FORTRAN 77 Language Reference

FORTRAN 77 Version 5.0

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Contents

Preface

This manual provides a reference to the Fortran 77 language accepted by the Sun™ FORTRAN 5.0 compiler `f77`.

Who Should Use This Book

This is a *reference* manual intended for programmers with a working knowledge of the Fortran language and some understanding of the Solaris™ operating environment and UNIX commands.

How This Book Is Organized

This book is organized into the following chapters and appendixes:

Chapter 1, "Elements of FORTRAN" introduces the basic parts of Sun FORTRAN 77, standards conformance, and elements of the language.

Chapter 2, "Data Types and Data Items" describes the data types and data structures in the language, including arrays, substrings, structures, and pointers.

Chapter 3, "Expressions" discusses FORTRAN expressions and how they are evaluated.

Chapter 4, "Statements" details the statements in the FORTRAN 77 language and the extensions recognized by the Sun compiler.

Chapter 5, "Input and Output" describes the general concepts of FORTRAN input/output and provides details on the different I/O operations.

Chapter 6, "Intrinsic Functions" tabulates and explains the intrinsic functions that are part of Sun FORTRAN 77, including VAX VMS extensions.

Appendix A, "ASCII Character Set" lists the standard ASCII character set.

Appendix B, "Sample Statements" shows samples of selected FORTRAN 77 statements for quick reference.

Appendix C, "Data Representations" introduces the way data is represented in FORTRAN.

Appendix D, "VMS Language Extensions" describes the VAX VMS language extensions provided in Sun FORTRAN 77.

Multi-Platform Release

Note - The name of the latest Solaris operating environment release is Solaris 7 but some documentation and path or package path names may still use Solaris 2.7 or SunOS 5.7.

The Sun™ WorkShop™ documentation applies to Solaris 2.5.1, Solaris 2.6, and Solaris 7 operating environments on:

- The SPARC™ platform
- The x86 platform, where x86 refers to the Intel® implementation of one of the following: Intel 80386™, Intel 80486™, Pentium™, or the equivalent

Note - The term “x86” refers to the Intel 8086 family of microprocessor chips, including the Pentium, Pentium Pro, and Pentium II processors and compatible microprocessor chips made by AMD and Cyrix. In this document, the term “x86” refers to the overall platform architecture. Features described in this book that are particular to a specific platform are differentiated by the terms “SPARC” and “x86” in the text.

Related Books

The following books augment this manual and provide essential information:

- *Fortran User's Guide*—provides information on command line options and how to use the compilers.
- *Fortran Programming Guide*—discusses issues relating to input/output, libraries, program analysis, debugging, performance, and so on.
- *Fortran Library Reference-gives details on the language and routines.*
- *Sun Performance WorkShop Fortran Overview* gives a high-level outline of the Fortran package suite.

Other Programming Books

- *C User's Guide*—describes compiler options, pragmas, and more.
- *Numerical Computation Guide*—details floating-point computation and numerical accuracy issues.
- *Sun WorkShop Performance Library Reference*-discusses the library of subroutines and functions to perform useful operations in computational linear algebra and Fourier transforms.

Other Sun WorkShop Books

- *Sun WorkShop Quick Install*-provides installation instructions.
- *Sun WorkShop Installation Reference*-provides supporting installation and licensing information.
- *Sun Visual WorkShop C++ Overview*-gives a high-level outline of the C++ package suite.
- *Using Sun WorkShop*—gives information on performing development operations through Sun WorkShop.
- *Debugging a Program With dbx*—provides information on using `dbx` commands to debug a program.
- *Analyzing Program Performance with Sun WorkShop*—describes the profiling tools; LoopTool, LoopReport, LockLint utilities; and the Sampling Analyzer to enhance program performance.
- *Sun WorkShop TeamWare User's Guide*—describes how to use the Sun WorkShop TeamWare code management tools.

Solaris Books

The following Solaris manuals and guides provide additional useful information:

- *The Solaris Linker and Libraries Guide*—gives information on linking and libraries.

- The Solaris *Programming Utilities Guide*—provides information for developers about the special built-in programming tools available in the SunOS system.

Ordering Sun Documents

The SunDocs℠ program provides more than 250 manuals from Sun Microsystems, Inc. If you live in the United States, Canada, Europe, or Japan, you can purchase documentation sets or individual manuals using this program.

For a list of documents and how to order them, see the catalog section of the SunExpress™ Internet site at `http://www.sun.com/sunexpress`.

Accessing Sun Documents Online

Sun WorkShop documentation is available online from several sources:

- The `docs.sun.com` Web site
- AnswerBook2™ collections
- HTML documents
- Online help and release notes

Using the `docs.sun.com` Web site

The `docs.sun.com` Web site enables you to access Sun technical documentation online. You can browse the `docs.sun.com` archive or search for a specific book title or subject. The URL is `http://docs.sun.com`.

Accessing AnswerBook2 Collections

The Sun WorkShop documentation is also available using AnswerBook2 software. To access the AnswerBook2 collections, your system administrator must have installed the AnswerBook2 documents during the installation process (if the documents are not installed, see your system administrator or Chapter 3 of *Sun WorkShop Quick Install* for installation instructions). For information about accessing AnswerBook2

documents, see Chapter 6 of *Sun WorkShop Quick Install*, Solaris installation documentation, or your system administrator.

Note - To access AnswerBook2 documents, Solaris 2.5.1 users must first download AnswerBook2 documentation server software from a Sun Web page. For more information, see Chapter 6 of *Sun WorkShop Quick Install*.

Accessing HTML Documents

The following Sun Workshop documents are available online only in HTML format:

- Tools.h++ Class Library Reference
- Tools.h++ User's Guide
- *Numerical Computation Guide*
- Standard C++ Library User's Guide
- *Standard C++ Class Library Reference*
- *Sun WorkShop Performance Library Reference Manual*
- *Sun WorkShop Visual User's Guide*
- Sun WorkShop Memory Monitor User's Manual

To access these HTML documents:

1. **Open the following file through your HTML browser:**

   install-directory`/SUNWspro/DOC5.0/lib/locale/C/html/index.html`

   Replace *install-directory* with the name of the directory where your Sun WorkShop software is installed (the default is `/opt`).

   The browser displays an index of the HTML documents for the Sun WorkShop products that are installed.

2. **Open a document in the index by clicking the document's title.**

Accessing Sun WorkShop Online Help and Release Notes

This release of Sun WorkShop includes an online help system as well as online manuals. To find out more see:

- Online Help. A help system containing extensive task-oriented, context-sensitive help. To access the help, choose Help Help Contents. Help menus are available in all Sun WorkShop windows.

- Release Notes. The Release Notes contain general information about Sun WorkShop and specific information about software limitations and bugs. To access the Release Notes, choose Help Release Notes.
- You can view the latest release information regarding the FORTRAN 77 compiler, `f77`, by invoking the compiler with the `-xhelp=readme` flag.

What Typographic Changes Mean

The following table describes the typographic changes used in this book.

TABLE P–1 Typographic Conventions

Typeface or Symbol	Meaning	Example
`AaBbCc123`	The names of commands, files, and directories; on-screen computer output	Edit your `.login` file. Use `ls -a` to list all files. `machine_name% You have mail.`
`AaBbCc123`	What you type, contrasted with on-screen computer output	`machine_name% su` `Password:`
AaBbCc123	Command-line placeholder: replace with a real name or value	To delete a file, type `rm` *filename*.
AaBbCc123	Book titles, new words or terms, or words to be emphasized	Read Chapter 6 in *User's Guide*. These are called *class* options. You *must* be root to do this.

- Examples use the `csh` shell and `demo%` as the system prompt, or the `sh` shell and `demo$` as the prompt.
- The symbol ¤ stands for a blank space where a blank is significant:

```
¤¤36.001
```

- Nonstandard features are tagged with the symbol "@". Standards are discussed in Chapter 1.

- FORTRAN examples appear in tab format, not fixed columns. See the discussion of source line formats in the *Fortran User's Guide* for details.
- The FORTRAN 77 standard uses an older convention of spelling the name "FORTRAN" capitalized. Sun documentation uses both FORTRAN and Fortran. The current convention is to use lower case: "Fortran 95".

Shell Prompts in Command Examples

The following table shows the default system prompt and superuser prompt for the C shell, Bourne shell, and Korn shell.

TABLE P–2 Shell Prompts

Shell	Prompt
C shell prompt	`machine_name%`
C shell superuser prompt	`machine_name#`
Bourne shell and Korn shell prompt	`$`
Bourne shell and Korn shell superuser prompt	`#`

CHAPTER 1

Elements of FORTRAN

This chapter introduces the basic elements of Sun FORTRAN 77.

Standards Conformance

- `f77` was designed to be compatible with the ANSI X3.9-1978 FORTRAN standard and the corresponding International Organization for Standardization (ISO) 1539-1980, as well as standards FIPS 69-1, BS 6832, and MIL-STD-1753.
- Floating-point arithmetic for both compilers is based on IEEE standard 754-1985, and international standard IEC 60559:1989.
- On SPARC platforms, both compilers provide support for the optimization-exploiting features of SPARC V8, and SPARC V9, including the UltraSPARC™ implementation. These features are defined in the SPARC Architecture Manuals, Version 8 (ISBN 0-13-825001-4), and Version 9 (ISBN 0-13-099227-5), published by Prentice-Hall for SPARC International.
- In this document, "Standard" means conforming to the versions of the standards listed above. "Non-standard" or "Extension" refers to features that go beyond these versions of these standards.

The responsible standards bodies may revise these standards from time to time. The versions of the applicable standards to which these compilers conform may be revised or replaced, resulting in features in future releases of the Sun Fortran compilers that create incompatibilities with earlier releases.

Extensions

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

Sun FORTRAN 77 accepts many VMS extensions, so that programs originally written for VAX systems will port easily to Solaris.

Features implemented in Sun `f77` that are not part of the applicable standards mentioned in "Standards Conformance" on page 1 are flagged with the special character mark `@@` throughout this manual.

Basic Terms

Some of the FORTRAN 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 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.

Character Set

The character set consists of the following:

- Uppercase and lowercase letters, A – Z and a – z
- Numerals 0 – 9
- Special characters—The following table shows the special characters that are used for punctuation:

TABLE 1–1 Special Character Usage

Character	Name	Usage
Space	Space	Ignored in statements, except as part of a character constant
Tab	Tab	Establish the line as a tab-format source line @
=	Equals	Assignment
+	Plus	Add, unary operator
-	Minus	Subtract, unary operator
*	Asterisk	Multiply, alternate returns, comments, exponentiation, `stdin`, `stdout`, list-directed I/O
/	Slash	Divide, delimit data, labeled commons, structures, end-of-record
( )	Parentheses	Enclose expressions, complex constants, equivalence, parameter, or implicit groups, formats, argument lists, subscripts
,	Comma	Separator for data, expressions, complex constants, equivalence groups, formats, argument lists, subscripts
.	Period	Radix point, delimiter for logical constants and operators, record fields
'	Apostrophe	Quoted character literals
"	Quote	Quoted character literals, octal constants @
$	Dollar sign	Delimit namelist input, edit descriptor, directives @
!	Exclamation	Comments @
:	Colon	Array declarators, substrings, edit descriptor
%	Percent	Special functions: %REF, %VAL, %LOC @
&	Ampersand	Continuation, alternate return, delimit namelist input; use in column 1 establishes the line as a tab-format source line @

TABLE 1–1 Special Character Usage *(continued)*

Character	Name	Usage
?	Question mark	Request names in namelist group@
\	Backslash	Escape character @
< >	Angle brackets	Enclose variable expressions in formats @

Note the following usage and restrictions:

- Uppercase or lowercase is not significant in the key words of FORTRAN statements or in symbolic names. The `-U` option of `f77` makes case significant in symbolic names.@
- Most control characters are allowed as data even though they are not in the character set. The exceptions are: Control `A`, Control `B`, Control `C`, which are *not* allowed as data. These characters can be entered into the program in other ways, such as with the `char()` function.@
- 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. For the newline (`\n`) character, you must use an escape sequence. See also Table 2–3.

Symbolic Names

The items in the following table can have symbolic names:

TABLE 1–2 Items with Symbolic Names

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

The following restrictions apply:

- Symbolic names can any number of characters long. 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 may conflict with names in the Fortran and system libraries.

