

Chapter 21

The Standard Library

Using the Library

- The C89 standard library is divided into 15 parts, with each part described by a header.
- C99 has an additional nine headers.

<code><assert.h></code>	<code><inttypes.h>†</code>	<code><signal.h></code>	<code><stdlib.h></code>
<code><complex.h>†</code>	<code><iso646.h>†</code>	<code><stdarg.h></code>	<code><string.h></code>
<code><ctype.h></code>	<code><limits.h></code>	<code><stdbool.h>†</code>	<code><tgmath.h>†</code>
<code><errno.h></code>	<code><locale.h></code>	<code><stddef.h></code>	<code><time.h></code>
<code><fenv.h>†</code>	<code><math.h></code>	<code><stdint.h>†</code>	<code><wchar.h>†</code>
<code><float.h></code>	<code><setjmp.h></code>	<code><stdio.h></code>	<code><wctype.h>†</code>

†C99 only

Using the Library

- Most compilers come with a more extensive library that has additional (nonstandard) headers.
- Nonstandard headers often provide:
 - Functions that are specific to a particular computer or operating system
 - Functions that allow more control over the screen and keyboard
 - Support for graphics or a window-based user interface

Using the Library

- The standard headers consist primarily of function prototypes, type definitions, and macro definitions.
- When a file includes several standard headers, the order of `#include` directives doesn't matter.
- It's also legal to include a standard header more than once.

Restrictions on Names Used in the Library

- Any file that includes a standard header must obey two rules:
 - The names of macros defined in that header can't be used for any other purpose.
 - Library names with file scope (typedef names, in particular) can't be redefined at the file level.

Restrictions on Names Used in the Library

- Other restrictions are less obvious:
 - *Identifiers that begin with an underscore followed by an upper-case letter or a second underscore* are reserved for use within the library.
 - *Identifiers that begin with an underscore* are reserved for use as identifiers and tags with file scope.
 - *Every identifier with external linkage in the standard library* is reserved for use as an identifier with external linkage. In particular, the names of all standard library functions are reserved.

Restrictions on Names Used in the Library

- These rules apply to *every* file in a program, regardless of which headers the file includes.
- Moreover, they apply not just to names that are currently used in the library, but also to names that are set aside for future use.
- For example, C reserves identifiers that begin with `str` followed by a lower-case letter.

Functions Hidden by Macros

- The C standard allows headers to define macros that have the same names as library functions, but requires that a true function be available as well.
- It's not unusual for a library header to declare a function *and* define a macro with the same name.

Functions Hidden by Macros

- `getchar` is a library function declared in the `<stdio.h>` header:

```
int getchar(void);
```
- `<stdio.h>` usually defines `getchar` as a macro as well:

```
#define getchar() getc(stdin)
```
- By default, a call of `getchar` will be treated as a macro invocation.

Functions Hidden by Macros

- A macro is usually preferable to a true function, because it will probably improve the speed of a program.
- Occasionally, a genuine function is needed, perhaps to minimize the size of the executable code.

Functions Hidden by Macros

- A macro definition can be removed (thus gaining access to the true function) by using `#undef`:

```
#include <stdio.h>
#undef getchar
```
- `#undef` has no effect when given a name that's not defined as a macro.

Functions Hidden by Macros

- Individual uses of a macro can be disabled by putting parentheses around its name:

```
ch = (getchar)();
/* instead of ch = getchar(); */
```
- The preprocessor can't spot a parameterized macro unless its name is followed by a left parenthesis.
- However, the compiler can still recognize `getchar` as a function.

C89 Library Overview

<assert.h> *Diagnostics*

Contains only the `assert` macro, which can be used to insert self-checks into a program. If any check fails, the program terminates.

<ctype.h> *Character Handling*

Provides functions for classifying characters and for converting letters from lower to upper case or vice versa.

C89 Library Overview

<errno.h> *Errors*

Provides `errno` (“error number”), an lvalue that can be tested after a call of certain library functions to see if an error occurred.

<float.h> *Characteristics of Floating Types*

Provides macros that describe the characteristics of floating types, including their range and accuracy.

C89 Library Overview

<limits.h> *Sizes of Integer Types*

Provides macros that describe the characteristics of integer types (including character types), including their maximum and minimum values.

<locale.h> *Localization*

Provides functions to help a program adapt its behavior to a country or other geographic region.

C89 Library Overview

<math.h> *Mathematics*

Provides common mathematical functions.

