

Number Literals

Integers

0b11111111	binary	0B11111111	binary
0377	octal	255	decimal
0xff	hexadecimal	0xFF	hexadecimal

Real Numbers

88.0f / 88.1234567f

single precision float (f suffix)

88.0 / 88.123456789012345

double precision float (no f suffix)

Signage

42 / +42 positive -42 negative

Binary notation 0b... / 0B... is available on GCC and most but not all C compilers.

Variables

Declaring

int x;	A variable.
char x = 'C';	A variable & initialising it.
float x, y, z;	Multiple variables of the same type.
const int x = 88;	A constant variable: can't assign to after declaration (compiler enforced.)

Naming

johnny5IsAlive; ✓ Alphanumeric, not a keyword, begins with a letter.

~~2001ASpaceOddysey;~~ ✗ Doesn't begin with a letter.

~~while;~~ ✗ Reserved keyword.

~~how-exciting+;~~ ✗ Non-alphanumeric.

~~i am a very long variable name oh my gosh yes i am;~~ ✗

Longer than 31 characters (C89 & C90 only)

Constants are CAPITALISED. Function names usually take the form of a verb eg. plotRobotUprising().

Primitive Variable Types

**applicable but not limited to most ARM, AVR, x86 & x64 installations*

[class] [qualifier] [unsigned] type/void name;

by ascending arithmetic conversion

Integers

Type	Bytes	Value Range
char	1	unsigned OR signed
unsigned char	1	0 to 2 ⁸ -1
signed char	1	-2 ⁷ to 2 ⁷ -1
int	2 / 4	unsigned OR signed
unsigned int	2 / 4	0 to 2 ¹⁶ -1 OR 2 ³¹ -1
signed int	2 / 4	-2 ¹⁵ to 2 ¹⁵ -1 OR -2 ³¹ to 2 ³² -1
short	2	unsigned OR signed
unsigned short	2	0 to 2 ¹⁶ -1
signed short	2	-2 ¹⁵ to 2 ¹⁵ -1
long	4 / 8	unsigned OR signed
unsigned long	4 / 8	0 to 2 ³² -1 OR 2 ⁶⁴ -1
signed long	4 / 8	-2 ³¹ to 2 ³¹ -1 OR -2 ⁶³ to 2 ⁶³ -1
long long	8	unsigned OR signed
unsigned long long	8	0 to 2 ⁶⁴ -1
signed long long	8	-2 ⁶³ to 2 ⁶³ -1

Floats

Type Bytes Value Range (Normalized)



Primitive Variable Types (cont)

float	4	$\pm 1.2 \times 10^{-38}$ to $\pm 3.4 \times 10^{38}$
double	8 / 4	$\pm 2.3 \times 10^{-308}$ to $\pm 1.7 \times 10^{308}$ OR alias to float for AVR.
long double	ARM: 8, AVR: 4, x86: 10, x64: 16	

Qualifiers

const type	Flags variable as read-only (compiler can optimise.)
volatile type	Flags variable as unpredictable (compiler cannot optimise.)

Storage Classes

register	Quick access required. May be stored in RAMOR a register. Maximum size is register size.
static	Retained when out of scope. static global variables are confined to the scope of the compiled object file they were declared in.
extern	Variable is declared by another file.

Typecasting

(type)a	Returns a as data type.
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Primitive Variable Types (cont)

```
char x = 1, y = 2; float z = (float) x / y;
```

Some types (denoted with **OR**) are architecture dependent.

There is no primitive boolean type, only zero (false, 0) and non-zero (true, usually 1.)