Note - Procedure names that begin with exactly two underscores are considered special support functions internal to the compiler. Avoid naming functions or subroutines with exactly two initial underscores (for example _ _`xfunc`) as this will conflict with the compiler's usage. @

- 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
```

- 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 1–3 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

Program Units

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.

Statements

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

Executable and 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 Statements

TABLE 1–4 FORTRAN Statements

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*

The asterisk (*) in the table indicates an executable statement.

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” on page 10.
- 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” on page 10.

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 extend 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
C234567890123456789012345678901234567890123456789012345678901234567890123456789012
      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

See the Sun *Fortran User's Guide* and the *Fortran Programming Guide* for details on the specific directives available with `f77`.

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*[=*options*]

The variable *id* identifies the directive keyword; *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 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.

Parallelization Directives

Parallelization directives explicitly request the compiler attempt to parallelize the DO loop that follows the directive. The syntax differs from general directives. Parallelization directives are only recognized when compilation options `–-parallel`

or –-explicitpar are used. (f77 parallelization options are described in the *Fortran User's Guide*.)

Parallelization directives have the following syntax:

- The first character must be in column one.
- The first character can be any one of c, C, *, or !.
- The next four characters are $PAR, no blanks, either upper or lower case.
- Next follows the directive keyword and options, separated by blanks.

  The explicit parallelization directive keywords are:

  TASKCOMMON, DOALL, DOSERIAL, and DOSERIAL*

Each parallelization directive has its own set of optional qualifiers that follow the keyword.

Example: Specifying a loop with a shared variable:

```
C$PAR DOALL SHARED(yvalue)
```

See the *Fortran Programming Guide* for details about parallelization and these directives.

CHAPTER 2

Data Types and Data Items

This chapter describes the data types and data structures in Sun FORTRAN 77: “Types” on page 13, “Constants” on page 24, “Variables” on page 36, “Arrays ” on page 37, “Substrings” on page 43, “Structures” on page 45, and “Pointers ” on page 52.

Nonstandard features are tagged with a small black diamond (@).

Types

Except for specifically typeless constants, any constant, constant expression, variable, array, array element, substring, or function usually represents typed data.

On the other hand, data types are not associated with the names of programs or subroutines, block data routines, common blocks, namelist groups, or 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 6.

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. The f77 compiler does no type checking across program units.

Properties of Data Types

This section describes the data types in Sun FORTRAN 77.

Default data declarations, those that do not explicitly declare a data size can have their meanings changed by certain compiler options. The next section, “Size and Alignment of Data Types ” on page 20 summarizes data sizes and alignments and the effects of these options.

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 the compiler expects INTEGER explicitly, it will not allow BYTE.

Examples:

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

A BYTE item occupies 1 byte (8 bits) 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 and 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 and 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 defaults to a synonym for 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 default size for a COMPLEX item (no size specified) is 8 bytes. The default alignment is on 4-byte boundaries. However, these defaults can be changed by compiling with certain special options (see “Size and Alignment of Data Types ” on page 20).

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.

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.

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 bytes.

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.

INTEGER

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

The default size for INTEGER with no size specified is 4, and is aligned on 4-byte boundaries. However, these defaults can be changed by compiling with certain special options (see “Size and Alignment of Data Types ” on page 20).

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 compilation option is in effect. With -i2, the default length of LOGICAL quantities is 2 bytes.

Ordinary integers follow the FORTRAN rules about occupying the same space as a REAL variable. They are assumed to be equivalent to the C type long int, and 2-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.

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, and is aligned on 4-byte boundaries. However, these defaults can be changed by compiling with certain special options.

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. 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, and is aligned on 4-byte boundaries. However, these defaults can be changed by compiling with certain special options.

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. 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 of Data Types

Storage and alignment are always given in bytes. Values that can fit into a single byte are byte-aligned.

The size and alignment of types depends on various compiler options and platforms, and how variables are declared. The maximum alignment in COMMON blocks is to 4-byte boundaries.

Default data alignment and storage allocation can be changed by compiling with special options, such as `-f`, `-dalign`, `-dbl_align_all`, `-dbl`, `-r8`, `-i2`, and `-xtypemap`. The default descriptions in this manual assume that these options are not in force.

Refer to the *Fortran User's Guide* for details of specific compiler options.

The following table summarizes the default size and alignment, ignoring other aspects of types and options.

TABLE 2–1 Default Data Sizes and Alignments (in Bytes)

		Default Alignment		Alignment in COMMON	
Fortran 77 Data Type	**Size**	**SPARC**	**x86**	**SPARC**	**x86**
BYTE X	1	1	1	1	1
CHARACTER X	1	1	1	1	1
CHARACTER*n X	n	1	1	1	1
COMPLEX X	8	4	4	4	4
COMPLEX*8 X	8	4	4	4	4
DOUBLE COMPLEX X	16	8	4	4	4
COMPLEX*16 X	16	8	4	4	4
COMPLEX*32 X	32	8/16	—	4	—
DOUBLE PRECISION X	8	8	4	4	4
REAL X	4	4	4	4	4
REAL*4 X	4	4	4	4	4
REAL*8 X	8	8	4	4	4
REAL*16 X	16	8/16	—	4	—

TABLE 2–1 Default Data Sizes and Alignments (in Bytes) *(continued)*

		Default Alignment		Alignment in COMMON	
Fortran 77 Data Type	**Size**	**SPARC**	**x86**	**SPARC**	**x86**
INTEGER X	4	4	4	4	4
INTEGER*2 X	2	2	2	2	2
INTEGER*4 X	4	4	4	4	4
INTEGER*8 X	8	8	4	4	4
LOGICAL X	4	4	4	4	4
LOGICAL*1 X	1	1	1	1	1
LOGICAL*2 X	2	2	2	2	2
LOGICAL*4 X	4	4	4	4	4
LOGICAL*8 X	8	8	4	4	4

Note the following:

- REAL*16 and COMPLEX*32 are only available on SPARC only. In 64-bit environments (compiling with -xarch=v9 or v9a) the default alignment is on 16-byte (rather than 8-byte) boundaries, as indicated by 8/16 in the table.
- 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.

Compiling with options -i2,-r8, or -dbl changes the defaults for certain data declarations that appear without an explicit size:

TABLE 2–2 Data Defaults Changed by -i2, -r8, -dbl

Default Type	**With** -i2	**With** -r8 **or** -dbl
INTEGER	INTEGER*2	INTEGER*8
LOGICAL	LOGICAL*2	LOGICAL*8
REAL	REAL*4	REAL*8
DOUBLE	REAL*8	REAL*16

TABLE 2–2 Data Defaults Changed by `-i2, -r8, -dbl` *(continued)*

Default Type	**With** `-i2`	**With** `-r8` **or** `-dbl`
`COMPLEX`	COMPLEX*8	COMPLEX*16
`DOUBLE COMPLEX`	COMPLEX*16	COMPLEX*32

Do not combine `-i2` with `-r8` as this can produce unexpected results. `REAL*16` and `COMPLEX*32` are *SPARC only*.

With `-dbl` or `-r8`, `INTEGER` and `LOGICAL` are allocated the larger space indicated above. This is done to maintain the FORTRAN 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. A disadvantage of using `-r8` or `-dbl` is that it also promotes `DOUBLE PRECISION` data to `QUAD PRECISION`, possibly degrading performance.

Use of the more flexible `-xtypemap` option is preferred over the older `-r8` and `-dbl` options. Both `-dbl` and `-r8` have their `-xtypemap` equivalents:

- On SPARC:

  `-dbl` *same as:* `-xtypemap=real:64,double:128,integer:64` `-r8` *same as:* `-xtypemap=real:64,double`

- On x86:

  `-dbl` *same as:* `-xtypemap=real:64,double:64,integer:64` `-r8` *same as:* `-xtypemap=real:64,double:`

The mapping `integer:mixed` indicates 8 byte integers but only 4 byte arithmetic.

There are two additional possibilities on SPARC:

`-xtypemap=real:64,double:64,integer:mixed` `-xtypemap=real:64,double:64,integer:64`

which map both default `REAL` and `DOUBLE` to 8 bytes, and should be preferable over using `-r8` or `-dbl`.

Note that `INTEGER` and `LOGICAL` are treated the same, and `COMPLEX` is mapped as two `REAL values`. Also, `DOUBLE COMPLEX` will be treated the way `DOUBLE` is mapped.

Options `-f` or `-dalign` (*SPARC only*) force alignment of all 8, 16, or 32-byte data onto 8-byte boundaries. Option `-dbl_align_all` causes all data to be aligned on 8-byte boundaries. Programs that depend on the use of these options may not be portable.

See the *Fortran User's Guide* for details on these compiler options.

Constants

A literal *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. (For a *named* constant, defined by a PARAMETER statement, the name defines the data type.)

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.

Compiling with any of the options `-i2`, `-dbl`, `-r8`, or `-xtypemap` alters the default size of integer, real, complex, and double precision constants. These options are described in Chapter 2, and in the *Fortran User's Guide.*

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 2–3.

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 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 2–3 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 (or `PARAMETER` 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 `INTEGER*4` range (-2147483648, 2147483647), unless compiled with an option that promotes integers to 64 bits, in which case the range becomes `INTEGER*8` (-9223372036854775808,9223372036854775807). See “Size and Alignment of Data Types ” on page 20.

Example: Integer constants:

```
-2147483648
-2147483649          Invalid-too small, error message
-10
0
+199
29002
2.71828          Not INTEGER-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 32.

Long Integers @

Compiling with an option that promotes the range from `INTEGER*4`(-21474836, 21474836) to `INTEGER*8` (-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 compiling with the `-i2` option will cause it to be 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 compiled with the `-i2` option, 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* or an integer constant, such that it is followed by a quadruple-precision exponent. See "Real Constants" on page 29. @

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:

```
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 8-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, 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 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.

Fortran 90-Style Constants @

The Sun Fortran 77 compiler (release 5.0) recognizes the Fortran 90-style syntax for integer and real constants that allows literal specification of the size of the data item. In Fortran 90 terminology, a constant literal may include an optional trailing underscore followed by a “kind type parameter”. @

In the Sun Fortran 77 implementation, the “kind type parameter” is limited to the digits 1, 2, 4, or 8, and its use specifies the data size, in bytes, of the literal constant. For example:

```
12_8               specifies an 8-byte integer constant, value = 12
12_4               specifies a 4-byte integer constant, value = 12
1.345E-10_8        specifies an 8-byte real constant, value = 1.345E-10
(-1.5_8,.895E-3_8) specifies a complex constant with 8-byte real and imaginary parts
```

With complex constants, the real and imaginary parts may be specified with different kind type parameters, `(1.0_8,2.0_4)`, but the resulting data item will have the real and imaginary parts with the same size, taking the larger one specified.

This construction is valuable when calling subprograms with constant arguments when a specific data type is required, as in the following example:

```
call suby(A,1.5_8,0_8,Y)
...
subroutine suby(H0, M, N, W)
INTEGER *8 M, N,
...
```

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 “Types” on page 13 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.

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 40 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

An array must appear only once in an array declarator within a program unit (main program, subroutine, function, or block common). The compiler flags multiple or duplicate array declarations within the same unit as errors.

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 that is a dummy argument or local array@ with one or more of its dimensions or bounds as an expression of integer variables that are either themselves dummy arguments, or are in a common block.

You can declare adjustable arrays in the usual `DIMENSION` 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 arrays;

```
SUBROUTINE POPUP ( A, B, N )
COMMON / DEFS / M, L
REAL A(3:5, L, M:N), B(N+1:2*N) ! These arrays are dummy args
REAL C(N+1,2*N)  !  This array is local
```

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.
- You cannot declare an adjustable array in `COMMON`.

If the array is local to the routine, memory is allocated on entry to the routine and deallocated on return to the caller.@

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.

Ihe following f77 extensions allow you to:@

- declare assumed-size arrays in a RECORD statement, if that RECORD statement is not inside a structure declaration block.
- use an assumed-size array as a unit identifier for an internal file in an I/O statement.
- 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, 2:*)
```

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, complex, logical, or byte expression. According to the FORTRAN 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` in 32-bit environments. It is not controlled, but if the subscript expression is not in the range (-2147483648, 2147483647), then the results are unpredictable. When compiled for 64-bit environments, `INTEGER*8` subscript expressions are allowed.

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. This corresponds to traditional mathematical *nxm* matrix notation:

$a_{1,1}$	$a_{1,2}$	$a_{1,3}$	...	$a_{1,m}$
$a_{2,1}$	$a_{2,2}$	...		$a_{2,m}$
...	...	$a_{i,j}$	...	$a_{i,m}$
$a_{n,1}$	$a_{n,2}$	...		$a_{n,m}$

Element $a_{i,j}$ is located in row *i*, column *j*.

For example:

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

The elements of A are conceptually arranged 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.

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` on 32-bit environments. If the expression is not in the range (-2147483648, 2147483647), then the results are unpredictable. When compiled for 64-bit environments, the substring character position expressions can be in the range of `INTEGER*8`.