<setjmp.h> *Nonlocal Jumps*

Provides the `setjmp` and `longjmp` functions. `setjmp` “marks” a place in a program; `longjmp` can then be used to return to that place later.

C89 Library Overview

<signal.h> *Signal Handling*

Provides functions that deal with exceptional conditions (signals).

- The `signal` function installs a function to be called if a given signal should occur later.
- The `raise` function causes a signal to occur.

<stdarg.h> *Variable Arguments*

Provides tools for writing functions that can have a variable number of arguments.

C89 Library Overview

<stddef.h> *Common Definitions*

Provides definitions of frequently used types and macros.

<stdio.h> *Input/Output*

Provides a large assortment of input/output functions, including operations on both sequential and random-access files.

C89 Library Overview

<stdlib.h> *General Utilities*

Provides functions that perform the following operations:

- Converting strings to numbers
- Generating pseudo-random numbers
- Performing memory management tasks
- Communicating with the operating system
- Searching and sorting
- Performing conversions between multibyte characters and wide characters

C89 Library Overview

<string.h> *String Handling*

Provides functions that perform string operations, as well as functions that operate on arbitrary blocks of memory.

<time.h> *Date and Time*

Provides functions for determining the time (and date), manipulating times, and formatting times for display.

C99 Library Changes

- Some of the biggest changes in C99 affect the standard library:
 - **Additional headers.** The C99 standard library has nine headers that don't exist in C89.
 - **Additional macros and functions.** C99 adds macros and functions to several existing headers (especially `<math.h>`).
 - **Enhanced versions of existing functions.** Some existing functions, including `printf` and `scanf`, have additional capabilities in C99.

C99 Library Changes

`<complex.h>` *Complex Arithmetic*

Defines the `complex` and `I` macros.

Provides functions for performing mathematical operations on complex numbers.

`<fenv.h>` *Floating-Point Environment*

Provides access to floating-point status flags and control modes.

C99 Library Changes

`<inttypes.h>` *Format Conversion of Integer Types*

Defines macros that can be used in format strings for input/output of the integer types declared in `<stdint.h>`.

Provides functions for working with greatest-width integers.

`<iso646.h>` *Alternative Spellings*

Defines macros representing the operators whose symbols contain the characters `&`, `|`, `~`, `!`, and `^`.

C99 Library Changes

`<stdbool.h>` *Boolean Type and Values*

Defines the `bool`, `true`, and `false` macros, as well as a macro that can be used to test whether these macros have been defined.

`<stdint.h>` *Integer Types*

Declares integer types with specified widths and defines related macros.

Defines parameterized macros that construct integer constants with specific types.

C99 Library Changes

<tgmath.h> *Type-Generic Math*

Provides “type-generic” macros that can detect argument types and substitute a call of a `<math.h>` or `<complex.h>` function.

<wchar.h> *Extended Multibyte and Wide-Character Utilities*

Provides functions for wide-character input/output and wide string manipulation.

C99 Library Changes

<wctype.h> *Wide-Character Classification and Mapping Utilities*

The wide-character version of `<ctype.h>`.

Provides functions for classifying and changing the case of wide characters.

The **<stddef.h>** Header: Common Definitions

- Types defined in `<stddef.h>`:
 - `ptrdiff_t`. The type of the result when two pointers are subtracted.
 - `size_t`. The type returned by the `sizeof` operator.
 - `wchar_t`. A type large enough to represent all possible characters in all supported locales.
- Macros defined in `<stddef.h>`:
 - `NULL`. Represents the null pointer.
 - `offsetof`. Computes the number of bytes between the beginning of a structure and one of its members.

The **<stddef.h>** Header: Common Definitions

- An example structure:


```
struct s {
    char a;
    int b[2];
    float c;
};
```
- The value of `offsetof(struct s, a)` must be 0, but the offsets of `b` and `c` depend on the compiler.
- One possibility is that `offsetof(struct s, b)` is 1, and `offsetof(struct s, c)` is 9.
- If a compiler should leave a three-byte hole after `a`, the offsets of `b` and `c` would be 4 and 12.

The `<stdbool.h>` Header (C99): Boolean Type and Values

- Macros defined in `<stdbool.h>`:
 `bool` (defined to be `_Bool`)
 `true` (defined to be 1)
 `false` (defined to be 0)
 `__bool_true_false_are_defined` (defined to be 1)
- A program could use a preprocessing directive to test the last of these before attempting to define its own version of `bool`, `true`, or `false`.