Extended Variable Types

```
[class] [qualifier] type name;
```

by ascending arithmetic conversion

From the stdint.h Library

Type	Bytes	Value Range
int8_t	1	-2^7 to 2^7-1
uint8_t	1	0 to 2^8-1
int16_t	2	-2^{15} to $2^{15}-1$
uint16_t	2	0 to $2^{16}-1$
int32_t	4	-2^{31} to $2^{31}-1$
uint32_t	4	0 to $2^{32}-1$
int64_t	8	-2^{63} to $2^{63}-1$
uint64_t	8	0 to $2^{64}-1$

From the stdbool.h Library

Type	Bytes	Value Range
bool	1	true / false or 0 / 1

The `stdint.h` library was introduced in C99 to give integer types architecture-independent lengths.

Structures

Defining

<pre>struct strctName{ type x; type y; };</pre>	A structure type <code>strctName</code> with two members, <code>x</code> and <code>y</code> . <i>Note trailing semicolon</i>
<pre>struct item{ struct item *next; };</pre>	A structure with a recursive structure pointer inside. Useful for linked lists.

Declaring

<pre>struct strctName varName;</pre>	A variable <code>varName</code> as structure type <code>strctName</code> .
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Structures (cont)

<code>struct structName *ptrName;</code>	A <code>structName</code> structure type pointer, <code>ptrName</code> .
<code>struct structName{ type a; type b; } varName;</code>	Shorthand for defining <code>structName</code> and declaring <code>varName</code> as that structure type.
<code>struct structName varName = { a, b };</code>	A variable <code>varName</code> as structure type <code>structName</code> and initialising its members.

Accessing

<code>varName.x</code>	Member <code>x</code> of structure <code>varName</code> .
<code>ptrName->x</code>	Value of structure pointer <code>ptrName</code> member <code>x</code> .

Bit Fields

<code>struct{char a:4, b:4} x;</code>	Declares <code>x</code> with two members <code>a</code> and <code>b</code> , both four bits in size (0 to 15.)
-------------------------------------------	-------------------------------------------------------------------------------------------------------------------

Array members can't be assigned bit fields.

Type Definitions

Defining

<code>typedef unsigned short uint16;</code>	Abbreviating a longer type name to <code>uint16</code> .
<code>typedef struct structName{int a, b;}newType;</code>	Creating a new type from a structure.
<code>typedef enum typeName{false, true}bool;</code>	Creating an enumerated <code>bool</code> type.

Declaring

<code>uint16 x = 65535;</code>	Variable <code>x</code> as type <code>uint16</code> .
<code>newType y = {0, 0};</code>	Structure <code>y</code> as type <code>newType</code> .

Unions

Defining

<code>union uName{int x; char y[8];}</code>	A union type <code>uName</code> with two members, <code>x</code> & <code>y</code> . Size is same as biggest member size.
-------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------

Declaring

<code>union uN vName;</code>	A variable <code>vName</code> as union type <code>uN</code> .
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Accessing

<code>vName.y[int]</code>	Members cannot store values concurrently. Setting <code>y</code> will corrupt <code>x</code> .
---------------------------	---------------------------------------------------------------------------------------------------

Unions are used for storing multiple data types in the same area of memory.

Enumeration

Defining

<code>enum bool { false, true };</code>	A custom data type <code>bool</code> with two possible states: <code>false</code> or <code>true</code> .
---------------------------------------------	-------------------------------------------------------------------------------------------------------------

Declaring

<code>enum bool varName;</code>	A variable <code>varName</code> of data type <code>bool</code> .
-------------------------------------	------------------------------------------------------------------

Assigning

<code>varName = true;</code>	Variable <code>varName</code> can only be assigned values of either <code>false</code> or <code>true</code> .
------------------------------	------------------------------------------------------------------------------------------------------------------

Evaluating

<code>if(varName == false)</code>	Testing the value of <code>varName</code> .
---------------------------------------	---------------------------------------------

Pointers

Declaring

<code>type *x;</code>	Pointers have a data type like normal variables.
-----------------------	--------------------------------------------------



Pointers (cont)

`void *v;` They can also have an incomplete type. Operators other than assignment cannot be applied as the length of the type is unknown.

`struct` A data structure pointer.

`type *y;`

`type` An array/string name can be used as a pointer to the first
`z [];` array element.