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 £ L£ 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%
```

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 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 49.

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 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. 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 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 50.
- 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.

Pointers

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

Syntax Rules

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

The POINTER statement has the following syntax:

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.

See “POINTER” on page 183, for more examples.

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 and should not appear in a type declaration.

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 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.

The `loc(), malloc(),` and `free()` routines associate and deassociate memory addresses with pointers. (These routines are described in Chapter 6.)

When compiled for 64-bit environments, pointers declared by the `POINTER` statement are `INTEGER*8` values.

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.

When compiled for 64-bit environments, LOC() returns an INTEGER*8 value. The receiving variable must be either a pointer or an INTEGER*8 variable to avoid possible address truncation.

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, MALLOC() allocates 10,000 bytes of memory and associates the address of that block of memory with the pointer P1.

Deallocation of Memory by FREE() Subroutine

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, `MALLOC()` allocates 10,000 bytes of memory, which are associated with pointer `P1`. `FREE()` later returns those same 10,000 bytes to the memory manager.

Special Considerations

Here are some special considerations when working with pointers and memory allocation with `malloc(), loc(),` and `free()`:

- 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` on 32-bit environments. If the expression is not in the range (-2147483648, 2147483647), then the results are unpredictable.
- When compiling for 64-bit environments, use `malloc64()` to access the 64-bit address space. Routine `malloc64()` takes an `INTEGER*8` argument and returns a 64-bit pointer value. In 64-bit programs, pointers defined by the `POINTER` statement are 64-bit `INTEGER*8` values. See the *Fortran Library Reference Manual* and the *malloc*(3F) man pages.

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)     This programming unit does
POINTER ( P, V )             nothing else with P other than
P = MALLOC(10000)         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 avoid using 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: Code that could cause trouble with -O3 or -O4:

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

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

CHAPTER 3

Expressions

This chapter discusses Fortran expressions and how they are evaluated.

Expressions, Operators, and Operands

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

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)
- An expression

Arithmetic Expressions

An *arithmetic expressio*n 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 `**`.

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 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. 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*	**Conversion 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 - Compiling with any of the options `-i2`, `-dbl`, `-r8`, or `-xtypemap` will have an effect on the assumed type of *e*. This is discussed in Chapter 2. See also the *Fortran User's Guide* for a description of these options.

Example: Arithmetic assignment:

```
INTEGER I2*2, J2*2, I4*4
LOGICAL L1, L2
REAL R4*4, R16*16
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
```

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 (nonstandard) 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 `joinedDD`:

```
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:

Variable	Receiving Value	Comment
C2	'zD'	**A trailing blank**
C3	'uvw'	
C5	'ABxyz'	
C6	'ABxyzz'	*The final* `'z'` *comes from* `C2`
I	'abcd'	

Variable	Receiving Value	Comment
C2	'zD'	**A trailing blank**
Z	'wxyz'	
BELL	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 substring assignment cannot overlap. See the “Substrings” on page 43 .

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.	Lowest
.OR.	
.NEQV.,.XOR., .EQV.	

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	Lowest
Relational	
Logical	

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

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. (All non-zero values are treated as .TRUE., and zero is .FALSE.) 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.
```

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     STR1 and STR2 are character type
S .EQ. "a"         S is character type
```

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.

Constant Expressions

A *constant expression* is made up of explicit constants and parameters and the FORTRAN operators. Each operand is either itself another constant expression, a constant, a symbolic name of a constant, or one of the intrinsic functions called with constant arguments.

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%
```

Record Assignment

The general form of record assignment is: @

v = *e*
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.

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.

CHAPTER 4

Statements

This chapter describes the statements recognized by Sun FORTRAN 77. Nonstandard features are indicated by the symbol "@". (See Chapter 1 for a discussion of the conforming standards). A table of sample statements appears in Appendix B.

ACCEPT

The ACCEPT @ statement reads from standard input and requires the following syntax:

ACCEPT *f* [, *iolist*]

ACCEPT *grname*

Parameter	Description
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. An example of list-directed input:

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

ASSIGN

The ASSIGN statement assigns a statement label to a variable.

ASSIGN *s* TO *i*

Parameter	Description
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. It can not be declared INTEGER*2.

After assigning a statement label to a variable, you can reference it in:

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

Restrictions

The variable must be assigned a statement label *before* referencing it as a label in an assigned GO TO statement, or as a format identifier.

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

On 64-bit platforms, the actual value stored in variable *i* by the ASSIGN statement is not available to the program, except by the assigned GO TO statement, or as a format identifier in an I/O statement. Also, only variables set by an ASSIGN statement can be used in an assigned GO TO or as a format identifier.

Examples

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

```
      IF(LB.EQ.0) ASSIGN 9 TO K
      …
      GO TO K
      …
9     AKX = 0.0
```

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."
```

Assignment

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

v = *e*

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

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.

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 - Compiling with any of the options `-i2`, `-dbl`, `-r8`, or `-xtypemap` can alter the default data size of variables and expressions. This is discussed in Chapter 2. See also the *Fortran User's Guide* for a description of these options.

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        ! (REAL*16 is SPARC only)
DOUBLE PRECISION DP
COMPLEX C8, C16*16, QC*32  ! (COMPLEX*32 is 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	*receives* 'zD' *a trailing blank*
C3	*receives* 'uvw"
C5	*receives* 'ABxyz"
C6	*receives* 'ABxyzz' *an extra* z *left over from* C5
BELL	*receives* 07 hex *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
```

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.

AUTOMATIC *vlist*

Parameter	Description
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. See also the discussion of the -stackvar option in the *Fortran 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 should 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%
```

Restrictions

An AUTOMATIC statement and a type statement cannot be combined to make an AUTOMATIC *type* statement. For example, AUTOMATIC REAL X does *not* declare the variable X to be both AUTOMATIC and REAL; it declares the variable REALX to be AUTOMATIC.

BACKSPACE

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

```
BACKSPACE u
BACKSPACE ([UNIT= ]u [, IOSTAT=ios ] [, ERR=s ])
```

Parameter	Description
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
```

BLOCK DATA

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

BLOCK DATA [*name*]

Parameter	Description
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
```

BYTE

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

BYTE *v* [*/c/*]

Parameter	Description
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"/, M/127/, SWITCH/.FALSE./
```

CALL

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

`CALL` *sub* `[([`*ar*`[, `*ar*`])]`

Parameter	Description
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 4–2.
- 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.**

Note - A `CALL` to a subprogram defined as a `FUNCTION` rather than as a `SUBROUTINE` will cause unexpected results and is not recommended. The compiler does not automatically detect such inappropriate `CALL`s and no warning is issued unless the `-Xlist` option is specified.

Examples

Example 1: Character string:

```
      CHARACTER *25 TEXT
      TEXT = "Some kind of text string"
      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.

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.

CHARACTER [* *len*[,]] *v* [* *len* /*c*/]]

Parameter	Description
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 SWAN( A )
CHARACTER A*32
```

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

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

Example 5: Symbolic constant with parenthesized asterisk:

```
CHARACTER *(*) INODE
PARAMETER (INODE = "Warning: INODE corrupted!")
```

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.

CLOSE

The CLOSE statement disconnects a file from a unit.

CLOSE([UNIT=] *u* [, STATUS= *sta*] [, IOSTAT= *ios*] [, ERR= *s*])

Parameter	Description
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

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.

Note - For tape I/O, use the TOPEN( ) routines.

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 keep a scratch file even though the status is SCRATCH:

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

COMMON

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

COMMON [/[*cb*]/] *nlist* [[,]/[*cb*]/ *nlist*]

Parameter	Description
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:

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

Unlabeled common and labeled common:

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
```

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.

COMPLEX [*len[,]] v [*len[/c/]] [, v [*len[/c/]] …

Parameter	Description
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`. Specifying the size is nonstandard. `@`

COMPLEX

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

If you do *not* specify the size, a default size is used.

The default size for a declaration such as `COMPLEX W` can be altered by compiling with any of the options `-dbl`, `-r8`, or `-xtypemap`. See the discussion in Chapter 2 for details.

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.

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.

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 variables. These statements are equivalent.

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

Example 2: Initialize complex variables:

```
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, with initialization:

```
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, with initialization *(SPARC only)*:

```
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 *(SPARC only)*:

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

CONTINUE

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

[*label*] CONTINUE

Parameter	Description
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
        . . .
```

DATA

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

DATA *nlist* / *clist* / [[,] *nlist* / *clist* /] ...

Parameter	Description
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, although this is non-standard@.

Note - Initializing a local variable in a DATA statement after an executable reference to that variable is flagged as an error when compiling with the `-stackvar` option. See the Sun *Fortran User's Guide.*

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.

Automatic variables or arrays cannot appear on a DATA statement.

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*])

Parameter	Description
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.

Implied DO lists may also appear within the variables lists on I/O statements PRINT, READ, and WRITE.

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 /"00"/,N/4Hs12t/,CR/13/
      …
```

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.

ENCODE (*size*, *f*, *buf* [, IOSTAT=*ios*] [, ERR=*s*]) [*iolist*]

DECODE (*size*, *f*, *buf* [, IOSTAT=*ios*] [, ERR=*s*]) [*iolist*]

Parameter	Description
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 can be: 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'.

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.

DIMENSION *a*(*d*) [, *a*(*d*)] ...

Parameter	Description
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
```

Example 7: Assumed-size arrays:

```
SUBROUTINE RUN(A,B,N)
DIMENSION A(*), B(N,*)
...
```

DO

The DO statement repeatedly executes a set of statements.

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

or

DO *loop-control* @

where *s* is a statement number. The form of *loop-control* is

variable = *e1*, *e2* [, *e3*]

Parameter	Description
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 IF
- ELSE
- END IF
- END
- *Logical* IF

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.

Control 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
```

DO WHILE

The `DO WHILE` @ statement repeatedly executes a set of statements while the specified condition is true.

`DO [` *s* `[,]] WHILE (`*e*`)`

Parameter	Description
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

Jumping into the range of a DO WHILE loop from outside its range can produce unpredictable results.

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
```

DOUBLE COMPLEX

The DOUBLE COMPLEX @ statement specifies the type to be double complex. It optionally specifies array dimensions and size, and initializes with values.

DOUBLE COMPLEX *v*[/*c*/] [, *v*[/*c*/] ...

Parameter	Description
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 two `REAL*8` elements contiguous in memory, interpreted as one double-width complex number.

If you do *not* specify the size, a default size is used.

The default size, for a declaration such as `DOUBLE COMPLEX Z`, can be altered by compiling with any of the options `-dbl`, `-r8`, or `-xtypemap`. See the discussion in Chapter 2 for details.

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.

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
```

DOUBLE PRECISION

The `DOUBLE PRECISION` statement specifies the type to be double precision, and optionally specifies array dimensions and initializes with values.

`DOUBLE PRECISION` *v*`[`*/c/*`]` `[,` *v*`[`*/c/*`]` ...

Parameter	Description
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 a REAL*8 element in memory, interpreted as one double-width real number.

If you do *not* specify the size, a default size is used. The default size, for a declaration such as DOUBLE PRECISION X, can be altered by compiling with any of the options -dbl, -r8, or -xtypemap. See the discussion in Chapter 2 for details.

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.

Example

For example:

```
DOUBLE PRECISION R, S(3,6)
REAL*8 T(-1:0,5)
```

ELSE

The ELSE statement indicates the beginning of an ELSE block.

```
IF (e) THEN
...
ELSE
...
END IF
```

where *e* is a 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 "IF (Block)" on page 146 for more information.

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
…
```

ELSE IF

The ELSE IF provides a multiple alternative decision structure.

ELSE IF (*e2*) THEN

IF (*e1*) THEN

END IF

where *e1* and *e2* are 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 (*e*) proceeds as follows, depending on the value of the logical expression, *e*:

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
```

ENCODE / DECODE

The ENCODE @ statement writes data from a list to memory.

ENCODE(*size*, *f*, *buf* [, IOSTAT=*ios*] [, ERR=*s*]) [*iolist*]

Parameter	Description
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. 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 "DECODE/ENCODE" on page 105 for more information and a full example.

END

The END statement indicates the end of a program unit with the following 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
```

END DO

The END DO @ statement terminates a DO loop and requires the following 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
```

END FILE

The END FILE statement writes an end-of-file record as the next record of the file connected to the specified unit.

END FILE *u*

END FILE ([UNIT=]*u* [, IOSTAT=*ios*] [, ERR=*s*])

Parameter	Description
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.
iost	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 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
```

END IF

The `END IF` statement ends the block `IF` that the `IF` began and requires the following 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
```

END MAP

The END MAP @ statement terminates the MAP declaration and requires the following syntax:

```
END MAP
```

Description

See "UNION and MAP" on page 217 for more information.

Restrictions

The MAP statement must be within a UNION statement.

Example

```
…
MAP
       CHARACTER *16 MAJOR
END MAP
…
```

END STRUCTURE

The END STRUCTURE @ statement terminates the STRUCTURE statement and requires the following syntax:

```
END STRUCTURE
```

Description

See “STRUCTURE” on page 208 for more information.

Example

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

END UNION

The END UNION @ statement terminates the UNION statement and requires the following syntax:

```
END UNION
```

Description

See “UNION and MAP” on page 217 for more information.

Example

```
UNION
MAP
       CHARACTER*16
END MAP
MAP
       INTEGER*2    CREDITS
       CHARACTER *8 GRAD_DATE
END MAP
END UNION
```

ENTRY

The ENTRY statement defines an alternate entry point within a subprogram.

ENTRY *en* [([*fa*[, *fa*]])]

Parameter	Description
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.

Argument 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 FIN( A, B, C )
INTEGER A, B
CHARACTER C*4
…
RETURN

ENTRY HLEP( A, B, C )
…
RETURN

ENTRY MOOZ
…
RETURN
END
```

:

In the above example, the subroutine FIN has two alternate entries: the entry HLEP has an argument list; the entry MOOZ 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 FIN( A, B, C )
…
CALL MOOZ
…
CALL HLEP( 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
```

EQUIVALENCE

The EQUIVALENCE statement specifies that two or more variables or arrays in a program unit share the same memory.

EQUIVALENCE (*nlist*) [, (*nlist*)] …

Parameter	Description
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)
```

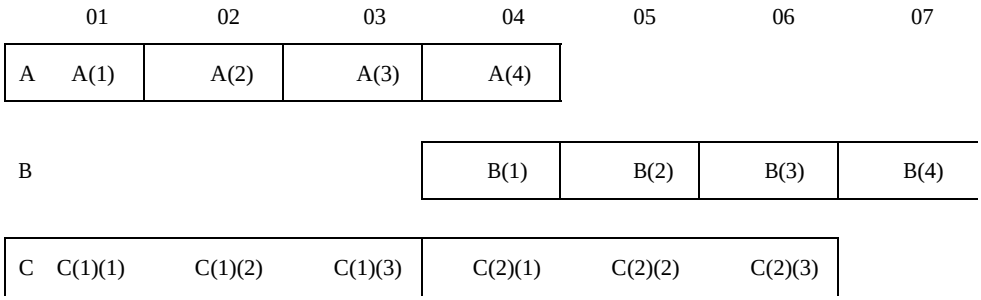
```
EQUIVALENCE (A(1), D(1)), (A(2), D(2))
```

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. The first seven character positions are arranged in memory as follows:



EXTERNAL

The EXTERNAL statement specifies procedures or dummy procedures as external, and allows their symbolic names to be used as actual arguments.

