grname*)

Examples

Example 1: Formatted output:

```
    INTEGER V(5)
    TYPE 1, V
1   FORMAT( 5 I3 )
```

Example 2: Namelist output:

```
      CHARACTER S*16
      INTEGER N
      NAMELIST /G/ N, S
      …
      TYPE G
```

4.69 The Type Statement

The type statement specifies the data type of items in the list, optionally specifies array dimensions, and initializes with values.

Syntax

type *v* [/ *clist* /] [,*v* [/ *clist* /]…	
v	Variable name, array name, array declarator, symbolic name of a constant, statement function or function subprogram name
clist	List of constants. There are more details about *clist* in the section on the DATA statement.

type can be preceded by either AUTOMATIC or STATIC.

type can be one of the following type specifiers:

BYTE ♦	INTEGER
CHARACTER	INTEGER*2 ♦
CHARACTER**n*	INTEGER*4 ♦
CHARACTER*(*)	INTEGER*8 ♦
COMPLEX	LOGICAL
COMPLEX*8 ♦	LOGICAL*1 ♦
COMPLEX*16 ♦	LOGICAL*2 ♦
COMPLEX*32 *(SPARC only)* ♦	LOGICAL*4 ♦
DOUBLE COMPLEX ♦	LOGICAL*8 ♦
DOUBLE PRECISION	REAL
	REAL*4 ♦
	REAL*8 ♦
	REAL*16 *(SPARC only)* ♦

n, as in CHARACTER**n*, must be greater than 0.

Description

A *type* statement can be used to:

- Confirm or to override the type established by default or by the IMPLICIT statement
- Specify dimension information for an array, or confirm the *type* of an intrinsic function
- Override the length by one of the acceptable lengths for that data type

A *type* statement can assign initial values to variables, arrays, or record fields by specifying a list of constants (*clist*) as in a DATA statement. ♦

The general form of a *type* statement is:

type VariableName / *constant* / …

or:

type ArrayName / *constant*, … /

or:

type ArrayName / *r*constant* /

where *r* is a repeat factor.

Example: Various *type* statements:

```
    CHARACTER LABEL*12 / 'Standard' /
    COMPLEX STRESSPT / ( 0.0, 1.0 ) /
    INTEGER COUNT / 99 /, Z / 1 /
    REAL PRICE / 0.0 /, COST / 0.0 /
    REAL LIST(8) / 0.0, 6*1.0, 0.0 /
```

When you initialize a data type, remember the following restrictions:

- For a simple variable, there must be exactly one constant.
- If any element of an array is initialized, all must be initialized.

- You can use an integer as a *repeat factor*, followed by an asterisk (*), followed by a constant. In the example above, six values of 1.0 are stored into array elements 2, 3, 4, 5, 6, and 7 of LIST.
- If a variable or array is declared AUTOMATIC, then it cannot be initialized.
- A pointer-based variable or array cannot be initialized. For example:

```
      INTEGER Z / 4 /
      POINTER ( x, Z )
```

  In this case, the compiler issues a warning message, and Z is *not* initialized.

  If a variable or array is not initialized, its values are undefined.

  If such initialization statements involve variables in COMMON, and the –ansi compiler flag is set, then a warning is issued.

Restrictions

A symbolic name can appear only once in *type* statements in a program unit.

A *type* statement must precede all executable statements.

Example

Example: The *type* statement:

```
      INTEGER*2 I, J/0/
      REAL*4 PI/3.141592654/,ARRAY(10)/5*0.0,5*1.0/
      CHARACTER*10 NAME
      CHARACTER*10 TITLE/'Heading'/
```

In the above example:

- J is initialized to 0
- PI is initialized to 3.141592654
- The first five elements of ARRAY are initialized to 0.0
- The second five elements of ARRAY are initialized to 1.0
- TITLE is initialized to 'Heading'

4.70 UNION *and* MAP

The UNION ♦ statement defines groups of fields that share memory at runtime.

Syntax

The syntax of a UNION declaration is as follows:

```
UNION
        map-declaration
        map-declaration
        [map-declaration]
        ...
END UNION
```

The syntax of a MAP declaration is:

```
MAP
field-declaration
[field-declaration]
...
[field-declaration]
END MAP
```

Description

A MAP statement defines alternate groups of fields in a union. During execution, one map at a time is associated with a shared storage location. When you reference a field in a map, the fields in any previous map become undefined, and are succeeded by the fields in the map of the newly referenced field. Also:

- A UNION declaration can appear only within a STRUCTURE declaration.
- The amount of memory used by a union is that of its biggest map.
- Within a UNION declaration, the order of the MAP statements is not relevant.

The UNION line is part of an inherently multiline group of statements, and neither the UNION line nor the END UNION line has any special indication of continuation. You do not put a nonblank in column six, nor an & in column one.

Each *field-declaration* in a *map* declaration can be one of the following:

- Structure declaration
- Record
- Union declaration
- Declaration of a typed data field

Example

Declare the structure /STUDENT/ to contain either NAME, CLASS, and MAJOR, or NAME, CLASS, CREDITS, and GRAD_DATE:

```
STRUCTURE /STUDENT/
    CHARACTER*32  NAME
    INTEGER*2  CLASS
    UNION
        MAP
            CHARACTER*16 MAJOR
        END MAP
        MAP
            INTEGER*2  CREDITS
            CHARACTER*8  GRAD_DATE
        END MAP
    END UNION
END STRUCTURE
RECORD /STUDENT/ PERSON
```

In the above example, the variable PERSON has the structure /STUDENT/, so:

- PERSON.MAJOR references a field from the first map; PERSON.CREDITS references a field from the second map.
- If the variables of the second map field are initialized, and then the program references the variable PERSON.MAJOR, the first map becomes active, and the variables of the second map become undefined.

4.71 VIRTUAL

The VIRTUAL ♦ statement is treated the same as the DIMENSION statement.

Syntax

VIRTUAL *a* (*d*) [, *a* (*d*)] …	
a	Name of an array
a(d)	Specifies the dimension of the array. It is a list of 1 to 7 declarators separated by commas

Description

The VIRTUAL statement has the same form and effect as the DIMENSION statement. It is included for compatibility with older versions of FORTRAN 77.

Example

```
      VIRTUAL M(4,4), V(1000)
      …
      END
```

4.72 VOLATILE

The VOLATILE ♦ statement prevents optimization on the specified items.

Syntax

VOLATILE *nlist*	
nlist	List of variables, arrays, or common blocks

Description

The VOLATILE statement prevents optimization on the items in the list. Programs relying on it are usually nonportable.

Example

Example: VOLATILE: ♦

```
    PROGRAM FFT
    INTEGER NODE*2, NSTEPS*2
    REAL DELTA, MAT(10,10), V(1000), X, Z
    COMMON /INI/ NODE, DELTA, V
    …
    VOLATILE V, Z, MAT, /INI/
    …
    EQUIVALENCE ( X, V )
    …
```

In the above example, the array V, the variable Z, and the common block /INI/ are explicitly specified as VOLATILE. The variable X is VOLATILE through an equivalence.

4.73 WRITE

The WRITE statement writes data from the list to a file.

Syntax

`WRITE( [ UNIT=] ` *u* `  [, [FMT=] ` *f* ` ]  [, IOSTAT=`*ios* ` ] [, REC=`*rn* ` ]` `[, ERR=`*s* ` ] )` *iolist*	
`WRITE( [ UNIT= ] ` *u*`, [ NML= ] ` *grname* ` [, IOSTAT= ` *ios* ` ] [, ERR= ` *s* ` ] )`	
u	Unit identifier of the unit connected to the file
f	Format identifier
ios	I/O status specifier
rn	Record number
s	Error specifier (statement label)
iolist	List of variables
grname	Name of the `namelist` group

The options can be specified in any order.

An alternate for the `REC=`*rn* form is allowed, as follows: ♦

`WRITE(` *u* `'` *rn* … `)` *iolist* ♦

See Example 3, later on in this section.

Description

For tapes, we recommend the `TOPEN()` routines because they are more reliable.

Unit Identifier

u is either an external unit identifier or an internal file identifier.

An external unit identifier must be one of the following:

- A nonnegative integer expression
- An asterisk, identifying `stdout`, which is normally connected to the console

If the optional characters `UNIT=` are omitted from the unit specifier, then *u* must be the first item in the list of specifiers.

Format Identifier

f is a format identifier and can be:

- An asterisk (*), indicating list-directed I/O. See “List-Directed I/O” on page 301 for details.
- The label of a `FORMAT` statement that appears in the same program unit
- An integer variable name that has been assigned the label of a `FORMAT` statement that appears in the same program unit
- A character expression or integer array that specifies the format string. This is called a runtime format or a variable format. The integer array is nonstandard. ♦

If the optional characters, `FMT=`, are omitted from the format specifier, then *f* must appear as the second argument for a formatted write; otherwise, it must not appear at all.

f must not be an asterisk for direct access.

f can be an asterisk for internal files. ♦

If a file is connected for formatted I/O, unformatted data transfer is prohibited, and vice versa.

I/O Status Specifier

ios must be an integer variable, integer array element, or integer record field.

Record Number

rn must be a positive integer expression. This argument can appear only for direct-access files. *rn* can be specified for internal files. ♦

Error Specifier

s must be the label of an executable statement in the same program unit in which this `WRITE` statement occurs.

Output List

iolist can be empty, or it can contain output items or implied DO lists. The output items must be one of the following:

- Variables
- Substrings
- Arrays
- Array elements
- Record fields
- Any other expression

A simple unsubscripted array name specifies all of the elements of the array in memory storage order, with the leftmost subscript increasing more rapidly.

If the output item is a character expression that employs the concatenation operator, the length specifiers of its operands can be an asterisk (*). This rule is nonstandard. ♦

If a function appears in the output list, that function must not cause an input/output statement to be executed.

Namelist-Directed WRITE

The second form of WRITE is used to output the items of the specified namelist group. Here, *grname* is the name of the list previously defined in a NAMELIST statement.

Execution

Execution proceeds as follows:

1. **The file associated with the specified unit is determined.**
   The format, if specified, is established. The file is positioned appropriately prior to data transfer.

2. **If the output list is not empty, data is transferred from the list to the file.**
   Data is edited according to the format, if specified.

3. **In the second form of namelist-directed WRITE, the data is transferred from the items of the specified namelist group according to the rules of namelist-directed output.**

4. **The file is repositioned appropriately after the data transfer.**
5. **If *ios* is specified, and no error occurs, it is set to zero; otherwise, it is set to a positive value.**
6. **If *s* is specified and an error occurs, control is transferred to *s*.**

Restrictions

Note these restrictions:

- Output from an exception handler is unpredictable.

  If you make your own exception handler, do not do any FORTRAN 77 output from it. If you must do some, then call abort right after the output. Doing so reduces the relative risk of a system freeze. FORTRAN 77 I/O from an exception handler amounts to recursive I/O. See the next paragraph.

- Recursive I/O does not work reliably.

  If you list a function in an I/O list, and if that function does I/O, then during runtime, the execution may freeze, or some other unpredictable problem results. This risk exists independent of using parallelization.

  Example: Recursive I/O fails intermittently:

```
      WRITE(*,*) x, f(x)     ! Not allowed, f() does I/O.
      END
      FUNCTION F(X)
      WRITE(*,*) X
      RETURN
      END
```

Comments

If *u* specifies an external unit that is not connected to a file, an implicit `OPEN` operation is performed that is equivalent to opening the file with the following options:

```
    OPEN( u, FILE='FORT.u', STATUS='UNKNOWN',
&          ACCESS='SEQUENTIAL', FORM=fmt )
```

The value of *fmt* is `'FORMATTED'` if the write is formatted, and `'UNFORMATTED'` otherwise.

A simple unsubscripted array name specifies all of the elements of the array in memory storage order, with the leftmost subscript increasing more rapidly.

The record number for direct-access files starts from one onwards.

Namelist-directed output is permitted on sequential access files only.

Examples

Example 1: Formatted write with trap I/O errors and I/O status:

```
    WRITE( 1, 2, ERR=8, IOSTAT=N ) X, Y
    RETURN
    …
8   WRITE( *, * ) 'I/O error # ', N, ', on 1'
    STOP
    END
```

Example 2: Direct, unformatted write, trap I/O errors, and I/O status:

```
    …
    WRITE( 1, REC=3, IOSTAT=N, ERR=8 ) V
    …
4   CONTINUE
    RETURN
8   WRITE( *, * ) 'I/O error # ', N, ', on 1'
    END
```

Example 3: Direct, alternate syntax (equivalent to above example):

```
      …
      WRITE( 1 ' 3, IOSTAT=N, ERR=8 ) V
      …
 4    CONTINUE
      RETURN
8   WRITE( *, * ) 'I/O error # ', N, ', on 1'
      END
```

Example 4: List-directed write to screen:

```
    WRITE( *, * ) A, V
or
    PRINT *, A, V
```

Example 5: Formatted write to an internal file:

```
    CHARACTER CA*16, L*8 /'abcdefgh'/, R*8 /'ijklmnop'/
     WRITE( CA, 1 ) L, R
 1   FORMAT( 2 A8 )
```

Example 6: Write an entire array:

```
      DIMENSION V(5)
    WRITE( 3, '(5F4.1)') V
```

Example 7: Namelist-directed write:.

```
    CHARACTER SAMPLE*16
    LOGICAL NEW*4
    REAL DELTA*4
    NAMELIST /G/ SAMPLE, NEW, DELTA
    …
    WRITE( 1, G )
or
    WRITE( UNIT=1, NML=G )
or
    WRITE( 1, NML=G )
```

Input and Output 5

This chapter describes the general concepts of FORTRAN 77 input and output, and provides details on the different kids of I/O. It is organized into the following sections:

5.1 General Concepts of FORTRAN 77 I/O

Any operating system based on the UNIX operating system is not as record-oriented as FORTRAN 77. This operating system treats files as sequences of characters instead of collections of records. The FORTRAN 77 runtime system keeps track of file formats and access mode during runtimes. It also provides the file facilities, including the FORTRAN 77 libraries and the standard I/O library.

Logical Units

The FORTRAN 77 default value for the maximum number of logical units that a program can have open at one time is 64. For current Solaris releases, this limit is 256. A FORTRAN 77 program can increase this limit beyond 64 by calling the `setrlim()` function. See the `man` page `setrlim`(2). If you are running `csh`, you can also do this with the `limit` or `unlimit` command; see `csh`(1).

The standard logical units 0, 5, and 6 are preconnected to Solaris as `stderr`, `stdin`, and `stdout`, respectively. These are not actual file names, and cannot be used for opening these units. `INQUIRE` does not return these names, and indicates that the above units are not named unless they have been opened to real files. However, these units can be redefined with an `OPEN` statement.

The names, `stderr`, `stdin`, and `stdout`, are meant to make error reporting more meaningful. To preserve error reporting, the system makes it is an error to close logical unit 0, although it can be reopened to another file.

If you want to open a file with the default file name for any preconnected logical unit, remember to close the unit first. Redefining the standard units can impair normal console I/O. An alternative is to use shell redirection to externally redefine the above units.

To redefine default blank control or the format of the standard input or output files, use the `OPEN` statement, specifying the unit number and no file name, and use the options for the kind of blank control you want.

I/O Errors

Any error detected during I/O processing causes the program to abort, unless alternative action has been provided specifically in the program. Any I/O statement can include an `ERR=` clause (and `IOSTAT=` clause) to specify an alternative branch to be taken on errors and return the specific error code. Read statements can include `END=`*n* to branch on end-of-file. File position and the value of I/O list items are undefined following an error. `END=` catches both EOF and error conditions; `ERR=` catches only error conditions.

If your program does not trap I/O errors, then before aborting, an error message is written to `stderr` with an error number in square brackets, `[ ]`, and the logical unit and I/O state. The signal that causes the abort is `IOT`.

Error numbers less than 1000 refer to operating system errors; see `intro`(2). Error numbers greater than or equal to 1000 come from the I/O library.

For external I/O, part of the current record is displayed if the error was caused during reading from a file that can backspace. For internal I/O, part of the string is printed with a vertical bar (|) at the current position in the string.

General Restriction

Do not reference a function in an I/O list if executing that function causes an I/O statement to be executed. Example:

```
WRITE( 1, 10)  Y, A + 2.0 * F(X) ! Wrong if F() does I/O
```

Kinds of I/O

The four kinds of I/O are: formatted, unformatted, list-directed, and `NAMELIST`.

The two modes of access to files are *sequential* and *direct*. When you open a file, the access mode is set to either sequential or direct. If you do not set it explicitly, you get sequential by default.

The two types of files are: external files and internal files. An external file resides on a physical peripheral device, such as disk or tape. An internal file is a location in main memory, is of character type, and is either a variable, substring, array, array element, or a field of a structured record.

Combinations of I/O

I/O combinations on external files are:

Allowed	**Not Allowed**
Sequential unformatted	Direct-access, list-directed I/O
Sequential formatted	Direct-access, `NAMELIST` I/O
Sequential list-directed	`NAMELIST` I/O on internal files
Sequential `NAMELIST`	Unformatted, internal I/O
Direct unformatted	
Direct formatted	

The following table shows combinations of I/O form, access mode, and physical file types.

Table 5-1 Summary of `f77` Input and Output

Kind of I/O		**Access Mode**	
Form	**File Type**	**Sequential**	**Direct**
Formatted	Internal	The file is a character variable, substring, array, or array element. ♦	The file is a character array; each record is one array element.
	External	Only formatted records of same or variable length.	Only formatted records, all the same length.
Unformatted	Internal	Not allowed.	Not allowed.
	External	Contains only unformatted records.	`READ`: Gets one logical record at a time. `WRITE`: Unfilled part of record is undefined.
List-directed	Internal	`READ`: Reads characters until EOF or I/O list is satisfied. `WRITE`: Writes records until list is satisfied. ♦	Not allowed.
	External	Uses standard formats based on type of variable and size of element. Blanks or commas are separators. Any columns.	Not allowed.
`NAMELIST`	Internal	Not allowed.	Not allowed.
	External	`READ`: Reads records until it finds $*groupname* in columns 2-80. Then reads records searching for names in that group, and stores data in those variables. Stops reading on `$` or `eof`. `WRITE`: Writes records showing the group name and each variable name with value.	Not allowed.

Avoid list-directed internal writes. The number of lines and items per line varies with the values of items.

Printing Files

You get a print file by using the nonstandard `FORM='PRINT'` in `OPEN`. ♦

```
    OPEN ( ..., FORM='PRINT', ... )
```

This specifier works for sequential access files only.

Definition

A print file has the following features:

- With formatted output, you get vertical format control for that logical unit:
  - Column one is not printed.
  - If column one is blank, 0, or 1, then vertical spacing is one line, two lines, or top of page, respectively.
  - If column 1 is +, it is replaced by a control sequence that causes a return to the beginning of the previous line.
- With list-directed output, you get for that logical unit, column one is not printed.

In general, if you open a file with `FORM='PRINT'`, then for that file list-directed output does *not* provide the FORTRAN 77 Standard blank in column one; otherwise, it does provide that blank. `FORM='PRINT'` is for one file per call.

If you open a file with `FORM='PRINT'`, then that file has the same content as if it was opened with `FORM='FORMATTED'`, and filtered with the output filter, `asa`.

If you compile with the `-oldldo` option (old list-directed output), then all the files written by the program do list-directed output *without* that blank in column one; otherwise, they all get that blank. The `-oldldo` option is global.

The `INQUIRE` Statement

The `INQUIRE` statement returns '`PRINT'` in the `FORM` variable for logical units opened as print files. It returns `-1` for the unit number of an unopened file.

Special Uses of OPEN

If a logical unit is already open, an OPEN statement using the BLANK option does nothing but redefine that option.

As a nonstandard extension, if a logical unit is already open, an OPEN statement using the FORM option does nothing but redefine that option. ♦

These forms of the OPEN statement need not include the file name, and must not include a file name if UNIT refers to standard input, output, or standard error.

If you connect a unit with OPEN and do not use the file name parameter, then you get the default file name, fort.*nn*, where *nn* is the unit number. Therefore, to redefine the standard output as a *print* file, use:

```
    OPEN( UNIT=6, FORM='PRINT')
```

Scratch Files

Scratch files are temporary files that normally disappears after execution is completed.

Example: Create a scratch file:

```
    OPEN( UNIT=7, STATUS='SCRATCH' )
```

To prevent a temporary file from disappearing after execution is completed, you must execute a CLOSE statement with STATUS='KEEP'. KEEP is the default status for all other files.

Example: Close a scratch file that you want to access later:

```
    CLOSE( UNIT=7, STATUS='KEEP' )
```

Remember to get the real name of the scratch file. Use INQUIRE if you want to reopen it later.

Changing I/O Initialization with IOINIT

Traditional FORTRAN 77 environments usually assume carriage control on all logical units. They usually interpret blank spaces on input as zeroes, and often provide attachment of global file names to logical units at runtime. The routine IOINIT(3F) can be called to specify these I/O control parameters. This routine:

- Recognizes carriage control for all formatted files.
- Ignores trailing and embedded blanks in input files.
- Positions files at the beginning or end upon opening.
- Preattaches file names of a specified pattern with logical units.

Example: IOINIT and logical unit preattachment:

```
    CALL IOINIT ( .TRUE., .FALSE., .FALSE., 'FORT', .FALSE.)
```

For the above call, the FORTRAN 77 runtime system looks in the environment for names of the form FORT*nn*, and then opens the corresponding logical unit for sequential formatted I/O.

With the above example, suppose your program opened unit 7, as follows:

```
    OPEN( UNIT=07, FORM='FORMATTED' )
```

The FORTRAN 77 runtime system looks in the environment for the FORT07 file, and connects it to unit 7.

In general, names must be of the form *PREFIXnn*, where the particular *PREFIX* is specified in the call to IOINIT, and *nn* is the logical unit to be opened. Unit numbers less than 10 must include the leading 0. For details, see IOINIT(3F).

Example: Attach external files ini1.inp and ini1.out to units 1and 2:

In sh:

```
demo$ TST01=ini1.inp
demo$ TST02=ini1.out
demo$ export TST01 TST02
```

In csh:

```
demo% setenv TST01 ini1.inp
demo% setenv TST02 ini1.out
```

Example: Attach the file, s ini1.inp and ini1.out, to units 1 and 2:

```
demo% cat ini1.f
       CHARACTER PRFX*8
       LOGICAL CCTL, BZRO, APND, VRBOSE
       DATA CCTL, BZRO, APND, PRFX, VRBOSE
&          /.TRUE., .FALSE., .FALSE., 'TST', .FALSE. /
C
       CALL IOINIT( CCTL, BZRO, APND, PRFX, VRBOSE )
       READ( 1, *) I, B, N
       WRITE( *, *) 'I = ', I, ' B = ', B, ' N = ', N
       WRITE( 2, *) I, B, N
       END
demo% f77 ini1.f
ini1.f:
 MAIN:
demo% a.out
  I = 12 B = 3.14159012 N = 6
demo%
```

IOINIT should prove adequate for most programs as written. However, it is written in FORTRAN 77 so that it can serve as an example for similar user-supplied routines. A copy can be retrieved as follows:

In Solaris 2.x:

```
demo% cp /opt/SUNWspro/SC3.0.1/src/ioinit.f  .
```

In Solaris 1.x:

```
demo% cp /usr/lang/SC3.0.1/src/ioinit.f  .
```

5.2 Direct Access

A direct-access file contains a number of records that are written to or read from by referring to the record number. Direct access is also called random access.

In direct access:

- Records must be all the same length.
- Records are usually all the same type.
- A logical record in a direct access, external file is a string of bytes of a length specified when the file is opened.
- Read and write statements must not specify logical records longer than the original record size definition.
- Shorter logical records are allowed.
  - Unformatted direct writes leave the unfilled part of the record undefined.
  - Formatted direct writes pass the unfilled record with blanks.
- Each `READ` operation acts on exactly *one* record.
- In using direct unformatted I/O, be careful with the number of values your program expects to read.
- Direct access `READ` and `WRITE` statements have an argument, `REC=`*n*, which gives the record number to be read or written. An alternate, nonstandard form is `'`*n*.

Unformatted I/O

Example: Direct access, *unformatted*:

```
    OPEN( 2, FILE='data.db', ACCESS='DIRECT', RECL=20,
&         FORM='UNFORMATTED', ERR=90 )
    READ( 2, REC=13, ERR=30 ) X, Y
    READ( 2 ' 13, ERR=30 ) X, Y   ! ← Alternate form ♦
```

This code opens a file for direct-access, unformatted I/O, with a record length of 20 characters, then reads the thirteenth record as is.

Formatted I/O

Example: Direct access, *formatted*:

```
    OPEN( 2, FILE='inven.db', ACCESS='DIRECT', RECL=20,
&          FORM='FORMATTED', ERR=90 )
    READ( 2, FMT='(I10,F10.3)', REC=13, ERR=30 ) A, B
```

This code opens a file for direct-access, formatted I/O, with a record length of 20 characters, then reads the thirteenth record and converts it according to the `(I10,F10.3)` format.

5.3 Internal Files

An internal file is a character-string object, such as a constant, variable, substring, array, element of an array, or field of a structured record—all of type character. For a variable or substring, there is only a single record in the file but for an array; each array element is a record.

Sequential Formatted I/O

On internal files, the FORTRAN 77 Standard includes only sequential formatted I/O. (I/O is not a precise term to use here, but internal files are dealt with using `READ` and `WRITE` statements.) Internal files are used by giving the name of the character object in place of the unit number. The first read from a sequential-access internal file always starts at the beginning of the internal file; similarly for a write.

Example: Sequential, formatted reads:

```
    CHARACTER X*80
    READ( 5, '(A)' ) X
    READ( X, '(I3,I4)' ) N1, N2
```

The above code reads a print-line image into `X`, and then reads two integers from `X`.

Direct Access I/O

`f77` extends direct I/O to internal files.♦

This is like direct I/O on external files, except that the number of records in the file cannot be changed. In this case, a record is a single element of an array of character strings.

Example: Direct access read of the third record of the internal file, `LINE`:

```
demo% cat intern.f
      CHARACTER LINE(3)*14
      DATA LINE(1) / ' 81 81 ' /
      DATA LINE(2) / ' 82 82 ' /
      DATA LINE(3) / ' 83 83 ' /
      READ ( LINE, FMT='(2I4)', REC=3 ) M, N
      PRINT *, M, N
      END
demo% f77 -silent intern.f
demo% a.out
  83 83
demo%
```

5.4 Formatted I/O

In formatted I/O:

- The list items are processed in the order they appear in the list.
- Any list item is completely processed before the next item is started.
- Each sequential access reads or writes one or more logical records.

Input Actions

In general, a formatted read statement does the following:

- Reads character data from the external record or from an internal file.
- Converts the items of the list from character to binary form according to the instructions in the associated format.
- Puts converted data into internal storage for each list item of the list.

Example: Formatted read:

```
   READ( 6, 10 ) A, B
10  FORMAT( F8.3, F6.2 )
```

Output Actions

In general, a formatted write statement does the following:

- Gets data from internal storage for each list item specified by the list.
- Converts the items from binary to character form according to the instructions in the associated format.
- Transfers the items to the external record or to an internal file.
- Terminates formatted output records with newline characters.

Example: Formatted write:

```
   REAL  A / 1.0 /,  B / 9.0 /
   WRITE( 6, 10 ) A, B
10  FORMAT( F8.3, F6.2 )
```

For formatted write statements, the logical record length is determined by the format statement that interacts with the list of input or output variables (I/O list) at execution time.

For formatted write statements, if the external representation of a datum is too large for the field width specified, the specified field is filled with asterisks (*).

For formatted read statements, if there are fewer items in the list than there are data fields, the extra fields are ignored.

Format Specifiers

Table 5-2 Format Specifiers

Specifiers can be uppercase as well as lowercase characters in format statements and in all the alphabetic arguments to the I/O library routines.

Purpose	**FORTRAN 77**	`f77` **Extensions**
Blank control	`BN, BZ`	`B`
Carriage control	`/`, *space*, `0`, `1`	`$`
Character edit	*n*`H`, `A`*w*, `'aaa'`	`"aaa"`, `A`

Floating-point edit	`D`*w*`.`*d*`E`*e*`,`
	`E`*w*`.`*d*`E`*e*`,`
	`F`*w*`.`*d*`E`*e*`,`
	`G`*w*`.`*d*`E`*e*
		`E`*w*`.`*d*`.`*e*`,`
		`D`*w*`.`*d*`.`*e*`,`
		`G`*w*`.`*d*`.`*e*

Hexadecimal edit		`Z`*w*`.`*m*
Integer edit	`I`*w*.*m*	
Logical edit	`L`*w*	
Octal edit		`O`*w*`.`*m*
Position control	*n*`X`, `T`*n*, `TL`*n*, `TR`*n*	*n*`T, T, X`
Radix control		*n*`R, R`
Remaining characters		`Q`
Scale control	*n*`P`	`P`
Sign control	`S, SP, SS`	`SU`
Terminate a format	`:`	
Variable format expression		< *e* >

w, m, d, e Parameters (As In `G`*w*`.`*d*`E`*e)*

The definitions for the parameters, *w*, *m*, *d*, and *e* are:

- *w* specifies that the field occupies *w* positions.
- *m* specifies the insertion of leading zeros to a width of *m*.
- *d* specifies the number of digits to the right of the decimal point.
- *e* specifies the width of the exponent field.

Defaults for w, d, and e

You can write field descriptors A, D, E, F, G, I, L, O, or Z without the *w*, *d*, or *e* field indicators. ♦ If these are not unspecified, the appropriate defaults are used based on the data type of the I/O list element. See Table 5-3.

Typical format field descriptor forms that use *w*, *d*, or *e* include:

A*w*, I*w*, L*w*, O*w*, Z*w*, D*w*.*d*, E*w*.*d*, G*w*.*d*, E*w*.*d*E*e*, G*w*.*d*E*e*

Example: With the default *w*=7 for INTEGER*2, and since 161 decimal = A1 hex:

```
    INTEGER*2 M
    M = 161
    WRITE ( *, 8 ) M
8   FORMAT ( Z )
    END
```

This example produces the following output:

```
demo% f77 def1.f
def1.f:
 MAIN:
demo% a.out
ΔΔΔΔΔa1
demo%
```

↑ column 6

The defaults for *w*, *d*, and *e* are summarized in the following table.

Table 5-3 Default *w, d, e* Values in Format Field Descriptors

Field Descriptor	**List Element**	***w***	***d***	***e***
I,O,Z	BYTE	7	-	-
I,O,Z	INTEGER*2, LOGICAL*2	7	-	-
I,O,Z	INTEGER*4, LOGICAL*4	12	-	-
O,Z	REAL*4	12	-	-
O,Z	REAL*8	23	-	-
O,Z	REAL*16, COMPLEX*32	44	-	-
L	LOGICAL	2	-	-
F,E,D,G	REAL, COMPLEX*8	15	7	2
F,E,D,G	REAL*8, COMPLEX*16	25	16	2
F,E,D,G	REAL*16, COMPLEX*32	42	33	3
A	LOGICAL*1	1	-	-
A	LOGICAL*2, INTEGER*2	2	-	-
A	LOGICAL*4, INTEGER*4	4	-	-
A	REAL*4, COMPLEX*8	4	-	-
A	REAL*8, COMPLEX*16	8	-	-
A	REAL*16, COMPLEX*32	16	-	-
A	CHARACTER*n	n	-	-

For complex items, the value for *w* is for each real component. The default for the A descriptor with character data is the declared length of the corresponding I/O list element. REAL*16 and COMPLEX*32 are for SPARC only.

Apostrophe Editing ('aaa ')

The apostrophe edit specifier is in the form of a character constant. It causes characters to be written from the enclosed characters of the edit specifier itself, including blanks. An apostrophe edit specifier must not be used on input. The width of the field is the number of characters contained in, but not including, the delimiting apostrophes. Within the field, two consecutive apostrophes with no intervening blanks are counted as a single apostrophe. You can use quotes in a similar way.

Example: `apos.f`, apostrophe edit (two equivalent ways):

```
      WRITE( *, 1 )
1     FORMAT( 'This is an apostrophe ''.')
      WRITE( *, 2 )
2     FORMAT( "This is an apostrophe '.")
      END
```

The above program writes this message twice: `This is an apostrophe '.`

Blank Editing (B, BN, BZ)

The `B`, `BN`, and `BZ` edit specifiers control interpretation of imbedded and trailing blanks for numeric input.

The following blank specifiers are available:

- `BN`—If `BN` precedes a specification, a nonleading blank in the input data is considered null, and is ignored.
- `BZ`—If `BZ` precedes a specification, a nonleading blank in the input data is considered *zero*.
- `B`—If `B` precedes a specification, it returns interpretation to the default mode of blank interpretation. This is consistent with `S`, which returns to the default sign control. ♦

Without any specific blank specifiers in the format, nonleading blanks in numeric input fields are normally interpreted as zeros or ignored, depending on the value of the `BLANK=` suboption of `OPEN` currently in effect for the unit. The default value for that suboption is `ignore`, so if you use defaults for both `BN/BZ/B` and `BLANK=`, you get `ignore`.