Accessing

`x` A memory address.

`*x` Value stored at that address.

`y->a` Value stored in structure pointer `y` member `a`.

`&varName` Memory address of normal variable `varName`.

`*(type` Dereferencing a void pointer as a `type` pointer.
`*)v`

A pointer is a variable that holds a memory location.

Arrays

Declaring

`type name[int];` You set array length.

`type name[int] = {x,` You set array length and initialise
`y, z};` elements.

`type name[int] = {x};` You set array length and initialise all
elements to `x`.

`type name[] = {x, y,` Compiler sets array length based on initial
`z};` elements.

Size cannot be changed after declaration.

Dimensions

`name[int]` One dimension array.

`name[int][int]` Two dimensional array.

Accessing

`name[int]` Value of element `int` in array `name`.

Arrays (cont)

`*(name + int)` Same as `name[int]`.

Elements are contiguously numbered ascending from 0.

`&name[int]` Memory address of element `int` in
array `name`.

`name + int` Same as `&name[int]`.

Elements are stored in contiguous memory.

Measuring

`sizeof(array) /` Returns length of array. (*Unsafe*)
`sizeof(arrayType)`

`sizeof(array) /` Returns length of array. (*Safe*)
`sizeof(array[0])`

Strings

`'A'` character Single quotes.

`"AB"` string Double quotes.

`\0` Null terminator.

Strings are char arrays.

`char name[4] = "Ash";`

is equivalent to

`char name[4] = {'A', 's', 'h', '\0'};`

`int i; for(i = 0; name[i]; i++){}`

`\0` evaluates as false.

Strings must include a `char` element for `\0`.

Escape Characters

`\a` alarm (bell/beep) `\b` backspace

`\f` formfeed `\n` newline

`\r` carriage return `\t` horizontal tab

`\v` vertical tab `\\` backslash

`\'` single quote `\"` double quote

`\?` question mark

`\nnn` Any octal ANSI character code.

`\xhh` Any hexadecimal ANSI character code.

Functions

Declaring

```
type/void funcName([args...]) { [return var;] }
```

Function names follow the same restrictions as variable names but must **also** be unique.

type/void	Return value type (void if none.)
funcName()	Function name and argument parenthesis.
args...	Argument types & names (void if none.)
{}	Function content delimiters.
return var;	Value to return to function call origin. Skip for void type functions. Functions exit immediately after a return.

By Value vs By Pointer

void f(type x); f(y);	Passing variable y to function f argument x (by value.)
void f(type *x); f(array);	Passing an array/string to function f argument x (by pointer.)
void f(type *x); f(structure);	Passing a structure to function f argument x (by pointer.)
void f(type *x); f(&y);	Passing variable y to function f argument x (by pointer.)
type f() { return x; }	Returning by value.
type f() { type x; return &x; }	Returning a variable by pointer.

Functions (cont)

```
type f() { static type x[]; return &x; }
```

Returning an array/string/structure by pointer. The static qualifier is necessary otherwise x won't exist after the function exits.

Passing by pointer allows you to change the originating variable within the function.

Scope

```
int f() { int i = 0; } i++, x
```

i is declared inside f(), it doesn't exist outside that function.

Prototyping

```
type funcName(args...);
```

Place before declaring or referencing respective function (usually before main.)

type funcName([args...]);	Same type, name and args... as respective function.
;	Semicolon instead of function delimiters.

main()

```
int main(int argc, char *argv[]) { return int; }
```

Anatomy

int main	Program entry point.
int argc	# of command line arguments.
char *argv[]	Command line arguments in an array of strings. #1 is always the program filename.
return int;	Exit status (integer) returned to the OS upon program exit.

Command Line Arguments

app two 3	Three arguments, "app", "two" and "3".
app "two 3"	Two arguments, "app" and "two 3".

main is the first function called when the program executes.



Conditional (Branching)

if, else if, else

`if (a) b;` Evaluates `b` if `a` is true.