EXTERNAL *proc* [, *proc*] ...

Parameter	Description
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
```

FORMAT

The FORMAT statement specifies the layout of the input or output records.

label FORMAT (*f*)

Parameter	Description
label	Statement number
f	Format specification list

The items in *f* have the form: *label* FORMAT (*f*)

[*r*] *desc*

[*r*] (*f*)

r	A repeat factor
desc	An edit descriptor (repeatable or nonrepeatable). If *r* is present, then *d* must be repeatable.

The repeatable edit descriptors are:

I	F	E	D	G
I*w*	F*w*	E*w*	D*w*	G*w*
I*w.d*	F*w.d*	E*w.d*	D*w.d*	G*w.d*
O	A	E*w.d.e*	D*w.d.e*	G*w.d.e*
O*w*	A*w*	Ee*w.dE*	D*w.d*E*e*	G*w.d*E*e*
O*w.d*	L			
Z	L*w*			
Z*w*				
Z*w.d*				

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

The nonrepeatable edit descriptors are:

- "*a1a2 an*" single quote-delimited character string
- *"a1a2 ... an"* double quote-delimited character string
- *n*H*a1a2 ... an* Hollerith string
- $
- /
- :
- [*k*]R (*k* defaults to 10)
- [*k*]P (*k* defaults to 0)
- B, BN, and BZ
- S, SU, SP, and SS
- T*n* and *n*T
- TL[*n*] and TR[*n*] (*n* defaults to 1)
- [*n*]X (n defaults to 1)

See “Formatted I/O” on page 236 for full details of these edit descriptors.

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. u

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.

Restrictions

The FORMAT statement label cannot be used in a GO TO, IF-arithmetic, DO, or alternate return.

Warnings

For *explicit* 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 “Runtime Formats ” on page 267 for details.

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 )
```

FUNCTION (External)

The FUNCTION statement identifies a program unit as a function subprogram.

[*type*] FUNCTION *fun* ([*ar*[, *ar*]])

Parameter	Description
type	BYTE @
	CHARACTER
	CHARACTER*_n_ (where _n_ must be greater than zero)
	CHARACTER*(*)
	COMPLEX
	COMPLEX*8 @
	COMPLEX*16 @
	COMPLEX*32 @
	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 @
fun	Symbolic name assigned to function
ar	Formal argument name

(COMPLEX*32 and REAL*16 are SPARC only.)

An alternate nonstandard syntax for length specifier is as follows: @

[*type*]FUNCTION *name* [* *m*]([*ar* [,*ar*]])

Parameter	Description
m	Unsigned, nonzero integer constant specifying length of the data type.
ar	Formal argument name

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.

Note - Compiling with any of the options -dbl, -r8, -i2, or -xtypemap can alter the default data size assumed in the call to or definition of functions unless the data type size is explicitly declared. See Chapter 2 and the *Fortran User Guide* for details on these options.

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 )
```

GO TO (Assigned)

The *assigned* GO TO statement branches to a statement label identified by the assigned label value of a variable.

GO TO *i* [[,](*s*[, *s*])]

Parameter	Description
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 control jumps to must be *executable*, not DATA, ENTRY, FORMAT, or INCLUDE.

Control 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
```

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.

GO TO (*s*[, *s*])[,]*e*

Parameter	Description
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 control jumps to must be *executable*, not `DATA`, `ENTRY`, `FORMAT`, or `INCLUDE`.

Control 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` equals one, then go to 10.
- If `N` equals two, then go to 20.
- If `N` equals three, then go to 30.
- If `N` equals four, then go to 40.
- If `N` is less than one or `N` is greater than four, then fall through to 10.

GO TO (Unconditional)

The *unconditional* GO TO statement transfers control to a specified statement.

GO TO *s*

Parameter	Description
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 control jumps to must be executable, not a DATA, ENTRY, FORMAT, or INCLUDE statement.

Control 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
```

IF (Arithmetic)

The *arithmetic* IF statement branches to one of three specified statements, depending on the value of an arithmetic expression.

IF (*e*) *s1*, *s2*, *s3*

Parameter	Description
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 control jumps to must be *executable*, not DATA, ENTRY, FORMAT, or INCLUDE.
- Control 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.

IF (Block)

The *block* IF statement executes one of two or more sequences of statements, depending on the value of a logical expression.

IF (*e*) THEN

Parameter	Description
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

Control 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
```

IF (Logical)

The *logical* IF statement executes one single statement, or does not execute it, depending on the value of a logical expression.

IF (*e*) *st*

Parameter	Description
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
```

IMPLICIT

The IMPLICIT statement confirms or changes the default type of names.

IMPLICIT *type* (*a*[, *a*]) [, *type* (*a*[, *a*])]

IMPLICIT NONE

IMPLICIT UNDEFINED(A-Z) *u*

Parameter	Description
type	BYTE u
	CHARACTER
	CHARACTER*_n_ (where _n_ must be greater than 0)
	CHARACTER*(*)
	COMPLEX
	COMPLEX*8 u
	COMPLEX*16 u
	COMPLEX*32 u (SPARC only)
	DOUBLE COMPLEX u
	DOUBLE PRECISION
	INTEGER
	INTEGER*2 u
	INTEGER*4 u
	INTEGER*8 u
	LOGICAL
	LOGICAL*1 u
	LOGICAL*2 u
	LOGICAL*4 u
	LOGICAL*8 u
	REAL
	REAL*4 u
	REAL*8 u
	REAL*16 u (SPARC only)
	AUTOMATIC u
	STATIC u
a	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.

Note - Compiling with any of the options `-dbl`, `-i2`, `-r8`, or `-xtypemap` can alter the assumed size of names typed with an `IMPLICIT` statement that does not specify a size: `IMPLICIT REAL (A-Z)`. See Chapter 2 and the *Fortran User's Guide* for details.

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`.

INCLUDE

The INCLUDE @ statement inserts a file into the source program.

INCLUDE *'file'*

Parameter	Description
file	Name of the file to be inserted

INCLUDE "*file*"

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. For a standard install, the default list is:

   /opt/SUNWspro/SC5.0/include/f77 /usr/include

   For a non-standard install to a directory */mydir/*, the default list is:

   /mydir/SUNWspro/SC5.0/include/f77 /usr/include

The release number, SC5.0, 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 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 statements.

VMS Logical File Names in the INCLUDE Statement

f77 interprets VMS logical file names on the INCLUDE statement if:

- The -xl[d] or -vax=*spec* compiler options are 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 a standard install, `f77` searches these directories:

- `/usr/ftn/projA/ver1`
- `/usr/ftn/ver1`
- `/opt/SUNWspro/SC5.0/include/f77/ver1`
- `/usr/include`

For a non-standard install to a directory `/`*mydir*, it searches these directories:

- `/usr/ftn/projA/ver1`
- `/usr/ftn/ver1`
- `/`*mydir*`/SUNWspro/SC5.0/include/f77/ver1`
- `usr/include`

INQUIRE

The `INQUIRE` statement returns information about a *unit* or *file*.

`INQUIRE([UNIT =] `*u*`, `*slist*`)`

`INQUIRE(FILE = `*fn*`, `*slist*`)`

Parameter	Description
fn	Name of the file being queried
u	Number of the file being queried
slist	The specifiers list *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).

Inquire either by unit or by file, but not by both in the same 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 following table summarizes the INQUIRE specifiers:

TABLE 4–1 INQUIRE Specifiers Summary

Form: SPECIFIER = Variable

SPECIFIER	Value of Variable	Data Type of Variable
ACCESS	'DIRECT' 'SEQUENTIAL'	CHARACTER
BLANK	'NULL'	CHARACTER
	'ZERO'	
DIRECT *	'YES' 'NO' 'UNKNOWN'	CHARACTER
ERR	Statement number	INTEGER
EXIST	.TRUE.	LOGICAL
	.FALSE.	
FORM	'FORMATTED' 'UNFORMATTED'	CHARACTER
FORMATTED *	'YES' 'NO' 'UNKNOWN'	CHARACTER
IOSTAT	Error number	INTEGER
NAME	Name of the file	CHARACTER
NAMED	.TRUE.	LOGICAL
	.FALSE.	
NEXTREC	Next record number	INTEGER
NUMBER *	Unit number	INTEGER
OPENED	.TRUE.	LOGICAL
	.FALSE.	

TABLE 4–1 INQUIRE Specifiers Summary *(continued)*

Form: SPECIFIER = Variable

SPECIFIER	Value of Variable	Data Type of Variable
RECL	Record length	INTEGER
SEQUENTIAL *	'YES' 'NO' 'UNKNOWN'	CHARACTER
UNFORMATTED *	'YES' 'NO' 'UNKNOWN'	CHARACTER

* indicates non-standard for inquire-by-unit, but accepted by f77. indicates non-standard for inquire-by-file, but accepted by 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.

INQUIRE Specifier Keywords

The following provides a detailed list of the INQUIRE specifier keywords:

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.

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.

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.

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. If the file is a link, `INQUIRE` always returns `.TRUE.`, even if the linked file does not exist.

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.

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.

IOSTAT=*ios*

- *ios* is as in the OPEN statement.

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.

NAMED=*nmd*

- *nmd* is a logical variable that is assigned .TRUE. if the file has a name, .FALSE. otherwise.

NEXTREC=*nr*

- *nr* is an integer variable that is assigned one plus the number of the last record read from a file connected for direct access. If the file is not connect, -1 is returned in *nr*.

NUMBER=*num*

- *num* is an integer variable that is set to the number of the unit connected to the file, if any. If no file is connected, *num* is set to -1.

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.

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. See "Details of Features That Require -xl[d]" on page 341 for an explanation of -xl[d]. If no file is connected, *rcl* is set to -1.

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.

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.

UNIT=*u*

- *u* is an integer expression or * with the value of the unit. Exactly one of FILE or UNIT must be used.

Examples

Example 1: Inquire by *unit*:

```
LOGICAL OK
INQUIRE( UNIT=3, OPENED=OK )
IF ( OK ) CALL GETSTD ( 3, STDS )
```

Example 2: Inquire by *file:*

```
LOGICAL THERE
INQUIRE( FILE=".profile", EXIST=THERE )
IF ( THERE ) CALL GETPROFILE( FC, PROFILE )
```

Example 3: More than one answer, omitting the UNIT=:

```
CHARACTER FN*32
LOGICAL HASNAME, OK
INQUIRE ( 3, OPENED=OK, NAMED=HASNAME, NAME=FN )
IF ( OK .AND. HASNAME ) PRINT *, "Filename="", FN, """
```

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.

INTEGER [*len[,]] *v*[* *len*[/*c*/]] [, *v*[*len[/*c*/]] ...

Parameter	Description
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.
c	List of constants for the immediately preceding name

Description

The declarations can be: INTEGER, INTEGER*2, INTEGER*4, INTEGER*8.

INTEGER

For a declaration such as INTEGER H, the variable H is usually one INTEGER*4 element in memory, interpreted as a single integer number. Specifying the size is nonstandard. @

If you do *not* specify the size, a default size is used. The default size, for a declaration such as INTEGER H, can be altered by compiling with any of the options -dbl, -i2, -r8, or -xtypemap. See the discussion in Chapter 2 for details.

INTEGER*2 @

For a declaration such as INTEGER*2 H, the variable H is always an INTEGER*2 element in memory, interpreted as a single integer number.

INTEGER*4 @

For a declaration such as `INTEGER*4 H`, the variable `H` is always an `INTEGER*4` element in memory, interpreted as a single integer number.

INTEGER*8 @

For a declaration such as `INTEGER*8 H`, the variable `H` is always an `INTEGER*8` element in memory, interpreted as a single integer number.

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.

Examples

Example 1: Each of these integer declarations are equivalent:

```
INTEGER U, V(9)
INTEGER*4 U, V(9)
INTEGER U*4, V(9)*4
```

Example 2: Initialize:

```
INTEGER U / 1 /, V / 4 /, W*2 / 1 /, X*2 / 4 /
```

INTRINSIC

The `INTRINSIC` statement lists intrinsic functions that can be passed as actual arguments.

`INTRINSIC` *fun* [, *fun*] ...

Parameter	Description
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 4–2 Intrinsics That Cannot Be Passed As Actual Arguments

LOC	INT	SNGL	AIMAX0	AMIN1
AND	IINT	SNGLQ	AJMAX0	DMIN1
IAND	JINT	REAL	IMAX0	IMIN1
IIAND	IQINT	DREAL	JMAX0	JMIN1
JIAND	IIQINT	DBLE	MAX1	QMIN1
OR	JIQINT	DBLEQ	AMAX1	IMAG
IOR	IFIX	QEXT	DMAX1	LOG
IIOR	IIFIX	QEXTD	IMAX1	LOG10
IEOR	JIFIX	QFLOAT	JMAX1	QREAL
IIEOR	IDINT	CMPLX	QMAX1	QCMPLX
JIOR	IIDINT	DCMPLX	MIN	SIZEOF
JIEOR	JIDINT	ICHAR	MIN0	EPBASE
NOT	FLOAT	IACHAR	AMIN0	EPEMAX
INOT	FLOATI	ACHAR	AIMIN0	EPEMIN
JNOT	FLOATJ	CHAR	AJMIN0	EPHUGE
XOR	DFLOAT	MAX	IMIN0	EPMRSP
LSHIFT	DFLOTI	MAX0	JMIN0	EPPREC
RSHIFT	DFLOTJ	AMAX0	MIN1	EPTINY
LRSHIFT	IZTEXT	JZTEXT	ZEXT	

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.

```
LOGICAL [*len[,]] v[*len[/c/]] [, v[*len[/c/]] ...
```

Parameter	Description
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

The declarations can be: `LOGICAL`, `LOGICAL*1`, `LOGICAL*2`, `LOGICAL*4`, `LOGICAL*8`.

LOGICAL

For a declaration such as `LOGICAL H`, the variable `H` is usually one `INTEGER*4` element in memory, interpreted as a single logical value. Specifying the size is nonstandard. @

If you do *not* specify the size, a default size is used. The default size, for a declaration such as `LOGICAL Z`, can be altered by compiling with any of the options `-dbl`, `-i2`,`-r8`, or `-xtypemap`. See the discussion in Chapter 2 for details.

LOGICAL*1 @

For a declaration such as `LOGICAL*1 H`, the variable `H` is always an `BYTE` element in memory, interpreted as a single logical value.

LOGICAL*2 @

For a declaration such as `LOGICAL*2 H`, the variable `H` is always an `INTEGER*2` element in memory, interpreted as a single logical value.

LOGICAL*4 @

For a declaration such as LOGICAL*4 H, the variable H is always an INTEGER*4 element in memory, interpreted as a single logical value.

LOGICAL*8 @

For a declaration such as LOGICAL*8 H, the variable H is always an INTEGER*8 element in memory, interpreted as a single logical value.

Examples

Example 1: Each of these declarations are equivalent:

```
LOGICAL U, V(9)
LOGICAL*4 U, V(9)
LOGICAL U*4, V(9)*4
```

Example 2: Initialize:

```
LOGICAL U /.false./, V /0/, W*4 /.true./, X*4 /"z"/
```

MAP

The MAP @ declaration defines alternate groups of fields in a *union*.

```
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 “UNION and MAP” on page 217 for more information.

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
```

NAMELIST

The NAMELIST @ statement defines a list of variables or array names, and associates it with a unique group name.

NAMELIST / *grname* / *namelist* [[,] / *grname* / *namelist*] ...

Parameter	Description
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

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.

OPEN

The OPEN statement can connect an existing external file to a unit, create a file and connect it to a unit, or change some specifiers of the connection.

OPEN ([UNIT=] *u*, *slist*)

Parameter	Description
UNIT	Unit number
slist	The specifiers list *slist* can include one or more of the following ■ FILE = *fin* or alternativly NAME = *fin* ■ ACCESS = *acc* ■ BLANK = *blnk* ■ ERR = *s* ■ FORM = *fm* ■ IOSTAT = *ios* ■ RECL = *rl* or alternativly RECORDSIZE = *rl* ■ STATUS = *sta* or alternativly TYPE = *sta* ■ FILEOPT = *fopt* @ ■ READONLY @ ■ ACTION = *act* @

Description

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.

Note - For tape I/O, use the TOPEN( ) routines.

The following table summarizes the OPEN specifiers:

TABLE 4–3 OPEN Specifiers Summary

Form: SPECIFIER = Variable

SPECIFIER	Value of Variable	Data Type of Variable
ACCESS	'APPEND' 'DIRECT' 'SEQUENTIAL'	CHARACTER
ACTION	'READ" "WRITE" "READWRITE"	CHARACTER
BLANK	'NULL'	CHARACTER
	'ZERO'	
ERR	Statement number	INTEGER
FORM	'FORMATTED' 'UNFORMATTED' 'PRINT'	CHARACTER
FILE *	Filename or '*'	CHARACTER
FILEOPT	'NOPAT" "BUFFER=n" 'EOF'	CHARACTER
IOSTAT	Error number	INTEGER
READONLY	-	-
RECL	Record length	INTEGER
STATUS	'OLD' 'NEW' 'UNKNOWN' 'SCRATCH'	CHARACTER

The keywords can be specified in any order.

OPEN Specifier Keywords

The following provides a detailed list of the OPEN specifier keywords:

[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 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*.

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 and can be applied only to disk files. @
- 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 , 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 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.

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 235 for more information.
- 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.
- 'SCRATCH' — For a file opened with STATUS='SCRATCH', a temporary file with a name of the form tmp.*FAAAxnnnnn* 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 extends the standard by allowing opening named files as scratch. @ Such files are normally deleted when closed or at normal termination.

- TMPDIR: FORTRAN 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 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)
```

See "Direct Access I/O" on page 235 for more information about variable-length records.

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.

OPTIONS

The OPTIONS @ statement overrides compiler command-line options.

OPTIONS */qualifier* [*/qualifier*]

Description

The following table shows the OPTIONS statement qualifiers:

TABLE 4–4 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)
/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.

PARAMETER

The PARAMETER statement assigns a symbolic name to a constant.

PARAMETER (*p*=*e* [, *p*=*e*])

Parameter	Description
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 operators. See "Constant Expressions" on page 73 for more information.

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` compilation flag is specified:

```
       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 specified.

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.
```

PAUSE

The PAUSE statement suspends execution, and waits for you to type: go.

PAUSE [*str*]

Parameter	Description
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 -silent
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
```

POINTER

The POINTER @ statement establishes pairs of variables and pointers.

POINTER (*p1, v1*) [, (*p2, v2*)]

Parameter	Description
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.

The use of pointers is described in “Pointers ” on page 52.

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:

```
demo% cat 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.

PRINT

The `PRINT` statement writes from a list to `stdout`.

`PRINT` *f* `[,` *iolist*`]`

`PRINT` *grname*

Parameter	Description
f	Format identifier
iolist	List of variables, substrings, arrays, and 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 “List-Directed I/O ” on page 271 on for more information.
- 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.

Implied DO lists are described on “Implied DO Lists” on page 103.

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 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 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 because 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
```

PROGRAM

The PROGRAM statement identifies the program unit as a main program.

PROGRAM *pgm*

Parameter	Description
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
…
```

READ

The READ statement reads data from a file or the keyboard to items in the list.

Note - Use the TOPEN() routines to read from tape devices. See the *Fortran Library Reference Manual.*

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*

Parameter	Description
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

An alternate to the UNIT=*u*, REC=*rn* form is as follows: @

READ(*u 'rn* ...) *iolist*

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 "List-Directed I/O " on page 271 for more information.
- 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. @

See “Runtime Formats ” on page 267 for details on formats evaluated at runtime.

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.

Implied DO lists are described on “Implied DO Lists” on page 103.

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 equivalent to opening the file with the options in the following example:

```
      OPEN(u,
FILE='FORT.u', STATUS='OLD', ACCESS='SEQUENTIAL',
&             FORM=fmt
)
```

Note also:

- 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)
```

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.

REAL [*len[,]] *v*[*len[/c/]] [, *v*[*len[/c/]] ...

Parameter	Description
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. Specifying the size is nonstandard. @

The default size, for a declaration such as REAL H, can be altered by compiling with any of the options -dbl, -r8, or -xtypemap. See the discussion in Chapter 2 for details.

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.

Examples

Example 1: Simple real variables—these declarations are all equivalent:

```
REAL U, V(9)
REAL*4 U, V(9)
REAL U*4, V(9)*4
```

Example 2: Initialize variables (REAL*16 *is 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 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.

RECORD

The RECORD @ statement defines variables to have a specified structure, or arrays to be arrays of variables with such structures.

RECORD */struct-name/ record-list* [,*/struct-name/ record-list*]...

Parameter	Description
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.

Structures, fields, and records are discussed in "Structures" on page 45.

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 “STRUCTURE” on page 208 for more information.

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
```

RETURN

A RETURN statement returns control to the calling program unit.

RETURN [*e*]

Parameter	Description
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
```

REWIND

The REWIND statement positions the file associated with the specified unit to its initial point.

Note - Use the TOPEN() routines to rewind tape devices. See the *Fortran Library Reference Manual* for details.

REWIND *u*

REWIND ([UNIT=] *u* [, IOSTAT=*ios*] [, ERR= *s*])

Parameter	Description
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.

Using a REWIND statement on a direct-access file 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
```

SAVE

The SAVE statement preserves items in a subprogram after the RETURN or END statements are executed, preventing them from becoming undefined.

SAVE [*v* [, *v*]]

Parameter	Description
v	Name of an array, variable, or common block (enclosed in slashes), occurring in a subprogram

Description

SAVE variables are placed in an internal static area. All common blocks are already preserved because they have been allocated to a static area. Therefore, common block names specified in SAVE statements are allowed but ignored.

A SAVE statement is optional in the main program and has no effect.

A SAVE with no list preserves all local variables and arrays in the routine.

Local variables and arrays are already static by default, predisposing the need for SAVE. However, using SAVE can ensure portability, especially with routines that 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 FFA(N)
DIMENSION A(1000,1000), V(1000)
SAVE A
…
RETURN
END
```

Statement Function

A *statement function* statement is a function-like declaration, made in a single statement.

fun ([*d*[, *d*]]) = *e*

Parameter	Description
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.
- If a dummy argument is defined as a structure, the corresponding actual argument must be similarly defined as the same structure.
- A dummy argument cannot be an array or function name, or have the same name as the function.
- The same argument cannot be specified more than once in the argument list.
- The statement function may 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, S*1
FIRST(S) = S(1:1)
READ( *, * ) STR
IF ( FIRST(STR) .LT. " " ) CALL CONTROL ( S, A )
…
```

STATIC

The STATIC @ statement ensures that the specified items are stored in static memory.

STATIC *list*

Parameter	Description
list	List of variables and arrays

Description

All local variables and arrays are classified static by default: 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.

However, you can still use STATIC to ensure portability, especially with routines that 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 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)
```

STOP

The STOP statement terminates execution of the program.

STOP [*str*]

Parameter	Description
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 "error"
```

The above statement displays:

```
STOP: error
```

STRUCTURE

The STRUCTURE @ statement organizes data into structures.

STRUCTURE [/*structure-name*/] [*field-list*]

field-declaration

field-declaration

. . .

END STRUCTURE

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.

Structures, fields, and records are described in "Structures" on page 45.

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 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 pseudo-name %FILL for a field name. The %FILL is provided for compatibility with other versions of FORTRAN. 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
```

SUBROUTINE

The SUBROUTINE statement identifies a named program unit as a subroutine, and specifies arguments for it.

SUBROUTINE *sub* [([*d*[, *d*]])]

Parameter	Description
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:

```
      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
```

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.

TYPE

The TYPE @ statement writes to stdout.

TYPE *f* [, *iolist*]

TYPE *grname*

Parameter	Description
f	Format identifier
iolist	List of variables, substrings, arrays, and records
grname	Name of the namelist group

Description

The TYPE statement is provided for compatibility and is equivalent to:

- PRINT *f* [, *iolist*]
- PRINT *grname*
- WRITE(*, *f*) [*iolist*]
- WRITE(*,*grname*)

Example

Example: Formatted and namelist output:

```
       INTEGER V(5)
       REAL X(9), Y
       NAMELIST /GNAM/ X, Y
       …
       TYPE 1, V
1     FORMAT( 5 I3 )
       …
       TYPE GNAM
       …
```

The Type Statement

The type statement specifies the data type of items in the list, optionally specifies array dimensions, and initializes with values.

type v [*/ clist /*] [*, v* [*/ clist /*]]...

Parameter	Description

type	*One of the following:*
	`BYTE` @
	`CHARACTER`
	`CHARACTER*`*n* (where *n* is greater than 0)
	`CHARACTER*(*)`
	`COMPLEX`
	`COMPLEX*8` @
	`COMPLEX*16` @
	`COMPLEX*32` @(*SPARC only)*
	`DOUBLE COMPLEX` @
	`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)*
	`DOUBLE PRECISION`

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.

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 /*

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 )    Warning issued, not initialized
```

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.