Example: Read and print the same data once with BZ and once with BN:

```
demo% cat bz1.f
*               12341234
    CHARACTER LINE*18 / ' 82 82 ' /
    READ ( LINE, '( I4, BZ, I4 ) ') M, N
    PRINT *, M, N
    READ ( LINE, '( I4, BN, I4 ) ') M, N
    PRINT *, M, N
    END
demo% f77 -silent  bz1.f
demo% a.out
  82 8200
  82 82
demo%
```

Note these rules for blank control:

- Blank control specifiers apply to input only.
- A blank control specifier remains in effect until another blank control specifier is encountered, or format interpretation is complete.
- The B, BN, and BZ specifiers affect only I, F, E, D, and G editing.

Carriage Control ($, *Space*, 0, 1)

You use $, the space, 0, and 1 for carriage control.

Dollar $

The special edit descriptor $ suppresses the carriage return. ♦

The action does *not* depend on the first character of the format. It is used typically for console prompts. For instance, you can use this descriptor to make a typed response follow the output prompt on the same line. This edit descriptor is constrained by the same rules as the colon (:).

Example: The `$` carriage control:

```
* dol1.f The $ edit descriptor with space
    WRITE ( *, 2 )
2   FORMAT (' Enter the node number: ', $ )
    READ ( *, * ) NODENUM
    END
```

The above code produces a displayed prompt and user input response, such as:

```
Enter the node number:  82
```

The first character of the format is printed out, in this case, a blank. For an input statement, the `$` descriptor is ignored.

Space, `0`*,* `1`*, and* `+`

The following first-character slew controls and actions are provided:

Table 5-4 Carriage Control with Blank, `0`, `1`, and `+`

Character	Vertical spacing before printing
Blank	One line
0	Two lines
1	To first line of next page
+	No advance (`stdout` only, not files)

If the first character of the format is not space, `0`, `1`, or `+`, then it is treated as a space, and it is not printed.

The behavior of the slew control character `+` is: if the character in the first column is `+`, it is replaced by a control sequence that causes printing to return to the first column of the previous line, where the rest of the input line is printed.

Space, `0`, `1`, and `+` work for `stdout` if piped through `asa`.

Example: First-character formatting, standard output piped through `asa`:

```
demo% cat slew1.f
       WRITE( *, '("abcd")')
       WRITE( *, '(" efg")')  ! The blank single spaces
       WRITE( *, '("0hij")')  ! The "0" double spaces
       WRITE( *, '("1klm")')  ! The "1" starts this on a new page
       WRITE( *, '("+", T5, "nop")')  ! The "+" starts this at col 1 of latest line
       END
demo% f77 -silent slew1.f
demo% a.out | asa | lpr
demo%
```

The program, `slew1.f` produces file, `slew1.out`, as printed by `lpr`:

Printer

```
bcd
efg

hij
-----------------------------------
klmnop          ← This starts on a new page.  The + of +nop is obeyed.
```

The results are different on a screen; the tabbing puts in spaces:

Screen

```
demo% cat slew1.out
bcd
efg

hij
-----------------------------------
   nop          ← This starts on a new page. The + of +nop is obeyed.
demo%
```

See `asa`(1).

The space, `0`, and `1`, and `+` work for a file opened with:

- Sequential access
- `FORM='PRINT'`

Example: First-character formatting, file output:

```
demo% cat slew2.f
       OPEN( 1,FILE='slew.out',FORM='PRINT' )
       WRITE( 1, '("abcd")')
       WRITE( 1, '("efg")')
       WRITE( 1, '("0hij")')
       WRITE( 1, '("1klm")')
       WRITE( 1, '("+", T5, "nop")')
       CLOSE( 1, STATUS='KEEP')
       END
demo% f77 -silent slew2.f
demo% a.out
```

The program, `slew2.f`, produces the file, `slew2.out`, that is equal to the file, `slew1.out`, in the example above.

Slew control codes `'0'`, `'1'`, and `'+'` in column one are in the output file as `'\n'`, `'\f'`, and `'\r'`, respectively.

*Character Editing (*A*)*

The A specifier is used for character type data items. The general form is:

```
A  [ w ]
```

On input, character data is stored in the corresponding list item.

On output, the corresponding list item is displayed as character data.

If *w* is omitted, then:

- For character data type variables, it assumes the size of the variable.
- For noncharacter data type variables, it assumes the maximum number of characters that fit in a variable of that data type. This is nonstandard behavior. ♦

Each of the following examples read into a size *n* variable (`CHARACTER*`*n*), for various values of *n*, for instance, for *n* = 9.

```
    CHARACTER C*9
    READ '( A7 )', C
```

The various values of *n*, in `CHARACTER C*`*n* are:

Size *n*	**9**	**7**	**4**	**1**
Data	`NodeΔId`	`NodeΔId`	`NodeΔId`	`NodeΔId`
Format	`A7`	`A7`	`A7`	`A7`
Memory	`NodeΔIdΔΔ`	`NodeΔId`	`eΔId`	`d`

Δ indicates a blank space.

Example: Output strings of 3, 5, and 7 characters, each in a 5 character field:

```
    PRINT 1, 'The', 'whole', 'shebang'
1   FORMAT( A5 / A5 / A5 )
    END
```

The above program displays:

```
ΔΔThe
whole
sheba
```

The maximum characters in noncharacter types are summarized in the following table.

Table 5-5 Maximum Characters in Noncharacter Type Hollerith (nHaaa)

Type of List Item	Maximum Number of Characters
BYTE	1
LOGICAL*1	1
LOGICAL*2	2
LOGICAL*4	4
LOGICAL*8	8
INTEGER*2	2
INTEGER*4	4
INTEGER*8	8
REAL	4
REAL*4	4
REAL*8	8
REAL*16 *(SPARC only)*	16
DOUBLE PRECISION	8
COMPLEX	8
COMPLEX*8	8
COMPLEX*16	16
COMPLEX*32 *(SPARC only)*	32
DOUBLE COMPLEX	16

In f77, you can use Hollerith constants wherever a character constant can be used in FORMAT statements, assignment statements, and DATA statements.♦ These constants are not recommended. FORTRAN 77 does not have these old Hollerith (*n* H) notations, although the FORTRAN 77 Standard recommends implementing the Hollerith feature to improve compatibility with old programs. But such constants cannot be used as input data elements in list-directed or NAMELIST input.

For example, these two formats are equivalent:

```
10  FORMAT( 8H Code = , A6 )
20  FORMAT( ' Code = ', A6 )
```

In f77, commas between edit descriptors are generally optional:

```
10  FORMAT( 5H flex 4Hible )
```

READs into Hollerith Edit Descriptors

For compatibility with older programs, f77 also allows READs into Hollerith edit descriptors. ♦

Example: Read into hollerith edit descriptor—no *list* in the READ statement:

```
demo% cat hol1.f
       WRITE( *, 1 )
1      FORMAT( 6Holder )
       READ( *, 1 )
       WRITE( *, 1 )
       END
demo% f77 hol1.f
hol1.f:
 MAIN
demo% a.out
older
newer
newer
demo%
```

In the above code, if the format is a runtime format (variable format), then the reading into the actual format does not work, and the format remains unchanged. Hence, the following program fails:

```
       CHARACTER F*18 / '(A8)' /
       READ(*,F)   ! ← Does not work.
       …
```

Obviously, there are better ways to read into the actual format.

Integer Editing (I)

The I specifier is used for decimal integer data items. The general form is:

```
I [w [ . m ] ]
```

The I *w* and I *w.m* edit specifiers indicate that the field to be edited occupies *w* positions. The specified input/output list item must be of type integer. On input, the specified list item becomes defined with an integer datum. On output, the specified list item must be defined as an integer datum.

On input, an I *w.m* edit specifier is treated identically to an I *w* edit specifier.

The output field for the I *w* edit specifier consists of:

- Zero or more leading blanks followed by
- Either a minus if the value is negative, or an optional plus, followed by
- The magnitude of the value in the form on an unsigned integer constant without leading zeros

An integer constant always has at least one digit.

The output field for the I *w.m* edit specifier is the same as for the I *w* edit specifier, except that the unsigned integer constant consists of at least *m* digits, and, if necessary, has leading zeros. The value of *m* must not exceed the value of *w*. If *m* is zero, and the value of the item is zero, the output field consists of only blank characters, regardless of the sign control in effect.

Example: int1.f, integer input:

```
      CHARACTER LINE*8 / '12345678' /
      READ( LINE, '(I2, I3, I2 )') I, J, K
      PRINT *, I, J, K
      END
```

The program above displays:

```
 12 345 67
```

Example: `int2.f`, integer output:

```
    N = 1234
    PRINT 1, N, N, N, N
1   FORMAT( I6 / I4 / I2 / I6.5 )
    END
```

The above program displays:

```
  1234
1234
**
01234
```

Logical Editing (L)

The `L` specifier is used for logical data items. The general form is:

```
 L  w
```

The `L` *w* edit specifier indicates that the field occupies *w* positions. The specified input/output list item must be of type `LOGICAL`. On input, the list item becomes defined with a logical datum. On output, the specified list item must be defined as a logical datum.

The input field consists of optional blanks, optionally followed by a decimal point, followed by a `T` for true, or `F` for false. The `T` or `F` can be followed by additional characters in the field. The logical constants, `.TRUE.` and `.FALSE.,` are acceptable as input. The output field consists of *w*-1 blanks followed by a `T` for true, or `F` for false.

Example: `log1.f`, logical output:

```
    LOGICAL A*1 /.TRUE./, B*2 /.TRUE./, C*4 /.FALSE./
    PRINT '( L1 / L2 / L4 )', A, B, C
    END
```

The program above displays:

```
T
ΔT
ΔΔΔF
```

Example: `log2.f`, logical input:

```
    LOGICAL*4 A
1   READ '(L8)', A
    PRINT *, A
    GO TO 1
    END
```

The program above accepts any of the following as valid input data:

```
t true T TRUE .t .t. .T .T. .TRUE. TooTrue
f false F FALSE .f .F .F. .FALSE. Flakey
```

Octal and Hexadecimal Editing (O, Z)

The `O` and `Z` field descriptors for a `FORMAT` statement are for octal and hexadecimal integers, respectively, but they can be used with any data type.♦

The general form is:

O*w*[.*m*]
Z*w*[.*m*]

where *w* is the number of characters in the external field. For output, *m*, if specified, determines the total number of digits in the external field; that is, if there are fewer than *m* nonzero digits, the field is zero-filled on the left to a total of *m* digits. *m* has no effect on input.

Octal and Hex Input

A READ, with the O or Z field descriptors in the FORMAT, reads in *w* characters as octal or hexadecimal, respectively, and assigns the value to the corresponding member of the I/O list.

Example: Octal input, the external data field is:

```
654321
```

↑ column 1

The program that does the input is:

```
   READ ( *, 2 ) M
2  FORMAT ( O6 )
```

The above data and program result in the octal value 654321 being loaded into the variable M. Further examples are included in the following table.

Table 5-6 Sample Octal/Hex Input Values

Format	External Field	Internal (Octal or Hex) Value
O4	1234Δ	1234
O4	16234	1623
O3	97ΔΔΔ	Error: “9” not allowed
Z5	A23DEΔ	A23DE
Z5	A23DEF	A23DE
Z4	95.AF2	Error: “.” not allowed

The general rules for octal and hex input are:

- For octal values, the external field can contain only numerals 0 through 7.
- For hexadecimal values, the external field can contain only numerals 0 through 9 and the letters A through F or a through f.
- Signs, decimal points, and exponent fields are not allowed.
- All-blank fields are treated as having a value of zero.
- If a data item is too big for the corresponding variable, an error message is displayed.

Octal and Hex Output

A WRITE, with the O or Z field descriptors in the FORMAT, writes out values as octal or hexadecimal integers, respectively. It writes to a field that is *w* characters wide, right-justified.

Example: Hex output:

```
    M = 161
    WRITE ( *, 8 ) M
8   FORMAT ( Z3 )
    END
```

The program above displays A1 (161 decimal = A1 hex):

```
ΔA1
```

↑ column 2

Further examples are included in the following table.

Table 5-7 Sample Octal / Hex Output Value

Format	Internal (Decimal) Value	External (Octal/Hex) Representation
O6	32767	Δ77777
O2	14251	**
O4.3	27	Δ033
O4.4	27	0033
O6	-32767	100001
Z4	32767	7FFF
Z3.3	2708	A94
Z6.4	2708	ΔΔ0A94
Z5	-32767	Δ8001

The general rules for octal and hex output are:

- Negative values are written as if unsigned; no negative sign is printed.
- The external field is filled with leading spaces, as needed, up to the width *w*.
- If the field is too narrow, it is filled with asterisks.
- If *m* is specified, the field is left-filled with leading zeros, to a width of *m*.

*Positional Editing (*T*, n*T*,* TR*n,* TL*n, n*X*)*

For horizontal positioning along the print line, f77 supports the forms:

TR*n*, TL*n*, T*n*, *n*T, T

where *n* is a strictly positive integer. The format specifier T can appear by itself, or be preceded or followed by a positive nonzero number.

T*n*—*Absolute Columns*

This tab reads from the *n*th column or writes to the *n*th column.

TL*n*—*Relative Columns*

This tab reads from the *n*th column to the *left* or writes to the *n*th column to the *left*.

TR*n*—*Relative Columns*

This tab reads from the *n*th column to the *right* or writes to the *n*th column to the *right*.

*n*TL—*Relative Tab Stop*

This tab tabs to the *n*th tab stop for both read and write. If *n* is omitted, this tab uses *n* = 1 and tabs to the *next* tab stop.

TL—*Relative Tab Stop*

This tab tabs to the *next* tab stop for both read and write. It is the same as the *n*TL with *n* omitted; it tabs to the *next* tab stop.

The rules and Restrictions for tabbing are:

- Tabbing right beyond the end of an input logical record is an error.
- Tabbing left beyond the beginning of an input logical record leaves the input pointer at the beginning of the record.
- Nondestructive tabbing is implemented for both internal and external formatted I/O. Nondestructive tabbing means that tabbing left or right on output does not destroy previously written portions of a record.

- Tabbing right on output causes unwritten portions of a record to be filled with blanks.
- Tabbing left requires that the logical unit allows a seek. Therefore, it is not allowed in I/O to or from a terminal or pipe.
- Likewise, nondestructive tabbing in either direction is possible only on a unit that can seek. Otherwise, tabbing right or spacing with the X edit specifier writes blanks on the output.
- Tab stops are hard-coded every eight columns.

*n*X—*Positions*

The *n*X edit specifier indicates that the transmission of the next character to or from a record is to occur at the position *n* characters forward from the current position.

On input, the *n*X edit specifier advances the record pointer by *n* positions, skipping *n* characters.

A position beyond the last character of the record can be specified if no characters are transmitted from such positions.

On output, the *n*X specifier writes *n* blanks.

The *n* defaults to 1.

Example: Input, T*n* (absolute tabs):

```
demo% cat rtab.f
      CHARACTER C*2, S*2
      OPEN( 1, FILE='mytab.data')
      DO I = 1, 2
          READ( 1, 2 ) C, S
2         FORMAT( T5, A2, T1, A2 )
          PRINT *, C, S
      END DO
      END
demo%
```

The two-line data file is:

```
demo% cat mytab.data
defguvwx
12345678
demo%
```

The run and the output are:

```
demo% a.out
uvde
5612
demo%
```

The above example first reads columns 5 and 6, then columns 1 and 2.

Example: Output T*n* (absolute tabs); this program writes an output file:

```
demo% cat otab.f
   CHARACTER C*20 / "12345678901234567890" /
   OPEN( 1, FILE='mytab.rep')
   WRITE( 1, 2 ) C, ":", ":"
2  FORMAT( A20, T10, A1, T20, A1 )
   END
demo%
```

The output file is:

```
demo% cat mytab.rep
123456789:123456789:
demo%
```

The above example writes 20 characters, then changes columns 10 and 20.

Example: Input, TR*n* and TL *n* (relative tabs)—the program reads:

```
demo% cat rtabi.f
       CHARACTER C, S, T
       OPEN( 1, FILE='mytab.data')
       DO I = 1, 2
          READ( 1, 2 ) C, S, T
2         FORMAT( A1, TR5, A1, TL4, A1 )
          PRINT *, C, S, T
       END DO
       END
demo%
```

The two-line data file is:

```
demo% cat mytab.data
defguvwx
12345678
demo%
```

The run and the output are:

```
demo% a.out
dwg
174
demo%
```

The above example reads column 1, then tabs right 5 to column 7, then tabs left 4 to column 4.

Example: Output TR *n* and TL *n* (relative tabs)—this program writes an output file:

```
demo% cat rtabo.f
    CHARACTER C*20 / "12345678901234567890" /
    OPEN( 1, FILE='rtabo.rep')
    WRITE( 1, 2 ) C, ":", ":"
2   FORMAT( A20, TL11, A1, TR9, A1 )
    END
demo%
```

The run shows nothing, but you can list the mytab.rep output file:

```
demo% cat rtabo.rep
123456789:123456789:
demo%
```

The above program writes 20 characters, tabs left 11 to column 10, then tabs right 9 to column 20.

Quotes Editing ("aaa"*)*

The quotes edit specifier is in the form of a character constant.♦ It causes characters to be written from the enclosed characters of the edit specifier itself, including blanks. A quotes edit specifier must not be used on input.

The width of the field is the number of characters contained in, but not including, the delimiting quotes. Within the field, two consecutive quotes with no intervening blanks are counted as a single quote. You can use apostrophes in a similar way.

Example: quote.f (two equivalent ways):

```
    WRITE( *, 1 )
1   FORMAT( 'This is a quote ".' )
    WRITE( *, 2 )
2   FORMAT( "This is a quote ""." )
    END
```

This program writes this message twice: `This is a quote ".`

Radix Control (R)

The format specifier is R or *n*R, where 2 ≤ *n* ≤36. ♦ If *n* is omitted, the default decimal radix is restored.

You can specify radixes other than 10 for formatted integer I/O conversion. The specifier is patterned after P, the scale factor for floating-point conversion. It remains in effect until another radix is specified or format interpretation is complete. The I/O item is treated as a 32-bit integer.

Example: Radix 16—the format for an unsigned, hex, integer, 10 places wide, zero-filled to 8 digits, is `(su, 16r, I10.8)`, as in:

SU is described in the section, “Sign Editing (SU, SP, SS, S)."

```
demo% cat radix.f
   integer i / 110 /
   write( *, 1 ) i
1  format( su, 16r, I10.8 )
   end
demo% f77 -silent radix.f
demo% a.out
 ΔΔ0000006e
demo%
```

Real Editing (D, E, F, G)

The D, E, F, and G specifiers are for decimal real data items.

D Editing

The D specifier is for the exponential form of decimal double-precision items. The general form is:

```
D [ w [ .d ] ]
```

The D *w* and D *w.d* edit specifiers indicate that the field to be edited occupies *w* positions. *d* indicates that the fractional part of the number (the part to the right of the decimal point) has *d* digits. However, if the input datum contains a decimal point, that decimal point overrides the *d* value.

On input, the specified list item becomes defined with a real datum. On output, the specified list item must be defined as a real datum.

In an output statement, the `D` edit descriptor does the same thing as the `E` edit descriptor, except that a `D` is used in place of an `E`. The output field for the `D` *w.d* edit specifier has the width *w*. The value is right-justified in that field. The field consists of zero or more leading blanks followed by either a minus if the value is negative, or an optional plus, followed by the magnitude of the value of the list item rounded to *d* decimal digits.

w must allow for a minus sign, at least one digit to the left of the decimal point, the decimal point, and *d* digits to the right of the decimal point. Therefore, it must be the case that $w \geq w+3$.

Example: Real input with `D` editing in the program, `Dinp.f`:

```
      CHARACTER LINE*24 / '12345678 23.5678 .345678' /
      READ( LINE, '( D8.3, D8.3, D8.3 )') R, S, T
      PRINT '( D10.3, D11.4, D13.6 )', R, S, T
      END
```

The above program displays:

```
0.123D+05 0.2357D+02 0.345678D+00
```

In the above example, the first input data item has no decimal point, so `D8.3` determines the decimal point. The other input data items have decimal points, so those decimal points override the `D` edit descriptor as far as decimal points are concerned.

Example: Real output with `D` editing in the program `Dout.f`:

```
      R = 1234.678
      PRINT 1, R, R, R
1     FORMAT( D9.3 / D8.4 / D13.4 )
      END
```

The above program displays:

```
0.123D+04
********
ΔΔΔ0.1235D+04
```

In the above example, the second printed line is asterisks because the `D8.4` does not allow for the sign; in the third printed line the `D13.4` results in three leading blanks.

E Editing

The `E` specifier is for the exponential form of decimal real data items. The general form is:

```
E [ w [ .d ] [ Ee ] ]
```

w indicates that the field to be edited occupies *w* positions.

d indicates that the fractional part of the number (the part to the right of the decimal point) has *d* digits. However, if the input datum contains a decimal point, that decimal point overrides the *d* value.

e indicates the number of digits in the exponent field. The default is 2.

The specified input/output list item must be of type real. On input, the specified list item becomes defined with a real datum. On output, the specified list item must be defined as a real datum.

The output field for the `E` *w.d* edit specifier has the width *w*. The value is right-justified in that field. The field consists of zero or more leading blanks followed by either a minus if the value is negative, or an optional plus, followed by a zero, a decimal point, the magnitude of the value of the list item rounded to *d* decimal digits, and an exponent.

For the form `E`*w*`.`*d*:

- If | exponent | ≤ 99, it has the form `E`±*nn* or `0`±*nn*.
- If 99 ≤ | exponent | ≤ 999, it has the form ±*nnn*.

For the form `E`*w*`.`*d*`E`*e*, if | exponent | ≤ (10^e) - 1, then the exponent has the form ±*nnn*.

For the form `D`*w*`.`*d*:

- If | exponent | ≤ 99, it has the form `D`±*nn* or `E`±*nn* or `0`±*nn*.
- If 99 ≤ | exponent | ≤ 999, it has the form ±*nnn*.

n is any digit.

The sign in the exponent is required.

w need not allow for a minus sign, but must allow for a zero, the decimal point, and *d* digits to the right of the decimal point, and an exponent. Therefore, for nonnegative numbers, $w \geq d+6$; if *e* is present, then $w \geq d+e+4$. For negative numbers, $w \geq d+7$; if *e* is present, then $w \geq d+e+5$.

Example: Real input with `E` editing in the program, `Einp.f`:

```
* 123456789 23456789012 23456789012
    CHARACTER L*40/'1234567E2 1234.67E-3 12.4567 '/
    READ( L, '( E9.3, E12.3, E12.6 )') R, S, T
    PRINT '( E15.6, E15.6, E15.7 )', R, S, T
    END
```

The above program displays:

```
ΔΔΔ0.123457E+06ΔΔΔ0.123467E+01ΔΔ0.1245670E+02
```

In the above example, the first input data item has no decimal point, so `E9.3` determines the decimal point. The other input data items have decimal points, so those decimal points override the `D` edit descriptor as far as decimal points are concerned.

Example: Real output with `E` editing in the program `Eout.f`:

```
    R = 1234.678
    PRINT 1, R, R, R
1   FORMAT( E9.3 / E8.4 / E13.4 )
    END
```

The above program displays:

```
0.123E+04
********
ΔΔΔ0.1235E+04
```

In the above example, `E8.4` does not allow for the sign, so we get asterisks. Also, the extra wide field of the `E13.4` results in three leading blanks.

Example: Real output with E*w.d*E*e* editing in the program `EwdEe.f`:

```
    REAL  X / 0.000789 /
    WRITE(*,'( E13.3)') X
    WRITE(*,'( E13.3E4)') X
    WRITE(*,'( E13.3E5)') X
    END
```

The above program displays:

```
ΔΔΔΔ0.789E-03
ΔΔ0.789E-0003
Δ0.789E-00003
```

F Editing

The `F` specifier is for decimal real data items. The general form is:

```
    F [ w [ .d ] ]
```

The F*w* and F*w.d* edit specifiers indicate that the field to be edited occupies *w* positions.

d indicates that the fractional part of the number (the part to the right of the decimal point) has *d* digits. However, if the input datum contains a decimal point, that decimal point overrides the *d* value.

The specified input/output list item must be of type real. On input, the specified list item becomes defined with a real datum. On output, the specified list item must be defined as a real datum.

The output field for the F *w.d* edit specifier has the width *w*. The value is right-justified in that field. The field consists of zero or more leading blanks followed by either a minus if the value is negative, or an optional plus, followed by the magnitude of the value of the list item rounded to *d* decimal digits.

w must allow for a minus sign, at least one digit to the left of the decimal point, the decimal point, and *d* digits to the right of the decimal point. Therefore, it must be the case that $w \geq d+3$.

Example: Real input with F editing in the program `Finp.f`:

```
    CHARACTER LINE*24 / '12345678 23.5678 .345678' /
    READ( LINE, '( F8.3, F8.3, F8.3 )') R, S, T
    PRINT '( F9.3, F9.4, F9.6 )', R, S, T
    END
```

The program displays:

```
12345.678DD23.5678D0.345678
```

In the above example, the first input data item has no decimal point, so `F8.3` determines the decimal point. The other input data items have decimal points, so those decimal points override the F edit descriptor as far as decimal points are concerned.

Example: Real output with F editing in the program `Fout.f`:

```
    R = 1234.678
    PRINT 1, R, R, R
1   FORMAT( F9.3 / F8.4 / F13.4 )
    END
```

The above program displays:

```
∆1234.678
********
∆∆∆∆1234.6780
```

In the above example, F8.4 does not allow for the sign; F13.4 results in four leading blanks and one trailing zero.

G Editing

The G specifier is for decimal real data items. The general form is:

```
G [ w [ .d ] ]
or:
G w.d E e
```

The D, E, F, and G edit specifiers interpret data in the same way.

The representation for output by the G edit descriptor depends on the magnitude of the internal datum. In the following table, *N* is the magnitude of the internal datum.

Range	Form
$0.1 \le N < 1.0$	F(*w*-4).*d*, *n*(Δ)
$1.0 \le N < 10.0$	F(*w*-4).(*d*-1), *n*(Δ)
…	…
$10^{(d-2)} \le N \le 10^{(d-1)}$	F(*w*-4).1, *n*(Δ)
$10^{(d-1)} \le N < 10^{d}$	F(*w*-4).0, *n*(Δ)

Commas in Formatted Input

If you are entering numeric data that is controlled by a fixed-column format, then you can use commas to override any exacting column restrictions.

Example: Format:

```
    (I10, F20.10, I4)
```

Using the above format reads the following record correctly:

```
–345,.05e–3,12
```

The I/O system is just being more lenient than described in the FORTRAN 77 Standard. In general, when doing a *formatted* read of *noncharacter* variables, commas override field lengths. More precisely, for the I*w*, F*w.d*, E*w.d*[E*e*], and G*w.d* input fields, the field ends when *w* characters have been scanned, or a comma has been scanned, whichever occurs first. If it is a comma, the field consists of the characters up to, but not including, the comma; the next field begins with the character following the comma.

*Remaining Characters (*Q*)*

The Q edit descriptor gets the length of an input record or the remaining portion of it that is unread. ♦ It gets the number of characters remaining to be read from the current record.

Example: From a real and a string, get: real, string length, and string:

```
demo% cat qed1.f
* qed1.f Q edit descriptor (real & string)
   CHARACTER CVECT(80)*1
   OPEN ( UNIT=4, FILE='qed1.data' )
   READ ( 4, 1 ) R, L, ( CVECT(I), I=1,L )
1  FORMAT ( F4.2, Q, 80 A1 )
   WRITE ( *, 2 ) R, L, '"', (CVECT(I),I=1,L), '"'
2  FORMAT ( 1X, F7.2, 1X, I2, 1X, 80A1 )
   END
demo% cat qed1.data
8.10qwerty
demo% f77 qed1.f -o qed1
qed1.f:
 MAIN:
demo% qed1
   8.10 6 "qwerty"
demo%
```

The above program reads a field into the variable R, then reads the number of characters remaining after that field into L, then reads L characters into CVECT. Q as the *n*th edit descriptor matches with L as the *n*th element in the READ list.

Example: Get length of input record; put the Q descriptor first:

```
demo% cat qed2.f
       CHARACTER CVECT(80)*1
       OPEN ( UNIT=4, FILE='qed2.data' )
       READ ( 4, 1 ) L, ( CVECT(I), I=1,L )
1      FORMAT ( Q, 80A1 )
       WRITE ( *, 2 ) L, '"', (CVECT(I),I=1,L), '"'
2      FORMAT ( 1X, I2, 1X, 80A1 )
       END
demo% cat qed2.data
qwerty
demo% f77 qed2.f -o qed2
qed2.f:
 MAIN:
demo% qed2
  6 "qwerty"
demo%
```

The above example gets the length of the input record. With the whole input string and its length, you can then parse it yourself.

Several restrictions on the Q edit descriptor apply:

- The list element Q corresponds to must be of INTEGER or LOGICAL data type.
- Q does strictly a character count. It gets the number of characters remaining in the input record, and does not get the number of integers or reals or anything else.
- The Q edit descriptor cannot be applied for pipe files, as Q edit requires that the file be rereadable.
- This descriptor operates on files and stdin (terminal) input.
- This descriptor is ignored for output.

Scale Factor (P)

The P edit descriptor scales real input values by a power of 10. It also gives you more control over the significant digit displayed for output values.

The general form is:

[*k*] P	
k	Integer constant, with an optional sign

k is called the scale factor, and the default value is zero.

Example: I/O statements with scale factors:

```
    READ ( 1, '( 3P E8.2 )' ) X
    WRITE ( 1, '( 1P E8.2 )' ) X
```

P by itself is equivalent to 0P. It resets the scale factor to the default value 0P. This P by itself is nonstandard.

Scope

The scale factor is reset to zero at the start of execution of each I/O statement. The scale factor can have an effect on D, E, F, and G edit descriptors.

Input

On input, any external datum that does not have an exponent field is divided by 10*k* before it is stored internally.

Input examples: Showing data, scale factors, and resulting value stored:

Data	18.63	18.63	18.63E2	18.63
Format	E8.2	3P E8.2	3P E8.2	-3P E8.2
Memory	18.63	.01863	18.63E2	18630.

Output

On output, with D, and E descriptors, and with G descriptors if the E editing is required, the internal item gets its basic real constant part multiplied by 10^k, and the exponent is reduced by *k* before it is written out.

On output with the F descriptor and with G descriptors, if the F editing is sufficient, the internal item gets its basic real constant part multiplied by 10^k before it is written out.

Output Examples: Showing value stored, scale factors, and resulting output:

Memory	290.0	290.0	290.0	290.0
Format	2P E9.3	1P E9.3	-1P E9.3	F9.3
Display	29.00E+01	2.900E+02	0.029E+04	0.290E+03

*Sign Editing (*SU, SP, SS, S*)*

The SU, SP, and S edit descriptors control leading signs for output. For normal output, without any specific sign specifiers, if a value is negative, a minus sign is printed in the first position to the left of the leftmost digit; if the value is positive, printing a plus sign depends on the implementation, but f77 omits the plus sign.

The following sign specifiers are available:

- SP—If SP precedes a specification, a sign is printed.
- SS—If SS precedes a specification, plus-sign printing is suppressed.
- S—If S precedes a specification, the system default is restored. The default is SS.
- SU—If SU precedes a specification, integer values are interpreted as unsigned. This is nonstandard. ♦

For example, the unsigned specifier can be used with the radix specifier to format a hexadecimal dump, as follows:

```
2000 FORMAT( SU, 16R, 8I10.8 )
```

The rules and restrictions for sign control are:

- Sign-control specifiers apply to output only.
- A sign-control specifier remains in effect until another sign-control specifier is encountered, or format interpretation is complete.
- The S, SP, and SS specifiers affect only I, F, E, D, and G editing.
- The SU specifier affects only I editing.

Slash Editing (/)

The slash (/) edit specifier indicates the end of data transfer on the current record.

Sequential Access

On input, any remaining portion of the current record is skipped, and the file is positioned at the beginning of the next record. Two successive slashes (//) skip a whole record.

On output, an end-of-record is written, and a new record is started. Two successive slashes (//) produce a record of no characters. If the file is an internal file, that record is filled with blanks.

Direct Access

Each slash increases the record number by one, and the file is positioned at the start of the record with that record number.

On output, two successive slashes (//) produce a record of no characters, and that record is filled with blanks.

Termination Control (:)

The colon (:) edit descriptor allows for conditional termination of the format. If the I/O list is exhausted before the format, then the format terminates at the colon.