`if (a) { b; c; }` Evaluates `b` and `c` if `a` is true.

`if (a) { b; } else { c; }` Evaluates `b` if `a` is true, `c` otherwise.

`if (a) { b; } else if (c) { d; } else { e; }` Evaluates `b` if `a` is true, otherwise `d` if `c` is true, otherwise `e`.

switch, case, break

`switch (a) { case b: c; }` Evaluates `c` if `a` equals `b`.

`switch (a) { default: b; }` Evaluates `b` if `a` matches no other case.

`switch (a) { case b: case c: d; }` Evaluates `d` if `a` equals either `b` or `c`.

`switch (a) { case b: c; case d: e; default: f; }` Evaluates `c, e` and `f` if `a` equals `b, e` and `f` if `a` equals `d`, otherwise `f`.

`switch (a) { case b: c; break; case d: e; break; default: f; }` Evaluates `c` if `a` equals `b, e` if `a` equals `d` and `e` otherwise.

Iterative (Looping)

while

```
int x = 0; while(x < 10) { x += 2; }
```

Loop skipped if test condition initially false.

`int x = 0;` Declare and initialise integer `x`.

`while ()` Loop keyword and condition parenthesis.

`x < 10` Test condition.

`{}` Loop delimiters.

`x += 2;` Loop contents.

do while

```
char c = 'A'; do { c++; } while(c != 'Z');
```

Always runs through loop at least once.

`char c = 'A';` Declare and initialise character `c`.

Iterative (Looping) (cont)

`do` Loop keyword.

`{}` Loop delimiters.

`c++;` Loop contents.

`while ();` Loop keyword and condition parenthesis. *Note semicolon.*

`c != 'Z'` Test condition.

for

```
int i; for(i = 0; n[i] != '\0'; i++) {} (C89)
```

OR

```
for(int i = 0; n[i] != '\0'; i++) {} (C99+)
```

Compact increment/decrement based loop.

`int i;` Declares integer `i`.

`for ()` Loop keyword.

`i = 0;` Initialises integer `i`. *Semicolon.*

`n[i] != '\0';` Test condition. *Semicolon.*

`i++` Increments `i`. *No semicolon.*

`{}` Loop delimiters.

continue

```
int i=0; while(i<10) { i++; continue; i--; }
```

Skips rest of loop contents and restarts at the beginning of the loop.

break

```
int i=0; while(1) { if(x==10) {break;} i++; }
```

Skips rest of loop contents and exits loop.

Console Input/Output

```
#include <stdio.h>
```

Characters

`getchar ()` Returns a single character's ANSI code from the input stream buffer as an *integer*. (*safe*)

`putchar (int)` Prints a single character from an ANSI code *integer* to the output stream buffer.

Strings



Console Input/Output (cont)

`gets(strName)` Reads a line from the input stream into a string variable. (*Unsafe, removed in C11.*)

Alternative

`fgets(strName, length, stdin)`; Reads a line from the input stream into a string variable. (*Safe*)

`puts("string")` Prints a string to the output stream.

Formatted Data

`scanf("%d", &x)` Read value/s (type defined by format string) into variable/s (type must match) from the input stream. Stops reading at the first whitespace. *& prefix not required for arrays (including strings.) (unsafe)*

`printf("I love %c %d!", 'C', 99)` Prints data (formats defined by the format string) as a string to the output stream.

Alternative

`fgets(strName, length, stdin)`; `sscanf(strName, "%d", &x)`; Uses `fgets` to limit the input length, then uses `sscanf` to read the resulting string in place of `scanf`. (*safe*)

The stream buffers must be flushed to reflect changes. String terminator characters can flush the output while newline characters can flush the input.

Safe functions are those that let you specify the length of the input. *Unsafe* functions do not, and carry the risk of memory overflow.