Note - Compiling with any of the options -dbl, -r8, -i2, or -xtypemap can alter the default size of names typed without an explicit size. See the discussion in Chapter 2.

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"

UNION and MAP

The UNION @ statement defines groups of fields that share memory at runtime.

The syntax of a UNION declaration is as follows:

```
UNION
       MAP
```

```
            field-declaration
            field-declaration
            . . .
      MAP
            field-declaration
            field-declaration
            . . .
      END
MAP
END UNION
```

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.

VIRTUAL

The VIRTUAL @ statement is treated the same as the DIMENSION statement.

VIRTUAL *a*(*d*) [, *a*(*d*)] ...

Parameter	Description
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.

Example

```
VIRTUAL M(4,4), V(1000)
…
END
```

VOLATILE

The VOLATILE @ statement prevents optimization on the specified items.

VOLATILE *nlist*

Parameter	Description
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.

WRITE

The WRITE statement writes data from the list to a file.

Note - For tape I/O, use the `TOPEN()` routines.

`WRITE([UNIT=]` *u* `[, [FMT=]` *f*`] [, IOSTAT=`*ios*`] [, REC=`*rn*`] [, ERR=`*s*`])` *iolist*

`WRITE([ UNIT=]` *u*`, [NML=]` *grname* `[, IOSTAT=`*ios*`] [, ERR=`*s*`])`

Parameter	Description
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

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 271 for more information.
- 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. @

See "Runtime Formats " on page 267 for details on formats evaluated at runtime.

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.

Implied DO lists are described in “Implied DO Lists” on page 103.

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 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 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 because 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 )
```

CHAPTER 5

Input and Output

This chapter describes the general concepts of FORTRAN input and output, and provides details on the different kinds of I/O. See also the Input/Output chapter in the *Fortran Programming Guide*.

Essential FORTRAN I/O Concepts

Any operating system based on the UNIX operating system is not as record-oriented as FORTRAN. This operating system treats files as sequences of characters instead of collections of records. The FORTRAN runtime system keeps track of file formats and access mode during runtimes. It also provides the file facilities, including the FORTRAN libraries and the standard I/O library.

Logical Units

The FORTRAN 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 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 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 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 Sequential formatted Sequential list-directed Sequential NAMELIST Direct unformatted Direct formatted	Direct-access, list-directed I/O Direct-access, NAMELIST I/O NAMELIST I/O on internal files Unformatted, internal I/O

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.

TABLE 5–1 Summary of f77 Input and Output *(continued)*

Kind of I/O		**Access Mode:**	
Form	**File Type**	**Sequential**	**Direct**
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 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 to switch between `FORM='PRINT'` and `FORM='FORMATTED'` 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 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 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 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) and the Sun *Fortran Library Reference*.

Example: Attach external files `ini1.inp` and `ini1.out` to units 1 and 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 files, `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% cat $TST01
 12 3.14159012 6
demo% f77 ini1.f
ini1.f:
 MAIN:
demo% a.out
 I =   12 B =     3.14159 N =   6
demo% cat $TST02
   12    3.14159  6
```

`IOINIT` should prove adequate for most programs as written. However, it is written in FORTRAN so that it can serve as an example for similar user-supplied routines. A copy can be retrieved as follows:

```
demo% cp /opt/SUNWspro/SC5.0/src/ioinit.f  .
```

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.
- 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.

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 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%
```

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

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	

TABLE 5–2 Format Specifiers *(continued)*

Purpose	FORTRAN 77	f77 Extensions
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* >

Specifiers can be uppercase as well as lowercase characters in format statements and in all the alphabetic arguments to the I/O library routines.

w, *m*, *d*, *e* Parameters (As In G*w*.*d*E*e*)

The definitions for the parameters, *w*, *m*, *d*, and *e* are:

- *w* and *e* are non-zero, unsigned integer constants.
- *d* and *m* are unsigned integer constants.
- *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 left 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
␣␣␣␣␣a1
demo%
```

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

TABLE 5–3 Default *w*, *d*, *e* Values in Format Field Descriptors *(continued)*

Field Descriptor	List Element	*w*	*d*	*e*
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 *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)

Use edit descriptor $, and space, 0, or 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:

```
 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:

```
 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	Node¤Id	Node¤Id	Node¤Id	Node¤Id
Format	A7	A7	A7	A7
Memory	Node¤Id¤¤	Node¤Id	e¤Id	d

¤ 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:

```
¤¤The
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 does not have these old Hollerith (*n* H) notations, although the FORTRAN 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 )
```

Reading 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
¤T
¤¤¤F
```

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
```

The first digit in the example appears in input 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	1234¤	1234
O4	16234	1623
O3	97¤¤¤	Error: "9" not allowed
Z5	A23DE¤	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):

```
¤A1
```

The letter A appears in output 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 O2 O4.3 O4.4 O6	32767 14251 27 27 -32767	D77777 ** D033 0033 *****
Z4 Z3.3 Z6.4 Z5	32767 2708 2708 -32767	7FFF A94 DD0A94 ******

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:

```
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
 DD0000006E
demo%
```

SU is described in “Sign Editing (SU, SP, SS, S) ” on page 265.

Editing REAL Data (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 d*+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
********
¤¤¤0.1235D+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 | .le. 99, it has the form `E`*nn* or `0`*nn*.
- If 99 .le. | exponent | .le. 999, it has the form *nnn*.

For the form `E`*w.d*`E`*e*, if | exponent | .le. (10^e)- 1, then the exponent has the form *nnn*.

For the form `D`*w.d*:

- If | exponent | .le. 99, it has the form `D`*nn* or `E`*nn* or `0`*nn*.

- If 99 £ | exponent | .le. 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* .le. *d*+6; if *e* is present, then *w* .le. *d*+*e*+4. For negative numbers, *w* .le. *d*+7; if *e* is present, then *w* .le. *d*+*e*+5.

Example: Real input with E editing in the program, Einp.f:

```
 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:

```
¤¤¤0.123457E+06¤¤¤0.123467E+01¤¤0.1245670E+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
********
¤¤¤0.1235E+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:

```
¤¤¤¤0.789E-03
¤¤0.789E-0003
¤0.789E-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*`.le.`*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 <= *N* < 1.0	F(*w*-4).*d*, *n*(¤)
1.0 <= *N* < 10.0	F(*w*-4).(*d*-1), *n*(¤)
…	…
$10^{(d-2)}$ <= *N* <= $10^{(d-1)}$	F(*w*-4).1, *n*(¤)
$10^{(d-1)}$ <= *N* < 10^{d}	F(*w*-4).0, *n*(¤)

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 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*[Ee], 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

Parameter	Description
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 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.

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 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 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 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 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—create 3 records with 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 the 3 records:

```
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%
```

Here we knew beforehand the size of the records on the file. In this case we can read the file just as it was written.

However, if we only know the size of each item but not the size of the records on a file we can use recl=1 on the OPEN statement to have the I/O list itself determine how many items to read:

Example: Direct-access read, variable-length records, recl=1:

```
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.

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 ” on page 274), 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" on page 230 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	'¤¤(', 1PE14.5E2, ',', 1PE14.5E2, ')'
COMPLEX*16	'¤¤(', 1PE22.13.E2, ',', 1PE22.13.E2, ')'
COMPLEX*32	'¤¤(', 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	1PE44.34E4

COMPLEX*32 and REAL*16 are *SPARC only.*

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.

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*`]...`

Parameter	Description
group-name	Name of group
namelist	List of variables or arrays, separated by commas

See "NAMELIST" on page 169 for details.

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, array elements, dummy assumed-size arrays, 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
D&case sample= Demo , new= T, delta= 0.100000
D&end
demo%
```

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:

```
¤$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:

```
¤$case delta=0.05, mat( 2, 2 ) = 2.2, sample="Demo" $
```

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:

```
¤$case
¤delta=0.05
¤mat( 2, 2 ) = 2.2
¤sample="Demo"
¤$
```

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 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' (Read as:
use $ in 2)
¤sample='don''t'       (Read as:
don't)
¤sample="don''t"       (Read as:
don''t)
¤sample="don't"        (Read 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 $
```

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 ( *, G
```

The input for nam3.f is:

```
¤$GRID PSI = 5*980 $
```

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 $
```

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?
¤?                                          <– Keyboard Input
¤$case
¤sample
¤new
¤delta
¤$end

¤$case sample="Test 2", delta=0.03
$       <– Keyboard Input
demo%
```

CHAPTER 6

Intrinsic Functions

This chapter tabulates and explains the set of intrinsic functions that are part of Sun FORTRAN 77. (For information about Fortran library routines, see the *Fortran Library Reference*.)

Intrinsic functions that are Sun extensions of the ANSI FORTRAN 77 standard are marked with @.

Intrinsic functions have *generic* and *specific* names when they accept arguments of more than one data type. In general, the *generic* name returns a value with the same data type as its argument. However, there are exceptions such as the type conversion functions (Table 6–2) and the inquiry functions (Table 6–7). The function may also be called by one of its *specific* names to handle a specific argument data type.

With functions that work on more than one data item (e.g. `sign(a1,a2)`), all the data arguments must be the same type.

In the following tables, the FORTRAN 77 intrinsic functions are listed by:

- Intrinsic Function –description of what the function does
- Definition – a mathematical definition
- No. of Args. – number of arguments the function accepts
- Generic Name – the function's generic name
- Specific Names – the function's specific names
- Argument Type – data type associated with each specific name
- Function Type – data type returned for specific argument data type

Note - Compiler options `-dbl`, `-i2`, `-r8`, and `-xtypemap` change the default sizes of variables and have an effect on intrinsic references. See “Remarks” on page 296, and the discussion of default sizes and alignment in “Size and Alignment of Data Types ” on page 20.

Arithmetic and Mathematical Functions

This section details arithmetic, type conversion, trigonometric, and other functions. “a” stands for a function’s single argument, “a1” and “a2” for the first and second arguments of a two argument function, and “ar” and “ai” for the real and imaginary parts of a function’s complex argument.

Note that `REAL*16` and `COMPLEX*32` are `SPARC` only.

Arithmetic

TABLE 6–1 Arithmetic Functions

Intrinsic Function	Definition	No. of Args.	Generic Name	Specific Names	Argument Type	Function Type
Absolute value *See Note (6).*	|a| = (ar**2+ai**2)**.5	1	ABS	IABS ABS DABS CABS QABS @ ZABS @ CDABS @ CQABS @	INTEGER REAL DOUBLE COMPLEX REAL*16 DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32	INTEGER REAL DOUBLE REAL REAL*16 DOUBLE DOUBLE REAL*16
Truncation *See Note (1).*	int(a)	1	AINT	AINT DINT QINT @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16

TABLE 6–1 Arithmetic Functions *(continued)*

Intrinsic Function	Definition	No. of Args	Generic Name	Specific Names	Argument Type	Function Type
Nearest whole number	int(a+.5) if a 0 int(a-.5) if a < 0	1	ANINT	ANINT DNINT QNINT @	REAL DOUBLE REAL*16	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
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
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 @	INTEGER REAL DOUBLE REAL*16	INTEGER REAL DOUBLE REAL*16
			AMAX0	AMAX0	INTEGER	REAL
			MAX1	MAX1	REAL	INTEGER
Choosing smallest value	min(a1, a2, …)	2	MIN	MIN0 AMIN1 DMIN1 QMIN1 @	INTEGER REAL DOUBLE REAL*16	INTEGER REAL DOUBLE REAL*16

TABLE 6–1 Arithmetic Functions *(continued)*

Intrinsic Function	Definition	No. Of Args	Generic Name	Specific Names	Argument Type	Function Type
			AMIN0	AMIN0	INTEGER	REAL
			MIN1	MIN1	REAL	INTEGER

Type Conversion

TABLE 6–2 Type Conversion Functions

Conversion to	No. of Args	Generic Name	Specific Names	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	REAL REAL REAL REAL REAL REAL REAL REAL

TABLE 6–2 Type Conversion Functions *(continued)*

Conversion to	No. of Args	Generic Name	Specific Names	Argument Type	Function Type
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 REAL INTEGER DOUBLE REAL*16 COMPLEX COMPLEX*16 COMPLEX*32	REAL*16 REAL*16 REAL*16 REAL*16 REAL*16 REAL*16 REAL*16 REAL*16 REAL*16
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

TABLE 6–2 Type Conversion Functions *(continued)*

Conversion to	No. of Args	Generic Name	Specific Names	Argument Type	Function Type
DOUBLE COMPLEX *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 6–3 Trigonometric Functions