Example: Termination control:

```
* col1.f The colon (:) edit descriptor
    DATA INIT / 3 /, LAST / 8 /
    WRITE ( *, 2 ) INIT
    WRITE ( *, 2 ) INIT, LAST
2   FORMAT ( 1X 'INIT = ', I2, :, 3X, 'LAST = ', I2 )
    END
```

The above program produces output like the following

```
    INIT = 3
    INIT = 3 LAST = 8
```

Without the colon, the output is more like this:

```
    INIT = 3 LAST =
    INIT = 3 LAST = 8
```

Runtime Formats

You can put the format specifier into an object that you can change during execution. Doing so improves flexibility. There is some increase in execution time because this kind of format specifier is parsed every time the I/O statement is executed. These are also called variable formats.

The object must be one of the following kinds:

- **Character expression**—The character expression can be a scalar, an array, an element of an array, a substring, a field of a structured record ♦, the concatenation of any of the above, and so forth.
- **Integer array ♦**—The integer array can get its character values by a `DATA` statement, an assignment statement, a `READ` statement, and so forth.

You must provide the delimiting left and right parentheses, but not the word `FORMAT`, and not a statement number.

You must declare the object so that it is big enough to hold the entire format. For instance, `'(8X,12I)'` does not fit in an `INTEGER*4` or a `CHARACTER*4` object.

Examples: Runtime formats in character expressions and integer arrays:

```
demo% cat runtim.f
    CHARACTER CS*8
    CHARACTER CA(1:7)*1 /'(','1','X',',','I','2',')'/
    CHARACTER S(1:7)*6
    INTEGER*4 IA(2)
    STRUCTURE / STR /
        CHARACTER*4 A
        INTEGER*4 K
    END STRUCTURE
    CHARACTER*8 LEFT, RIGHT
    RECORD /STR/ R
    N = 9
    CS = '(I8)'
    WRITE( *, CS ) N ! Character Scalar
    CA(2) = '6'
    WRITE( *, CA ) N ! Character Array
    S(2) = '(I8)'
    WRITE( *, S(2) ) N ! Element of Character Array
    IA(1) = '(I8)'
    WRITE(*, IA ) N ! Integer Array
    R.A = '(I8)'
    WRITE( *, R.A ) N ! Field Of Record
    LEFT = '(I'
    RIGHT = '8)'
    WRITE(*, LEFT // RIGHT ) N ! Concatenate
    END
demo% f77 -silent runtim.f
demo% a.out
       9
       9
       9
       9
       9
       9
demo%
```

Variable Format Expressions (<e>)

In general, inside a FORMAT statement, any integer constant can be replaced by an arbitrary expression. ♦

The expression itself must be enclosed in angle brackets.

For example, the 6 in:

```
1   FORMAT( 3F6.1 )
```

can be replaced by the variable N, as in:

```
1   FORMAT( 3F<N>.1 )
```

or by the slightly more complicated expression 2*N+M, as in:

```
1   FORMAT( 3F<2*N+M>.1 )
```

Similarly, the 3 or 1 can be replaced by any expression.

The single exception is the *n* in an *n*H… edit descriptor.

The rules and restrictions for variable format expressions are:

- The expression is reevaluated each time it is encountered in a format scan.
- If necessary, the expression is converted to integer type.
- Any valid FORTRAN 77 expression is allowed, including function calls.
- Variable expressions are not allowed in formats generated at runtime.
- The *n* in an *n*H… edit descriptor cannot be a variable expression.

5.5 Unformatted I/O

Unformatted I/O is used to transfer binary information to or from memory locations without changing its internal representation. Each execution of an unformatted I/O statement causes a single logical record to be read or written. Since internal representation varies with different architectures, unformatted I/O is limited in its portability.

You can use unformatted I/O to write data out temporarily, or to write data out quickly for subsequent input to another FORTRAN 77 program running on a machine with the same architecture.

Sequential Access I/O

Logical record length for unformatted, sequential files is determined by the number of bytes required by the items in the I/O list. The requirements of this form of I/O cause the external physical record size to be somewhat larger than the logical record size.

Example:

```
    WRITE( 8 ) A, B
```

The FORTRAN 77 runtime system embeds the record boundaries in the data by inserting an `INTEGER*4` byte count at the beginning and end of each unformatted sequential record during an unformatted sequential `WRITE`. The trailing byte count enables `BACKSPACE` to operate on records. The result is that FORTRAN 77 programs can use an unformatted sequential `READ` only on data that was written by an unformatted sequential `WRITE` operation. Any attempt to read such a record as formatted would have unpredictable results.

Here are some guidelines:

- Avoid using the unformatted sequential `READ` unless your file was written that way.
- Because of the extra data at the beginning and end of each unformatted sequential record, you might want to try using the unformatted direct `I/O` whenever that extra data is significant. It is more significant with short records than with very long ones.

Direct Access I/O

If your I/O lists are different lengths, you can `OPEN` the file with the `RECL=1` option. This signals FORTRAN 77 to use the I/O list to determine how many items to read or write.

For each read, you still must tell it the initial record to start at, in this case which byte, so you must know the size of each item. ♦

A simple example follows.

Example: Direct access—write 3 records, 2 integers each:

```
demo% cat Direct1.f
       integer u/4/, v /5/, w /6/, x /7/, y /8/, z /9/
       open( 1, access='DIRECT', recl=8 )
       write( 1, rec=1 ) u, v
       write( 1, rec=2 ) w, x
       write( 1, rec=3 ) y, z
       end
demo% f77 -silent Direct1.f
demo% a.out
demo%
```

Example: Direct access—read 3 records, 2 integers each:

If you know record length is *n*, then you can use the `recl=`*n* option.

Here you read it as it was written.

This method is simpler, easier, and better.

```
demo% cat Direct2.f
       integer u, v, w, x, y, z
       open( 1, access='DIRECT', recl=8 )
       read( 1, rec=1 ) u, v
       read( 1, rec=2 ) w, x
       read( 1, rec=3 ) y, z
       write(*,*) u, v, w, x, y, z
       end
demo% f77 -silent Direct2.f
demo% a.out
  4  5  6  7  8  9
demo%
```

Example: Direct-access read, variable-length records, `recl=1`:

If you know the size of each item, but not the record length, then you can use the `recl=1` option.

Here you can read it using different record lengths than it was written with.

This method is trickier.

```
demo% cat Direct3.f
       integer u, v, w, x, y, z
       open( 1, access='DIRECT', recl=1 )
       read( 1, rec=1 ) u, v, w
       read( 1, rec=13 ) x, y, z
       write(*,*) u, v, w, x, y, z
       end
demo% f77 -silent Direct3.f
demo% a.out
  4  5  6  7  8  9
demo%
```

In the above example, after reading 3 integers (12 bytes), you start the next read at record 13.

5.6 List-Directed I/O

List-directed I/O is a free-form I/O for sequential access devices. To get it, use an asterisk as the format identifier, as in:

```
READ( 6, * ) A, B, C
```

Note these rules for list-directed input:

- On input, values are separated by strings of blanks and, possibly, a comma.
- Values, except for character strings, cannot contain blanks.
- Character strings can be quoted strings, using pairs of quotes ("), pairs of apostrophes ('), or unquoted strings (see "Unquoted Strings"), but *not* hollerith (*n*Hxyz) strings.
- End-of-record counts as a blank, except in character strings, where it is ignored.
- Complex constants are given as two real constants separated by a comma and enclosed in parentheses.
- A null input field, such as between two consecutive commas, means that the corresponding variable in the I/O list is not changed.
- Input data items can be preceded by repetition counts, as in:

```
4*(3.,2.) 2*, 4*'hello'
```

The above input stands for 4 complex constants, 2 null input fields, and 4 string constants.

- A slash (/) in the input list terminates assignment of values to the input list during list-directed input, and the remainder of the current input line is skipped. Any text that follows the slash is ignored and can be used to comment the data line.

Output Format

List-directed output provides a quick and easy way to print output without fussing with format details. If you need exact formats, use formatted I/O. A suitable format is chosen for each item, and where a conflict exists between complete accuracy and simple output form, the simple form is chosen.

Note these rules for list-directed output:

- In general, each record starts with a blank space. For a *print* file, that blank is not printed. See "Printing Files," for details. ♦
- Character strings are printed as is. They are not enclosed in quotes, so only certain forms of strings can be read back using list-directed input. These forms are described in the next section.
- A number with no exact binary representation is rounded off.

  Example: No exact binary representation:

```
demo% cat lis5.f
    READ ( 5, * ) X
    WRITE( 6, * ) X, '    beauty'
    WRITE( 6, 1 ) X
1   FORMAT( 1X, F13.8, ' truth' )
    END
demo% f77 lis5.f
lis5.f:
 MAIN:
demo% a.out
1.4
    1.40000000 beauty
    1.39999998 truth
demo%
```

In the above example, if you need accuracy, specify the format.

Also note:

- Output lines longer than 80 characters are avoided where possible.
- Complex and double complex values include an appropriate comma.
- Real, double, and quadruple precision values are formatted differently.

- A backslash-n (\n) in a character string is output as a carriage return, unless the –xl option is on, and then it is output as a backslash-n(\n).

Example: List-directed I/O and backslash-n, with and without -xl:

```
demo% cat f77 bslash.f
       CHARACTER S*8 / '12\n3' /
       PRINT *, S
       END
demo%
```

Without –xl, \n prints as a carriage return:

```
demo% f77 -silent bslash.f
demo% a.out
12
3
demo%
```

With –xl, \n prints as a character string:

```
demo% f77 -xl -silent bslash.f
demo% a.out
12\n3
demo%
```

Table 5-8 Default Formats for List-Directed Output

Type	Format
BYTE	Two blanks followed by the number
CHARACTER*n	An {n = length of character expression}
COMPLEX	'ΔΔ(', 1PE14.5E2, ',', 1PE14.5E2, ')'
COMPLEX*16	'ΔΔ(', 1PE22.13.E2, ',', 1PE22.13.E2, ')'
COMPLEX*32 (*SPARC only*)	'ΔΔ(', 1PE44.34E3, ',', 1PE44.34E3, ')'
INTEGER*2	Two blanks followed by the number
INTEGER*4	Two blanks followed by the number
INTEGER*8	Two blanks followed by the number
LOGICAL*1	Two blanks followed by the number
LOGICAL*2	L3
LOGICAL*4	L3
LOGICAL*8	L3
REAL	1PE14.5E2
REAL*8	1PE22.13.E2
REAL*16 (*SPARC only*)	1PE44.34E4

Unquoted Strings

f77 list-directed I/O allows reading of a string not enclosed in quotes. ♦

The string must not start with a digit, and cannot contain separators (commas or slashes (/)) or whitespace (spaces or tabs). A newline terminates the string unless escaped with a backslash (\). Any string not meeting the above restrictions must be enclosed in single or double quotes.

Example: List-directed input of unquoted strings:

```
      CHARACTER C*6, S*8
      READ *, I, C, N, S
      PRINT *, I, C, N, S
      END
```

The above program, `unquoted.f`, reads and displays as follows:

```
demo% a.out
23 label 82 locked
  23label 82locked
demo%
```

Internal I/O

`f77` extends list-directed I/O to allow internal I/O. ♦

During internal, list-directed reads, characters are consumed until the input list is satisfied or the end-of-file is reached. During internal, list-directed writes, records are filled until the output list is satisfied. The length of an internal array element should be at least 20 characters to avoid logical record overflow when writing double-precision values. Internal, list-directed read was implemented to make command line decoding easier. Internal, list-directed output should be avoided.

5.7 NAMELIST I/O

`NAMELIST` I/O produces format-free input or output of whole groups of variables, or input of selected items in a group of variables. ♦

The `NAMELIST` statement defines a group of variables or arrays. It specifies a group name, and lists the variables and arrays of that group.

Syntax Rules

The syntax of the `NAMELIST` statement is:

`NAMELIST /`*group-name*`/`*namelist*`[[,]/`*group-name*`/`*namelist*`]...`	
group-name	Identifier
namelist	List of variables or arrays, separated by commas

Example: NAMELIST statement:

```
    CHARACTER*18 SAMPLE
    LOGICAL*4 NEW
    REAL*4 DELTA
    NAMELIST /CASE/ SAMPLE, NEW, DELTA
```

A variable or array can be listed in more than one NAMELIST group.

The input data can include array elements and strings. It can include substrings in the sense that the input constant data string can be shorter than the declared size of the variable.

Restrictions

group name can appear in only the NAMELIST, READ, or WRITE statements, and must be unique for the program.

list cannot include constants, dummy arguments, array elements, structures, substrings, records, record fields, pointers, or pointer-based variables.

Example: A variable in two NAMELIST groups:

```
    REAL ARRAY(4,4)
    CHARACTER*18 SAMPLE
    LOGICAL*4 NEW
    REAL*4 DELTA
    NAMELIST /CASE/ SAMPLE, NEW, DELTA
    NAMELIST /GRID/ ARRAY, DELTA
```

In the above example, DELTA is in the group CASE and in the group GRID.

Output Actions

NAMELIST output uses a special form of WRITE statement, which makes a report that shows the group name. For each variable of the group, it shows the name and current value in memory. It formats each value according to the type of each variable, and writes the report so that NAMELIST input can read it.

The syntax of NAMELIST WRITE is:

```
WRITE ( extu, namelist-specifier [, iostat] [, err])
```

where *namelist-specifier* has the form:

```
[NML=]group-name
```

and *group-name* has been previously defined in a NAMELIST statement.

The NAMELIST WRITE statement writes values of all variables in the group, in the same order as in the NAMELIST statement.

Example: NAMELIST output:

```
demo% cat nam1.f
* nam1.f Namelist output
    CHARACTER*8 SAMPLE
    LOGICAL*4 NEW
    REAL*4 DELTA
    NAMELIST /CASE/ SAMPLE, NEW, DELTA
    DATA SAMPLE /'Demo'/, NEW /.TRUE./, DELTA /0.1/
    WRITE ( *, CASE )
    END
demo% f77 nam1.f
f77 nam1.f
nam1.f:
 MAIN:
demo% a.out
Δ&case sample= Demo , new= T, delta= 0.100000
Δ&end
demo%
```

↑ column 2

Note that if you do omit the keyword NML then the unit parameter must be first, *namelist-specifier* must be second, and there must *not* be a format specifier.

The `WRITE` can have the form of the following example:

```
    WRITE ( UNIT=6, NML=CASE )
```

Input Actions

The `NAMELIST` input statement reads the next external record, skipping over column one, and looking for the symbol `$` in column two or beyond, followed by the group name specified in the `READ` statement.

If the $*group-name* is not found, the input records are read until end of file.

The records are input and values assigned by matching names in the data with names in the group, using the data types of the variables in the group.

Variables in the group that are not found in the input data are unaltered.

The syntax of `NAMELIST READ` is:

```
READ ( extu, namelist-specifier [, iostat] [, err] [, end])
```

where *namelist-specifier* has the form:

```
[NML=]group-name
```

and *group-name* has been previously defined in a `NAMELIST` statement.

Example: `NAMELIST` input:

```
    CHARACTER*14 SAMPLE
    LOGICAL*4 NEW
    REAL*4 DELTA, MAT(2,2)
    NAMELIST /CASE/ SAMPLE, NEW, DELTA, MAT
    READ ( 1, CASE )
```

In this example, the group CASE consists of the variables, SAMPLE, NEW, DELTA, and MAT. If you do omit the keyword NML, then you must also omit the keyword UNIT. The unit parameter must be first, *namelist-specifier* must be second, and there must *not* be a format specifier.

The READ can have the form of the following example:

```
    READ ( UNIT=1, NML=CASE )
```

Data Syntax

The first record of NAMELIST input data has the special symbol $ (dollar sign) in column two or beyond, followed by the NAMELIST group name. This is followed by a series of assignment statements, starting in or after column two, on the same or subsequent records, each assigning a value to a variable (or one or more values to array elements) of the specified group. The input data is terminated with another $ in or after column two, as in the pattern:

```
Δ$group-name variable=value  [,variable=value,…] $[END]
```

You can alternatively use an ampersand (&) in place of each dollar sign, but the beginning and ending delimiters must match. END is an optional part of the last delimiter.

The input data assignment statements must be in one of the following forms:

```
variable=value
array=value1[, value2,]…
array(subscript)=value1[, value2,]…
array(subscript,subscript)=value1[, value2,]…
variable=character constant
variable(index:index)=character constant
```

If an array is subscripted, it must be subscripted with the appropriate number of subscripts: 1, 2, 3,…

Use quotes (either " or ') to delimit character constants. For more on character constants, see the next section.

The following is sample data to be read by the program segment above:

```
Δ$case delta=0.05, mat( 2, 2 ) = 2.2, sample='Demo' $
```

↑ column 2

The data could be on several records:

Here NEW was not input, and the order is not the same as in the example NAMELIST statement.

```
Δ$case
Δdelta=0.05
Δmat( 2, 2 ) = 2.2
Δsample='Demo'
Δ$
```

↑ column 2

Syntax Rules

The following syntax rules apply for input data to be read by NAMELIST:

- The variables of the named group can be in any order, and any can be omitted.
- The data must start in or after column two. Column one is totally ignored.
- There must be at least one comma, space, or tab between variables, and one or more spaces or tabs are the same as a single space. Consecutive commas are not permitted before a variable name. Spaces before or after a comma have no effect.
- No spaces or tabs are allowed inside a group name or a *variable* name, except around the commas of a subscript, around the colon of a substring, and after the (and before the) marks. No name can be split over two records.
- The end of a record acts like a space character.

Note an exception—in a character constant, it is ignored, and the character constant is continued with the next record. The last character of the current record is immediately followed by the second character of the next record. The first character of each record is ignored.

- The equal sign of the assignment statement can have zero or more blanks or tabs on each side of it.
- Only *constant* values can be used for subscripts, range indicators of substrings, and the values assigned to variables or arrays. You cannot use a symbolic constant (parameter) in the actual input data.

Hollerith, octal, and hexadecimal constants are not permitted.

Each constant assigned has the same form as the corresponding FORTRAN 77 constant.

There must be at least one comma, space, or tab between constants. Zero or more spaces or tabs are the same as a single space. You can enter: `1,2,3`, or `1 2 3`, or `1,  2,  3`, and so forth.

Inside a character constant, consecutive spaces or tabs are preserved, not compressed.

A character constant is delimited by apostrophes (`'`) or quotes (`"`), but if you start with one of those, you must finish that character constant with the same one. If you use the apostrophe as the delimiter, then to get an apostrophe in a string, use two consecutive apostrophes.

Example: Character constants:

```
∆sample='use "$" in 2'(Goes in as: use $ in 2)
∆sample='don''t'       (Goes in as: don't)
∆sample="don''t"       (Goes in as: don''t)
∆sample="don't"        (Goes in as: don't)
```

A complex constant is a pair of real or integer constants separated by a comma and enclosed in parentheses. Spaces can occur only around the punctuation.

A logical constant is any form of true or false value, such as `.TRUE.` or `.FALSE.`, or any value beginning with `.T`, `.F`, and so on.

A null data item is denoted by two consecutive commas, and it means the corresponding array element or complex variable value is not to be changed. Null data item can be used with array elements or complex variables only. One null data item represents an entire complex constant; you cannot use it for either part of a complex constant.

Example: NAMELIST input with some null data:

```
* nam2.f Namelist input with consecutive commas
    REAL ARRAY(4,4)
    NAMELIST /GRID/ ARRAY
    WRITE ( *, * ) 'Input?'
    READ ( *, GRID )
    WRITE ( *, GRID )
    END
```

The data for nam2.f is:

```
∆$GRID ARRAY = 9,9,9,9,,,,,8,8,8,8 $
```

↑ column 2 ↑ 5 consecutive commas

This code loads 9s into row 1, skips 4 elements, and loads 8s into row 3 of ARRAY.

Arrays Only

The forms *r**c* and *r** can be used only with an array.

The form *r**c* stores *r* copies of the constant *c* into an array, where *r* is a nonzero, unsigned integer constant, and *c* is any constant.

Example: NAMELIST with repeat-factor in data:

```
* nam3.f Namelist "r*c" and "r* "
     REAL PSI(10)
     NAMELIST /GRID/ PSI
     WRITE ( *, * ) 'Input?'
     READ ( *, GRID )
     WRITE ( *, GRID )
     END
```

The input for nam3.f is:

```
∆$GRID PSI = 5*980 $
```

↑ column 2

The program, nam3.f, reads the above input and loads 980.0 into the first 5 elements of the array PSI.

- The form *r** skips *r* elements of an array (that is, does *not* change them), where *r* is an unsigned integer constant.

Example: NAMELIST input with some skipped data.

The other input is:

```
∆$GRID PSI = 3* 5*980 $
```

↑ column 2

The program, nam3.f, with the above input, skips the first 3 elements and loads 980.0 into elements 4,5,6,7,8 of PSI.

Name Requests

If your program is doing NAMELIST input from the terminal, you can request the group name and NAMELIST names that it accepts.

To do so, enter a question mark (?) in column two and press Return. The group name and variable names are then displayed. The program then waits again for input.

Example: Requesting names:

```
demo% cat nam4.f
* nam4.f Namelist: requesting names
    CHARACTER*14 SAMPLE
    LOGICAL*4 NEW
    REAL*4 DELTA
    NAMELIST /CASE/ SAMPLE, NEW, DELTA
    WRITE ( *, * ) 'Input?'
    READ ( *, CASE )
    END
demo% f77 -silent nam4.f
demo% a.out
  Input?
Δ?
Δ$case
Δsample
Δnew
Δdelta
D

Δ$case sample="Test 2", delta=0.03 $
demo%
```

User input 1 → (line "Δ?")

User input 2 → (line "Δ$case sample=...")

↑ column 2

Intrinsic Functions 6

This chapter contains a number of tables on intrinsic functions, as well as some explanatory notes. It is organized into the following sections:

6.1 Arithmetic and Mathematical Functions

This section provides details on arithmetic functions, type conversions, trigonometric functions, and other functions.

Arithmetic

Table 6-1 Arithmetic Functions

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Names	Argument Type	Function Type
Truncation See Note (1).	int(a)	1	AINT	AINT DINT QINT ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Nearest whole number	int(a+.5) if a ≥ 0 int(a-.5) if a < 0	1	ANINT	ANINT DNINT QNINT ♦	REAL DOUBLE REAL*16 *(SPARC only)*	REAL DOUBLE REAL*16
Nearest integer	int(a+.5) if a ≥ 0 int(a-.5) if a < 0	1	NINT	NINT IDNINT IQNINT ♦	REAL DOUBLE REAL*16	INTEGER INTEGER INTEGER

Table 6-2 More Arithmetic Functions

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Name	Argument Type	Function Type
Absolute value See Note (6).	|a| $(ar^2 + ai^2)^{**}(1/2)$	1	ABS	IABS ABS DABS CABS QABS ♦ ZABS ♦ CDABS ♦ CQABS ♦	INTEGER REAL DOUBLE COMPLEX REAL*16 COMPLEX*16 COMPLEX*16 COMPLEX*32	INTEGER REAL DOUBLE REAL REAL*16 DOUBLE DOUBLE REAL*16
Remainder See Note (1).	a1-int(a1/a2)*a2	2	MOD	MOD AMOD DMOD QMOD ♦	INTEGER REAL DOUBLE REAL*16	INTEGER REAL DOUBLE REAL*16
Transfer of sign	|a1| if a2 ≥ 0 -|a1| if a2 < 0	2	SIGN	ISIGN SIGN DSIGN QSIGN ♦	INTEGER REAL DOUBLE REAL*16	INTEGER REAL DOUBLE REAL*16

Table 6-2 More Arithmetic Functions *(Continued)*

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Name	Argument Type	Function Type

Positive difference	a1-a2 if a1 > a2
	0 if a1 ≤ a2
		2	`DIM`	`IDIM`
				`DIM`
				`DDIM`
				`QDIM` ♦
					`INTEGER`
					`REAL`
					`DOUBLE`
					`REAL*16`
						`INTEGER`
						`REAL`
						`DOUBLE`
						`REAL*16`

Double and quad products	a1 * a2	2	-	`DPROD` `QPROD` ♦	`REAL` `DOUBLE`	`DOUBLE` `REAL*16`

Choosing largest value	max(a1, a2, …)	≥ 2	`MAX`	`MAX0`
				`AMAX1`
				`DMAX1`
				`QMAX1` ♦
				`AMAX0`
				`MAX1`
					`INTEGER`
					`REAL`
					`DOUBLE`
					`REAL*16`
					`INTEGER`
					`REAL`
						`INTEGER`
						`REAL`
						`DOUBLE`
						`REAL*16`
						`REAL`
						`INTEGER`

Choosing smallest value	min(a1, a2, …)	≥ 2	`MIN`	`MIN0`
				`AMIN1`
				`DMIN1`
				`QMIN1` ♦
				`AMIN0`
				`MIN1`
					`INTEGER`
					`REAL`
					`DOUBLE`
					`REAL*16`
					`INTEGER`
					`REAL`
						`INTEGER`
						`REAL`
						`DOUBLE`
						`REAL*16`
						`REAL`
						`INTEGER`

Type Conversion

Table 6-3 Type Conversion Functions

Conversion to	No. of Arguments	Generic Name	Specific Name	Argument Type	Function Type
INTEGER See Note (1).	1	INT	- INT IFIX IDINT - - - IQINT ♦	INTEGER REAL REAL DOUBLE COMPLEX COMPLEX*16 COMPLEX*32 REAL*16	INTEGER INTEGER INTEGER INTEGER INTEGER INTEGER INTEGER INTEGER
REAL See Note (2).	1	REAL	REAL FLOAT - SNGL - - - - SNGLQ ♦ - - - -	INTEGER INTEGER REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32 DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32	REAL REAL REAL REAL REAL REAL REAL REAL REAL REAL REAL REAL REAL
DOUBLE See Note (3).	1	DBLE	DBLE DFLOAT DREAL ♦ DBLEQ - - - -	INTEGER INTEGER REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32	DOUBLE PRECISION DOUBLE PRECISION DOUBLE PRECISION DOUBLE PRECISION DOUBLE PRECISION DOUBLE PRECISION DOUBLE PRECISION DOUBLE PRECISION
REAL*16 See Note (3').	1	QREAL QEXT	QREAL ♦ QFLOAT ♦ QEXT ♦ QEXTD ♦	INTEGER INTEGER INTEGER DOUBLE COMPLEX COMPLEX*16 COMPLEX*32	REAL*16 REAL*16 REAL*16 REAL*16 REAL*16 REAL*16 REAL*16

Table 6-3 Type Conversion Functions *(Continued)*

Conversion to	No. of Arguments	Generic Name	Specific Name	Argument Type	Function Type
COMPLEX See Notes (4) and (8).	1 or 2	CMPLX	- - - - - - -	INTEGER REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32	COMPLEX COMPLEX COMPLEX COMPLEX COMPLEX COMPLEX COMPLEX
COMPLEX*16 See Note (8).	1 or 2	DCMPLX	- - - - - - -	INTEGER REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32	DOUBLE COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX
COMPLEX*32 See Note (8).	1 or 2	QCMPLX	- - - - - - -	INTEGER REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32	COMPLEX*32 COMPLEX*32 COMPLEX*32 COMPLEX*32 COMPLEX*32 COMPLEX*32 COMPLEX*32
INTEGER See Note (5).	1	- -	ICHAR IACHAR ♦	CHARACTER	INTEGER
CHARACTER See Note (5).	1	- -	CHAR ACHAR ♦	INTEGER	CHARACTER

On an ASCII machine, including Sun systems:

- ACHAR is a nonstandard synonym for CHAR
- IACHAR is a nonstandard synonym for ICHAR

On a non-ASCII machine, ACHAR and IACHAR were intended to provide a way to deal directly with ASCII.

Trigonometric Functions

Table 6-4 Trigonometric Functions

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Name	Argument Type	Function Type
Sine See Note (7).	sin(a)	1	SIN	SIN DSIN QSIN CSIN ZSIN ♦ CDSIN ♦ CQSIN ♦	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32
Sine (degrees) See Note (7).	sin(a)	1	SIND ♦	SIND ♦ DSIND ♦ QSIND ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Cosine See Note (7).	cos(a)	1	COS	COS DCOS QCOS CCOS ZCOS ♦ CDCOS ♦ CQCOS ♦	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32
Cosine (degrees) See Note (7).	cos(a)	1	COSD ♦	COSD ♦ DCOSD ♦ QCOSD ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Tangent See Note (7).	tan(a)	1	TAN	TAN DTAN QTAN ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Tangent (degrees) See Note (7).	tan(a)	1	TAND ♦	TAND ♦ DTAND ♦ QTAND ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arcsine See Note (7).	arcsin(a)	1	ASIN	ASIN DASIN QASIN ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arcsine (degrees) See Note (7).	arcsin(a)	1	ASIND ♦	ASIND ♦ DASIND ♦ QASIND ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16

Table 6-4 Trigonometric Functions *(Continued)*

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Name	Argument Type	Function Type
Arccosine See Note (7).	arccos(a)	1	ACOS	ACOS DACOS QACOS ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arccosine (degrees) See Note (7).	arccos(a)	1	ACOSD ♦	ACOSD ♦ DACOSD ♦ QACOSD ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arctangent See Note (7).	arctan(a)	1	ATAN	ATAN DATAN QATAN ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
	arctan(a1 / a2)	2	ATAN2	ATAN2 DATAN2 QATAN2 ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arctangent (degrees) See Note (7).	arctan(a)	1	ATAND ♦	ATAND ♦ DATAND ♦ QATAND ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
	arctan(a1 / a2)	2	ATAN2D ♦	ATAN2D ♦ DATAN2D ♦ QATAN2D ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Hyperbolic Sine See Note (7).	sinh(a)	1	SINH	SINH DSINH QSINH ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Hyperbolic Cosine See Note (7).	cosh(a)	1	COSH	COSH DCOSH QCOSH ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Hyperbolic Tangent See Note (7).	tanh(a)	1	TANH	TANH DTANH QTANH ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16

REAL*16 and COMPLEX*32 are SPARC only.

Other Mathematical Functions

Table 6-5 Other Mathematical Functions

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Name	Argument Type	Function Type
Imaginary part of a complex See Note (6).	ai	1	IMAG	AIMAG DIMAG ♦ QIMAG ♦	COMPLEX COMPLEX*16 COMPLEX*32	REAL DOUBLE COMPLEX*32
Conjugate of a complex See Note (6).	(ar, -ai)	1	CONJG	CONJG DCONJG ♦ QCONJG ♦	COMPLEX COMPLEX*16 COMPLEX*32	COMPLEX COMPLEX*16 COMPLEX*32
Square root	a**(1/2)	1	SQRT	SQRT DSQRT QSQRT CSQRT ZSQRT ♦ CDSQRT ♦ CQSQRT ♦	REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*16 COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*16 COMPLEX*32
Cube root See Note(8').	a**(1/3)	1	CBRT	CBRT ♦ DCBRT ♦ QCBRT ♦ CCBRT ♦ CDCBRT ♦ CQCBRT ♦	REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32
Exponential	e**a	1	EXP	EXP DEXP QEXP ♦ CEXP ZEXP ♦ CDEXP ♦ CQEXP ♦	REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*16 COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*16 COMPLEX*32
Natural logarithm	log(a)	1	LOG	ALOG DLOG QLOG ♦ CLOG ZLOG ♦ CDLOG ♦ CQLOG ♦	REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*16 COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*16 COMPLEX*32

Table 6-5 Other Mathematical Functions *(Continued)*

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Name	Argument Type	Function Type
Common logarithm	log10(a)	1	LOG10	ALOG10 DLOG10 QLOG10 ♦	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Error function	2/sqrt(pi)* integral from 0 to a of exp(-t*t) dt	1	ERF	ERF ♦ DERF ♦	REAL DOUBLE	REAL DOUBLE
Error function	1.0 - erf(a)	1	ERFC	ERFC ♦ DERFC ♦	REAL DOUBLE	REAL DOUBLE

REAL*16 and COMPLEX*32 are SPARC only.

6.2 Character Functions

Table 6-6 Character Functions

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Name	Argument Type	Function Type
Conversion See Note (5).	Conversion to character Conversion to integer	1 1	- - - -	CHAR ACHAR ♦ ICHAR IACHAR ♦ (See also Table 6-3.)	INTEGER CHARACTER	CHARACTER INTEGER
Index of a substring	Location of substring a2 in string a1 See Note (10).	2	-	INDEX	CHARACTER	INTEGER
Length	Length of character entity See Note (11).	1	-	LEN	CHARACTER	INTEGER
Lexically greater than or equal	a1 ≥ a2 See Note (12).	2	-	LGE	CHARACTER	LOGICAL
Lexically greater than	a1 > a2 See Note (12).	2	-	LGT	CHARACTER	LOGICAL
Lexically less than or equal	a1 ≤ a2 See Note (12).	2	-	LLE	CHARACTER	LOGICAL
Lexically less than	a1 < a2 See Note (12).	2	-	LLT	CHARACTER	LOGICAL

On an ASCII machine (including Sun systems):

- ACHAR is a nonstandard synonym for CHAR
- IACHAR is a nonstandard synonym for ICHAR

On a non-ASCII machine, ACHAR and IACHAR were intended to provide a way to deal directly with ASCII.