File Input/Output

```
#include <stdio.h>
```

Opening

```
FILE *fptr = fopen(filename, mode);
```

`FILE *fptr` Declares `fptr` as a FILE type pointer (stores stream location instead of memory location.)

`fopen()` Returns a stream location pointer if successful, 0 otherwise.

`filename` String containing file's directory path & name.

`mode` String specifying the file access mode.

Modes

"r" / "rb" Read existing text/binary file.

"w" / "wb" Write new/over existing text/binary file.

"a" / "ab" Write new/append to existing text/binary file.

"r+" / "r+b" / "rb+" Read and write existing text/binary file.

"w+" / "w+b" / "wb+" Read and write new/over existing text/binary file.

"a+" / "a+b" / "ab+" Read and write new/append to existing text/binary file.

Closing

`fclose(fptr)`; Flushes buffers and closes stream. Returns 0 if successful, EOF otherwise.

Random Access

`ftell(fptr)` Return current file position as a long integer.



File Input/Output (cont)

`fseek(fp, offset, origin);` Sets current file position. Returns *false* if successful, *true* otherwise. The *offset* is a long integer type.

Origins

`SEEK_SET` Beginning of file.

`SEEK_CUR` Current position in file.

`SEEK_END` End of file.

Utilities

`feof(fp)` Tests end-of-file indicator.

`rename(strOldName, strNewName)` Renames a file.

`remove(strName)` Deletes a file.

Characters

`fgetc(fp)` Returns character read or EOF if unsuccessful. (*safe*)

`fputc(int c, fp)` Returns character written or EOF if unsuccessful.

Strings

`fgets(char *s, int n, fp)` Reads *n-1* characters from file *fp* into string *s*. Stops at EOF and `\n`. (*safe*)

`fputs(char *s, fp)` Writes string *s* to file *fp*. Returns non-negative on success, EOF otherwise.

Formatted Data

`fscanf(fp, format, [...])` Same as `scanf` with additional file pointer parameter. (*unsafe*)

`fprintf(fp, format, [...])` Same as `printf` with additional file pointer parameter.

Alternative

File Input/Output (cont)

`fgets(strName, length, fp);` Uses `fgetc` to limit the input length, then uses `sscanf` to read the resulting string in place of `scanf`. (*safe*)

`sscanf(strName, "%d", &x);`

Binary

`fread(void *ptr, sizeof(element), number, fp)` Reads a number of elements from *fp* to array *ptr*. (*safe*)

`fwrite(void *ptr, sizeof(element), number, fp)` Writes a number of elements to file *fp* from array *ptr*.

Safe functions are those that let you specify the length of the input. *Unsafe* functions do not, and carry the risk of memory overflow.

Placeholder Types (f/printf And f/scanf)

`printf("%d%d...", arg1, arg2...);`

Type	Example	Description
<code>%d</code> or <code>%i</code>	-42	Signed decimal integer.
<code>%u</code>	42	Unsigned decimal integer.
<code>%o</code>	52	Unsigned octal integer.
<code>%x</code> or <code>%X</code>	2a or 2A	Unsigned hexadecimal integer.
<code>%f</code> or <code>%F</code>	1.21	Signed decimal float.
<code>%e</code> or <code>%E</code>	1.21e+9 or 1.21E+9	Signed decimal w/ scientific notation.
<code>%g</code> or <code>%G</code>	1.21e+9 or 1.21E+9	Shortest representation of <code>%f/%F</code> or <code>%e/%E</code> .
<code>%a</code> or <code>%A</code>	0x1.207c8ap+30 or 0X1.207C8AP+30	Signed hexadecimal float.
<code>%c</code>	a	A character.
<code>%s</code>	A String.	A character string.



Placeholder Types (f/printf And f/scanf) (cont)

%p	A pointer.
%%	% A percent character.
%n	No output, saves # of characters printed so far. Respective printf argument must be an integer pointer.
The pointer format is architecture and implementation dependant.	