Intrinsic Function	Definition	Generic Name	Specific Names	Argument Type	Function Type
Sine *See Note (7).*	sin(a)	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)	SIND @	SIND @ DSIND @ QSIND @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Cosine *See Note (7).*	cos(a)	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)	COSD @	COSD @ DCOSD @ QCOSD @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Tangent *See Note (7).*	tan(a)	TAN	TAN DTAN QTAN @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Tangent (degrees) *See Note (7).*	tan(a)	TAND @	TAND @ DTAND @ QTAND @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arcsine *See Note (7).*	arcsin(a)	ASIN	ASIN DASIN QASIN @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16

TABLE 6–3 Trigonometric Functions *(continued)*

Intrinsic Function	Definition	Generic Name	Specific Names	Argument Type	Function Type
Arcsine (degrees) *See Note (7).*	arcsin(a)	ASIND @	ASIND @ DASIND @ QASIND @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arccosine *See Note (7).*	arccos(a)	ACOS	ACOS DACOS QACOS @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arccosine (degrees) *See Note (7).*	arccos(a)	ACOSD @	ACOSD @ DACOSD @ QACOSD @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arctangent *See Note (7).*	arctan(a)	ATAN	ATAN DATAN QATAN @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
	arctan (a1/a2)	ATAN2	ATAN2 DATAN2 QATAN2 @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Arctangent (degrees) *See Note (7).*	arctan(a)	ATAND @	ATAND @ DATAND @ QATAND @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
	arctan (a1/a2)	ATAN2D@	ATAN2D @ DATAN2D @ QATAN2D @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Hyperbolic Sine *See Note (7).*	sinh(a)	SINH	SINH DSINH QSINH @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Hyperbolic Cosine *See Note (7).*	cosh(a)	COSH	COSH DCOSH QCOSH @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Hyperbolic Tangent *See Note (7).*	tanh(a)	TANH	TANH DTANH QTANH @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16

Other Mathematical Functions

TABLE 6–4 Other Mathematical Functions

Intrinsic Function	Definition	No. Generic Specific Names	Argument Type	Function Type
Imaginary part of a complex number *See Note (6).*	ai	AIMAG DIMAG @ QIMAG @	COMPLEX DOUBLE COMPLEX COMPLEX*32	REAL DOUBLE REAL*16
Conjugate of a complex number *See Note (6).*	(ar, -ai)	CONJG DCONJG @ QCONJG @	COMPLEX DOUBLE COMPLEX COMPLEX*32	COMPLEX DOUBLE COMPLEX COMPLEX*32
Square root	a**(1/2)	SQRT DSQRT QSQRT @ CSQRT ZSQRT @ CDSQRT @ CQSQRT @	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32
Cube root *See Note(8').*	a**(1/3)	CBRT @ DCBRT @ QCBRT @ CCBRT @ ZCBRT @ CDCBRT @ CQCBRT @	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32
Exponential	e**a	EXP DEXP QEXP @ CEXP ZEXP @ CDEXP @ CQEXP @	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32

TABLE 6–4 Other Mathematical Functions *(continued)*

Intrinsic Function	Definition	No. of Arguments	Generic & Specific Names	Argument Type	Function Type
Natural logarithm	log(a)	1	ALOG DLOG QLOG @ CLOG ZLOG @ CDLOG @ CQLOG @	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32	REAL DOUBLE REAL*16 COMPLEX DOUBLE COMPLEX DOUBLE COMPLEX COMPLEX*32
Common logarithm	log10(a)	1	ALOG10 DLOG10 QLOG10 @	REAL DOUBLE REAL*16	REAL DOUBLE REAL*16
Error function *(See note below)*	erf(a)	1	ERF @ DERF @	REAL DOUBLE	REAL DOUBLE
Error function	1.0 - erf(a)	1	ERFC @ DERFC @	REAL DOUBLE	REAL DOUBLE

- The error function: 2/sqrt(pi)* integral from 0 to a of exp(-t*t) dt

Character Functions

TABLE 6–5 Character Functions

Intrinsic Function	Definition	No. of Args.	Specific Names	Argument Type	Function Type
Conversion *See Note (5).*	Conversion to character Conversion to integer *See also:* Table 6–2.	1 1 @	CHAR ACHAR @ ICHAR IACHAR @	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.

Miscellaneous Functions

Other miscellaneous functions include bitwise functions, environmental inquiry functions, and memory allocation and deallocation functions.

Bit Manipulation @

None of these functions are part of the FORTRAN 77 Standard.

TABLE 6–6 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
Circular shift	3	ISHFTC	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

The above functions are available as intrinsic or extrinsic functions. See also the discussion of the library bit manipulation routines in the *Fortran Library Reference* manual.

Environmental Inquiry Functions @

None of these functions are part of the FORTRAN 77 Standard.

TABLE 6–7 Environmental Inquiry Functions

Definition	No. of Args.	Generic Name	Argument Type	Function Type
Base of Number System	1	EPBASE	INTEGER	INTEGER
			REAL	INTEGER
			DOUBLE	INTEGER
			REAL*16	INTEGER
Number of Significant Bits	1	EPPREC	INTEGER	INTEGER
			REAL	INTEGER
			DOUBLE	INTEGER
			REAL*16	INTEGER
Minimum Exponent	1	EPEMIN	REAL	INTEGER
			DOUBLE	INTEGER
			REAL*16	INTEGER
Maximum Exponent	1	EPEMAX	REAL	INTEGER
			DOUBLE	INTEGER
			REAL*16	INTEGER
Least Nonzero Number	1	EPTINY	REAL	REAL
			DOUBLE	DOUBLE
			REAL*16	REAL*16
Largest Number Representable	1	EPHUGE	INTEGER	INTEGER
			REAL	REAL
			DOUBLE	DOUBLE
			REAL*16	REAL*16
Epsilon *See Note (16).*	1	EPMRSP	REAL	REAL
			DOUBLE	DOUBLE
			REAL*16	REAL*16

Memory @

None of these functions are part of the FORTRAN 77 Standard.

TABLE 6–8 Memory Functions

Intrinsic Function	Definition	Specific Name	No. of Args	Argument Type	Function Type
Location	Address of *See Note (17).*	LOC	1	*Any*	INTEGER*4 INTEGER*8
Allocate	Allocate memory and return address. *See Note (17).*	MALLOC MALLOC64	1	INTEGER*4 INTEGER*8	INTEGER INTEGER*8
Deallocate	Deallocate memory allocated by MALLOC. *See Note (17).*	FREE	1	*Any*	-
Size	Return the size of the argument in bytes. *See Note (18).*	SIZEOF	1	*Any expression*	INTEGER

Although `malloc` and `free` are not, strictly speaking, intrinsics, they are listed here and in the *Fortran Library Reference*.

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 `INTEGER` arguments accepts `INTEGER*2`, `INTEGER*4`, or `INTEGER*8`.

- INTEGER intrinsics that take INTEGER arguments return values of INTEGER type determined as follows – note that options -i2, -dbl, and -xtypemap may alter the default sizes of actual arguments:

  - mod sign dim max min and iand or ior xor ieor — size of the value returned is the largest of the sizes of the arguments.
  - abs ishft lshift rshift lrshft ibset btest ivclr ishftc ibits — size of the value returned is the size of the first argument.
  - int epbase epprec — size of the value returned is the size of default INTEGER.
  - ephuge — size of the value returned is the size of the default INTEGER, or the size of the argument, whichever is largest.

- Options that change the default data sizes (see “Size and Alignment of Data Types ” on page 20)also change the way some intrinsics are used. For example, with -dbl in effect, a call to ZCOS with a DOUBLE COMPLEX argument will automatically become a call to CQCOS because the argument has been promoted to COMPLEX*32. The following functions have this capability:

  aimag alog amod cabs ccbrt ccos cdabs cdcbrt cdcos cdexp cdlog cdsin cdsqrt cexp clog csin

  The following functions permit arguments of an integer or logical type of any size:

  and iand ieor iiand iieor iior inot ior jiand jieor jior jnot lrshft lshift not or rshift x

- *(SPARC only)* An intrinsic that is shown to return a *default* REAL, DOUBLE PRECISION, COMPLEX, or DOUBLE COMPLEX value will return the prevailing type depending on certain compilation options. (See “Size and Alignment of Data Types ” on page 20.) For example, if compiled with -xtypemap=real:64,double:64:

  - A call to a REAL function returns REAL*8
  - A call to a DOUBLE PRECISION function returns REAL*8
  - A call to a COMPLEX function returns COMPLEX*16
  - A call to a DOUBLE COMPLEX function returns COMPLEX*16

  Other options that alter the data sizes of default data types are -r8 and -dbl, which also promote DOUBLE to QUAD. The -xtypemap= option provides more flexibility than these older compiler options and is preferred.

- 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, the absolute value of a complex argument, and others. 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.

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 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.

INDEX returns default INTEGER*4 data. If compiling for a 64-bit environment, the compiler will issue a warning if the result overflows the INTEGER*4 data range. To use INDEX in a 64-bit environment with character strings larger than the INTEGER*4 limit (2 Gbytes), the INDEX function and the variables receiving the result must be declared INTEGER*8.

(11) LEN

LEN returns the declared length of the CHARACTER argument variable. The actual value of the argument is of no importance.

LEN returns default INTEGER*4 data. If compiling for a 64-bit environment, the compiler will issue a warning if the result overflows the INTEGER*4 data range. To use LEN in a 64-bit environment with character variables larger than the INTEGER*4 limit (2 Gbytes), the LEN function and the variables receiving the result must be declared INTEGER*8.

(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 Appendix D 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 analogs of the C << and >> operators. As in C, the semantics depend on the hardware.

The behavior of the shift functions with an out of range shift count is hardware dependent and generally unpredictable. In this release, shift counts larger than 31 result in hardware dependent behavior.

(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, MALLOC, and FREE

The LOC function returns the 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 address of that block.

LOC returns default INTEGER*4 in 32-bit environments, INTEGER*8 in 64-bit environments.

MALLOC is a library function and not an intrinsic. It too returns default INTEGER*4 in 32-bit environments, INTEGER*8 in 64-bit environments. However, MALLOC must be explicitly declared INTEGER*8 when compiling for 64-bit environments.

The value returned by LOC or MALLOC should be stored in variables typed POINTER, INTEGER*4, or INTEGER*8 in 64-bit environments. The argument to FREE must be the value returned by a previous call to MALLOC and hence should have data type POINTER, INTEGER*4, or INTEGER*8.

MALLOC64 always takes an INTEGER*8 argument (size of memory request in bytes) and always returns an INTEGER*8 value. Use this routine rather than MALLOC when compiling programs that must run in both 32-bit and 64-bit environments. The receiving variable must be declared either POINTER or INTEGER*8.

(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. SIZEOF returns default INTEGER*4 data. If compiling for a 64-bit environment, the compiler will issue a

warning if the result overflows the INTEGER*4 data range. To use SIZEOF in a 64-bit environment with arrays larger than the INTEGER*4 limit (2 Gbytes), the SIZEOF function and the variables receiving the result must be declared INTEGER*8.

VMS Intrinsic Functions

This section lists VMS FORTRAN intrinsic routines recognized by f77. They are, of course, nonstandard. @

VMS Double-Precision Complex

TABLE 6–9 VMS Double-Precision Complex Functions

Generic Name	Specific Names	Function	Argument Type	Result Type
	CDABS	Absolute value	COMPLEX*16	REAL*8
	CDEXP	Exponential, e**a	COMPLEX*16	COMPLEX*16
	CDLOG	Natural log	COMPLEX*16	COMPLEX*16
	CDSQRT	Square root	COMPLEX*16	COMPLEX*16
	CDSIN	Sine	COMPLEX*16	COMPLEX*16
	CDCOS	Cosine	COMPLEX*16	COMPLEX*16
DCMPLX	DCONJG	Convert to DOUBLE COMPLEX	*Any numeric*	COMPLEX*16
	DIMAG	Complex conjugate	COMPLEX*16	COMPLEX*16
	DREAL	Imaginary part of complex	COMPLEX*16	REAL*8
		Real part of complex	COMPLEX*16	REAL*8

VMS Degree-Based Trigonometric

TABLE 6–10 VMS Degree-Based Trigonometric Functions

Generic Name	Specific Names	Function	Argument Type	Result Type
SIND	SIND DSIND QSIND	Sine	- REAL*4 REAL*8 REAL*16	- REAL*4 REAL*8 REAL*16
COSD	COSD DCOSD QCOSD	Cosine	- REAL*4 REAL*8 REAL*16	- REAL*4 REAL*8 REAL*16
TAND	TAND DTAND QTAND	Tangent	- REAL*4 REAL*8 REAL*16	- REAL*4 REAL*8 REAL*16
ASIND	ASIND DASIND QASIND	Arc sine	- REAL*4 REAL*8 REAL*16	- REAL*4 REAL*8 REAL*16
ACOSD	ACOSD DACOSD QACOSD	Arc cosine	- REAL*4 REAL*8 REAL*16	- REAL*4 REAL*8 REAL*16
ATAND	ATAND DATAND QATAND	Arc tangent	- REAL*4 REAL*8 REAL*16	- REAL*4 REAL*8 REAL*16
ATAN2D	ATAN2D DATAN2D QATAN2D	Arc tangent of a1/a2	- REAL*4 REAL*8 REAL*16	- REAL*4 REAL*8 REAL*16

VMS Bit-Manipulation

TABLE 6–11 VMS Bit-Manipulation Functions

Generic Name	Specific Names	Function	Argument Type	Result Type
IBITS	IIBITS JIBITS	From a1, initial bit a2, extract a3 bits	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
ISHFT	IISHFT JISHFT	Shift a1 logically by a2 bits; if a2 positive shift left, if a2 negative shift right Shift a1 logically left by a2 bits Shift a1 logically left by a2 bits	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
ISHFTC	IISHFTC JISHFTC	In a1, circular shift by a2 places, of right a3 bits	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
IAND	IIAND JIAND	Bitwise AND of a1, a2	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
IOR	IIOR JIOR	Bitwise OR of a1, a2	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
IEOR	IIEOR JIEOR	Bitwise exclusive OR of a1, a2	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
NOT	INOT JNOT	Bitwise complement	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
IBSET	IIBSET JIBSET	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	If bit a2 of a1 is 1, return .TRUE.	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4
IBCLR	IIBCLR JIBCLR	In a1, set bit a2 to 0; return new a1	- INTEGER*2 INTEGER*4	- INTEGER*2 INTEGER*4

TABLE 6–11 VMS Bit-Manipulation Functions *(continued)*

VMS Multiple Integer Types

The possibility of multiple integer types is not addressed by the FORTRAN Standard. `f77` copes with their existence by treating a specific `INTEGER`-to-`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 takes a similar approach, but makes the specific names available.