6.3 Miscellaneous Functions

Other miscellaneous functions include bitwise functions, environmental inquiry functions, and memory allocation and deallocation functions.

Bit Manipulation

Table 6-7 Bitwise Functions

Bitwise Operations	No. of Args.	Specific Name	Argument Type	Function Type
Complement	1	`NOT` ♦	`INTEGER`	`INTEGER`
And	2 2	`AND` ♦ `IAND` ♦	`INTEGER` `INTEGER`	`INTEGER` `INTEGER`
Inclusive or	2 2	`OR` ♦ `IOR` ♦	`INTEGER` `INTEGER`	`INTEGER` `INTEGER`
Exclusive or	2 2	`XOR` ♦ `IEOR` ♦	`INTEGER` `INTEGER`	`INTEGER` `INTEGER`
Shift See Note (14).	2	`ISHFT` ♦	`INTEGER`	`INTEGER`
Left shift See Note (14).	2	`LSHIFT` ♦	`INTEGER`	`INTEGER`
Right shift See Note (14).	2	`RSHIFT` ♦	`INTEGER`	`INTEGER`
Logical right shift See Note (14).	2	`LRSHFT` ♦	`INTEGER`	`INTEGER`
Bit extraction	3	`IBITS` ♦	`INTEGER`	`INTEGER`
Bit set	2	`IBSET` ♦	`INTEGER`	`INTEGER`
Bit test	2	`BTEST` ♦	`INTEGER`	`LOGICAL`
Bit clear	2	`IBCLR` ♦	`INTEGER`	`INTEGER`
Circular shift	3	`ISHFTC` ♦	`INTEGER`	`INTEGER`

The above functions are available as intrinsic or extrinsic functions. See also "bit: Bit Functions: and, or, …, bit, setbit, …," on page 342.

See Chapter 8, “VMS Language Extensions,” for details on other bitwise operations. ♦

Environmental Inquiry Functions

Table 6-8 Environmental Inquiry Functions

Definition	**No. of Args.**	**Generic Name**	**Specific Name**	**Argument Type**	**Function Type**
Base of Number System	1	EPBASE ♦	-	INTEGER REAL DOUBLE REAL*16	INTEGER INTEGER INTEGER INTEGER
Number of Significant Bits	1	EPPREC ♦	-	INTEGER REAL DOUBLE REAL*16	INTEGER INTEGER INTEGER INTEGER
Minimum Exponent	1	EPEMIN ♦	-	REAL DOUBLE REAL*16	INTEGER INTEGER INTEGER
Maximum Exponent	1	EPEMAX ♦	-	REAL DOUBLE REAL*16	INTEGER INTEGER INTEGER
Least Nonzero Number	1	EPTINY ♦	-	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Largest Number Representable	1	EPHUGE ♦	-	INTEGER REAL DOUBLE REAL*16	INTEGER REAL DOUBLE REAL*16
Epsilon See Note (16).	1	EPMRSP ♦	-	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16

Memory

Table 6-9 Memory Functions

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Name	Argument Type	Function Type
Location	Address of See Note (17).	1	-	LOC ♦	Any	INTEGER
Allocate	Allocate memory and return address. See Note (17).	1	-	MALLOC ♦	INTEGER	INTEGER
Deallocate	Deallocate memory allocated by MALLOC.	1	-	FREE ♦	Any	-
Size	Return the size of the argument in bytes. See Note (18).	1	-	SIZEOF ♦	Any expression or type name	INTEGER

6.4 Remarks

The following remarks apply to all of the intrinsic function tables in this chapter.

- The abbreviation DOUBLE stands for DOUBLE PRECISION.
- An intrinsic that takes an INTEGER argument accepts INTEGER*2, INTEGER*4, or INTEGER*8.
- An intrinsic that returns an INTEGER value returns the prevailing INTEGER type: if no -i2 or -dbl, then INTEGER*4; if -i2, then INTEGER*4; if -dbl, then INTEGER*8.

  The exceptions are LOC and MALLOC, which always return an INTEGER*4.
- *(SPARC only)* An intrinsic that returns a REAL value returns the prevailing REAL type: if no -r8, then REAL*4; if -r8, then REAL*8.
- *(SPARC only)* An intrinsic that returns a DOUBLE PRECISION value returns the prevailing DOUBLE PRECISION type: if no -r8, then REAL*8; if -r8 then REAL*16.
- *(SPARC only)* An intrinsic that returns a COMPLEX value returns the prevailing COMPLEX type: if no -r8, then COMPLEX*8; if -r8, then COMPLEX*16.

- *(SPARC only)* An intrinsic that returns a `DOUBLE COMPLEX` value returns the prevailing `DOUBLE COMPLEX` type: if no `-r8`, then `COMPLEX*16`; if `-r8`, then `COMPLEX*32`.
- A function with a generic name returns a value with the same type as the argument—except for type conversion functions, the nearest integer function, and the absolute value of a complex argument. If there is more than one argument, they must all be of the same type.
- If a function name is used as an actual argument, then it must be a specific name.
- If a function name is used as a dummy argument, then it does not identify an intrinsic function in the subprogram, and it has a data type according to the same rules as for variables and arrays.

6.5 Notes on Functions

Tables and notes 1 through 12 are based on the “Table of Intrinsic Functions,” from *ANSI X3.9-1978 Programming Language FORTRAN*, with the FORTRAN 77 extensions added.

(1) `INT`

If `A` is type integer, then `INT(A)` is `A`.

If `A` is type real or double precision, then:

if `|A| < 1`, then `INT(A)` is 0
if `|A| ≥ 1`, then `INT(A)` is the greatest integer that does not exceed the magnitude of `A`, and whose sign is the same as the sign of `A`. (Such a mathematical integer value may be too large to fit in the computer integer type.)

If `A` is type complex or double complex, then apply the above rule to the real part of `A`.

If `A` is type real, then `IFIX(A)` is the same as `INT(A)`.

(2) `REAL`

If `A` is type real, then `REAL(A)` is `A`.

If `A` is type integer or double precision, then `REAL(A)` is as much precision of the significant part of `A` as a real datum can contain.

If A is type complex, then REAL(A) is the real part of A.

If A is type double complex, then REAL(A) is as much precision of the significant part of the real part of A as a real datum can contain.

(3) DBLE

If A is type double precision, then DBLE(A) is A.

If A is type integer or real, then DBLE(A) is as much precision of the significant part of A as a double precision datum can contain.

If A is type complex, then DBLE(A) is as much precision of the significant part of the real part of A as a double precision datum can contain.

If A is type COMPLEX*16, then DBLE(A) is the real part of A.

(3') QREAL

If A is type REAL*16, then QREAL(A) is A.

If A is type integer, real, or double precision, then QREAL(A) is as much precision of the significant part of A as a REAL*16 datum can contain.

If A is type complex or double complex, then QREAL(A) is as much precision of the significant part of the real part of A as a REAL*16 datum can contain.

If A is type COMPLEX*16 or COMPLEX*32, then QREAL(A) is the real part of A.

(4) CMPLX

If A is type complex, then CMPLX(A) is A.

If A is type integer, real, or double precision, then CMPLX(A) is REAL(A) + 0i.

If A1 and A2 are type integer, real, or double precision, then CMPLX(A1,A2) is REAL(A1) + REAL(A2)*i.

If A is type double complex, then CMPLX(A) is REAL(DBLE(A)) + i*REAL(DIMAG(A)).

If CMPLX has two arguments, then they must be of the same type, and they may be one of integer, real, or double precision.

If CMPLX has one argument, then it may be one of integer, real, double precision, complex, COMPLEX*16, or COMPLEX*32.

(4') DCMPLX

If A is type COMPLEX*16, then DCMPLX(A) is A.

If A is type integer, real, or double precision, then DCMPLX(A) is DBLE(A) + 0i.

If A1 and A2 are type integer, real, or double precision, then DCMPLX(A1,A2) is DBLE(A1) + DBLE(A2)*i.

If DCMPLX has two arguments, then they must be of the same type, and they may be one of integer, real, or double precision.

If DCMPLX has one argument, then it may be one of integer, real, double precision, complex, COMPLEX*16, or COMPLEX*32.

(5) ICHAR

ICHAR(A) is the position of A in the collating sequence.

The first position is 0, the last is N-1, 0≤ICHAR(A)≤N-1, where N is the number of characters in the collating sequence, and A is of type character of length one.

CHAR and ICHAR are inverses in the following sense:

- ICHAR(CHAR(I)) = I, for 0≤I≤N-1
- CHAR(ICHAR(C)) = C, for any character C capable of representation in the processor

(6) COMPLEX

A COMPLEX value is expressed as an ordered pair of reals, (ar, ai), where ar is the real part, and ai is the imaginary part.

(7) Radians

All angles are expressed in radians, unless the "Intrinsic Function" column includes the "*(degrees)*" remark.

(8) COMPLEX Function

The result of a function of type COMPLEX is the principal value.

(8') `CBRT`

If `a` is of `COMPLEX` type, `CBRT` results in `COMPLEX RT1=(A, B)`, where: `A>= 0.0`, and -60 degrees `<= arctan (B/A) <` + 60 degrees.

Other two possible results can be evaluated as follows:
- `RT2 = RT1 * (-0.5, square_root (0.75))`
- `RT3 = RT1 * (-0.5, square_root (0.75))`

(9) Argument types

All arguments in an intrinsic function reference must be of the same type.

(10) `INDEX`

`INDEX(X,Y)` is the place in `X` where `Y` starts. That is, it is the starting position within character string `X` of the first occurrence of character string `Y`.

If `Y` does not occur in `X`, then `INDEX(X,Y)` is 0.

If `LEN(X) < LEN(Y)`, then `INDEX(X,Y)` is 0.

(11) Argument to `LEN`

The value of the argument of the `LEN` function need not be defined at the time the function reference is executed.

(12) Lexical Compare

`LGE( X, Y )` is true if `X=Y`, or if `X` follows `Y` in the collating sequence; otherwise, it is false.

`LGT( X, Y )` is true if `X` follows `Y` in the collating sequence; otherwise, it is false.

`LLE( X, Y )` is true if `X=Y`, or if `X` precedes `Y` in the collating sequence; otherwise, it is false.

`LLT( X, Y )` is true if `X` precedes `Y` in the collating sequence; otherwise, it is false.

If the operands for `LGE`, `LGT`, `LLE`, and `LLT` are of unequal length, the shorter operand is considered as if it were extended on the right with blanks.

(13) Bit Functions

See Chapter 8, “VMS Language Extensions,” for details on other bitwise operations. ♦

(14) Shift

`LSHIFT` shifts *a1* logically *left* by *a2* bits (inline code).

`LRSHFT` shifts *a1* logically *right* by *a2* bits (inline code).

`RSHIFT` shifts *a1* arithmetically *right* by *a2* bits.

`ISHFT` shifts *a1* logically *left* if *a2* > 0 and *right* if *a2* < 0.

The `LSHIFT` and `RSHIFT` functions are the FORTRAN 77 analogs of the C `<<` and `>>` operators. As in C, the semantics depend on the hardware.

(15) Environmental inquiries

Only the type of the argument is significant.

(16) Epsilon

Epsilon is the least `e`, such that `1.0 + e` ≠ `1.0`.

(17) `LOC` and `MALLOC`

The `LOC` function returns the 32-bit address of a variable or of an external procedure. The function call `MALLOC(` *n* `)` allocates a block of at least *n* bytes, and returns the 32-bit address of that block.

(18) `SIZEOF`

The `SIZEOF` intrinsic cannot be applied to arrays of an assumed size, characters of a length that is passed, or subroutine calls or names.

6.6 VMS Intrinsic Functions

This section lists VMS FORTRAN intrinsic routines recognized by `f77`. They are, of course, nonstandard. ♦

Double-Precision Complex

Table 6-10 Double-Precision Complex Functions

Name	Generic/Specific	Function	Argument Type	Result Type
CDABS	Specific	Absolute value	COMPLEX*16	REAL*8
CDEXP	Specific	Exponential, e**a	COMPLEX*16	COMPLEX*16
CDLOG	Specific	Natural log	COMPLEX*16	COMPLEX*16
CDSQRT	Specific	Square root	COMPLEX*16	COMPLEX*16
CDSIN	Specific	Sine	COMPLEX*16	COMPLEX*16
CDCOS	Specific	Cosine	COMPLEX*16	COMPLEX*16
DCMPLX	Generic	Convert to DOUBLE COMPLEX	Any numeric	COMPLEX*16
DCONJG	Specific	Complex conjugate	COMPLEX*16	COMPLEX*16
DIMAG	Specific	Imaginary part of complex	COMPLEX*16	REAL*8
DREAL	Specific	Real part of complex	COMPLEX*16	REAL*8

Degree-Based Trigonometric

Table 6-11 Degree-Based Trigonometric Functions

Name	Generic/Specific	Function	Argument Type	Result Type
SIND	Generic	Sine	-	-
SIND	Specific	Sine	REAL*4	REAL*4
DSIND	Specific	Sine	REAL*8	REAL*8
QSIND	Specific	Sine	REAL*16	REAL*16
COSD	Generic	Cosine	-	-
COSD	Specific	Cosine	REAL*4	REAL*4
DCOSD	Specific	Cosine	REAL*8	REAL*8
QCOSD	Specific	Cosine	REAL*16	REAL*16
TAND	Generic	Tangent	-	-
TAND	Specific	Tangent	REAL*4	REAL*4
DTAND	Specific	Tangent	REAL*8	REAL*8
QTAND	Specific	Tangent	REAL*16	REAL*16
ASIND	Generic	Arc sine	-	-
ASIND	Specific	Arc sine	REAL*4	REAL*4
DASIND	Specific	Arc sine	REAL*8	REAL*8
QASIND	Specific	Arc sine	REAL*16	REAL*16

Table 6-11 Degree-Based Trigonometric Functions *(Continued)*

Name	Generic/Specific	Function	Argument Type	Result Type
ACOSD	Generic	Arc cosine	-	-
ACOSD	Specific	Arc cosine	REAL*4	REAL*4
DACOSD	Specific	Arc cosine	REAL*8	REAL*8
QACOSD	Specific	Arc cosine	REAL*16	REAL*16
ATAND	Generic	Arc tangent	-	-
ATAND	Specific	Arc tangent	REAL*4	REAL*4
DATAND	Specific	Arc tangent	REAL*8	REAL*8
QATAND	Specific	Arc tangent	REAL*16	REAL*16
ATAN2D	Generic	Arc tangent of a1/a2	-	-
ATAN2D	Specific	Arc tangent of a1/a2	REAL*4	REAL*4
DATAN2D	Specific	Arc tangent of a1/a2	REAL*8	REAL*8
QATAN2D	Specific	Arc tangent of a1/a2	REAL*16	REAL*16

Bit-Manipulation

Table 6-12 Bit-Manipulation Functions

Name	Generic/Specific	Function	Argument Type	Result Type
IBITS	Generic	From a1, initial bit a2, extract a3 bits	-	-
IIBITS	Specific	From a1, initial bit a2, extract a3 bits	INTEGER*2	INTEGER*2
JIBITS	Specific	From a1, initial bit a2, extract a3 bits	INTEGER*4	INTEGER*4
ISHFT	Generic	Shift a1 logically by a2 bits *	-	-
IISHFT	Specific	Shift a1 logically left by a2 bits	INTEGER*2	INTEGER*2
JISHFT	Specific	Shift a1 logically left by a2 bits	INTEGER*4	INTEGER*4
ISHFTC	Generic	In a1, circular shift by a2 places, of right a3 bits	-	-
IISHFTC	Specific	In a1, circular shift by a2 places, of right a3 bits	INTEGER*2	INTEGER*2
JISHFTC	Specific	In a1, circular shift by a2 places, of right a3 bits	INTEGER*4	INTEGER*4
IAND	Generic	Bitwise AND of a1, a2	-	-
IIAND	Specific	Bitwise AND of a1, a2	INTEGER*2	INTEGER*2
JIAND	Specific	Bitwise AND of a1, a2	INTEGER*4	INTEGER*4
IOR	Generic	Bitwise OR of a1, a2	-	-
IIOR	Specific	Bitwise OR of a1, a2	INTEGER*2	INTEGER*2
JIOR	Specific	Bitwise OR of a1, a2	INTEGER*4	INTEGER*4
IEOR	Generic	Bitwise exclusive OR of a1, a2	-	-
IIEOR	Specific	Bitwise exclusive OR of a1, a2	INTEGER*2	INTEGER*2
JIEOR	Specific	Bitwise exclusive OR of a1, a2	INTEGER*4	INTEGER*4

Table 6-12 Bit-Manipulation Functions *(Continued)*

Name	Generic/Specific	Function	Argument Type	Result Type
NOT INOT JNOT	Generic Specific Specific	Bitwise complement Bitwise complement Bitwise complement	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
IBSET IIBSET JIBSET	Generic Specific Specific	In a1, set bit a2 to 1 In a1, set bit a2 to 1; return new a1 In a1, set bit a2 to 1; return new a1	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
BTEST BITEST BJTEST	Generic Specific Specific	If bit a2 of a1 is 1, return .TRUE. If bit a2 of a1 is 1, return .TRUE. If bit a2 of a1 is 1, return .TRUE.	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
IBCLR IIBCLR JIBCLR	Generic Specific Specific	In a1, set bit a2 to 0; return new a1 In a1, set bit a2 to 0; return new a1 In a1, set bit a2 to 0; return new a1	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4

* ISHFT—If a2 is positive, then shift left; if negative, then shift right.

Multiple Integer Types

The possibility of multiple integer types is not addressed by the FORTRAN 77 Standard. f77 copes with their existence by treating a specific INTEGER → INTEGER function name (IABS, and so forth) as a special sort of generic. The argument type is used to select the appropriate runtime routine name, which is not accessible to the programmer.

VMS FORTRAN 77 takes a similar approach, but makes the specific names available.

Table 6-13 Integer Functions

Name	Generic/Specific	Function	Argument Type	Result Type
IIABS JIABS	Specific Specific	Absolute value Absolute value	INTEGER*2 INTEGER*4	INTEGER*2 INTEGER*4
IMAX0 JMAX0	Specific Specific	Maximum [1] Maximum [1]	INTEGER*2 INTEGER*4	INTEGER*2 INTEGER*4
IMIN0 JMIN0	Specific Specific	Minimum [1] Minimum [1]	INTEGER*2 INTEGER*4	INTEGER*2 INTEGER*4

Table 6-13 Integer Functions *(Continued)*

Name	Generic/Specific	Function	Argument Type	Result Type
IIDIM JIDIM	Specific Specific	Positive difference [2] Positive difference [2]	INTEGER*2 INTEGER*4	INTEGER*2 INTEGER*4
IMOD JMOD	Specific Specific	Remainder of a1/a2 Remainder of a1/a2	INTEGER*2 INTEGER*4	INTEGER*2 INTEGER*4
IISIGN JISIGN	Specific Specific	Transfer of sign, |a1|* sign(a2) Transfer of sign, |a1|* sign(a2)	INTEGER*2 INTEGER*4	INTEGER*2 INTEGER*4

1. There must be at least two arguments.

2. The positive difference is: `a1-min(a1,a2))`

Functions Coerced to a Particular Type

Some VMS FORTRAN functions coerce to a particular `INTEGER` type.

Table 6-14 Translated Functions that VMS Coerces to a Particular Type

Name	Generic/Specific	Function	Argument Type	Result Type
IINT JINT	Specific Specific	Truncation toward zero Truncation toward zero	REAL*4 REAL*4	INTEGER*2 INTEGER*4
IIDINT JIDINT	Specific Specific	Truncation toward zero Truncation toward zero	REAL*8 REAL*8	INTEGER*2 INTEGER*4
IQINT IIQINT JIQINT	Specific Specific Specific	Truncation toward zero Truncation toward zero Truncation toward zero	REAL*16 REAL*16 REAL*16	INTEGER INTEGER*2 INTEGER*4
ININT JNINT	Specific Specific	Nearest integer, `INT(a+.5*sign(a))` Nearest integer, `INT(a+.5*sign(a))`	REAL*4 REAL*4	INTEGER*2 INTEGER*4
IIDNNT JIDNNT	Specific Specific	Nearest integer, `INT(a+.5*sign(a))` Nearest integer, `INT(a+.5*sign(a))`	REAL*8 REAL*8	INTEGER*2 INTEGER*4
IQNINT IIQNNT JIQNNT	Generic Specific Specific	Nearest integer, `INT(a+.5*sign(a))` Nearest integer, `INT(a+.5*sign(a))` Nearest integer, `INT(a+.5*sign(a))`	REAL*16 REAL*16 REAL*16	INTEGER INTEGER*2 INTEGER*4
IIFIX JIFIX	Specific Specific	Fix Fix	REAL*4 REAL*4	INTEGER*2 INTEGER*4
IMAX1 JMAX1	Specific Specific	Maximum[1] Maximum[1]	REAL*4 REAL*4	INTEGER*2 INTEGER*4

Table 6-14 Translated Functions that VMS Coerces to a Particular Type *(Continued)*

Name	Generic/Specific	Function	Argument Type	Result Type
IMIN1	Specific	Minimum[1]	READ*4	INTEGER*2
JMIN1	Specific	Minimum[1]	READ*4	INTEGER*4

1. There must be at least two arguments.

REAL*16 is SPARC only.

Functions Translated to a Generic Name

In some cases, each VMS-specific name is translated into an f77 generic name.

Table 6-15 VMS Functions That Are Translated into f77 Generic Names

Name	Generic/Specific	Function	Argument Type	Result Type
FLOATI	Specific	Convert to REAL*4	INTEGER*2	REAL*4
FLOATJ	Specific	Convert to REAL*4	INTEGER*4	REAL*4
DFLOAT	Generic	Convert to REAL*8	INTEGER	REAL*8
DFLOTI	Specific	Convert to REAL*8	INTEGER*2	REAL*8
DFLOTJ	Specific	Convert to REAL*8	INTEGER*4	REAL*8
AIMAX0	Specific	Maximum	INTEGER*2	REAL*4
AJMAX0	Specific	Maximum	INTEGER*4	REAL*4
AIMIN0	Specific	Minimum	INTEGER*2	REAL*4
AJMIN0	Specific	Minimum	INTEGER*4	REAL*4

Zero Extend

The following zero-extend functions are recognized by f77. The first unused high-order bit is set to zero and extended toward the higher-order end to the width indicated in the table

Table 6-16 Zero-Extend Functions

Name	Generic/Specific	Function	Argument Type	Result Type
ZEXT	Generic	Zero-extend	-	-
IZEXT	Specific	Zero-extend	BYTE LOGICAL*1 LOGICAL*2 INTEGER*2	INTEGER*2
JZEXT	Specific	Zero-extend	BYTE LOGICAL*1 LOGICAL*2 LOGICAL*4 INTEGER INTEGER*2 INTEGER*4	INTEGER*4

FORTRAN 77 Library Routines 7

This chapter lists the `f77` library routines alphabetically, along with explanations and examples. See Chapter 6, "Intrinsic Functions," for VMS intrinsic functions.

7.1 `abort`: *Terminate and Write Memory to Core File*

The subroutine is:

```
call abort
```

`abort` cleans up the I/O buffers and then aborts producing a `core` file in the current directory. See also `abort`(3).

7.2 `access`: *Check File for Permissions or Existence*

The function is:

`status = access (` *name, mode* `)`			
name	`character`	Input	File name
mode	`character`	Input	Permissions
Return value	`INTEGER`	Output	*status*=0: OK *status*>0: Error code

`access` tells you if you can access the file *name* with the permissions *mode*.

You can set *mode* to one or more of `r`, `w`, or `x`, `in` any order, and in any combination, where `r`, `w`, `x` have the following meanings:

`r`	Read
`w`	Write
`x`	Execute
blank	Existence

Example 1: Write, and arguments are literals:

```
      integer  access, status
      status = access ( 'taccess.data', 'w' )
      if ( status .eq. 0 ) write(*,*) "ok"
      if ( status .ne. 0 ) write(*,*) 'cannot write', status
      end
```

Example 2: Test for existence:

```
      integer  access, status
      status = access ( 'taccess.data', ' ' )! blank mode
      if ( status .eq. 0 ) write(*,*) "ok"
      if ( status .ne. 0 ) write(*,*) 'no such file', status
      end
```

See also `access`(2) and `perror`(3F).

7.3 `alarm`: *Execute a Subroutine after a Specified Time*

The function is:

`n = alarm (` *time*, *sbrtn* `)`			
time	`INTEGER`	Input	Number of seconds to wait (0=do not call)
sbrtn	Routine name	Input	Subprogram to execute must be listed in an external statement.
Return value	`INTEGER`	Output	Time remaining on the last alarm

Example: `alarm`—wait 9 seconds then call `sbrtn`:

```
      integer alarm, time / 1 /
      common / alarmcom / i
      external sbrtn
      i = 9
      write(*,*) i
      nseconds =  alarm ( time, sbrtn )
      do n = 1,100000     ! Wait until alarm activates sbrtn.
         r = n     ! (any calculations that take enough time)
         x=sqrt(r)
      end do
      write(*,*) i
      end

      subroutine sbrtn
      common / alarmcom / i
      i = 3      ! Do no I/O in this routine.
      return
      end
```

See also: `alarm`(3C), `sleep`(3F), and `signal`(3F).

Note the following restrictions:

- A subroutine cannot pass its own name to `alarm` because of restrictions in the FORTRAN 77 Standard.
- Your subroutine must not do any I/O because the `alarm` routine generates signals, and signals interfere with any I/O. I/O is interrupt-driven.
- Do not call `alarm()` from a FORTRAN 77 MP program—it has unpredictable behavior in MP mode.

7.4 `bit`: *Bit Functions:* `and`, `or`, …, `bit`, `setbit`, …

The definitions are:

`and(` *word1*, *word2* `)`	Computes the bitwise *and* of its arguments.
`or(` *word1*, *word2* `)`	Computes the bitwise *inclusive or* of its arguments.
`xor(` *word1*, *word2* `)`	Computes the bitwise *exclusive or* of its arguments.
`not(` *word* `)`	Returns the bitwise *complement* of its argument.
`lshift(` *word*, *nbits* `)`	Is a logical left shift with no end around carry.
`rshift(` *word*, *nbits* `)`	Is an arithmetic right shift with sign extension.
`bis(` *bitnum*, *word* `)`	Sets bit *bitnum* in *word* to 1.
`bic(` *bitnum*, *word* `)`	Clears bit *bitnum* in *word* to 0.
`bit(` *bitnum*, *word* `)`	Tests bit *bitnum* in *word* and returns `.true.` if the bit is 1, `.false.` if it is 0.
`setbit(` *bitnum*, *word*, *state* `)`	Sets bit *bitnum* in *word* to 1 if *state* is nonzero, and clears it otherwise.

The alternate external versions for MIL-STD-1753 are:

`iand(` *m*, *n* `)`	Computes the bitwise *and* of its arguments.
`ior(` *m*, *n* `)`	Computes the bitwise *inclusive or* of its arguments.
`ieor(` *m*, *n* `)`	Computes the bitwise *exclusive or* of its arguments.
`ishft(` *m*, *k* `)`	Is a logical shift with no end around carry (left if *k*>0, right if *k*<0).
`ishftc(` *m*, *k*, *ic* `)`	Circular shift: right-most *ic* bits of *m* are left-shifted circularly *k* places.
`ibits(` *m*, *i*, *len* `)`	Extracts bits: from *m*, starting at bit *i*, extracts *len* bits.
`ibset(` *m*, *i* `)`	Sets bit: return value is equal to word *m* with bit number *i* set to 1.
`ibclr(` *m*, *i* `)`	Clears bit: return value is equal to word *m* with bit number *i* set to 0.
`btest(` *m*, *i* `)`	Tests bit *i* in *m*; returns `.true.` if the bit is 1, and `.false.` if it is 0.

See also “mvbits: Move a Bit Field,” on page 395, and “Miscellaneous Functions,” on page 325.

Usage: and, or, xor, not, rshift, lshift

x = and(*word1*, *word2*)		
x = or(*word1*, *word2*)		
x = xor(*word1*, *word2*)		
x = not(*word*)		
x = rshift(*word*, *nbits*)		
x = lshift(*word*, *nbits*)		
word1, *word2*, *word*, *nbits*	integer or logical (short or long)	Input

These are generic functions expanded inline by the compiler.

No test is made for a reasonable value of *nbits*.

Example: and, or, xor, not:

```
    print 1, and(7,4), or(7,4), xor(7,4), not(4)
 1  format(4x 'and(7,4)', 5x 'or(7,4)', 4x 'xor(7,4)',
&         6x 'not(4)'/4o12.11)
    end
demo% f77 -silent tandornot.f
demo% a.out
    and(7,4)     or(7,4)    xor(7,4)      not(4)
 00000000004 00000000007 00000000003 37777777773
demo%
```

Example: lshift, rshift:

```
    integer lshift, rshift
    print 1, lshift(7,1), rshift(4,1)
 1  format(1x 'lshift(7,1)', 1x 'rshift(4,1)'/2o12.11)
    end
demo% f77 -silent tlrshift.f
demo% a.out
 lshift(7,1) rshift(4,1)
 00000000016 00000000002
demo%
```

Usage: bic, bis, bit, setbit

`call bic(` *bitnum*`,` *word* `)`		
`call bis(` *bitnum*`,` *word* `)`		
`call setbit(` *bitnum*`,` *word*`,` *state* `)`		
x `= bit(` *bitnum*`,` *word* `)`		
Return value	`logical`	Logical value
bitnum	`INTEGER*4`	Input
state	`INTEGER*4`	Input
word	`INTEGER*4`	Input and output (an input that is changed)

Bits are numbered so that bit 0 is the least significant bit, and bit 31 is the most significant.

`bic`, `bis`, and `setbit` are external subroutines. `bit` is an external function.

Example 3: `bic`, `bis`, `setbit`, `bit`:

```
      integer bitnum/2/, state/0/, word/7/
      logical bit
      print 1, word
    1 format(13x 'word', o12.11)
      call bic( bitnum, word )
      print 2, word
    2 format('after bic(2,word)', o12.11)
      call bis( bitnum, word )
      print 3, word
    3 format('after bis(2,word)', o12.11)
      call setbit( bitnum, word, state )
      print 4, word
    4 format('after setbit(2,word,0)', o12.11)
      print 5, bit(bitnum, word)
    5 format('bit(2,word)', L )
      end
<output>
             word 00000000007
after bic(2,word) 00000000003
after bis(2,word) 00000000007
after setbit(2,word,0) 00000000003
bit(2,word) F
```

7.5 `chdir`: *Change Default Directory*

The function is:

n = `chdir(` *dirname* `)`			
dirname	`character`	Input	Directory name
Return value	`INTEGER`	Output	*n*=0: OK, *n*>0: Error code

Example: `chdir`—change `cwd` to `MyDir`:

```
       integer  chdir, n
       n =  chdir ( 'MyDir' )
       if ( n .ne. 0 ) stop 'chdir: error'
       end
```

See also: chdir(2), cd(1), and perror(3F).

Path names can be no longer than MAXPATHLEN as defined in <sys/param.h>.

Use of this function can cause inquire by unit to fail.

Certain FORTRAN 77 file operations reopen files by name. Using chdir while doing I/O can cause the runtime system to lose track of files created with relative path names. including the files that are created by open statements without file names.

7.6 chmod: *Change the Mode of a File*

The function is:

n = chmod(*name*, *mode*)			
name	character	Input	Single path name
mode	character	Input	Anything recognized by chmod(1), such as o-w, 444, etc.
Return value	INTEGER	Output	*n* = 0: OK; *n*>0: System error number

Example: chmod—add write permissions to MyFile.:

```
      character*18 name, mode
      integer chmod, n
      name = 'MyFile'
      mode = '+w'
      n =  chmod( name, mode )
      if ( n .ne. 0 ) stop ’chmod: error’
      end
```

See also: chmod(1). Note this bug: the path names cannot be longer than MAXPATHLEN as defined in <sys/param.h>.

7.7 `date`: *Get Current System Date as a Character String*

call date(*c*)			
c	CHARACTER*9	Output	Variable, array, array element, or character substring

The form of the returned string *c* is:

dd-mmm-yy	
dd	Day of the month, as a 2-digit integer
mmm	Month, as a 3-letter abbreviation
yy	Year, as a 2-digit integer

Example: `date`:

```
demo% cat dat1.f
* dat1.f -- Get the date as a character string.
     character c*9
     call date ( c )
     write(*,"(' The date today is: ', A9 )" ) c
     end
demo% f77 -silent dat1.f
demo% a.out
 The date today is: 23-Sep-88
demo%
```

See also Section 7.27, “idate: Return Current System Date.”

7.8 `dtime`, `etime`: *Elapsed Execution Time*

Both functions have return values of elapsed time (or -1.0 as error indicator). The time is in seconds. The resolution is to a nanosecond under Solaris 2.x, and is determined by the system clock frequency under Solaris 1.x.