Placeholder Formatting (f/printf And f/scanf)

%[Flags] [Width] [.Precision] [Length] Type

Flags

-	Left justify instead of default right justify.
+	Sign for both positive numbers and negative.
#	Precede with 0, 0x or 0X for %o, %x and %X tokens.
space	Left pad with spaces.
0	Left pad with zeroes.

Width

integer	Minimum number of characters to print: invokes padding if necessary. Will not truncate.
*	Width specified by a preceding argument in printf.

Precision

.integer	Minimum # of digits to print for %d, %i, %o, %u, %x, %X. Left pads with zeroes. Will not truncate. Skips values of 0.
	Minimum # of digits to print after decimal point for %a, %A, %e, %E, %f, %F (default of 6.)
	Minimum # of significant digits to print for %g & %G.
	Maximum # of characters to print from %s (a string.)
.	If no integer is given, default of 0.

Placeholder Formatting (f/printf And f/scanf) (cont)

. * Precision specified by a preceding argument in printf.

Length

hh	Display a char as int.
h	Display a short as int.
l	Display a long integer.
ll	Display a long long integer.
L	Display a long double float.
z	Display a size_t integer.
j	Display a intmax_t integer.
t	Display a ptrdiff_t integer.

Preprocessor Directives

#include	Replaces line with contents of a standard C header file.
#include	Replaces line with contents of a custom header file. <i>Note dir path prefix & quotations.</i>
#define NAME	Replaces all occurrences of NAME with value.

Comments

```
// We're single-line comments!
// Nothing compiled after // on these lines.
/* I'm a multi-line comment!
   Nothing compiled between
   these delimiters. */
```

C Reserved Keywords

_Alignas	break	float	signed
_Alignof	case	for	sizeof
_Atomic	char	goto	static
_Bool	const	if	struct
_Complex	continue	inline	switch
_Generic	default	int	typedef
_Imaginary	do	long	union



C Reserved Keywords (cont)

<code>_Noreturn</code>	<code>double</code>	<code>register</code>	<code>unsigned</code>
<code>_Static_assert</code>	<code>else</code>	<code>restrict</code>	<code>void</code>
<code>_Thread_local</code>	<code>enum</code>	<code>return</code>	<code>volatile</code>
<code>auto</code>	<code>extern</code>	<code>short</code>	<code>while</code>
<code>_A-Z...</code>	<code>__...</code>		

C / POSIX Reserved Keywords

<code>E[0-9]...</code>	<code>E[A-Z]...</code>	<code>is[a-z]...</code>	<code>to[a-z]...</code>
<code>LC_[A-Z]...</code>	<code>SIG[A-Z]...</code>	<code>SIG_[A-Z]...</code>	<code>str[a-z]...</code>
<code>mem[a-z]...</code>	<code>wcs[a-z]...</code>	<code>..._t</code>	

GNU Reserved Names

Header Reserved Keywords

Name	Reserved By Library
<code>d_...</code>	<code>dirent.h</code>
<code>l_...</code>	<code>fcntl.h</code>
<code>F_...</code>	<code>fcntl.h</code>
<code>O_...</code>	<code>fcntl.h</code>
<code>S_...</code>	<code>fcntl.h</code>
<code>gr_...</code>	<code>grp.h</code>
<code>..._MAX</code>	<code>limits.h</code>
<code>pw_...</code>	<code>pwd.h</code>
<code>sa_...</code>	<code>signal.h</code>
<code>SA_...</code>	<code>signal.h</code>
<code>st_...</code>	<code>sys/stat.h</code>
<code>S_...</code>	<code>sys/stat.h</code>
<code>tms_...</code>	<code>sys/times.h</code>
<code>c_...</code>	<code>termios.h</code>
<code>V_...</code>	<code>termios.h</code>
<code>I_...</code>	<code>termios.h</code>
<code>O_...</code>	<code>termios.h</code>
<code>TC_...</code>	<code>termios.h</code>
<code>B[0-9]...</code>	<code>termios.h</code>

GNU Reserved Names

Heap Space

```
#include <stdlib.h>
```

Allocating

`malloc()`; Returns a memory location if successful, `NULL` otherwise.