TABLE 6–12 VMS Integer Functions

Specific Names	Function	Argument Type	Result Type
`IIABS JIABS`	Absolute value Absolute value	`INTEGER*2` `INTEGER*4`	`INTEGER*2` `INTEGER*4`
`IMAX0 JMAX0`	Maximum [1] Maximum [1]	`INTEGER*2` `INTEGER*4`	`INTEGER*2` `INTEGER*4`
`IMIN0 JMIN0`	Minimum [1] Minimum [1]	`INTEGER*2` `INTEGER*4`	`INTEGER*2` `INTEGER*4`
`IIDIM JIDIM`	Positive difference [2] Positive difference [2]	`INTEGER*2` `INTEGER*4`	`INTEGER*2` `INTEGER*4`
`IMOD JMOD`	Remainder of a1/a2 Remainder of a1/a2	`INTEGER*2` `INTEGER*4`	`INTEGER*2` `INTEGER*4`
`IISIGN` `JISIGN`	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 6–13 Translated Functions that VMS Coerces to a Particular Type

Specific Names	Function	Argument Type	Result Type
IINT JINT	Truncation toward zero Truncation toward zero	REAL*4 REAL*4	INTEGER*2 INTEGER*4
IIDINT JIDINT	Truncation toward zero Truncation toward zero	REAL*8 REAL*8	INTEGER*2 INTEGER*4
IIQINT JIQINT	Truncation toward zero Truncation toward zero	REAL*16 REAL*16	INTEGER*2 INTEGER*4
ININT JNINT	Nearest integer, INT(a+.5*sign(a)) Nearest integer, INT(a+.5*sign(a))	REAL*4 REAL*4	INTEGER*2 INTEGER*4
IIDNNT JIDNNT	Nearest integer, INT(a+.5*sign(a)) Nearest integer, INT(a+.5*sign(a))	REAL*8 REAL*8	INTEGER*2 INTEGER*4
IIQNNT JIQNNT	Nearest integer, INT(a+.5*sign(a)) Nearest integer, INT(a+.5*sign(a))	REAL*16 REAL*16	INTEGER*2 INTEGER*4
IIFIX JIFIX	Fix Fix	REAL*4 REAL*4	INTEGER*2 INTEGER*4
IMAX1(*a,a2,...*) JMAX1(*a,a2,...*)	Maximum of two or more arguments Maximum of two or more arguments	REAL*4 REAL*4	INTEGER*2 INTEGER*4
IMIN1(*a,a2,...* JMIN1(*a,a2,...*	Minimum of two or more arguments Minimum of two or more arguments	READ*4 READ*4	INTEGER*2 INTEGER*4

TABLE 6–13 Translated Functions that VMS Coerces to a Particular Type *(continued)*

Functions Translated to a Generic Name

In some cases, each VMS-specific name is translated into an `f77` generic name.

TABLE 6–14 VMS Functions That Are Translated into `f77` Generic Names

Specific Names	Function	Argument Type	Result Type
FLOATI FLOATJ	Convert to REAL*4 Convert to REAL*4	INTEGER*2 INTEGER*4	REAL*4 REAL*4
DFLOTI DFLOTJ	Convert to REAL*8 Convert to REAL*8	INTEGER*2 INTEGER*4	REAL*8 REAL*8
AIMAX0 AJMAX0	Maximum Maximum	INTEGER*2 INTEGER*4	REAL*4 REAL*4
AIMIN0 AJMIN0	Minimum Minimum	INTEGER*2 INTEGER*4	REAL*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 6–15 Zero-Extend Functions

Generic Name	Specific Names	Function	Argument Type	Result Type
ZEXT		Zero-extend	-	-
	IZEXT	Zero-extend	BYTE LOGICAL*1 LOGICAL*2 INTEGER*2	INTEGER*2
	JZEXT	Zero-extend	BYTE LOGICAL*1 LOGICAL*2 LOGICAL*4 INTEGER INTEGER*2 INTEGER*4	INTEGER*4

APPENDIX **A**

ASCII Character Set

This appendix contains two tables: ASCII character sets and control characters.

TABLE A–1 ASCII Character Set

Name
L
H
K
X
T
Q
K
L
K
N
L

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)

TABLE A–2 Control Characters ^=Control Key s^=Shift and Control Keys *(continued)*

Dec	Oct	Hex	Name	Keys	Meaning
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 (^ _)

APPENDIX **B**

Sample Statements

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.

Nonstandard features are tagged with a small black diamond (@).

TABLE B–1 FORTRAN Statement Samples

Name	Examples	Comments
`ACCEPT @`	`ACCEPT *, A, I`	Compare to `READ`.
`ASSIGN`	`ASSIGN 9 TO I`	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
ASSIGNMENT	C = 'abc'	Character @
	C = "abc"	
	C = S // 'abc'	
	C = S(I:M)	
	L = L1 .OR. L2	Logical
	L = I .LE. 80	
	N = N+1	Arithmetic
	X = '7FF00000'x	Hex @
	CURR = NEXT	Compare to RECORD.
	NEXT.ID = 82	
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	Initialize A and B
	BYTE A, B, C(10)	
	BYTE A /'x'/, B /255/, C(10)	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
CALL	CALL P(A, B)	
	CALL P(A, B, *9)	Alternate return
	CALL P(A, B, &9)	Alternate return @
	CALL P	
CHARACTER	CHARACTER C*80, D*1(4)	
	CHARACTER*18 A, B, C	Initialize B and C@
	CHARACTER A, B*3 /'xyz'/, C /'z'/	
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)	
COMPLEX	COMPLEX U, V, U(3,6)	
	COMPLEX U*16	Double complex @
	COMPLEX U*32 *SPARC only*	Quad complex @
	COMPLEX U/(1.0,1.0)/,V/(1.0,10.0)/	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	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
DIMENSION	DIMENSION ARRAY(4, 4) DIMENSION V(1000), W(3)	
DO	DO 100 I = INIT, LAST 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	COMPLEX*16 @
	DOUBLE COMPLEX U, V	COMPLEX @
	COMPLEX U/(1.0,1.0D0)/, V/(1.0,1.0D0)/	Initialize U and V @
DOUBLE PRECISION	DOUBLE PRECISION A, D, Y(2)	REAL*8 @
	DOUBLE PRECISION A,D/1.2D3/,Y(2)	Initialize D @
ELSE	ELSE	Compare to IF (Block)
ELSE IF	ELSE IF	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
ENCODE @	ENCODE(4, 1, T)A, B, C	
END	END	
END DO @	END DO	Compare to DO
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	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
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)	
	10 FORMAT('a quoted string', " another", I2)	Strings @
	10 FORMAT(18Hhollerith string, I2)	Hollerith
	10 FORMAT(1X, T10, A1, T20, A1)	Tabs
	10 FORMAT(5X,TR10,A1,TR10,A1,TL5, A1)	Tab right, left
	10 FORMAT(" Init=", I2, :, 3X, "Last=", I2)	:
	10 FORMAT(1X,"Enter path name ", $)	$
	10 FORMAT(F4.2, Q, 80 A1	Q @
	10 FORMAT('Octal ',O6,', Hex ',Z6)	Octal, hex @
	10 FORMAT(3F<N>.2)	Variable expression @
FUNCTION	FUNCTION Z(A, B)	Short integer @
	FUNCTION W(P,D, *9)	
	CHARACTER FUNCTION R*4(P,D,*9)	
	INTEGER*2 FUNCTION M(I, J)	
GO TO	GO TO 99	Unconditional
	GO TO I, (10, 50, 99)	Assigned
	GO TO I	
	GO TO (10, 50, 99), I	Computed

TABLE B–1 FORTRAN 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'	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
INQUIRE	INQUIRE(UNIT=3, OPENED=OK)	
	INQUIRE(FILE='mydata', EXIST=OK)	
	INQUIRE(UNIT=3, OPENED=OK, IOSTAT=ERRNO)	
INTEGER	INTEGER C, D(4)	Short integer @
	INTEGER C*2	
	INTEGER*4 A, B, C	
	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 @
Map @	MAP	Compare to STRUCTURE and UNION
	CHARACTER *18 MAJOR	
	END MAP	
	MAP	
	INTEGER*2 CREDITS	
	CHARACTER*8 GRAD_DATE	
	END MAP	
NAMELIST @	NAMELIST /CASE/ S, N, D	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
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 RNG ! $PRAGMA C(RNG)	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 @

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
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 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 )`	Namelist read @
	`READ( 1, G )`	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 @

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
REAL	`REAL R, M(4)`	@
	`REAL R*4`	Double precision @
	`REAL*8 A, B, C`	Quad precision @
	`REAL*16 A, B, C` *SPARC only*	
	`REAL A / 3.14 /, B, C / 100.0 /`	Initialize A and C@
RECORD @	`RECORD /PROD/ CURR,PRIOR,NEXT`	
RETURN	`RETURN`	Standard return
	`RETURN 2`	Alternate return
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 done"`	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
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)	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
VOLATILE @	VOLATILE V, Z, MAT, /INI/	

TABLE B–1 FORTRAN Statement Samples *(continued)*

Name	Examples	Comments
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
	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 @

TABLE B–1 FORTRAN Statement Samples *(continued)*

APPENDIX **C**

Data Representations

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 Sun *Fortran Programming Guide* and *Numerical Computation Guide*.

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. Quad is *SPARC only*.

$(-1)^{sign} * 2^{exponent\text{-}bias} * 1.f$

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

TABLE C–1 Floating-point Representation *(continued)*

	Single	Double	Quadruple
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

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.

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	7FFxxxxxxxxxxxx

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

Left Operand	Right 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	*Note*	NaN
NaN	NaN	NaN	NaN	NaN	NaN

Note: Inf Inf and Inf + Inf = Inf ; Inf - Inf = NaN.

TABLE C–5 Extreme Values: Multiplication

Left Operand	Right Operand				
	0	**Sub**	**Num**	**Inf**	**NaN**
0	0	0	0	NaN	NaN
Sub	0	0	NS	Inf	NaN

TABLE C–5 Extreme Values: Multiplication *(continued)*

Left Operand	Right Operand				
	0	**Sub**	**Num**	**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

TABLE C–7 Extreme Values: Comparison *(continued)*

Left Operand	Right Operand				
	0	**Sub**	**Num**	**Inf**	**NaN**
Inf	>	>	>	=	Uno
NaN	Uno	Uno	Uno	Uno	Uno

Notes:

- 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.

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).

APPENDIX **D**

VMS Language Extensions

This chapter describes the VMS language extensions that Sun Fortran 77 supports. These extensions are all, of course, nonstandard. @

Background

This FORTRAN compiler includes the VMS extensions to make it as easy as possible to port FORTRAN programs from VMS environments to Solaris environments. The compiler provides almost complete compatibility with VMS FORTRAN. These extensions are included in `dbx` as well as `f77`.

VMS Language Features in Sun Fortran

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 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 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 * syntax. Example

```
 CALL SUBX ( I, *100, Z
)  ! Standard
 CALL SUBX ( I, &100, Z ) ! Nonstandard alternate syntax
```

:

- 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 accepted.

  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 accepted
  - %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 )
```

VMS Features Requiring -xl or -vax=*spec*

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.

Note also the –-vax=*spec* option, which allows specification of these VMS extensions individually. See the *Fortran User's Guide* for details.

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 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 statements (`-xld`)

  The compiler interprets debugging lines as comment lines or FORTRAN 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`

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.

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