`dtime`: *Elapsed Time Since the Last* `dtime` *Call*

For `dtime`, the elapsed time is:

- First call: elapsed time since start of execution

- Subsequent calls: elapsed time since the last call to `dtime`
- Single processor: time used by the CPU
- Multiple Processor: the sum of times for all the CPUs, which is not useful data; use `etime` instead.

Note – Do not call `dtime` from within a parallelized loop.

The function is:

e = `dtime(` *tarray* `)`				
tarray	`real(2)`	Output	*e*= -1.0: *e*≠ -1.0:	Error: *tarray* values are undefined User time in *tarray(1)* if no error System time in *tarray(2)* if no error
Return value	`real`	Output	*e*= -1.0: *e*≠ -1.0:	Error The sum of *tarray(1)* and *tarray(2)*

Example: `dtime()`, single processor:

```
    real e, dtime, t(2)
    print *, 'elapsed:', e, ', user:', t(1), ', sys:', t(2)
    do i = 1, 10000
        k=k+1
    end do
    e = dtime( t )
    print *, 'elapsed:', e, ', user:', t(1), ', sys:', t(2)
    end
demo% f77 -silent tdtime.f
demo% a.out
elapsed:  0., user:  0., sys:  0.
elapsed:   0.180000, user:    6.00000E-02, sys:   0.120000
demo%
```

`etime`: *Elapsed Time Since Start of Execution*

For `etime`, the elapsed time is:

- Single Processor—CPU time for the calling process
- Multiple Processor—wallclock time while processing your program

Here is how FORTRAN 77 decides single processor or multiple processor:

For a FORTRAN 77 MP program that uses an MP option—ultimately, linked with `libF77_mt`, if the environment variable `PARALLEL` is:

- Undefined, the current run is single processor.
- Defined and in the range 1, 2, 3, …, the current run is multiple processor.
- Defined, but some value other than 1, 2, 3, …, the results are unpredictable.

The function is:

e = `etime(` *tarray* `)`					
tarray	`real(2)`	Output	*e*= -1.0: *e*≠ -1.0:	Error: *tarray* values are undefined Single Processor: User time in System time in Multiple Processor: Wall clock time in 0.0 in	 *tarray(1)* *tarray(2)* *tarray(1)* *tarray(2)*
Return value	`real`	Output	*e*= -1.0: *e*≠ -1.0:	Error The sum of *tarray(1)* and *tarray(2)*	

Example: `etime()`, single processor:

```
    real e, etime, t(2)
    do i = 1, 10000
       k=k+1
    end do
    e = etime( t )
    print *, 'elapsed:', e, ', user:', t(1), ‘, sys:', t(2)
    end
demo% f77 -silent tetime.f
demo% a.out
elapsed:   0.190000, user:    6.00000E-02, sys:   0.130000
demo%
```

See also `times`(2), `f77`(1), and the *FORTRAN 77 User’s Guide*.

7.9 exit: *Terminate a Process and Set the Status*

The subroutine is:

call exit(*status*)		
status	INTEGER	Input

Example: exit():

```
    integer status
    status = 7
    call exit( status )
    end
```

exit flushes and closes all the files in the process, and notifies the parent process if it is executing a wait.

The low-order 8 bits of *status* are available to the parent process. These 8 bits are shifted left 8 bits, and all other bits are zero. (Therefore, *status* should be in the range of 256 - 65280). This call will never return.

The C function exit can cause cleanup actions before the final 'sys exit'.

If you call exit without an argument, you will get a warning message, and a zero will be automatically provided as an argument. See also: exit(2), fork(2), fork(3f), wait(2), wait(3f).

7.10 f77_floatingpoint: *FORTRAN 77 IEEE Definitions*

The file f77_floatingpoint.h defines constants and types used to implement standard floating-point according to ANSI/IEEE Std 754-1985.

Include the file in a source program as follows:

```
#include <f77/f77_floatingpoint.h>
```

The file f77_floatingpoint.h defines constants and types used to implement standard floating-point according to ANSI/IEEE Std 754-1985. Use these constants and types to write more easily understood .F source files that will undergo automatic preprocessing prior to FORTRAN 77 compilation.

IEEE Rounding Mode

fp_direction_type	The type of the IEEE rounding direction mode. The order of enumeration varies according to hardware.

SIGFPE Handling

sigfpe_code_type	The type of a SIGFPE code.
sigfpe_handler_type	The type of a user-definable SIGFPE exception handler called to handle a particular SIGFPE code.
SIGFPE_DEFAULT	A macro indicating default SIGFPE exception handling: IEEE exceptions to continue with a default result and to abort for other SIGFPE codes.
SIGFPE_IGNORE	A macro indicating an alternate SIGFPE exception handling, namely to ignore and continue execution.
SIGFPE_ABORT	A macro indicating an alternate SIGFPE exception handling, namely to abort with a core dump.

IEEE Exception Handling

N_IEEE_EXCEPTION	The number of distinct IEEE floating-point exceptions.
fp_exception_type	The type of the N_IEEE_EXCEPTION exceptions. Each exception is given a bit number.
fp_exception_field_type	The type intended to hold at least N_IEEE_EXCEPTION bits corresponding to the IEEE exceptions numbered by fp_exception_type. Thus, fp_inexact corresponds to the least significant bit and fp_invalid to the fifth least significant bit. Some operations can set more than one exception.

IEEE Classification

fp_class_type	A list of the classes of IEEE floating-point values and symbols.

Refer to the *Numerical Computation Guide*. See also ieee_environment(3M) and f77_ieee_environment(3F).

7.11 f77_ieee_environment: *IEEE Arithmetic*

Here is a summary:

ieee_flags	*ieeer* = ieee_flags(*action*, *mode*, *in*, *out*)	
ieee_handler	ieeer = ieee_handler(*action*, *exception*, *hdl*)	
sigfpe	ieeer = sigfpe(*code*, *hdl*)	
action	character	Input
code	sigfpe_code_type	Input
mode	character	Input
in	character	Input
exception	character	Input
hdl	sigfpe_handler_type	Input
out	character	Output
Return value	INTEGER	Output

These subprograms provide modes and status required to fully exploit ANSI/IEEE Std 754-1985 arithmetic in a FORTRAN 77 program. They correspond closely to the functions ieee_flags(3M), ieee_handler(3M), and sigfpe(3).

If you use sigfpe, you must do your own setting of the corresponding trap-enable-mask bits in the floating-point status register. The details are in the SPARC architecture manual. The libm function ieee_handler sets these trap-enable-mask bits for you.

Example 1: Set rounding direction to round toward zero, unless the hardware does not support directed rounding modes:

```
    integer ieeer
    character*1 mode, out, in
    ieeer = ieee_flags( 'set', 'direction', 'tozero', out )
```

Example 2: Clear rounding direction to default (round toward nearest):

```
character*1 out, in
ieeer = ieee_flags('clear','direction', in, out )
```

Example 3: Clear all accrued exception-occurred bits:

```
character*18 out
ieeer = ieee_flags( 'clear', 'exception', 'all', out )
```

Example 4: If Example 3 generates the overflow exception, detect it as follows:

```
character*18 out
ieeer = ieee_flags( 'get', 'exception', 'overflow', out )
```

The above code sets `out` to `overflow` and `ieeer` to 25. Similar coding detects exceptions, such as `invalid` or `inexact`.

Example 5: `hand1.f`, write and use a signal handler (*Solaris 2.x*):

```
      external hand
      real r / 14.2 /,  s / 0.0 /
      i = ieee_handler( 'set', 'division', hand )
      t = r/s
      end

      integer function hand ( sig, sip, uap )
      integer sig, address
      structure /fault/
          integer address
      end structure
      structure /siginfo/
          integer si_signo
          integer si_code
          integer si_errno
          record /fault/ fault
      end structure
      record /siginfo/ sip
      address = sip.fault.address
      write (*,10) address
   10 format('Exception at hex address ', z8 )
      end
```

Read the *Numerical Computation Guide*. See also: `floatingpoint`(3), `signal`(3), `sigfpe`(3), `f77_floatingpoint`(3F), `ieee_flags`(3M), and `ieee_handler`(3M).

7.12 `fdate`: *Return Date and Time in an ASCII String*

The subroutine or function:

call fdate(*string*)		
string	character*24	Output

or:

string = fdate()			If you use it as a function, the calling routine must define the type and length of fdate.
Return value	character*24	Output	

Example 1: fdate as a subroutine:

```
    character*24 string
    call fdate( string )
    write(*,*) string
    end
```

Output:

```
 Wed Aug  3 15:30:23 1994
```

Example 2: fdate as a function, same output:

```
    character*24 fdate
    write(*,*)  fdate()
    end
```

See also: ctime(3), time(3F), and idate(3F).

7.13 flush: *Flush Output to a Logical Unit*

The subroutine is:

call flush(*lunit*)			
lunit	INTEGER	Input	Logical unit

The flush subroutine flushes the contents of the buffer for the logical unit, lunit, to the associated file. This is most useful for logical units 0 and 6 when they are both associated with the control terminal.

See also fclose(3S).

7.14 `fork`: *Create a Copy of the Current Process*

The function is:

n = fork()			
Return value	INTEGER	Output	*n*>0: *n*=Process ID of copy *n*<0, *n*=System error code

The `fork` function creates a copy of the calling process. The only distinction between the two processes is that the value returned to one of them, referred to as the *parent* process, will be the process ID of the copy. The copy is usually referred to as the `child` process. The value returned to the child process will be zero.

All logical units open for writing are flushed before the fork to avoid duplication of the contents of I/O buffers in the external files.

Example: `fork()`:

```
    integer fork, pid
    pid = fork()
    end
```

A corresponding `exec` routine has not been provided because there is no satisfactory way to retain open logical units across the `exec` routine. However, the usual function of `fork/exec` can be performed using `system`(3F). See also: `fork`(2), `wait`(3F), `kill`(3F), `system`(3F), and `perror`(3F).

7.15 `free`: *Deallocate Memory Allocated by Malloc*

The subroutine is:

call free (*ptr*)		
ptr	pointer	Input

`free` deallocates a region of memory previously allocated by `malloc`. The region of memory is returned to the memory manager; it is not explicitly available to the user's program.

Example: `free()`:

```
      real x
      pointer ( ptr, x )
      ptr = malloc ( 10000 )
      call free ( ptr )
      end
```

See Section 7.40, “malloc: Allocate Memory and Get Address,” for details.

7.16 `fseek`, `ftell`: *Determine Position and Reposition a File*

`fseek` and `ftell` are routines that permit repositioning of a file. `ftell` returns a file’s curent position as an offset of so many bytes from the beginning of the file. At some later point in the program, `fseek` can use this saved offset value to reposition the file to that same place for reading.

CAUTION: On sequential files, following a call to `fseek` by an output operation (e.g. WRITE) causes all data records following the `fseek`’ed position to be deleted and replaced by the new data record (and an end-of-file mark). Rewriting a record in place can only be done with direct access files.

`fseek`: *Reposition a File on a Logical Unit*

The function is:

n = `fseek(` *lunit*, *offset*, *from* `)`			
lunit	`INTEGER`	Input	Open logical unit
offset	`INTEGER`	Input	Offset in bytes relative to position specified by *from*
from	`INTEGER`	Input	0=Beginning of file 1=Current position 2=End of file
Return value	`INTEGER`	Output	*n*=0: OK; *n*>0: System error code

Example: `fseek()`—Reposition `MyFile` to two bytes from the beginning:

```
    integer fseek, lunit/1/, offset/2/, from/0/, n
    open( UNIT=lunit, FILE='MyFile' )
    n = fseek( lunit, offset, from )
    if ( n .gt. 0 ) stop 'fseek error'
    end
```

`ftell`: *Return Current Position of File*

The function is:

n = ftell(*lunit*)			
lunit	INTEGER	Input	Open logical unit
Return value	INTEGER	Input	*n*>=0: *n*=Offset in bytes from start of file *n*<0: *n*=System error code

Example: `ftell()`:

```
    integer ftell, lunit/1/, n
    open( UNIT=lunit, FILE='MyFile' )
*   …
    n = ftell( lunit )
    if ( n .lt. 0 ) stop 'ftell error'
    end
```

See also `fseek`(3S) and `perror`(3F).

7.17 getarg, iargc: *Get Command-line Arguments*

gettarg and iargc return command-line arguments.

getarg: *Get the kth Command-Line Argument*

The subroutine is:

call getarg(*k*, *arg*)			
k	INTEGER	Input	Index of argument (0=first=command name)
arg	character**n*	Output	*k*th argument
n	INTEGER	Size of *arg*	Large enough to hold longest argument

iargc: *Get the Count of Command-Line Arguments*

The function is:

m = iargc()			
Return value	INTEGER	Output	Number of arguments on the command line

Example: iargc and getarg, get argument count and each argument:

```
      character argv*10
      integer i, iargc, n
      n = iargc()
      do i = 1, n
          call getarg( i, argv )
          write( *, '( i2, 1x, a )' ) i, argv
      end do
      end
```

After compiling, a sample run of the above source is:

```
demo% a.out first second last
1 first
2 second
3 last
demo%
```

See also `execve`(2) and `getenv`(3F).

7.18 `getc`, `fgetc`: *Get Next Character*

`getc` and `fgetc` get the next character.

`getc`: *Get Next Character from* `stdin`

The function is:

status = `getc(` *char* `)`			
char	`character`	Output	Next character
Return value	`INTEGER`	Output	*status*=0: OK *status*=-1: End of file *status*>0: System error code or `f77` I/O error code

Example: `getc` gets each character from the keyboard; note the Control-D (EOF):

```
    character char
    integer getc, status
    status = 0
    do while ( status .eq. 0 )
       status = getc( char )
       write(*, '(i3, o4.3)') status, char
    end do
    end
```

After compiling, a sample run of the above source is:

```
demo% a.out
ab
^D
0 141
0 142
0 012
-1 012
demo%
```

For any logical unit, do not mix normal FORTRAN 77 input with `getc()`.

`fgetc`: *Get Next Character from Specified Logical Unit*

The function is:

status = `fgetc(` *lunit*, *char* `)`			
lunit	`INTEGER`	Input	Logical unit
char	`character`	Output	Next character
Return value	`INTEGER`	Output	*status*=-1: End of File *status*>0: System error code or `f77` I/O error code

Example: `fgetc` gets each character from `tfgetc.data`; note the linefeeds (Octal 012):

```
      character char
      integer fgetc, status
      open( unit=1, file='tfgetc.data' )
      status = 0
      do while ( status .eq. 0 )
         status = fgetc( 1, char )
         write(*, '(i3, o4.3)') status, char
      end do
      end
```

After compiling, a sample run of the above source is:

```
demo% cat tfgetc.data
ab
yz
demo% a.out
0 141
0 142
0 012
0 171
0 172
0 012
-1 012
demo%
```

For any logical unit, do not mix normal FORTRAN 77 input with `fgetc()`.

See also: `getc`(3S), `intro`(2), and `perror`(3F).

7.19 `getcwd`: *Get Path of Current Working Directory*

The function is:

status = `getcwd(` *dirname* `)`			
dirname	`character*`*n*	Output	Path name of the current working directory
Return value	`INTEGER`	Output	*status*=0: OK *status*>0: Error code
n	`INTEGER`	Size of *dirname*, in bytes	Must be big enough for the longest path name

Example: `getcwd`:

```
      integer getcwd, status
      character*64 dirname
      status = getcwd( dirname )
      if ( status .ne. 0 ) stop 'getcwd: error'
      write(*,*) dirname
      end
```

See also: `chdir`(3F), `perror`(3F), and `getwd`(3).

Note this bug: the path names cannot be longer than `MAXPATHLEN` as defined in `<sys/param.h>`.

7.20 `getenv`: *Get Value of Environment Variables*

The subroutine is:

`call getenv(` *ename*, *evalue* `)`			
ename	`character*`*n*	Input	Name of the environment variable sought
evalue	`character*`*n*	Output	Value of the environment variable found; blanks if not successful
n	`INTEGER`	Size of *evalue*	*n* must be large enough for the value.

The `getenv` subroutine searches the environment list for a string of the form *ename=evalue* and returns the value in *evalue* if such a string is present; otherwise, it fills *evalue* with blanks.

Example: `getenv()`:

```
      character*18  evalue
      call getenv( 'SHELL', evalue )
      write(*,*) "'", evalue, "'"
      end
```

See also: `execve`(2) and `environ`(5).

7.21 `getfd`: *Get File Descriptor for External Unit Number*

The function is:

fildes `= getfd(` *unitn* `)`			
unitn	`INTEGER`	Input	External unit number
Return value	`INTEGER`	Output	File descriptor if the file is connected; -1 if the file is not connected

Example: `getfd()`:

```
      integer fildes, getfd, unitn/1/
      open( unitn, file='tgetfd.data' )
      fildes = getfd( unitn )
      if ( fildes .eq. -1 ) stop 'getfd: file not connected'
      write(*,*) 'file descriptor = ', fildes
      end
```

See also `open`(2).

7.22 `getfilep`: *Get File Pointer for External Unit Number*

The function is:

irtn = *c_read*(getfilep(*unitn*), *inbyte*, 1)			
c_read	C function	Input	You write this C function. See the example.
unitn	`INTEGER`	Input	External unit number.
`getfilep`	`INTEGER`	Return value	File pointer if the file is connected; -1 if the file is not connected

This function is used for mixing standard FORTRAN 77 I/O with C I/O. Such a mix is nonportable, and is not guaranteed for subsequent releases of the operating system or FORTRAN 77. Use of this function is not recommended, and no direct interface is provided. You must enter your own C routine to use the value returned by `getfilep`. A sample C routine is shown below.

Example: FORTRAN 77 uses `getfilep` by passing it to a C function:

`tgetfilepF.f`

```
      character*1  inbyte
      integer*4    c_read,  getfilep, unitn / 5 /
      external     getfilep
      write(*,'(a,$)') 'What is the digit? '

      irtn = c_read( getfilep( unitn ), inbyte, 1 )

      write(*,9)  inbyte
    9 format('The digit read by C is ', a )
      end
```

Sample C function actually using `getfilep`:

tgetfilepC.c

```
#include <stdio.h>
int c_read_ ( fd, buf, nbytes, buf_len )
FILE **fd ;
char *buf ;
int *nbytes, buf_len ;
{
   return fread( buf, 1, *nbytes, *fd ) ;
}
```

A sample compile-build-run is:

```
demo 11% cc -c tgetfilepC.c
demo 12% f77 tgetfilepC.o tgetfilepF.f
tgetfileF.f:
MAIN:
demo 13% a.out
What is the digit? 3
The digit read by C is 3
demo 14%
```

For more information, read the chapter on the C-FORTRAN 77 interface in the *FORTRAN 77 4.0 User's Guide*. See also `open`(2).

7.23 `getlog`: *Get User's Login Name*

The subroutine is:

call getlog(*name*)			
name	character**n*	Output	User's login name, or all blanks if the process is running detached from a terminal.
n	INTEGER	Size of *name*	Large enough to hold the longest name

Example: `getlog`:

```
      character*18 name
      call getlog( name )
      write(*,*) "'", name, "'"
      end
```

See also `getlogin`(3).

7.24 `getpid`: *Get Process ID*

The function is:

pid = getpid()			
Return value	INTEGER	Output	Process ID of the current process

Example: `getpid`:

```
      integer getpid, pid
      pid = getpid()
      write(*,*) 'process id = ', pid
      end
```

See also `getpid`(2).

7.25 `getuid`, `getgid`: *Get User or Group ID of Process*

`getuid` and `getgid` get the user or group ID of the process, respectively.

`getuid`: *Get User ID of the Process*

The function is:

uid = getuid()			
Return value	INTEGER	Output	User ID of the process

getgid: *Get Group ID of the Process*

The function is:

gid = getgid()			
Return value	INTEGER	Output	Group ID of the process

Example: getuid() and getpid():

```
    integer getuid, getgid, gid, uid
    uid = getuid()
    gid = getgid()
    write(*,*) uid, gid
    end
```

See also: getuid(2).

7.26 hostnm: *Get Name of Current Host*

The function is:

status = hostnm(*name*)			
name	character**n*	Output	Name of current host
Return value	INTEGER	Output	*status*=0: OK *status*>0: Error
n	INTEGER	Size of *name*	Big enough to hold the host name, or the memory is clobbered.

Example: hostnm():

```
    integer hostnm, status
    character*8 name
    status = hostnm( name )
    write(*,*) 'host name = "', name, '"'
    end
```

See also gethostname(2).

7.27 `idate`: *Return Current System Date*

`idate` has two versions:

- **Standard**—Put the current system date into an integer array: day, month, and year.
- **VMS**—Put the current system date into three integer variables: month, day, and year.

If you use the `-lV77` compiler option to request the VMS library, then you get the VMS versions of both `time()` and `idate()`; otherwise, you get the standard versions.

Standard Version

The standard version puts the current system date into one integer array: day, month, and year.

The subroutine is:

call idate(*iarray*)			
iarray	INTEGER	Output	`array`(3). Note the order: day, month, year.

Example: `idate` (standard version):

```
    integer iarray(3)
    call idate( iarray )
    write(*, "(' The date is: ',3i5)" )  iarray
    end
```

Compile and run the above source:

```
demo% f77 -silent tidate.f
demo% a.out
 The date is: 10 8 1994
demo%
```

VMS Version

The VMS version puts the current system date into three integer variables: month, day, and year

The subroutine is:.

call idate(*m*, *d*, *y*)			
m	INTEGER	Output	Month (1 - 12)
d	INTEGER	Output	Day (1 - 7)
y	INTEGER	Output	Year (1 - 99)

Example: `idate` (VMS version):

```
    integer m, d, y
    call idate ( m, d, y )
    write (*, "(' The date is: ',3i5)" ) m, d, y
    end
```

Compile and run the above source; note the `-lV77` option:

```
demo% f77 -silent tidateV.f -lV77
demo% a.out
 The date is: 8 10 94
demo%
```

7.28 `itime`: Current System Time

`itime` puts the current system time into an integer array: hour, minute, and second.

The subroutine is:

call itime(*iarray*)			
iarray	INTEGER	Output	`array`(3). Note the order: hour, minute, second

Example: `itime`:

```
    integer iarray(3)
    call itime( iarray )
    write (*, "(' The time is: ',3i5)" )  iarray
    end
```

Compile and run the above source:

```
demo% f77 -silent titime.f
demo% a.out
 The time is: 15 42 35
demo%
```

See also `time`(3f), `ctime`(3F), and `fdate`(3F).

7.29 `index`: *Index or Length of Substring*

`index` has the following forms:

`index(`*a1*`,`*a2*`)`	Index of first occurrence of string *a2* in string *a1*
`rindex(`*a1*`,`*a2*`)`	Index of last occurrence of string *a2* in string *a1*
`lnblnk(`*a1*`)`	Index of last nonblank in string *a1*
`len(`*a1*`)`	Declared length of string *a1*

`index`: *First Occurrence of String a2 in String a1*

The intrinsic function is:

n = `index(` *a1*, *a2* `)`			
a1	`character`	Input	Main string
a2	`character`	Input	Substring
Return value	`INTEGER`	Output	*n*>0: Index of first occurrence of *a2* in *a1* *n*=0: *a2* does not occur in *a1*.

`rindex`: *Last Occurrence of String a2 in String a1*

The function is:

n = `rindex(` *a1*`,` *a2* `)`			
a1	`character`	Input	Main string
a2	`character`	Input	Substring
Return value	`INTEGER`	Output	*n*>0: Index of last occurrence of *a2* in *a1* *n*=0: *a2* does not occur in *a1*

`lnblnk`: *Last Nonblank in String a1*

The function is:

n = `lnblnk(` *a1* `)`			
a1	`character`	Input	String
Return value	`INTEGER`	Output	*n*>0: Index of last nonblank in `a1` *n*=0: *a1* is all nonblank

`len`: *Declared Length of String a1*

The intrinsic function is:

declen = `len(` *a1* `)`			
a1	`character`	Input	String
Return value	`INTEGER`	Output	Declared length of *a1*

This function is useful since all `f77` character objects are of a fixed length and blank-padded.

Example: `len()`, `index()`, `rindex()`, `lnblnk()`:

```
*                    123456789 123456789 1234
    character s*24 / 'abcPDQxyz...abcPDQxyz   ' /
    integer declen, index, first, last, len, lnblnk, rindex
    declen = len( s )
    first = index( s, 'abc' )
    last = rindex( s, 'abc' )
    lastnb = lnblnk( s )
    write(*,*) declen, lastnb
    write(*,*) first, last
    end
demo% f77 -silent tindex.f
demo% a.out
32 21
1 13
demo%
```

In the above example, `declen` is 32, not 21.

7.30 `inmax`: *Return Maximum Positive Integer*

The function is:

m = inmax()			
Return value	INTEGER	Output	The maximum positive integer

Example: `inmax`:

```
      integer inmax, m
      m = inmax()
      write(*,*) m
      end
 demo% f77 -silent tinmax.f
 demo% a.out
    2147483647
 demo%
```

See also `libm_single`(3f) and `libm_double`(3f).

7.31 `ioinit`*: Initialize I/O: Carriage Control, File Names, …*

The `IOINIT` routine establishes properties of file I/O for files opened after the call to `IOINIT`. The file I/O properties that `IOINIT` controls are as follows:

Carriage control	Recognize carriage control on any logical unit.
Blanks/zeroes	Treat blanks in input data fields as blanks or zeroes.
File position	Open files at beginning or at EoF.
Prefix	Find and open files named *prefixNN*, $0 \le NN \le 19$.

`IOINIT` does the following:

- Initializes global parameters specifying `f77` file I/O properties
- Opens logical units 0 through 19 with the specified file I/O properties—attaches externally defined files to logical units at runtime

Duration of File I/O Properties

The file I/O properties apply as long as the connection exists. If you close the unit, the properties no longer apply. The exception is the preassigned units 5 and 6, to which *carriage control* and blanks/zeroes apply at any time.

Internal Flags

`IOINIT` uses labeled common to communicate with the runtime I/O system. It stores internal flags in the equivalent of the following labeled common block:

```
      INTEGER*2 IEOF, ICTL, IBZR
      COMMON /__IOIFLG/ IEOF, ICTL, IBZR ! Not in user name space
```

In releases prior to SC 3.0.1, the labeled common block was named `IOIFLG`. We changed this name to `__IOIFLG`, so that a user common block named `IOIFLG` does not cause problems. It is safer this way because `__IOIFLG` is not part of the user name space.

Source Code

Some user needs are not satisfied with a generic version of `IOINIT`, so we provide the source code. It is written in FORTRAN 77 77. The location is:

- For a standard installation, it is in: `/opt/SUNWspro/SC4.0/src/ioinit.f`
- If you installed in /*mydir*, it is in /*mydir*/`SC3.0.1/src/ioinit.f`

Usage: `ioinit`

`call ioinit (` *cctl*, *bzro*, *apnd*, *prefix*, *vrbose* `)`			
cctl	`logical`	Input	True: Recognize carriage control, all formatted output (except unit 0)
bzro	`logical`	Input	True: Treat trailing and imbedded blanks as zeroes.
apnd	`logical`	Input	True: Open files at EoF. Append.
prefix	`character*`*n*	Input	Nonblank: For unit *NN*, seek and open file *prefixNN*
vrbose	`logical`	Input	True: Report `ioinit` activity as it happens

See also `getarg`(3F) and `getenv`(3F).

Restrictions

Note the following restrictions:

- *prefix* can be no longer than 30 characters.
- A path name associated with an environment name can be no longer than 255 characters.
- The `+` carriage control does not work.

Details of Arguments

Here are the arguments for `ioinit`.

cctl (Carriage Control)

By default, carriage control is not recognized on any logical unit. If *cctl* is `.TRUE.`, then carriage control is recognized on formatted output to all logical units, except unit 0, the diagnostic channel. Otherwise, the default is restored.

bzro (Blanks)

By default, trailing and embedded blanks in input data fields are ignored. If *bzro* is `.TRUE.`, then such blanks are treated as zeros. Otherwise, the default is restored.

apnd (Append)

By default, all files opened for sequential access are positioned at their beginning. It is sometimes necessary or convenient to open at the end-of-file, so that a write will append to the existing data. If *apnd* is `.TRUE.`, then files opened subsequently on any logical unit are positioned at their end upon opening. A value of `.FALSE.` restores the default behavior.

prefix (Automatic File Connection)

If the argument *prefix* is a nonblank string, then names of the form *prefixNN* are sought in the program environment. The value associated with each such name found is used to open the logical unit *NN* for formatted sequential access.

This search and connection is provided only for *NN* between 0 and19, inclusive. For *NN* > 19, nothing is done; see “Source Code” on page 375.

vrbose (`IOINIT` *Activity)*

If the argument *vrbose* is `.TRUE.`, then `ioinit` reports on its own activity.

Example: The program `myprogram` has the following `ioinit` call:

```
     call ioinit( .true., .false., .false., 'FORT', .false.)
```

You can assign file name in at least two ways.

In sh:

```
demo$ FORT01=mydata
demo$ FORT12=myresults
demo$ export FORT02 FORT12
demo$ myprogram
```

In csh:

```
demo% setenv FORT01 mydata
demo% setenv FORT12 myresults
demo% myprogram
```

With either shell, the `ioinit` call in the above example gives these results:

- Open logical unit 1 to the file, `mydata`.
- Open logical unit 12 to the file, `myresults`.
- Both files are positioned at their beginning.
- Any formatted output has column 1 removed and interpreted as carriage control.
- Embedded and trailing blanks are to be ignored on input.

Example: `ioinit()`—list and compile:

```
demo% cat tioinit.f
    character*3  s
    call ioinit( .true., .false., .false., 'FORT', .false.)
    do i = 1, 2
        read( 1, '(a3,i4)')  s, n
        write( 12, 10 ) s, n
    end do
10  format(a3,i4)
    end
demo% cat tioinit.data
abc 123
PDQ 789
demo% f77 -silent tioinit.f
demo%
```

You can set environment variables as follows, using either `sh` or `csh`:

`ioinit()`—`sh`:

```
demo$ FORT01=tioinit.data
demo$ FORT12=tioinit.au
demo$ export tioinit.data tioinit.au
demo$
```

`ioinit()`—`csh`:

```
demo% a.out
demo% cat tioinit.au
abc 123
PDQ 789
demo%
```

`ioinit()`—Run and test:

```
demo% a.out
demo% cat tioinit.au
abc 123
PDQ 789
demo%
```

7.32 `kill`: *Send a Signal to a Process*

The function is:

status = `kill(` *pid*, *signum* `)`			
pid	`INTEGER`	Input	Process ID of one of the user's processes
signum	`INTEGER`	Input	Valid signal number. See `signal`(3).
Return value	`INTEGER`	Output	*status*=0: OK *status*>0: Error code

Example (fragment): Send a message using `kill()`:

```
      integer kill, pid, signum
*     …
      status = kill( pid, signum )
      if ( status .ne. 0 ) stop 'kill: error'
      write(*,*) 'Sent signal ', signum, ' to process ', pid
      end
```

This function just sends a message; it does not necessarily kill the process. Some users have been known to consider this a UNIX misnomer. If you really want to kill a process, see the following example.

Example (fragment): Kill a process using `kill()`:

```
      status = kill( pid, SIGKILL )
```

See also: `kill`(2), `signal`(3), `signal`(3F), `fork`(3F), and `perror`(3F).

7.33 `libm_double`*:* `libm` *Double-Precision Functions*

These subprograms are double-precision `libm` functions and subroutines.

Intrinsic Functions

The following FORTRAN 77 intrinsic functions return double-precision values if they have double-precision arguments. You need not put them in a type statement. If the function needed is available as an intrinsic function, it is simpler to use an intrinsic than a non-intrinsic function.

The ♦ symbol indicates it is nonstandard that this is an intrinsic function.

`sqrt(x)`	`asin(x)`	`cosd(x)` ♦
`log(x)`	`acos(x)`	`asind(x)` ♦
`log10(x)`	`atan(x)`	`acosd(x)` ♦
`exp(x)`	`atan2(x,y)`	`atand(x)` ♦
`x**y`	`sinh(x)`	`atan2d(x,y)` ♦
`sin(x)`	`cosh(x)`	`aint(x)`
`cos(x)`	`tanh(x)`	`anint(x)`
`tan(x)`	`sind(x)` ♦	`nint(x)`

Non-Intrinsic Functions

In general, these functions do *not* correspond to standard FORTRAN 77 generic intrinsic functions—data types are determined by the usual data typing rules.

Example: Subroutine and non-Intrinsic double-precision functions:

The DOUBLE PRECISION functions used are in a DOUBLE PRECISION statement.

```
DOUBLE PRECISION c, d_acosh, d_hypot, d_infinity, s, x, y, z
...
z = d_acosh( x )
i = id_finite( x )
z = d_hypot( x, y )
z = d_infinity()
CALL d_sincos( x, s, c )
```

For meanings of routines and arguments, type man on the routine name without the d_; it is a C man page, but the meanings are the same.

Variables c, l, p, s, u, x, and y are of type DOUBLE PRECISION.

If you use one of these DOUBLE PRECISION functions, put it into a DOUBLE PRECISION statement (or type it by some IMPLICIT statement).

sind(x), asind(x), ... involve *degrees* rather than *radians*.

Table 7-1 DOUBLE PRECISION libm Functions

d_acos(x)	DOUBLE PRECISION	Function	arc cosine
d_acosd(x)	DOUBLE PRECISION	Function	
d_acosh(x)	DOUBLE PRECISION	Function	arc cosh
d_acosp(x)	DOUBLE PRECISION	Function	
d_acospi(x)	DOUBLE PRECISION	Function	
d_atan(x)	DOUBLE PRECISION	Function	arc tangent
d_atand(x)	DOUBLE PRECISION	Function	
d_atanh(x)	DOUBLE PRECISION	Function	arc tanh
d_atanp(x)	DOUBLE PRECISION	Function	
d_atanpi(x)	DOUBLE PRECISION	Function	
d_asin(x)	DOUBLE PRECISION	Function	arc sine
d_asind(x)	DOUBLE PRECISION	Function	
d_asinh(x)	DOUBLE PRECISION	Function	arc sinh
d_asinp(x)	DOUBLE PRECISION	Function	
d_asinpi(x)	DOUBLE PRECISION	Function	
d_atan2((y, x)	DOUBLE PRECISION	Function	arc tangent
d_atan2d(y, x)	DOUBLE PRECISION	Function	
d_atan2pi(y, x)	DOUBLE PRECISION	Function	

Table 7-1 DOUBLE PRECISION libm Functions *(Continued)*

d_cbrt(*x*)	DOUBLE PRECISION	Function	cube root
d_ceil(*x*)	DOUBLE PRECISION	Function	ceiling
d_copysign(*x*, *x*)	DOUBLE PRECISION	Function	
d_cos(x)	DOUBLE PRECISION	Function	cosine
d_cosd(x)	DOUBLE PRECISION	Function	
d_cosh(x)	DOUBLE PRECISION	Function	hyperbolic cos
d_cosp(x)	DOUBLE PRECISION	Function	
d_cospi(x)	DOUBLE PRECISION	Function	
d_erf(x)	DOUBLE PRECISION	Function	error function
d_erfc(x)	DOUBLE PRECISION	Function	
d_expm1(x)	DOUBLE PRECISION	Function	(e**x)-1
d_floor(x)	DOUBLE PRECISION	Function	floor
d_hypot(x, y)	DOUBLE PRECISION	Function	hypotenuse
d_infinity( )	DOUBLE PRECISION	Function	
d_j0(x)	DOUBLE PRECISION	Function	bessel
d_j1(x)	DOUBLE PRECISION	Function	
d_jn(x)	DOUBLE PRECISION	Function	
id_finite(x)	INTEGER	Function	
id_fp_class(x)	INTEGER	Function	
id_ilogb(x)	INTEGER	Function	
id_irint(x)	INTEGER	Function	
id_isinf(x)	INTEGER	Function	
id_isnan(x)	INTEGER	Function	
id_isnormal(x)	INTEGER	Function	
id_issubnormal(x)	INTEGER	Function	
id_iszero(x)	INTEGER	Function	
id_signbit(x)	INTEGER	Function	
d_addran()	DOUBLE PRECISION	Function	random
d_addrans(x, p, l, u)	n/a	Function	number
d_lcran()	DOUBLE PRECISION	Subroutine	generators
d_lcrans(x, p, l, u)	n/a	Subroutine	
d_shufrans(x, p, l,u)	n/a	Subroutine	
d_lgamma(x)	DOUBLE PRECISION	Function	log gamma
d_logb(x)	DOUBLE PRECISION	Function	
d_log1p(x)	DOUBLE PRECISION	Function	
d_log2(x)	DOUBLE PRECISION	Function	

Table 7-1 DOUBLE PRECISION libm Functions *(Continued)*

d_max_normal()	DOUBLE PRECISION	Function	
d_max_subnormal()	DOUBLE PRECISION	Function	
d_min_normal()	DOUBLE PRECISION	Function	
d_min_subnormal()	DOUBLE PRECISION	Function	
d_nextafter(x, y)	DOUBLE PRECISION	Function	
d_quiet_nan(n)	DOUBLE PRECISION	Function	
d_remainder(x, y)	DOUBLE PRECISION	Function	
d_rint(x)	DOUBLE PRECISION	Function	
d_scalb(x, y)	DOUBLE PRECISION	Function	
d_scalbn(x, n)	DOUBLE PRECISION	Function	
d_signaling_nan(n)	DOUBLE PRECISION	Function	
d_significand(x)	DOUBLE PRECISION	Function	
d_sin(x)	DOUBLE PRECISION	Function	sine
d_sind(x)	DOUBLE PRECISION	Function	
d_sinh(x)	DOUBLE PRECISION	Function	hyperbolic sin
d_sinp(x)	DOUBLE PRECISION	Function	
d_sinpi(x)	DOUBLE PRECISION	Function	
d_sincos(x, s, c)	n/a	Subroutine	sine and cosine
d_sincosd(x, s, c)	n/a	Subroutine	
d_sincosp(x, s, c)	n/a	Subroutine	
d_sincospi(x, s, c)	n/a	Subroutine	
d_tan(x)	DOUBLE PRECISION	Function	tangent
d_tand(x)	DOUBLE PRECISION	Function	
d_tanh(x)	DOUBLE PRECISION	Function	hyperbolic tan
d_tanp(x)	DOUBLE PRECISION	Function	
d_tanpi(x)	DOUBLE PRECISION	Function	
d_y0(x)	DOUBLE PRECISION	Function	bessel
d_y1(x)	DOUBLE PRECISION	Function	
d_yn(n,x)	DOUBLE PRECISION	Function	

See also: intro(3M) and the *Numerical Computation Guide*.

7.34 `libm_quadruple`: `libm` *Quad-Precision Functions*

These subprograms are quadruple-precision (`REAL*16`) `libm` functions and subroutines *(SPARC only).*

Intrinsic Functions

The following FORTRAN 77 intrinsic functions return quadruple-precision values if they have quadruple-precision arguments. You need not put them in a type statement. If the function needed is available as an intrinsic function, it is simpler to use an intrinsic than a non-intrinsic function.

The ♦ symbol indicates it is nonstandard that this is an intrinsic function.

`sqrt(x)`	`asin(x)`	`cosd(x)` ♦
`log(x)`	`acos(x)`	`asind(x)` ♦
`log10(x)`	`atan(x)`	`acosd(x)` ♦
`exp(x)`	`atan2(x,y)`	`atand(x)` ♦
`x**y`	`sinh(x)`	`atan2d(x,y)` ♦
`sin(x)`	`cosh(x)`	`aint(x)`
`cos(x)`	`tanh(x)`	`anint(x)`
`tan(x)`	`sind(x)` ♦	`nint(x)`

Non-Intrinsic Functions

In general, these do *not* correspond to standard generic intrinsic functions; data types are determined by the usual data typing rules.

Samples: Quadruple precision functions:

The quadruple precision functions used are in a `REAL*16` statement.

```
REAL*16 c, q_acosh, q_hypot, q_infinity, s, x, y, z
...
z = q_acosh( x )
i = iq_finite( x )
z = q_hypot( x, y )
z = q_infinity()
CALL q_sincos( x, s, c )
```

The variables c, l, p, s, u, x, and y are of type quadruple precision.

If you use one of these quadruple precision functions, put it into a REAL*16 statement (or type it by some IMPLICIT statement).

sind(x), asind(x), … involve *degrees* rather than *radians*.

For meanings of routines and arguments, type man on the routine name without the q_; it is a C man page for the double precision function, but the meanings are the same.

Table 7-2 Quadruple-Precision libm Functions

q_copysign(x, y)	REAL*16	Function
q_fabs(x)	REAL*16	Function
q_fmod(x)	REAL*16	Function
q_infinity( )	REAL*16	Function
iq_finite(x)	INTEGER	Function
iq_fp_class(x)	INTEGER	Function
iq_ilogb(x)	INTEGER	Function
iq_isinf(x)	INTEGER	Function
iq_isnan(x)	INTEGER	Function
iq_isnormal(x)	INTEGER	Function
iq_issubnormal(x)	INTEGER	Function
iq_iszero(x)	INTEGER	Function
iq_signbit(x)	INTEGER	Function
q_max_normal()	REAL*16	Function
q_max_subnormal()	REAL*16	Function
q_min_normal()	REAL*16	Function
q_min_subnormal()	REAL*16	Function
q_nextafter(x, y)	REAL*16	Function
q_quiet_nan(n)	REAL*16	Function
q_remainder(x, y)	REAL*16	Function
q_scalbn(x, n)	REAL*16	Function
q_signaling_nan(n)	REAL*16	Function

If you need to use any other quadruple-precision libm function, you can call it using $PRAGMA C(*fcn*) before the call. For details, read the chapter, "The C–FORTRAN 77 Interface" in the *FORTRAN 77 User's Guide*.

7.35 `libm_single`: `libm` *Single-Precision Functions*

These subprograms are single-precision `libm` functions and subroutines.

Intrinsic Functions

The following FORTRAN 77 intrinsic functions return single-precision values if they have single-precision arguments. If the function needed is available as an *intrinsic* function, it may be simpler to use it than a *non-intrinsic* function.

The ♦ symbol indicates it is nonstandard that this is an intrinsic function.

`sqrt(x)`	`asin(x)`	`cosd(x)` ♦
`log(x)`	`acos(x)`	`asind(x)` ♦
`log10(x)`	`atan(x)`	`acosd(x)` ♦
`exp(x)`	`atan2(x,y)`	`atand(x)` ♦
`x**y`	`sinh(x)`	`atan2d(x,y)` ♦
`sin(x)`	`cosh(x)`	`aint(x)`
`cos(x)`	`tanh(x)`	`anint(x)`
`tan(x)`	`sind(x)` ♦	`nint(x)`

Non-Intrinsic Functions

In general, the functions below provide access to single-precision `libm` functions that do *not* correspond to standard FORTRAN 77 generic intrinsic functions—data types are determined by the usual data typing rules.

Samples: Single-precision `libm` functions:

The REAL functions used are not in a REAL statement. The type is determined by the default typing rules for the letter `r`.

```
REAL c, s, x, y, z
..
z = r_acosh( x )
i = ir_finite( x )
z = r_hypot( x, y )
z = r_infinity()
CALL r_sincos( x, s, c )
```

Variables c, l, p, s, u, x, and y are of type REAL.

If you use one of these REAL functions, it will get the default type of REAL, unless you have some IMPLICIT statement for variables starting with r.

sind(x), asind(x), … involve ***degrees*** rather than ***radians***

For meanings of routines and arguments, type man on the routine name without the r_; it is a C man page, but the meanings are the same.

Table 7-3 Single-Precision libm Functions

r_acos(x)	REAL	Function	arc cosine
r_acosd(x)	REAL	Function	
r_acosh(x)	REAL	Function	arc cosh
r_acosp(x)	REAL	Function	
r_acospi(x)	REAL	Function	
r_atan(x)	REAL	Function	arc tangent
r_atand(x)	REAL	Function	
r_atanh(x)	REAL	Function	arc tanh
r_atanp(x)	REAL	Function	
r_atanpi(x)	REAL	Function	
r_asin(x)	REAL	Function	arc sine
r_asind(x)	REAL	Function	
r_asinh(x)	REAL	Function	arc sinh
r_asinp(x)	REAL	Function	
r_asinpi(x)	REAL	Function	
r_atan2((y, x)	REAL	Function	arc tangent
r_atan2d(y, x)	REAL	Function	
r_atan2pi(y, x)	REAL	Function	
r_cbrt(x)	REAL	Function	cube root
r_ceil(x)	REAL	Function	ceiling
r_copysign(x, y)	REAL	Function	
r_cos(x)	REAL	Function	cosine
r_cosd(x)	REAL	Function	
r_cosh(x)	REAL	Function	hyperbolic cos
r_cosp(x)	REAL	Function	
r_cospi(x)	REAL	Function	
r_erf(x)	REAL	Function	error function
r_erfc(x)	REAL	Function	
r_expm1(x)	REAL	Function	(e**x)-1
r_floor(x)	REAL	Function	floor
r_hypot(x, y)	REAL	Function	hypotenuse
r_infinity( )	REAL	Function	bessel
r_j0(x)	REAL	Function	
r_j1(x)	REAL	Function	
r_jn(x)	REAL	Function	

Table 7-3 Single-Precision libm Functions *(Continued)*

ir_finite(x)	INTEGER	Function	
ir_fp_class(x)	INTEGER	Function	
ir_ilogb(x)	INTEGER	Function	
ir_irint(x)	INTEGER	Function	
ir_isinf(x)	INTEGER	Function	
ir_isnan(x)	INTEGER	Function	
ir_isnormal(x)	INTEGER	Function	
ir_issubnormal(x)	INTEGER	Function	
ir_iszero(x)	INTEGER	Function	
ir_signbit(x)	INTEGER	Function	
r_addran()	REal	Function	random number
r_addrans(x, p, l, u)	n/a	Function	
r_lcran()	REAL	Subroutine	
r_lcrans(x, p, l, u)	n/a	Subroutine	
r_shufrans(x, p, l, u)	n/a	Subroutine	
r_lgamma(x)	REAL	Function	log gamma
r_logb(x)	REAL	Function	
r_log1p(x)	REAL	Function	
r_log2(x)	REAL	Function	
r_max_normal()	REAL	Function	
r_max_subnormal()	REAL	Function	
r_min_normal()	REAL	Function	
r_min_subnormal()	REAL	Function	
r_nextafter(x, y)	REAL	Function	
r_quiet_nan(n)	REAL	Function	
r_remainder(x, y)	REAL	Function	
r_rint(x)	REAL	Function	
r_scalb(x, y)	REAL	Function	
r_scalbn(x, n)	REAL	Function	
r_signaling_nan(n)	REAL	Function	
r_significand(x)	REAL	Function	
r_sin(x)	REAL	Function	sine
r_sind(x)	REAL	Function	
r_sinh(x)	REAL	Function	hyperbolic sin
r_sinp(x)	REAL	Function	
r_sinpi(x)	REAL	Function	

Table 7-3 Single-Precision `libm` Functions *(Continued)*

`r_sincos( x, s, c )`	n/a	Subroutine	sine & cosine
`r_sincosd( x, s, c )`	n/a	Subroutine	
`r_sincosp( x, s, c )`	n/a	Subroutine	
`r_sincospi( x, s, c )`	n/a	Subroutine	
`r_tan( x )`	`REAL`	Function	tangent
`r_tand( x )`	`REAL`	Function	
`r_tanh( x )`	`REAL`	Function	hyperbolic tan
`r_tanp( x )`	`REAL`	Function	
`r_tanpi( x )`	`REAL`	Function	
`r_y0( x )`	`REAL`	Function	bessel
`r_y1( x )`	`REAL`	Function	
`r_yn( n, x )`	`REAL`	Function	

See also: `intro`(3M) and the *Numerical Computation Guide*.

7.36 `link`, `symlnk`: *Make a Link to an Existing File*

`link` creates a link to an existing file. `symlink` creates a symbolic link to an existing file.

The functions are:

`status = link(` *name1*, *name2* `)`			
`status = symlnk(` *name1*, *name2* `)`			
name1	`character*`*n*	Input	Path name of an existing file
name2	`character*`*n*	Input	Path name to be linked to the file, *name1*. *name2* must not already exist.
Return value	`INTEGER`	Output	*status*=0: OK *status*>0: System error code

`link`: Create a Link to an Existing File

Example 1: `link`: Create a link named `data1` to the file, `tlink.db.data.1`:

```
    character*34 name1/'tlink.db.data.1'/, name2/'data1'/
    integer link, status
    status = link( name1, name2 )
    if ( status .ne. 0 ) stop 'link: error'
    end
demo% f77 -silent tlink.f
demo% ls -l data1
data1 not found
demo% a.out
demo% ls -l data1
-rw-rw-r-- 2 generic 2 Aug 11 08:50 data1
demo%
```

`symlnk`: Create a Symbolic Link to an Existing File

Example 2: `symlnk`: Create a symbolic link named `data1` to the file, `tlink.db.data.1`:

```
    character*34 name1/'tlink.db.data.1'/, name2/'data1'/
    integer status, symlnk
    status = symlnk( name1, name2 )
    if ( status .ne. 0 ) stop 'symlnk: error'
    end
demo% f77 -silent tsymlnk.f
demo% ls -l data1
data1 not found
demo% a.out
demo% ls -l data1
lrwxrwxrwx 1 generic 15 Aug 11 11:09 data1 -> tlink.db.data.1
demo%
```

See also: `link`(2), `symlink`(2), `perror`(3F), and `unlink`(3F).

Note this bug: the path names cannot be longer than `MAXPATHLEN` as defined in `<sys/param.h>`.

7.37 `loc`: *Return the Address of an Object*

The function is:

k = loc(*arg*)			
arg	Any type	Input	Name of any variable, array, or structure
Return value	INTEGER	Output	Address of *arg*

Example: `loc`:

```
    integer k, loc
    real arg / 9.0 /
    k = loc( arg )
    write(*,*) k
    end
```

7.38 `long`, `short`: *Integer Object Conversion*

`long` and `short` handle integer object conversions.

`long`: *Convert a Short Integer to a Long Integer*

The function is:

call *ExpecLong*(long(*int2*))		
int2	INTEGER*2	Input
Return value	INTEGER*4	Output

`short`: *Convert a Long Integer to a Short Integer*

The function is:

call *ExpecShort*(short(*int4*))		
int4	INTEGER*4	Input
Return value	INTEGER*2	Output

Example (fragment): `long()` and `short()`:

```
    integer*4 int4/8/, long
    integer*2 int2/8/, short
    call ExpecLong( long(int2) )
    call ExpecShort( short(int4) )
    …
    end
```

`long` is useful if constants are used in calls to library routines and the code is compiled with the `-i2` option.

`short` is useful in similar context when an otherwise long object must be passed as a short integer.

7.39 `longjmp`, `isetjmp`: *Return to Location Set by* `isetjmp`

`isetjmp` sets a location for `longjmp`; `longjmp` returns to that location.

`isetjmp`: *Set the Location for* `longjmp`

The function is:

ival = `isetjmp(` *env* `)`			
env	`integer env(12)`	Output	*env* is a 12-word integer array
Return value	`INTEGER`	Output	*ival* = 0 if `isetjmp` is called explicitly *ival* ≠ 0 if `isetjmp` is called through `longjmp`

`longjmp`: *Return to the location set by* `isetjmp`

The subroutine is:

call `longjmp(` *env*`,` *ival* `)`			
env	`integer env(12)`	Input	*env* is the 12-word integer array initialized by `isetjmp`
ival	`INTEGER`	Output	*ival* = 0 if `isetjmp` is called explicitly *ival* ≠ 0 if `isetjmp` is called through `longjmp`

Description

The `isetjmp` and `longjmp` routines are used to deal with errors and interrupts encountered in a low-level routine of a program.

These routines should be used only as a last resort. They require discipline, and are not portable. Read the man page, `setjmp` (3V), for bugs and other details.

`isetjmp` saves the stack environment in *env*. It also saves the register environment.

`longjmp` restores the environment saved by the last call to `isetjmp`, and returns in such a way that execution continues as if the call to `isetjmp` had just returned the value *ival*.

The integer expression *ival* returned from `isetjmp` is zero if `longjmp` is not called, and nonzero if `longjmp` is called.

Example: Code fragment using `isetjmp` and `longjmp`:

```
    integer  env(12)
    common /jmpblk/ env
    j = isetjmp( env )                   ! ←isetjmp
    if ( j .eq. 0 ) then
       call  sbrtnA
    else
       call error_processor
    end if
    end
    subroutine sbrtnA
    integer  env(12)
    common /jmpblk/ env
    call longjmp( env, ival )            !← longjmp
    return
    end
```

Restrictions

You must invoke `isetjmp` before calling `longjmp()`.

The argument to `isetjmp` must be a 12-integer array.

You must pass the *env* variable from the routine that calls `isetjmp` to the routine that calls `longjmp`, either by common or as an argument.

`longjmp` attempts to clean up the stack. `longjmp` must be called from a lower call-level than `isetjmp`.

Passing `isetjmp` as an argument that is a procedure name does not work.

See `setjmp`(3V).

7.40 `malloc`: *Allocate Memory and Get Address*

The function is:

k = malloc(*n*)			
n	INTEGER	Input	Number of bytes of memory
Return value	INTEGER	Output	*k*>0: *k*=address of *the* start of the block of memory allocated *k*=0: Error

The function `malloc` allocates an area of memory and returns the address of the start of that area. The region of memory is not initialized in any way—assume it is garbage.

Example: Code fragment using `malloc()`:

```
pointer ( p1, X )
…
p1 = malloc( 1000 )
if ( p1 .eq. 0 ) stop 'malloc: cannot allocate'
…
end
```

In the above example, we get 1,000 bytes of memory.

See also Section 7.15, “free: Deallocate Memory Allocated by Malloc,” for more details.

7.41 `mvbits`: *Move a Bit Field*

call mvbits(*src*, *ini1*, *nbits*, *des*, *ini2*)			
src	INTEGER	Input	Source
ini1	INTEGER	Input	Initial bit position in the source
nbits	INTEGER	Input	Number of bits to move
des	INTEGER	Output	Destination
ini2	INTEGER	Input	Initial bit position in the destination

Example: `mvbits`:

```
demo% cat mvb1.f
* mvb1.f -- From src, initial bit 0, move 3 bits to des, initial
bit 3.
*    src    des
* 543210 543210 ← Bit numbers (VMS convention)
* 000111 000001 ← Values before move
* 000111 111001 ← Values after move
    integer src, ini1, nbits, des, ini2
    data src, ini1, nbits, des, ini2
&         / 7,    0,     3,   1,    3 /
    call mvbits ( src, ini1, nbits, des, ini2 )
    write (*,"(5o3)") src, ini1, nbits, des, ini2
    end
demo% f77 -silent mvb1.f
demo% a.out
  7  0  3 71  3
demo%
```

If you use `idate` or `time`, you get VMS versions.

Note the following:

- Bits are numbered according to VMS convention: from low-ordered end (as in the example above).
- `mvbits` changes only bits *ini2* through *ini2*+*nbits*`-1` of the *des* location, and no bits of the *src* location.

- The restrictions are:
  - *ini1* + *nbits* ≤ 32
  - *ini2* + *nbits* ≤ 32

7.42 perror, gerror, ierrno: *Get System Error Messages*

These routines perform the following functions:

perror	Print a message to FORTRAN 77 logical unit 0, stderr.
gerror	Get a system error message (of the last detected system error)
ierrno	Get the error number of the last detected system error.

perror: *Print Message to Logical Unit 0,* stderr

The subroutine is:

call perror(*string*)			
string	character**n*	Input	The message. It is written preceding the standard error message for the last detected system error.

Example 1:

```
…
    call perror( "file is for formatted I/O" )
…
```

gerror: *Get Message for Last Detected System Error*

The subroutine or function is:

call gerror(*string*)			
string	character**n*	Output	Message for the last detected system error

Example 2: `gerror()` as a subroutine:

```
    character string*30
    …
    call gerror ( string )
    write(*,*) string
    end
```

Example 3: `gerror()` as a function; *string* not used:

```
    character gerror*30, z*30
    …
    z = gerror( )
    write(*,*) z
    end
```

`ierrno`: *Get Number for Last Detected System Error*

The function is:

n = ierrno()			
Return value	`INTEGER`	Output	Error number of last detected system error

This number is updated only when an error actually occurs. Most routines and I/O statements that might generate such errors return an error code after the call; that value is a more reliable indicator of what caused the error condition.

Example 4: `ierrno()`:

```
    integer ierrno, n
    …
    n = ierrno()
    write(*,*) n
    end
```

See also `intro`(2) and `perror`(3).

Note these bugs:

- *string* in the call to `perror` cannot be longer than 127 characters.
- The length of the string returned by `gerror` is determined by the calling program.

`f77` I/O Error Codes and Meanings

If the error number is less than 1000, then it is a system error. See `intro` (2).

```
1000       error in format
1001       illegal unit number
1002       formatted io not allowed
1003       unformatted io not allowed
1004       direct io not allowed
1005       sequential io not allowed
1006       can't backspace file
1007       off beginning of record
1008       can't stat file
1009       no * after repeat count
1010       off end of record
1011       <not used>
1012       incomprehensible list input
1013       out of free space
1014       unit not connected
1015       read unexpected character
1016       illegal logical input field
1017       'new' file exists
1018       can't find 'old' file
1019       unknown system error
1020       requires seek ability
1021       illegal argument
1022       negative repeat count
1023       illegal operation for unit
1024        <not used>
1025       incompatible specifiers in open
1026       illegal input for namelist
1027       error in FILEOPT parameter
```

7.43 putc, fputc: *Write a Character to a Logical Unit*

`putc` writes to logical unit 6, normally the control terminal output.

`fputc` writes to a logical unit.

These functions write a character to the file associated with a FORTRAN 77 logical unit bypassing normal FORTRAN 77 I/O.

For any one unit, do not mix normal FORTRAN 77 output with output by these functions.

putc: *Write to Logical Unit 6*

The function is:

status = putc(*char*)			
char	character	Input	The character to write to the unit
Return value	INTEGER	Output	*status*=0: OK *status*>0: System error code

Example: `putc()`:

```
    character char, s*10 / 'OK by putc' /
    integer putc, status
    do i = 1, 10
       char = s(i:i)
       status = putc( char )
    end do
    status = putc( '\n' )
    end
demo% f77 -silent tputc.f
demo% a.out
OK by putc
demo%
```

`fputc`: *Write to Specified Logical Unit*

The function is:

status = `fputc(` *lunit*`,` *char* `)`			
lunit	`INTEGER`	Input	The unit to write to
char	`character`	Input	The character to write to the unit
Return value	`INTEGER`	Output	*status*=0: OK *status*>0: System error code

Example: `fputc()`:

```
    character char, s*11 / 'OK by fputc' /
    integer fputc, status
    open( 1, file='tfputc.data')
    do i = 1, 11
        char = s(i:i)
        status = fputc( 1, char )
    end do
    status = fputc( 1, '\n' )
    end
demo% f77 -silent tfputc.f
demo% a.out
demo% cat tfputc.data
OK by fputc
demo%
```

See also `putc`(3S), `intro`(2), and `perror`(3F).

7.44 `qsort`: *Sort the Elements of a One-dimensional Array*

The subroutine is:

call qsort(*array*, *len*, *isize*, *compar*)			
array	array	Input	Contains the elements to be sorted
len	INTEGER	Input	Number of elements in the array.
isize	INTEGER	Input	Size of an element, typically: 4 for integer or real 8 for double precision or complex 16 for double complex Length of character object for character arrays
compar	function name	Input	Name of a user-supplied INTEGER*2 function

The function `compar(`*arg1*`,`*arg2*`)` determines the sorting order. The two arguments are elements of *array*. The function must return:

Negative	If *arg1* is considered to precede *arg2*
Zero	If *arg1* is equivalent to *arg2*
Positive	If *arg1* is considered to follow *arg2*

Example: `qsort()`:

```
      external compar
      integer*2 compar
      integer array(10)/5,1,9,0,8,7,3,4,6,2/, len/10/, isize/4/
      call qsort( array, len, isize, compar )
      write(*,'(10i3)') array
      end

      integer*2 function compar( a, b )
      integer a, b
      if ( a .lt. b ) compar = -1
      if ( a .eq. b ) compar = 0
      if ( a .gt. b ) compar = 1
      return
      end
```

Compile and run the above source:

```
demo% f77 -silent tqsort.f
demo% a.out
  0 1 2 3 4 5 6 7 8 9
demo%
```

See also `qsort`(3).

7.45 `ran`: *Generate a Random Number between 0 and 1*

Repeated calls to `ran` generate a sequence of random numbers with a uniform distribution.

r = ran(*i*)			
i	INTEGER*4	Input	Variable or array element
r	REAL	Output	Variable or array element

See `lcrans`(3m).

Example: `ran`:

```
demo% cat ran1.f
* ran1.f -- Generate random numbers.
    integer i, n
    real r(10)
    i = 760013
    do n = 1, 10
        r(n) = ran ( i )
    end do
    write ( *, "( 5 f11.6 )" ) r
    end
demo% f77 -silent ran1.f
demo% a.out
   0.222058 0.299851 0.390777 0.607055 0.653188
   0.060174 0.149466 0.444353 0.002982 0.976519
demo%
```

Note the following:

- The range includes 0.0 and excludes 1.0.
- The algorithm is a multiplicative, congruential type, general random number generator.
- In general, the value of `i` is set *once* during execution of the calling program.
- The initial value of `i` should be a large odd integer.
- Each call to `RAN` gets the next random number in the sequence.
- To get a different sequence of random numbers each time you run the program, you must set the argument to a different initial value for each run.
- The argument is used by `RAN` to store a value for the calculation of the next random number according to the following algorithm:

```
SEED = 6909 * SEED + 1 (MOD 2**32)
```

- `SEED` contains a 32-bit number, and the high-order 24 bits are converted to floating point, and that value is returned.

7.46 `rand`, `drand`, `irand`: *Return Random Values*

`rand` returns real values in the range 0.0 through 1.0.

`drand` returns double precision values in the range 0.0 through 1.0.

`irand` returns positive integers in the range 0 through 2147483647.

These functions use `random`(3) to generate sequences of random numbers. The three functions share the same 256 byte state array. The only advantage of these functions is that they are widely available on UNIX systems. For better random number generators, compare `lcrans`, `addrans`, and `shufrans`; also read the *Numerical Computation Guide.*

i = `irand(` *k* `)`			
r = `rand(` *k* `)`			
d = `drand(` *k* `)`			
k, r, d	`INTEGER*4`	Input	*k*=0: Get next random number in the sequence *k*=1: Restart sequence, return first number *k*>0: Use as a seed for new sequence, return first number
`rand`	`REAL*4`	Output	
`drand`	`REAL*8`	Output	
`irand`	`INTEGER*4`	Output	

Example: `irand()`:

```
      integer*4 v(5), iflag/0/
      do i = 1, 5
          v(i) = irand( iflag )
      end do
      write(*,*) v
      end
demo% f77 -silent trand.f
demo% a.out
     2078917053 143302914 1027100827 1953210302 755253631
demo%
```

See also `random`(3).

7.47 `rename`: *Rename a File*

The function is:

status = rename(*from*, *to*)			
from	`character*`*n*	Input	Path name of an existing file
to	`character*`*n*	Input	New path name for the file
Return value	`INTEGER`	Output	*status*=0: OK *status*>0: System error code

If *to* exists, then both *from* and *to* must be the same type of file, and must reside on the same file system. If *to* exists, it is removed first.

Example: `rename()`—Rename file `trename.old` to `trename.new`:

```
    integer rename, status
    character*18 from/'trename.old'/, to/'trename.new'/
    status = rename( from, to )
    if ( status .ne. 0 ) stop 'rename: error'
    end
demo% f77 - silent trename.f
demo% ls trename*
trename.f trename.old
demo% a.out
demo% ls trename*
trename.f trename.new
demo%
```

See also `rename`(2) and `perror`(3F).

Note the bug: the path names cannot be longer than `MAXPATHLEN` as defined in `<sys/param.h>`.

7.48 secnds: Get System Time in Seconds, Minus Argument

t = secnds(*t0*)			
t0	REAL	Input	Constant, variable, or array element
Return Value	REAL	Output	Number of seconds since midnight, minus *t0*

Example: secnds:

```
demo% cat sec1.f
    real elapsed, t0, t1, x, y
    t0 = 0.0
    t1 = secnds( t0 )
    y = 0.1
    do i = 1, 1000
        x = asin( y )
    end do
    elapsed = secnds( t1 )
    write ( *, 1 ) elapsed
1   format ( ' 1000 arcsines: ', f12.6, ' sec' )
    end
demo% f77 -silent sec1.f
demo% a.out
 1000 arcsines: 6.699141 sec
demo%
```

Note that:

- The returned value from SECNDS is accurate to 0.01 second.
- The value is the system time, as the number of seconds from midnight, and it correctly spans midnight.
- Some precision may be lost for small time intervals near the end of the day.

7.49 sh: *Fast Execution of an* sh *Command*

The function is:

status = sh(*string*)			
string	character*n	Input	String containing command to do
Return value	INTEGER	Output	Exit status of the shell executed. See wait(2) for an explanation of this value.

Example: sh():

```
    character*18 string / 'ls > MyOwnFile.names' /
    integer status, sh
    status = sh( string )
    if ( status .ne. 0 ) stop 'sh: error'
    ...
    end
```

The function sh passes *string* to the sh shell as input, as if the string had been typed as a command.

The current process waits until the command terminates.

The forked process flushes all open files:

- For output files, the buffer is flushed to the actual file.
- For input files, the position of the pointer is unpredictable.

The sh() function is not MT-safe. Do not call it from multithreaded programs; that is, do not call it from FORTRAN 77 MP programs.

See also: execve(2), wait(2), and system(3).

Note this bug: *string* cannot be longer than 1,024 characters.

7.50 `signal`: *Change the Action for a Signal*

The function is:

n = signal(*signum*, *proc*, *flag*)			
signum	INTEGER	Input	Signal number; see `signal`(3)
proc	Routine name	Input	Name of user signal handling routine; must be in an external statement
flag	INTEGER	Input	*flag*<0: Use *proc* as the signal handling routine *flag*≥0: Ignore *proc*; pass *flag* as the action *flag*=0: Use the default action *flag*=1: Ignore this signal
Return value	INTEGER	Output	*n*=-1: System error *n*>0: Definition of previous action *n*>1: *n*=Address of routine that would have been called *n*<-1: If *signum* is a valid signal number, then: *n*=address of routine that would have been called. If *signum* is a *not* a valid signal number, then: *n* is an error number.

If *proc* is called, it is passed the signal number as an integer argument.

If a process incurs a signal, the default action is usually to clean up and abort. You can change the action by writing an alternative signal handling routine, and then telling the system to use it.

You direct the system to use alternate action by calling `signal`.

The returned value can be used in subsequent calls to `signal` to restore a previous action definition.

You can get a negative return value even though there is no error. In fact, if you pass a *valid* signal number to `signal()`, and you get a return value less than -1, then it is OK.

`f77` arranges to trap certain signals when a process is started. The only way to restore the default `f77` action is to save the returned value from the first call to `signal`.

Example: Code fragment that uses `signal()`—if illegal instruction signal, then call `MyAct`:

```
#include <signal.h>
    integer flag/-1/, n, signal
    external MyAct
    …
    n = signal( SIGILL, MyAct, flag )
    if ( n .eq. -1 ) stop 'Error from signal()'
    if ( n .lt. -1 ) write(*,*) 'From signal: n = ', -n
    …
    end

    subroutine MyAct( signum )
    integer signum
    …
    return
    end
```

See also `kill`(1), `signal`(3), and `kill`(3F).

7.51 `sleep`: *Suspend Execution for an Interval*

The subroutine is:

subroutine sleep(*itime*)			
eyc	INTEGER	Input	Number of seconds to sleep

The actual time can be up to 1 second less than *itime* due to granularity in system timekeeping.

Example: `sleep()`:

```
    integer time / 5 /
    write(*,*) 'Start'
    call sleep( time )
    write(*,*) 'End'
    end
```

See also `sleep`(3).

7.52 `stat`, `lstat`, `fstat`: *Get File Status*

These functions return the following information:

device, inode number, protection, number of hard links,
user ID, group ID, device type, size, access time, modify time,
status change time, optimal blocksize, blocks allocated

Both `stat` and `lstat` query by file name. `fstat` queries by logical unit.

`stat`: *Get Status for File, by File Name*

The function is:

ierr = `stat` (*name*, *statb*)			
name	`character*`*n*	Input	Name of the file
statb	`INTEGER`	Output	Status structure for the file, 13-element array
Return value	`INTEGER`	Output	*ierr*=0: OK *ierr*>0: Error code

Example 1: `stat()`:

```
      character name*18 /'MyFile'/
      integer ierr, stat, lunit/1/, statb(13)
      open( unit=lunit, file=name )
      ierr = stat ( name, statb )
      if ( ierr .ne. 0 ) stop 'stat: error'
      write(*,*)'UID of owner = ',statb(5),', blocks = ',statb(13)
      end
```

`fstat`: *Get Status for File, by Logical Unit*

The function is:

ierr = `fstat` (*lunit*, *statb*)			
lunit	`INTEGER`	Input	Logical unit number
statb	`INTEGER`	Output	Status structure for the file, 13-element array
Return value	`INTEGER`	Output	*ierr*=0: OK *ierr*>0: Error code

Example 2: `fstat()`:

```
    character name*18 /'MyFile'/
    integer fstat, lunit/1/, statb(13)
    open( unit=lunit, file=name )
    ierr = fstat ( lunit, statb )
    if ( ierr .ne. 0 ) stop 'fstat: error'
    write(*,*)'UID of owner = ',statb(5),', blocks = ',statb(13)
    end
```

`lstat`: *Get Status for File, by File Name*

The function is:

ierr = `lstat` (*name*, *statb*)			
name	`character*`*n*	Input	File name
statb	`INTEGER`	Output	Status array of file, 13 elements
Return value	`INTEGER`	Output	*ierr*=0: OK *ierr*>0: Error code

Example 3: `lstat()`:

```
    character name*18 /'MyFile'/
    integer lstat, lunit/1/, statb(13)
    open( unit=lunit, file=name )
    ierr = lstat ( name, statb )
    if ( ierr .ne. 0 ) stop 'lstat: error'
    write(*,*)'UID of owner = ',statb(5),', blocks = ',statb(13)
    end
```

Detail of Status Array for Files

The meaning of the information returned in array *statb* is as described for the structure *stat* under `stat`(2).

Spare values are not included. The order is shown in the following table:

`statb`(1)	Device inode resides on
`statb`(2)	This inode's number
`statb`(3)	Protection
`statb`(4)	Number of hard links to the file
`statb`(5)	User ID of owner
`statb`(6)	Group ID of owner
`statb`(7)	Device type, for inode that is device
`statb`(8)	Total size of file
`statb`(9)	File last access time
`statb`(10)	File last modify time
`statb`(11)	File last status change time
`statb`(12)	Optimal blocksize for file system I/O ops
`statb`(13)	Actual number of blocks allocated

See also `stat`(2), `access`(3F), `perror`(3F), and `time`(3F).

Note this bug—the path names can be no longer than `MAXPATHLEN` as defined in `<sys/param.h>`.

7.53 system: *Execute a System Command*

The function is:

status = system(*string*)			
string	character**n*	Input	String containing command to do
Return value	INTEGER	Output	Exit status of the shell executed. See wait(2) for an explanation of this value.

Example: system():

```
    character*8 string / 'ls s*' /
    integer status, system
    status = system( string )
    if ( status .ne. 0 ) stop 'system: error'
    end
```

The function system passes *string* to your shell as input, as if the string had been typed as a command.

If system can find the environment variable SHELL, then system uses the value of SHELL as the command interpreter (shell); otherwise, it uses sh(1).

The current process waits until the command terminates.

Historically, cc and f77 developed with different assumptions:

- If cc calls system, the shell is always the Bourne shell.
- If f77 calls system, then which shell is called depends on the environment variable SHELL.

The system function flushes all open files:

- For output files, the buffer is flushed to the actual file.
- For input files, the position of the pointer is unpredictable.

See also: execve(2), wait(2), and system(3).

The system() function is not MT-safe. Do not call it from multithreaded programs; that is, do not call it from FORTRAN 77 MP programs.

Note the bug: *string* cannot be longer than 1,024 characters.

7.54 `time`, `ctime`, `ltime`, `gmtime`: *Get System Time*

These routines have the following functions:

`time`	Standard version: Get system time as integer (seconds since 0 GMT 1/1/70) VMS Version: Get the system time as character (hh:mm:ss)
`ctime`	Convert a system time to an ASCII string.
`ltime`	Dissect a system time into month, day, and so forth, local time.
`gmtime`	Dissect a system time into month, day, and so forth, GMT.

`time`: *Get System Time*

For `time()`, there are two versions, a standard version and a VMS version. If you use the `f77` command-line option `-lV77`, then you get the VMS version for `time()` and for `idate()`; otherwise, you get the standard versions.

Version Standard with Operating System

The function is:

n = `time()`			
Return value	`INTEGER`	Output	Time, in seconds, since 0:0:0, GMT, 1/1/70

The function `time()` returns an integer with the time since 00:00:00 GMT, January 1, 1970, measured in seconds. This is the value of the operating system clock.

Example: `time()`, version standard with the operating system:

Do not use `-lV77`.

```
    integer  n, time
    n = time()
    write(*,*) 'Seconds since 0 1/1/70 GMT = ', n
    end
demo% f77 -silent ttime.f
demo% a.out
 The time is:  771967850
demo%
```

VMS Version

This function `time` gets the current system time as a character string.

The function is:

`call time( t )`			
t	`character*8`	Output	Time, in the form *hh*:*mm*:*ss* *hh*, *mm*, and *ss* are each two digits: *hh* is the hour; *mm* is the minute; *ss* is the second

Example: `time(t)`, VMS version, `ctime`—convert the system time to ASCII:

Use `-lV77`.

```
    character  t*8
    call time( t )
    write(*, "(' The current time is ', A8 )")  t
    end
demo% f77 -silent ttimeV.f -lV77
demo% a.out
 The current time is 08:14:13
demo%
```

ctime: *Convert System Time to Character*

The function ctime converts a system time, *stime*, and returns it as a 24-character ASCII string.

The function is:

string = ctime(*stime*)			
stime	INTEGER*4	Input	System time from time() (standard version)
Return value	character*24	Output	System time as character string. You must type ctime and *string* as character*24.

The format of the ctime returned value is shown in the following example. It is described in the man page ctime, section 3C in Solaris 2.x, 3V in Solaris 1.x.

Example: ctime():

```
    character*24 ctime, string
    integer  n, time
    n = time()
    string = ctime( n )
    write(*,*) 'ctime: ', string
    end
demo% f77 -silent tctime.f
demo% a.out
 ctime: Mon Aug 12 10:35:38 1991
demo%
```

`ltime`: *Split System Time to Month, Day,… (Local)*

This routine dissects a system time into month, day, and so forth, for the local time zone.

The subroutine is:

call ltime(*stime*, *tarray*)			
stime	INTEGER*4	Input	System time from `time()` (standard version)
tarray	INTEGER*4(9)	Output	System time, local, as day, month, year, …

For the meaning of the elements in `tarray`, see the next section.

Example: `ltime()`:

```
    integer*4  stime, tarray(9), time
    stime = time()
    call ltime( stime, tarray )
    write(*,*) 'ltime: ', tarray
    end
demo% f77 -silent tltime.f
demo% a.out
 ltime: 25 49 10 12 7 91 1 223 1
demo%
```

`gmtime`: *Split System Time to Month, Day, … (GMT)*

This routine dissects a system time into month, day, and so on, for GMT.

The subroutine is:

call gmtime(*stime*, *tarray*)			
stime	INTEGER*4	Input	System time from `time()` (standard version)
tarray	INTEGER*4(9)	Output	System time, GMT, as day, month, year, …

Example: `gmtime`:

```
    integer*4  stime, tarray(9), time
    stime = time()
    call gmtime( stime, tarray )
    write(*,*) 'gmtime: ', tarray
    end
demo% f77 -silent tgmtime.f
demo% a.out
 gmtime:   12  44  19  18  5  94  6  168  0
demo%
```

Here are the `tarray()` values, from `ctime`: index, units, and range:

`tarray()`

For Solaris1.x, the range for seconds is 0 - 59

1	Seconds (0 - 61)	6	Year - 1900
2	Minutes (0 - 59)	7	Day of week (Sunday = 0)
3	Hours (0 - 23)	8	Day of year (0 - 365)
4	Day of month (1 - 31)	9	Daylight Saving Time, 1 if DST in effect
5	Months since January (0 - 11)		

These values are described in the `man` page `ctime`, section 3C in Solaris 2.x, 3V in Solaris 1.x.

See also: `ctime`, `idate`(3F), and `fdate`(3F).

7.55 `topen`, `tclose`, `tread`,…, `tstate`: *Do Tape I/O*

You can manipulate magnetic tape from FORTRAN 77 using these functions:

`topen`	Associate a device name with a tape logical unit.
`tclose`	Write EOF, close tape device channel, and remove association with *tlu*.
`tread`	Read next physical record from tape into buffer.
`twrite`	Write the next physical record from buffer to tape.
`trewin`	Rewind the tape to the beginning of the first data file.
`tskipf`	Skip forward over files and/or records, and reset EOF status.
`tstate`	Determine the logical state of the tape I/O channel.

On any one unit, do not mix these functions with standard FORTRAN 77 I/O.

You must first use `topen()` to open a tape logical unit, *tlu*, for the specified device. Then you do all other operations on the specified *tlu*. *tlu* has no relationship at all to any normal FORTRAN 77 logical unit.

Before you use one of these functions, its name must be in an `INTEGER` type statement.

`topen`: *Associate a Device with a Tape Logical Unit*

n = `topen(` *tlu*`,` *devnam*`,` *islabeled* `)`			
tlu	`INTEGER`	Input	Tape logical unit. It must be in the range 0 to 7.
islabeled	`LOGICAL`	Input	True=the tape is labeled A label is the first file on the tape.
Return value	`INTEGER`	Output	*n*=0: OK *n*<0: Error

This function does *not* move the tape. See `perror`(3f) for details.

EXAMPLE: `topen()`—open a 1/4-inch tape file:

```
    CHARACTER devnam*9 / '/dev/rst0' /
    INTEGER n / 0 /, tlu / 1 /, topen
    LOGICAL islabeled / .false. /
    n = topen( tlu, devnam, islabeled )
    IF ( n .LT. 0 ) STOP "topen: cannot open"
    WRITE(*,'("topen ok:", 2I3, 1X, A10)') n, tlu,  devnam
    END
```

The output is:

```
topen ok: 0 1 /dev/rst0
```

`tclose`: *Write EOF, Close Tape Channel, Disconnect tlu*

n = `tclose` (*tlu*)			
tlu	`INTEGER`	Input	Tape logical unit, in range 0 to 7
n	`INTEGER`	Return value	*n*=0: OK *n*<0: Error

Caution – `tclose()` places an EOF marker immediately after the current location of the unit pointer, and then closes the unit. So if you `trewin()` a unit before you `tclose()` it, its contents are discarded.

Example: `tclose()`—close an opened 1/4-inch tape file:

```
    CHARACTER devnam*9 / '/dev/rst0' /
    INTEGER n / 0 /, tlu / 1 /, tclose, topen
    LOGICAL islabeled / .false. /
    n = topen( tlu, devnam, islabeled )
    n = tclose( tlu )
    IF ( n .LT. 0 ) STOP "tclose: cannot close"
    WRITE(*, '("tclose ok:", 2I3, 1X, A10)')  n, tlu,  devnam
    END
```

The output is:

```
tclose ok: 0 1  /dev/rst0
```

`twrite`: *Write Next Physical Record to Tape*

n = twrite(*tlu*, *buffer*)			
tlu	INTEGER	Input	Tape logical unit, in range 0 to 7
buffer	character	Input	Must be sized at a multiple of 512
n	INTEGER	Return value	*n*>0: OK, and *n* = the number of bytes written *n*=0: End of Tape *n*<0: Error

The physical record length is the size of `buffer`.

Example: `twrite()`—write a 2-record file:

```
    CHARACTER devnam*9 / '/dev/rst0' /, rec1*512 / "abcd" /,
&          rec2*512 / "wxyz" /
    INTEGER n / 0 /, tlu / 1 /, tclose, topen, twrite
    LOGICAL islabeled / .false. /
    n = topen( tlu, devnam, islabeled )
    IF ( n .LT. 0 ) STOP "topen: cannot open"
    n = twrite( tlu, rec1 )
    IF ( n .LT. 0 ) STOP "twrite: cannot write 1"
    n = twrite( tlu, rec2 )
    IF ( n .LT. 0 ) STOP "twrite: cannot write 2"
    WRITE(*, '("twrite ok:", 2I4, 1X, A10)')  n, tlu, devnam
    END
```

The output is:

```
twrite ok: 512 1 /dev/rst0
```

`tread`: *Read Next Physical Record from Tape*

n = tread(*tlu*, *buffer*)			
tlu	INTEGER	Input	Tape logical unit, in range 0 to 7.
buffer	character	Input	Must be sized at a multiple of 512, and must be large enough to hold the largest physical record to be read.
n	INTEGER	Return value	*n*>0: OK, and *n* is the number of bytes read. *n*<0: Error *n*=0: EOF

If the tape is at EOF or EOT, then `tread` does a return; it does not read tapes.

Example: `tread()`—read the first record of the file written above:

```
      CHARACTER devnam*9 / '/dev/rst0' /, onerec*512 / " " /
      INTEGER n / 0 /, tlu / 1 /, topen, tread
      LOGICAL islabeled / .false. /
      n = topen( tlu, devnam, islabeled )
      IF ( n .LT. 0 ) STOP "topen: cannot open"
      n = tread( tlu, onerec )
      IF ( n .LT. 0 ) STOP "tread: cannot read"
      WRITE(*,'("tread ok:", 2I4, 1X, A10)')  n, tlu,  devnam
      WRITE(*,'( A4)')  onerec
      END
```

The output is:

```
tread ok: 512 1 /dev/rst0
abcd
```

`trewin`: *Rewind Tape to Beginning of First Data File*

n = trewin (*tlu*)			
tlu	INTEGER	Input	Tape logical unit, in range 0 to 7
n	INTEGER	Return value	*n*=0: OK *n*<0: Error

If the tape is labeled, then the label is skipped over after rewinding.

Example 1: `trewin()`—typical fragment:

```
CHARACTER devnam*9 / '/dev/rst0' /
INTEGER n /0/, tlu /1/, tclose, topen, tread, trewin
…
n = trewin( tlu )
IF ( n .LT. 0 ) STOP "trewin: cannot rewind"
WRITE(*, '("trewin ok:", 2I4, 1X, A10)') n, tlu, devnam
…
END
```

Example 2: `trewin()`—in a two-record file, try to read three records, rewind, read one record:

```
CHARACTER devnam*9 / '/dev/rst0' /, onerec*512 / " " /
INTEGER n / 0 /, r, tlu / 1 /, topen, tread, trewin
LOGICAL islabeled / .false. /
n = topen( tlu, devnam, islabeled )
IF ( n .LT. 0 ) STOP "topen: cannot open"
DO r = 1, 3
   n = tread( tlu, onerec )
   WRITE(*,'(1X, I2, 1X, A4)')  r, onerec
END DO
n = trewin( tlu )
IF ( n .LT. 0 ) STOP "trewin: cannot rewind"
WRITE(*, '("trewin ok:" 2I4, 1X, A10)')  n, tlu, devnam
n = tread( tlu, onerec )
IF ( n .LT. 0 ) STOP "tread: cannot read after rewind"
WRITE(*,'(A4)')  onerec
END
```

The output is:

```
1 abcd
2 wxyz
3 wxyz
trewin ok: 0 1 /dev/rst0
abcd
```

`tskipf`: *Skip Files and Records; Reset EoF Status*

n = tskipf(*tlu*, *nf*, *nr*)			
tlu	INTEGER	Input	Tape logical unit, in range 0 to 7
nf	INTEGER	Input	Number of end-of-file marks to skip over first
nr	INTEGER	Input	Number of physical records to skip over after skipping files
n	INTEGER	Return value	*n*=0: OK *n*<0: Error

This function does *not* skip backward.

First, the function skips forward over *nf* end-of-file marks. Then, it skips forward over *nr* physical records. If the current file is at EOF, this counts as one file to skip. This function also resets the EOF status.

Example: `tskipf()`—typical fragment: skip four files and then skip one record:

```
      INTEGER nfiles / 4 /, nrecords / 1 /, tskipf, tlu / 1 /
      …
      n = tskipf( tlu, nfiles, nrecords )
      IF ( n .LT. 0 ) STOP "tskipf: cannot skip"
      …
```

Compare with `tstate` in the next section.

`tstate`: *Get Logical State of Tape I/O Channel*

n = `tstate(` *tlu*, *fileno*, *recno*, *errf*, *eoff*, *eotf*, *tcsr* `)`			
tlu	`INTEGER`	Input	Tape logical unit, in range 0 to 7
fileno	`INTEGER`	Output	Current file number
recno	`INTEGER`	Output	Current record number
errf	`LOGICAL`	Output	True=an error occurred
eoff	`LOGICAL`	Output	True=the current file is at EOF
eotf	`LOGICAL`	Output	True=tape has reached logical end-of-tape
tcsr	`INTEGER`	Output	True=hardware errors on the device. It contains the tape drive control status register. If the error is software, then *tcsr* is returned as zero. The values returned in this status register vary grossly with the brand and size of tape drive.

For details, see `st`(4s).

While *eoff* is true, you cannot read from that *tlu*. You can set this EOF status flag to false by using `tskipf()` to skip one file and zero records:

```
    n = tskipf( tlu, 1, 0).
```

Then you can read any valid record that follows.

End-of-tape (EOT) is indicated by an empty file, often referred to as a double `EOF` mark. You cannot read past EOT, but you can write past it.

Example: Write three files of two records each:

```
      CHARACTER devnam*10 / '/dev/nrst0' /,
&                   f0rec1*512 / "eins" /, f0rec2*512 / "zwei" /,
&                   f1rec1*512 / "ichi" /, f1rec2*512 / "ni__" /,
&                   f2rec1*512 / "un__" /, f2rec2*512 / "deux" /
      INTEGER n / 0 /, tlu / 1 /, tclose, topen, trewin, twrite
      LOGICAL islabeled / .false. /
      n = topen( tlu, devnam, islabeled )
      n = trewin( tlu )
      n = twrite( tlu, f0rec1 )
      n = twrite( tlu, f0rec2 )
      n = tclose( tlu )
      n = topen( tlu, devnam, islabeled )
      n = twrite( tlu, f1rec1 )
      n = twrite( tlu, f1rec2 )
      n = tclose( tlu )
      n = topen( tlu, devnam, islabeled )
      n = twrite( tlu, f2rec1 )
      n = twrite( tlu, f2rec2 )
      n = tclose( tlu )
      END
```

The next example uses `tstate()` to trap EOF and get at all files.

Example: Use `tstate()` in a loop that reads all records of the 3 files written in the previous example:

```
    CHARACTER devnam*10 / '/dev/nrst0' /, onerec*512 / " " /
    INTEGER f, n / 0 /, tlu / 1 /, tcsr, topen, tread,
&       trewin, tskipf, tstate
    LOGICAL errf, eoff, eotf, islabeled / .false. /
    n = topen( tlu, devnam, islabeled )
    n = tstate( tlu, fn, rn, errf, eoff, eotf, tcsr )
    WRITE(*,1)  'open:', fn, rn, errf, eoff, eotf, tcsr
1   FORMAT(1X, A10, 2I2, 1X, 1L, 1X, 1L,1X, 1L, 1X, I2 )
2   FORMAT(1X, A10,1X,A4,1X,2I2,1X,1L,1X,1L,1X,1L,1X,I2)
    n = trewin( tlu )
    n = tstate( tlu, fn, rn, errf, eoff, eotf, tcsr )
    WRITE(*,1)  'rewind:', fn, rn, errf, eoff, eotf, tcsr
    DO f = 1, 3
       eoff = .false.
       DO WHILE ( .NOT. eoff )
          n = tread( tlu, onerec )
          n = tstate( tlu, fn, rn, errf, eoff, eotf, tcsr )
          IF (.NOT. eoff) WRITE(*,2) 'read:', onerec,
&          fn, rn, errf, eoff, eotf, tcsr
       END DO
       n = tskipf( tlu, 1, 0 )
       n = tstate( tlu, fn, rn, errf, eoff, eotf, tcsr )
       WRITE(*,1)  'tskip: ', fn, rn, errf, eoff, eotf, tcsr
    END DO
    END
```

The output is:

```
open: 0 0 F F F 0
rewind: 0 0 F F F 0
read: eins 0 1 F F F 0
read: zwei 0 2 F F F 0
tskip: 1 0 F F F 0
read: ichi 1 1 F F F 0
read: ni__ 1 2 F F F 0
tskip: 2 0 F F F 0
read: un__ 2 1 F F F 0
read: deux 2 2 F F F 0
tskip: 3 0 F F F 0
```

A summary of EOF and EOT follows:

- If you are at either EOF or EOT, then:
  - Any `tread()` just returns; it does not read the tape.
  - A successful `tskipf(tlu,1,0)` resets the EOF status to false, and returns; it does not advance the tape pointer.
- A successful `twrite()` resets the EOF and EOT status flags to false.
- A successful `tclose()` resets all those flags to false.
- `tclose()` truncates; it places an EOF marker immediately after the current location of the unit pointer, and then closes the unit. So, if you use `trewin()` to rewind a unit before you use `tclose()` to close it, its contents are discarded. This behavior of `tclose()` is inherited from the Berkeley code.

See also: `ioctl`(2), `mtio`(4s), `perror`(3f), `read`(2), `st`(4s), and `write`(2).

7.56 `ttynam`, `isatty`: *Get Name of a Terminal Port*

`ttynam` and `isatty` handle terminal port names.

`ttynam`: *Get Name of a Terminal Port*

The function `ttynam` returns a blank padded path name of the terminal device associated with logical unit *lunit*.

The function is:

name = `ttynam(` *lunit* `)`			
lunit	`INTEGER`	Input	Logical unit
Return value	`character*`*n*	Output	*name* is nonblank: *name*=path name of device on *lunit*. *name* is an empty string (all blanks): *lunit* is not associated with a terminal device in the directory, `/dev`
n	`INTEGER`	Size of *name*	Must be large enough for the longest path name

isatty: *Is this Unit a Terminal?*

The function is:

terminal = isatty(*lunit*)			
lunit	INTEGER	Input	Logical unit
Return value	LOGICAL	Output	*terminal*=true: It is a terminal device *terminal*=false: It is *not* a terminal device

Example: Determine if *lunit* is a tty:

```
      character*12 name, ttynam
      integer lunit /5/
      logical isatty, terminal
      terminal = isatty( lunit )
      name = ttynam( lunit )
      write(*,*) 'terminal = ', terminal, ', name = "', name, '"'
      end
```

The output is:

```
 terminal = T, name = "/dev/ttyp1  "
```

7.57 unlink: *Remove a File*

The function is:

n = unlink (*patnam*)			
patnam	character**n*	Input	File name
Return value	INTEGER	Output	*n*=0: OK *n*>0: Error

The function unlink removes the file specified by path name *patnam*. If this is the last link to the file, the contents of the file are lost.

Example: `unlink()`—Remove the `tunlink.data` file:

```
    call unlink( 'tunlink.data' )
    end
demo% f77 -silent tunlink.f
demo% ls tunl*
tunlink.f tunlink.data
demo% a.out
demo% ls tunl*
tunlink.f
demo%
```

See also: `unlink`(2), `link`(3F), and `perror`(3F). Note this bug—the path names cannot be longer than `MAXPATHLEN` as defined in `<sys/param.h>`.

7.58 `wait`*: Wait for a Process to Terminate*

The function is:

n = wait(*status*)			
status	INTEGER	Output	Termination status of the child process
Return value	INTEGER	Output	*n*>0: Process ID of the child process *n*<0: *n*=System error code; see `wait`(2).

`wait` suspends the caller until a signal is received, or one of its child processes terminates. If any child has terminated since the last `wait`, return is immediate. If there are no children, return is immediate with an error code.

Example: Code fragment using `wait()`:

```
    integer n, status, wait
    …
    n = wait( status )
    if ( n .lt. 0 ) stop 'wait: error'
    …
    end
```

See also: `wait`(2), `signal`(3F), `kill`(3F), and `perror`(3F).

VMS Language Extensions 8

This chapter describes the VMS language extensions that FORTRAN 77 supports. It is organized into the following sections:

These extensions are all, of course, nonstandard. ♦

8.1 Background

This FORTRAN 77 compiler includes the VMS extensions to make it as easy as possible to port FORTRAN 77 programs from VMS environments to Solaris environments. The compiler provides almost complete compatibility with VMS FORTRAN. These extensions are included in two systems:

- Compiler command: `f77`
- Debugger commands: `debugger`, `dbx`

8.2 VMS Language Features You Get Automatically

This list is a summary of the VMS features that are included in f77. Details are elsewhere in this manual.

- Namelist I/O
- Unlabeled DO … END DO
- Indefinite DO WHILE … END DO
- BYTE data type
- Logical operations on integers, and arithmetic operations on logicals
- Additional field and edit descriptors for FORMAT statements:
  - Remaining characters (Q)
  - Carriage Control ($)
  - Octal (O)
  - Hexadecimal (X)
  - Hexadecimal (Z)
- Default field indicators for *w*, *d*, and *e* fields in FORMAT statements
- Reading into Hollerith edit descriptors
- APPEND option for OPEN
- Long names (32 characters)
- _ and $ in names
- Long source lines (132-character), if the -e option is on
- Records, structures, unions, and maps
- Getting addresses by the %LOC function
- Passing arguments by the %VAL function
- End-of-line comments
- OPTIONS statement
- VMS Tab-format source lines are valid.

- Initialize in common

  You can initialize variables in common blocks outside of BLOCK DATA subprograms. You can initialize portions of common blocks, but you cannot initialize portions of one common block in more than one subprogram.

- Radix-50

  Radix-50 constants are implemented as f77 bit-string constants, that is, no type is assumed.

- IMPLICIT NONE is treated as IMPLICIT UNDEFINED (A-Z)
- VIRTUAL is treated as DIMENSION.
- Initialize in declarations

  Initialization of variables in declaration statements is allowed. Example:

```
   CHARACTER*10 NAME /'Nell'/
```

- Noncharacter format specifiers

  If a runtime format specifier is not of type CHARACTER, the compiler accepts that too, even though the FORTRAN 77 Standard requires the CHARACTER type.

- Omitted arguments in subprogram calls

  The compiler accepts omitted actual argument in a subroutine call, that is, two consecutive commas compile to a null pointer. Reference to that dummy argument gives a segmentation fault.

- REAL*16

  (SPARC only) The compiler treats variables of type REAL*16 as quadruple precision.

- Noncharacter variables

  The FORTRAN 77 Standard requires the FILE= specifier for OPEN and INQUIRE to be an expression of type CHARACTER. f77 accepts a numeric variable or array element reference.

- Consecutive operators

  f77 allows two consecutive arithmetic operators when the second operator is a unary + or -. Here are two consecutive operators:

```
X = A ** -B
```

The above statement is treated as follows:

```
X = A ** (-B)
```

- Illegal real expressions

  When the compiler finds a REAL expression where it expects an integer expression, it truncates and makes a type conversion to INTEGER.

  Examples: Contexts for illegal real expressions that f77 converts to integer:
  - Alternate RETURN
  - Dimension declarators and array subscripts
  - Substring selectors
  - Computed GO TO
  - Logical unit number, record number, and record length

- Typeless numeric constants

  Binary, hexadecimal and octal constants are accepted in VMS form.

  Example: Constants–Binary (B), Octal (O), Hexadecimal (X or Z):

```
DATA N1 /B'0011111'/, N2/O'37'/, N3/X'1f'/, N4/Z'1f'/
```

- Function length on function name, rather than on the word FUNCTION

  The compiler accepts nonstandard length specifiers in function declarations.

  Example: Size on function name, rather than on the word FUNCTION:

```
INTEGER FUNCTION FCN*2 ( A, B, C )
```

- TYPE and ACCEPT statements are allowed.
- Alternate return

  The nonstandard & syntax for alternate-return actual arguments is treated as the standard FORTRAN 77 * syntax. Example:

```
CALL SUBX ( I, *100, Z)  ! Standard (OK)
CALL SUBX ( I, &100, Z ) ! Nonstandard (OK)
```

- The ENCODE and DECODE statements are accepted.
- Direct I/O with 'N record specifier

  The nonstandard record specifier 'N for direct-access I/O statements is OK.

  Example: A nonstandard form for record specifier:

```
READ ( K ' N ) LIST
```

  The above is treated as:

```
READ ( UNIT=K, REC=N ) LIST
```

  The logical unit number is K and the number of the record is N.

- NAME, RECORDSIZE, and TYPE options—OPEN has the following alternative options:
  - NAME is treated as FILE
  - RECORDSIZE is treated as RECL
  - TYPE is treated as STATUS
- DISPOSE=*p*

  The DISPOSE=*p* clause in the CLOSE statement is treated as STATUS=*p*.

- Special Intrinsics

  The compiler processes certain special intrinsic functions:
  - %VAL is OK as is
  - %LOC is treated as LOC

- `%REF(`*expr*`)` is treated as *expr* (with a warning if *expr* is `CHARACTER`)
- `%DESCR` is reported as an untranslatable feature

- Variable Expressions in `FORMAT` Statements

  In general, inside a `FORMAT` statement, any integer constant can be replaced by an arbitrary expression; the single exception is the *n* in an *n*H… edit descriptor. The expression itself must be enclosed in angle brackets.

  Example: The `6` in the following statement is a constant:

```
1   FORMAT( 3F6.1 )
```

  `6` can be replaced by the variable `N`, as in:

```
1   FORMAT( 3F<N>.1 )
```

8.3 VMS Language Features that Require `-xl`

You get most VMS features automatically without any special options. For a few of them, however, you must add the `-xl` option on the `f77` command line.

In general, you need this `-xl` option if a source statement can be interpreted for either a VMS way of behavior or an `f77` way of behavior, and you want the VMS way of behavior. The `-xl` option forces the compiler to interpret it as VMS FORTRAN.

Summary of Features That Require `-xl[d]`

You must use `-xl[d]` to access the following features:

- Unformatted record `size` in words rather than bytes (`-xl`)
- VMS-style logical file names (`-xl`)
- Quote (") character introducing octal constants (`-xl`)
- Backslash (\) as ordinary character within character constants (`-xl`)
- Nonstandard form of the `PARAMETER` statement (`-xl`)
- Debugging lines as comment lines or FORTRAN 77 statements (`-xld`)
- Align structures as in VMS FORTRAN (`-xl`)

Details of Features That Require `-xl[d]`

Here are the details:

- Unformatted record `size` in words rather than bytes

  In `f77`, direct-access, unformatted files are always opened with the logical record size in *bytes*.

  If the `–xl[d]` option is *not* set, then the argument *n* in the `OPEN` option `RECL=`*n* is assumed to be the number of bytes to use for the record size.

  If the `–xl[d]` option is set, then the argument *n* in the `OPEN` option `RECL=`*n* is assumed to be the number of *words*, so the compiler uses *n*`*4` as the number of bytes for the record size.

  If the `–xl[d]` option is set, and if the compiler cannot determine if the file is formatted or unformatted, then it issues a warning message that the record size may need to be adjusted. This result could happen if the information is passed in variable character strings.

  The record size returned by an `INQUIRE` statement is *not* adjusted by the compiler; that is, `INQUIRE` always returns the number of *bytes*.

  These record sizes apply to direct-access, unformatted files only.

- VMS-style logical file names

  If the `–xl[d]` option is set, then the compiler interprets VMS logical file names on the `INCLUDE` statement if it finds the environment variable, `LOGICALNAMEMAPPING`, to define the mapping between the logical names and the UNIX path name.

  You set the environment variable to a string of the form:

```
"lname1=path1; lname2=path2; … "
```

  Remember these rules for VMS style logical file names:
  - Each *lname* is a logical name and each *path1*, *path2*, and so forth, is the path name of a directory (without a trailing `/`).
  - It ignores all blanks when parsing this string.
  - It strips any trailing `/[no]list` from the file name in the `INCLUDE` statement.

- Logical names in a file name are delimited by the first `:` in the VMS file name.
- It converts file names from *lname1:file* to the *path1/file* form.
- For logical names, uppercase and lowercase are significant. If a logical name is encountered on the `INCLUDE` statement which is not specified in the `LOGICALNAMEMAPPING`, the file name is used, unchanged.

- Quote (") character introducing octal constants

  If the `–xl[d]` compiler option is on, a VMS FORTRAN octal integer constant is treated as its decimal form.

  Example: VMS octal integer constant:

```
      JCOUNT = ICOUNT + "703
```

  The above statement is treated as:

```
    JCOUNT = ICOUNT + 451
```

  If the `–xl[d]` option is *not* on, then the `"703` is an error.

  With `–xl[d]`, the VMS FORTRAN notation `"703` signals `f77` to convert from the integer octal constant to its integer decimal equivalent, 451 in this case. In VMS FORTRAN, `"703` cannot be the start of a character constant, because VMS FORTRAN character constants are delimited by apostrophes, not quotes.

- Backslash (\) as ordinary character within character constants

  If the `–xl[d]` option is on, a backslash in a character string is treated as an ordinary character; otherwise, it is treated as an escape character.

- Nonstandard form of the `PARAMETER` statement

  The alternate `PARAMETER` statement syntax is allowed, if the `–xl[d]` option is on.

Example: VMS alternate form of `PARAMETER` statement omits the parentheses:

```
      PARAMETER FLAG1 = .TRUE.
```

- Debugging lines as comment lines or FORTRAN 77 statements (`-xld`)

  The compiler interprets debugging lines as comment lines or FORTRAN 77 statements, depending on whether the `–xld` option is set. If set, they are compiled; otherwise, they are treated as comments.

  Example: Debugging lines:

```
      REAL A(5) / 5.0, 6.0, 7.0, 8.0, 9.0 /
      DO I = 1, 5
          X = A(I)**2
D         PRINT *, I, X
      END DO
      PRINT *, 'done'
      END
```

  With `-xld`, this code prints `I` and `X`. Without `-xld`, it does not print them.

- Align structures as in VMS FORTRAN

  Use this feature if your program has some detailed knowledge of how VMS structures are implemented. If you need to share structures with C, you should use the default: no `-xl`

8.4 Unsupported VMS FORTRAN

Most VMS FORTRAN extensions are incorporated into the `f77` compiler. The compiler writes messages to standard error for any unsupported statements in the source file. The following is a list of the few VMS statements that are *not* supported.

- `DEFINE FILE` statement
- `DELETE` statement
- `UNLOCK` statement

- FIND statement
- REWRITE statement
- KEYID and key specifiers in READ statements
- Nonstandard INQUIRE specifiers
  - CARRIAGECONTROL
  - DEFAULTFILE
  - KEYED
  - ORGANIZATION
  - RECORDTYPE
- Nonstandard OPEN specifiers
  - ASSOCIATEVARIABLE
  - BLOCKSIZE
  - BUFFERCOUNT
  - CARRIAGECONTROL
  - DEFAULTFILE
  - DISP[OSE]
  - EXTENDSIZE
  - INITIALSIZE
  - KEY
  - MAXREC
  - NOSPANBLOCKS
  - ORGANIZATION
  - RECORDTYPE
  - SHARED
  - USEROPEN
- The intrinsic function, %DESCR
- The following parameters on the OPTIONS statement:
  - [NO]G_FLOATING
  - [NO]F77
  - CHECK=[NO]OVERFLOW
  - CHECK=[NO]UNDERFLOW
- Some of the INCLUDE statement

  Some aspects of the INCLUDE statement are converted. The INCLUDE statement is operating system–dependent, so it cannot be completely converted automatically. The VMS version allows a module-name and a LIST control directive that are indistinguishable from a continuation of a

UNIX file name. Also, VMS ignores alphabetic case, so if you are inconsistent about capitalization, distinctions are made where none are intended.

- Getting a long integer—expecting a short

  In VMS FORTRAN, you can pass a long integer argument to a subroutine that expects a short integer. This feature works if the long integer fits in 16 bits, because the VAX addresses an integer by its low-order byte. This feature does *not* work on SPARC systems.

- Those VMS system calls that are directly tied to that operating system
- Initializing a common block in more than one subprogram
- Alphabetizing common blocks so you can rely or depend on the order in which blocks are loaded. You can specify the older with the `-M` *mapfile* option to `ld`.
- If you use the defaults for both of the following:
  - The `OPEN` option `BLANK=`
  - The `BN/BZ/B` format edit specifiers

  then formatted numeric input ignores imbedded and trailing blanks. The corresponding VMS defaults treat them as zeros.

ASCII Character Set A

This appendix contains two tables: ASCII character sets and control characters.

Table A-1 ASCII Character Set

Dec	Oct	Hex	Name	Dec	Oct	Hex	Name	Dec	Oct	Hex	Name	Dec	Oct	Hex	Name
0	000	00	NUL	**32**	040	20	SP	64	100	40	@	**96**	140	60	‘
1	001	01	SOH	**33**	041	21	!	65	101	41	A	**97**	141	61	a
2	002	02	STX	**34**	042	22	"	66	102	42	B	**98**	142	62	b
3	003	03	ETX	**35**	043	23	#	67	103	43	C	**99**	143	63	c
4	004	04	EOT	**36**	044	24	$	68	104	44	D	**100**	144	64	d
5	005	05	ENQ	**37**	045	25	%	69	105	45	E	**101**	145	65	e
6	006	06	ACK	**38**	046	26	&	70	106	46	F	**102**	146	66	f
7	007	07	BEL	**39**	047	27	’	71	107	47	G	**103**	147	67	g
8	010	08	BS	**40**	050	28	(	72	110	48	H	**104**	150	68	h
9	011	09	HT	**41**	051	29	)	73	111	49	I	**105**	151	69	i
10	012	0A	LF	**42**	052	2A	*	74	112	4A	J	**106**	152	6A	j
11	013	0B	VT	**43**	053	2B	+	75	113	4B	K	**107**	153	6B	k
12	014	0C	FF	**44**	054	2C	,	76	114	4C	L	**108**	154	6C	l
13	015	0D	CR	**45**	055	2D	-	77	115	4D	M	**109**	155	6D	m
14	016	0E	SO	**46**	056	2E	.	78	116	4E	N	**110**	156	6E	n
15	017	0F	SI	**47**	057	2F	/	79	117	4F	O	**111**	157	6F	o
16	020	10	DLE	**48**	060	30	0	80	120	50	P	**112**	160	70	p
17	021	11	DC1	**49**	061	31	1	81	121	51	Q	**113**	161	71	q
18	022	12	DC2	**50**	062	32	2	82	122	52	R	**114**	162	72	r
19	023	13	DC3	**51**	063	33	3	83	123	53	S	**115**	163	73	s
20	024	14	DC4	**52**	064	34	4	84	124	54	T	**116**	164	74	t
21	025	15	NAK	**53**	065	35	5	85	125	55	U	**117**	165	75	u
22	026	16	SYN	**54**	066	36	6	86	126	56	V	**118**	166	76	v
23	027	17	ETB	**55**	067	37	7	87	127	57	W	**119**	167	77	w
24	030	18	CAN	**56**	070	38	8	88	130	58	X	**120**	170	78	x
25	031	19	EM	**57**	071	39	9	89	131	59	Y	**121**	171	79	y
26	032	1A	SUB	**58**	072	3A	:	90	132	5A	Z	**122**	172	7A	z
27	033	1B	ESC	**59**	073	3B	;	91	133	5B	[	**123**	173	7B	{
28	034	1C	FS	**60**	074	3C	<	92	134	5C	\	**124**	174	7C	|
29	035	1D	GS	**61**	075	3D	=	93	135	5D	]	**125**	175	7D	}
30	036	1E	RS	**62**	076	3E	>	94	136	5E	^	**126**	176	7E	~
31	037	1F	US	**63**	077	3F	?	95	137	5F	_	**127**	177	7F	DEL

Table A-2 Control Characters

^=Control key
s^=Shift and control keys

Dec	Oct	Hex	Name	Keys	Meaning
0	000	00	NUL	s^P	Null or time fill character
1	001	01	SOH	^A	Start of heading
2	002	02	STX	^B	Start of text
3	003	03	ETX	^C	End of text (EOM)
4	004	04	EOT	^D	End of transmission
5	005	05	ENQ	^E	Enquiry (WRU)
6	006	06	ACK	^F	Acknowledge (RU)
7	007	07	BEL	^G	Bell
8	010	08	BS	^H	Backspace
9	011	09	HT	^I	Horizontal tab
10	012	0A	LF	^J	Line feed (newline)
11	013	0B	VT	^K	Vertical tab
12	014	0C	FF	^L	Form Feed
13	015	0D	CR	^M	Carriage Return
14	016	0E	SO	^N	Shift Out
15	017	0F	SI	^O	Shift In
16	020	10	DLE	^P	Data link escape
17	021	11	DC1	^Q	Device control 1 (X-ON)
18	022	12	DC2	^R	Device control 2 (TAPE)
19	023	13	DC3	^S	Device control 3 (X-OFF)
20	024	14	DC4	^T	Device control 4 (TAPE)
21	025	15	NAK	^U	Negative acknowledge
22	026	16	SYN	^V	Synchronous idle
23	027	17	ETB	^W	End of transmission blocks
24	030	18	CAN	^X	Cancel
25	031	19	EM	^Y	End Of medium
26	032	1A	SS	^Z	Special sequence
27	033	1B	ESC	s^K	Escape (^ [ )
28	034	1C	FS	s^L	File separator (^ \ )
29	035	1D	GS	s^M	Group separator (^])
30	036	1E	RS	s^N	Record separator (^ ’)
31	037	1F	US	s^O	Unit separator (^ /)
127	177	7F	DEL	s^0	Delete or rubout (^ _)

Sample Statements B

This appendix shows a table that contains selected samples of the `f77` statement types. The purpose is to provide a quick reference for syntax details of the more common variations of each statement type.

In the table, the following conventions are used:

`C`	Character variable	`N`	Numeric variable
`CA`	Character array	`L`	Logical variable
`I`	Integer variable	`S`	Switch variable
`U`	External unit	♦	Nonstandard feature
`R`	Real variable		

Table B-1 FORTRAN 77 Statement Samples

Name	**Examples**	**Comments**
ACCEPT ♦	ACCEPT *, A, I	Compare to READ.
ASSIGN	ASSIGN 9 TO I	
ASSIGNMENT	C = 'abc' C = "abc" C = S // 'abc' C = S(I:M)	Character ♦
	L = L1 .OR. L2 L = I .LE. 80	Logical
	N = N+1 X = '7FF00000'x	Arithmetic Hex ♦
	CURR = NEXT NEXT.ID = 82	Compare to RECORD.
AUTOMATIC ♦	AUTOMATIC A, B, C AUTOMATIC REAL P, D, Q IMPLICIT AUTOMATIC REAL (X-Z)	
BACKSPACE	BACKSPACE U BACKSPACE(UNIT=U, IOSTAT=I, ERR=9)	
BLOCK DATA	BLOCK DATA BLOCK DATA COEFFS	
BYTE ♦	BYTE A, B, C BYTE A, B, C(10) BYTE A /'x'/, B /255/, C(10)	 Initialize A and B
CALL	CALL P(A, B) CALL P(A, B, *9) CALL P(A, B, &9) CALL P	 Alternate return Alternate return ♦
CHARACTER	CHARACTER C*80, D*1(4) CHARACTER*18 A, B, C CHARACTER A, B*3 /'xyz'/, C /'z'/	 Initialize B and C ♦
CLOSE	CLOSE (UNIT=I) CLOSE(UNIT=U, ERR=90, IOSTAT=I)	
COMMON	COMMON / DELTAS / H, P, T COMMON X, Y, Z COMMON P, D, Q(10,100)	

Table B-1 FORTRAN 77 Statement Samples *(Continued)*

Name	**Examples**	**Comments**
COMPLEX	COMPLEX U, V, U(3,6) COMPLEX U*16 COMPLEX U*32 COMPLEX U / (1.0,1.0) /, V /(1.0,10.0) /	 Double complex ♦ Quad complex ♦ (SPARC) Initialize U and V ♦
CONTINUE	100 CONTINUE	
DATA	DATA A, C / 4.01, 'z' / DATA (V(I),I=1,3) /.7, .8, .9/ DATA ARRAY(4,4) / 1.0 / DATA B,O,X,Y /B'0011111', O'37', X'1f', Z'1f'/	♦
DECODE ♦	DECODE (4, 1, S) V	
DIMENSION	DIMENSION ARRAY(4, 4) DIMENSION V(1000), W(3)	
DO	DO 100 I = INIT, LAST, INCR … 100 CONTINUE	
	DO I = INIT, LAST … END DO	Unlabeled DO ♦
	DO WHILE (DIFF .LE. DELTA) … END DO	DO WHILE ♦
	DO 100 WHILE (DIFF .LE. DELTA) … 100 CONTINUE	♦
DOUBLE COMPLEX ♦	DOUBLE COMPLEX U, V DOUBLE COMPLEX U, V COMPLEX U / (1.0,1.0D0) /, V / (1.0,1.0D0) /	COMPLEX*16 ♦ COMPLEX ♦ Initialize U and V
DOUBLE PRECISION	DOUBLE PRECISION A, D, Y(2) DOUBLE PRECISION A, D / 1.2D3 /, Y(2)	REAL*8 ♦ Initialize D ♦
ELSE	ELSE	Compare to IF (Block)
ELSE IF	ELSE IF	
ENCODE ♦	ENCODE(4, 1, T) A, B, C	
END	END	
END DO ♦	END DO	Compare to DO

Table B-1 FORTRAN 77 Statement Samples *(Continued)*

Name	**Examples**	**Comments**
ENDFILE	ENDFILE (UNIT=I) ENDFILE I ENDFILE(UNIT=U, IOSTAT=I, ERR=9)	
END IF	END IF	
END MAP ♦	END MAP	Compare to MAP
END STRUCTURE	END STRUCTURE	Compare to STRUCTURE
END UNION ♦	END UNION	Compare to UNION
ENTRY	ENTRY SCHLEP(X, Y) ENTRY SCHLEP(A1, A2, *4) ENTRY SCHLEP	
EQUIVALENCE	EQUIVALENCE (V(1), A(1,1)) EQUIVALENCE (V, A) EQUIVALENCE (X,V(10)), (P,D,Q)	
EXTERNAL	EXTERNAL RNGKTA, FIT	
FORMAT	10 FORMAT(// 2X, 2I3, 3F6.1, 4E12.2, 2A6,3L2) 10 FORMAT(// 2D6.1, 3G12.2) 10 FORMAT(2I3.3, 3G6.1E3, 4E12.2E3)	X I F E A L D G *w*
	10 FORMAT('a quoted string', " another", I2) 10 FORMAT(18Ha hollerith string, I2) 10 FORMAT(1X, T10, A1, T20, A1)	Strings ♦ Hollerith Tabs
	10 FORMAT(5X, TR10, A1, TR10, A1, TL5, A1) 10 FORMAT(" Init=", I2, :, 3X, "Last=", I2) 10 FORMAT(1X, "Enter path name ", $)	Tab right, left : $
	10 FORMAT(F4.2, Q, 80 A1) 10 FORMAT('Octal ', O6, ', Hex ' Z6) 10 FORMAT(3F<N>.2)	Q ♦ Octal, hex ♦ Variable expression ♦
FUNCTION	FUNCTION Z(A, B) FUNCTION W(P,D, *9) CHARACTER FUNCTION R*4(P,D,*9) INTEGER*2 FUNCTION M(I, J)	 Short integer ♦
GO TO	GO TO 99	Unconditional
	GO TO I, (10, 50, 99) GO TO I	Assigned
	GO TO (10, 50, 99), I	Computed

Table B-1 FORTRAN 77 Statement Samples *(Continued)*

Name	**Examples**	**Comments**
IF	IF (I -K) 10, 50, 90	Arithmetic IF
	IF (L) RETURN	LOGICAL IF

	IF (L) THEN
	N=N+1
	CALL CALC
	ELSE
	K=K+1
	CALL DISP
	ENDIF
		BLOCK IF

	IF (C .EQ. 'a') THEN
	NA=NA+1
	CALL APPEND
	ELSE IF (C .EQ. 'b') THEN
	NB=NB+1
	CALL BEFORE
	ELSE IF (C .EQ. 'c') THEN
	NC=NC+1
	CALL CENTER
	END IF
		BLOCK IF
		With ELSE IF

IMPLICIT	IMPLICIT COMPLEX (U-W,Z) IMPLICIT UNDEFINED (A-Z)	
INCLUDE ♦	INCLUDE 'project02/header'	
INQUIRE	INQUIRE(UNIT=3, OPENED=OK) INQUIRE(FILE='mydata', EXIST=OK) INQUIRE(UNIT=3, OPENED=OK, IOSTAT=ERRNO)	
INTEGER	INTEGER C, D(4) INTEGER C*2 INTEGER*4 A, B, C	 Short integer ♦
	INTEGER A/ 100 /, B, C / 9 /	Initialize A and C ♦
INTRINSIC	INTRINSIC SQRT, EXP	
LOGICAL	LOGICAL C LOGICAL B*1, C*1 LOGICAL*1 B, C LOGICAL*4 A, B, C	 ♦ ♦ ♦
	LOGICAL B / .FALSE. /, C	Initialize B ♦

Table B-1 FORTRAN 77 Statement Samples *(Continued)*

Name	Examples	Comments

Map ♦	`MAP`
	`   CHARACTER *18 MAJOR`
	`END MAP`
	`MAP`
	`   INTEGER*2 CREDITS`
	`   CHARACTER*8 GRAD_DATE`
	`END MAP`
		Compare to `STRUCTURE` and `UNION`

NAMELIST ♦	`NAMELIST /CASE/ S, N, D`	
OPEN	`OPEN( UNIT=3, FILE="data.test" )` `OPEN( UNIT=3, IOSTAT=ERRNO )`	
OPTIONS ♦	`OPTIONS /CHECK /EXTEND_SOURCE`	

PARAMETER	`PARAMETER (A="xyz"), (PI=3.14)`
	`PARAMETER (A="z", PI=3.14)`
	`PARAMETER X=11, Y=X/3`
		♦

PAUSE	`PAUSE`	
POINTER ♦	`POINTER ( P, V ), ( I, X )`	
PRAGMA ♦	`EXTERNAL RNGKTA, FIT !$PRAGMA C(RNGKTA, FIT)`	`C()` directive
PROGRAM	`PROGRAM FIDDLE`	
PRINT	`PRINT *, A, I`	List-directed
	`PRINT 10, A, I`	Formatted
	`PRINT 10, M`	Array `M`
	`PRINT 10, (M(I),I=J,K)`	Implied-`DO`
	`PRINT 10, C(I:K)`	Substring
	`PRINT '(A6,I3)', A, I` `PRINT FMT='(A6,I3)', A, I`	Character constant format
	`PRINT S, I` `PRINT FMT=S, I`	Switch variable has format number
	`PRINT G`	Namelist ♦
READ	`READ *, A, I`	List-directed
	`READ 1, A, I`	Formatted
	`READ 10, M`	Array `M`
	`READ 10, (M(I),I=J,K)`	Implied-`DO`
	`READ 10, C(I:K)`	Substring
	`READ '(A6,I3)', A, I`	Character constant format

Table B-1 FORTRAN 77 Statement Samples *(Continued)*

Name	**Examples**	**Comments**
	READ(1, 2) X, Y READ(UNIT=1, FMT=2) X,Y READ(1, 2, ERR=8,END=9) X,Y READ(UNIT=1, FMT=2, ERR=8,END=9) X,Y	Formatted read from a file
	READ(*, 2) X, Y	Formatted read from standard input
	READ(*, 10) M	Array M
	READ(*, 10) (M(I),I=J,K)	Implied-DO
	READ(*, 10) C(I:K)	Substring
	READ(1, *) X, Y READ(*, *) X, Y	List-directed from file—from standard input
	READ(1, '(A6,I3)') X, Y READ(1, FMT='(A6,I3)') X, Y	Character constant format
	READ(1, C) X, Y READ(1, FMT=C) X, Y	
	READ(1, S) X, Y READ(1, FMT=S) X, Y	Switch variable has format number
	READ(*, G) READ(1, G)	Namelist read ♦ Namelist read from a file ♦
	READ(1, END=8, ERR=9) X, Y	Unformatted direct access
	READ(1, REC=3) V READ(1 ' 3) V	Unformatted direct access
	READ(1, 2, REC=3) V	Formatted direct access
	READ(CA, 1, END=8, ERR=9) X, Y	Internal formatted sequential
	READ(CA, *, END=8, ERR=9) X, Y	Internal list-directed sequential access ♦
	READ(CA, REC=4, END=8, ERR=9) X, Y	Internal direct access ♦
REAL	REAL R, M(4) REAL R*4 REAL*8 A, B, C REAL*16 A, B, C	 ♦ Double precision ♦ Quad precision ♦ *(SPARC only)*
	REAL A / 3.14 /, B, C / 100.0 /	Initialize A and C ♦
RECORD ♦	RECORD /PROD/ CURR,PRIOR,NEXT	
RETURN	RETURN RETURN 2	Standard return Alternate return

Table B-1 FORTRAN 77 Statement Samples *(Continued)*

Name	Examples	Comments
REWIND	REWIND 1 REWIND I REWIND (UNIT=U, IOSTAT=I, ERR=9)	
SAVE	SAVE A, /B/, C SAVE	
STATIC ♦	STATIC A, B, C STATIC REAL P, D, Q IMPLICIT STATIC REAL (X-Z)	
STOP	STOP STOP "all gone"	

STRUCTURE	STRUCTURE /PROD/
	  INTEGER*4 ID / 99 /
	  CHARACTER*18 NAME
	  CHARACTER*8 MODEL / 'XL' /
	  REAL*4 COST
	  REAL*4 PRICE
	END STRUCTURE	

SUBROUTINE	SUBROUTINE SHR(A, B, *9) SUBROUTINE SHR(A, B, &9) SUBROUTINE SHR(A, B) SUBROUTINE SHR	Alternate return ♦
TYPE ♦	TYPE *, A, I	Compare to PRINT

UNION ♦	UNION
	  MAP
	      CHARACTER*18 MAJOR
	  END MAP
	  MAP
	      INTEGER*2 CREDITS
	      CHARACTER*8 GRAD_DATE
	  END MAP
	END UNION
		Compare to STRUCTURE

VIRTUAL ♦	VIRTUAL M(10,10), Y(100)	
VOLATILE ♦	VOLATILE V, Z, MAT, /INI/	
WRITE	WRITE(1, 2) X, Y } WRITE(UNIT=1, FMT=2) X, Y WRITE(1, 2, ERR=8, END=9) X, Y WRITE(UNIT=1, FMT=2, ERR=8, END=9) X, Y	Formatted write to a file

Table B-1 FORTRAN 77 Statement Samples *(Continued)*

Name	Examples	Comments
	`WRITE( *, 2 ) X, Y` `WRITE( *, 10 ) M`	Formatted `write` to `stdout` Array `M`
	`WRITE( *, 10 ) (M(I),I=J,K)`	Implied-`DO`
	`WRITE( *, 10) C(I:K)`	Substring
	`WRITE( 1, * ) X, Y` `WRITE( *, * ) X, Y`	List-directed `write` to a file List-directed `write` to standard output
	`WRITE( 1, '(A6,I3)') X, Y` `WRITE( 1, FMT='(A6,I3)') X, Y`	Character constant format
	`WRITE( 1, C ) X, Y` `WRITE( 1, FMT=C ) X, Y`	Character variable format
	`WRITE( 1, S ) X, Y` `WRITE( 1, FMT=S ) X, Y`	Switch variable has format number
	`WRITE( *, CASE )` `WRITE( 1, CASE )`	Namelist `write` ♦ Namelist `write` to a file ♦
	`WRITE( 1, END=8, ERR=9 ) X, Y`	Unformatted sequential access
	`WRITE( 1, REC=3 ) V` `WRITE( 1 ' 3 ) V`	Unformatted direct access
	`WRITE( 1, 2, REC=3 ) V`	Formatted direct access
	`WRITE( CA, 1, END=8, ERR=9 ) X, Y`	Internal formatted sequential
	`WRITE( CA, *, END=8, ERR=9 ) X, Y`	Internal list-directed sequential access ♦
	`WRITE( CA, REC=4, END=8, ERR=9 ) X, Y`	Internal direct access ♦

Data Representations C

Whatever the size of the data element in question, the most significant bit of the data element is always stored in the lowest-numbered byte of the byte sequence required to represent that object.

This appendix is a brief introduction to data representation. For more in-depth explanations, see the *FORTRAN 77 4.0 User's Guide* and the *Numerical Computation Guide*.

This appendix is organized into the following sections:

C.1 Real, Double, and Quadruple Precision

Real, double precision, and quadruple precision number data elements are represented according to the IEEE standard by the following form, where *f* is the bits in the fraction. The quad is *SPARC only.*

$$(-1)^{sign} * 2^{exponent-bias} *1.f$$

Table C-1 Floating-point Representation

	Single	Double	Quadruple
Sign	Bit 31	Bit 63	Bit 127
Exponent	Bits 30–23 Bias 127	Bits 62–52 Bias 1023	Bits 126-112 Bias 16583
Fraction	Bits 22–0	Bits 51–0	Bits 111-0
Range approx.	3.402823e+38 1.175494e-38	1.797693e+308 2.225074e-308	3.362E-4932 1.20E+4932

C.2 Extreme Exponents

The representations of extreme exponents are as follows.

Zero (signed)

Zero (signed) is represented by an exponent of zero and a fraction of zero.

Subnormal Number

The form of a subnormal number is:

$$(-1)^{sign} * 2^{1-bias} * 0.f$$

where *f* is the bits in the significand.

Signed Infinity

Signed infinity—that is, affine infinity—is represented by the largest value that the exponent can assume (all ones), and a zero fraction.

Not a Number (NaN)

Not a Number (NaN) is represented by the largest value that the exponent can assume (all ones), and a nonzero fraction.

Normalized REAL and DOUBLE PRECISION numbers have an implicit leading bit that provides one more bit of precision than is stored in memory. For example, IEEE double precision provides 53 bits of precision: 52 bits stored in the fraction, plus the implicit leading 1.

C.3 IEEE Representation of Selected Numbers

The values here are as shown by dbx, in hexadecimal.

Table C-2 IEEE Representation of Selected Numbers

Value	Single-Precision	Double-Precision
+0	00000000	0000000000000000
-0	80000000	8000000000000000
+1.0	3F800000	3FF0000000000000
-1.0	BF800000	BFF0000000000000
+2.0	40000000	4000000000000000
+3.0	40400000	4008000000000000
+Infinity	7F800000	7FF0000000000000
-Infinity	FF800000	FFF0000000000000
NaN	7Fxxxxxx	7FFxxxxxxxxxxxxx

C.4 Arithmetic Operations on Extreme Values

This section describes the results of basic arithmetic operations with extreme and ordinary values. We assume all inputs are positive, and no traps, overflow, underflow, or other exceptions happen.

Table C-3 Extreme Value Abbreviations

Abbreviation	Meaning
Sub	Subnormal number
Num	Normalized number
Inf	Infinity (positive or negative)
NaN	Not a Number
Uno	Unordered

Table C-4 Extreme Values: Addition and Subtraction

	Right Operand				
Left Operand	**0**	**Sub**	**Num**	**Inf**	**NaN**
0	0	Sub	Num	Inf	NaN
Sub	Sub	Sub	Num	Inf	NaN
Num	Num	Num	Num	Inf	NaN
Inf	Inf	Inf	Inf	Read Note	NaN
NaN	NaN	NaN	NaN	NaN	NaN

In the above table, for Inf ± Inf: Inf + Inf = Inf, and Inf - Inf = NaN.

Table C-5 Extreme Values: Multiplication

	Right Operand				
Left Operand	**0**	**Sub**	**Num**	**Inf**	**NaN**
0	0	0	0	NaN	NaN
Sub	0	0	NS	Inf	NaN
Num	0	NS	Num	Inf	NaN
Inf	NaN	Inf	Inf	Inf	NaN
NaN	NaN	NaN	NaN	NaN	NaN

In the above table, NS means either Num or Sub result possible.

Table C-6 Extreme Values: Division

Left Operand	Right Operand				
	0	**Sub**	**Num**	**Inf**	**NaN**
0	NaN	0	0	0	NaN
Sub	Inf	Num	Num	0	NaN
Num	Inf	Num	Num	0	NaN
Inf	Inf	Inf	Inf	NaN	NaN
NaN	NaN	NaN	NaN	NaN	NaN

Table C-7 Extreme Values: Comparison

Left Operand	Right Operand				
	0	**Sub**	**Num**	**Inf**	**NaN**
0	=	<	<	<	Uno
Sub	>		<	<	Uno
Num	>	>		<	Uno
Inf	>	>	>	=	Uno
NaN	Uno	Uno	Uno	Uno	Uno

Note:

- If either `X` or `Y` is NaN, then `X.NE.Y` is `.TRUE.`, and the others (`.EQ.`, `.GT.`, `.GE.`, `.LT.`, `.LE.`) are `.FALSE.`
- +0 compares equal to -0.
- If any argument is NaN, then the results of `MAX` or `MIN` are undefined.

C.5 Bits and Bytes by Architecture

The order in which the data—the bits and bytes—are arranged differs between VAX computers on the one hand, and SPARC computers on the other.

The bytes in a 32-bit integer, when read from address *n*, end up in the register as shown in the following tables.

Table C-8 Bits and Bytes for Intel and VAX Computers

Byte *n*+3	**Byte *n*+2**	**Byte *n*+1**	**Byte *n***
31 30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 09 08	07 06 05 04 03 02 01 00
Most Significant			Least significant

Table C-9 Bits and Bytes for 680x0 and SPARC Computers

Byte *n*	**Byte *n*+1**	**Byte *n*+2**	**Byte *n*+3**
31 30 29 28 27 26 25 24	23 22 21 20 19 18 17 16	15 14 13 12 11 10 09 08	07 06 05 04 03 02 01 00
Most Significant			Least significant

The bits are numbered the same on these systems, even though the bytes are numbered differently.

Following are some possible problem areas:

- Passing binary data over the network. Use External Data Representation (XDR) format or another standard network format to avoid problems.
- Porting raster graphics images between architectures. If your program uses graphics images in binary form, and they have byte ordering that is not the same as for images produced by SPARC system routines, you must convert them.
- If you convert character-to-integer or integer-to-character between architectures, you should use XDR.
- If you read binary data created on an architecture with a different byte order, then you must filter it to correct the byte order.

See also the `man` page, `xdr`(3N).

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