`type *x; x =` Memory for a variable.

```
malloc(sizeof(type));
```

`type *y; y =` Memory for an array/string.

```
malloc(sizeof(type) *
length);
```

`struct type *z; z =` Memory for a structure.

```
malloc(sizeof(struct
type));
```

Deallocating

`free(ptrName);` Removes the memory allocated to `ptrName`.

Reallocating

`realloc(ptrName, size);` Attempts to resize the memory block assigned to `ptrName`.

The memory addresses you see are from virtual memory the operating system assigns to the program; they are not physical addresses.

Referencing memory that isn't assigned to the program will produce an OS segmentation fault.

The Standard Library

```
#include <stdlib.h>
```

Randomicity

`rand()` Returns a (predictable) random integer between 0 and `RAND_MAX` based on the randomiser seed.

`RAND_MAX` The maximum value `rand()` can generate.

`srand(unsigned integer);` Seeds the randomiser with a positive integer.

`(unsigned) time(NULL)` Returns the computer's tick-tock value. Updates every second.

The Standard Library (cont)

Sorting

```
qsort(array, length, sizeof(type), compFunc);
```

`qsort()` Sort using the QuickSort algorithm.

`array` Array/string name.

`length` Length of the array/string.

`sizeof(type)` Byte size of each element.

`compFunc` Comparison function name.

compFunc

```
int compFunc( const void *a, const void *b ){ return(
    *(int *)a - *(int *)b); }
```

`int compFunc()` Function name unimportant but must return an integer.

`const void *a,`
`const void *b` Argument names unimportant but must be identical otherwise.

`return(*(int *)a` Negative result swaps `b` for `a`, positive result
`- *(int *)b);` swaps `a` for `b`, a result of 0 doesn't swap.

C's inbuilt randomiser is cryptographically insecure: DO NOT use it for security applications.

The Character Type Library

```
#include <ctype.h>
```

`tolower(char)` Lowercase char.

`toupper(char)` Uppercase char.

`isalpha(char)` True if `char` is a letter of the alphabet, false otherwise.

`islower(char)` True if `char` is a lowercase letter of the alphabet, false otherwise.

`isupper(char)` True if `char` is an uppercase letter of the alphabet, false otherwise.

`isnumber(char)` True if `char` is numerical (0 to 9) and false otherwise.

The Character Type Library (cont)

`isblank` True if `char` is a whitespace character (' ', '\t', '\n') and false otherwise.

The String Library

```
#include <string.h>
```

`strlen(a)` Returns # of `char` in string `a` as an integer. Excludes `\0`. (*unsafe*)

`strcpy(a, b)` Copies strings. Copies string `b` over string `a` up to and including `\0`. (*unsafe*)

`strcat(a, b)` Concatenates strings. Copies string `b` over string `a` up to and including `\0`, starting at the position of `\0` in string `a`. (*unsafe*)

`strcmp(a, b)` Compares strings. Returns *false* if string `a` equals string `b`, *true* otherwise. Ignores characters after `\0`. (*unsafe*)

`strstr(a, b)` Searches for string `b` inside string `a`. Returns a pointer if successful, `NULL` otherwise. (*unsafe*)

Alternatives

`strncpy(a, b, n)` Copies strings. Copies `n` characters from string `b` over string `a` up to and including `\0`. (*safe*)

`strncat(a, b, n)` Concatenates strings. Copies `n` characters from string `b` over string `a` up to and including `\0`, starting at the position of `\0` in string `a`. (*safe*)

`strncmp(a, b, n)` Compares first `n` characters of two strings. Returns *false* if string `a` equals string `b`, *true* otherwise. Ignores characters after `\0`. (*safe*)

Safe functions are those that let you specify the length of the input. *Unsafe* functions do not, and carry the risk of memory overflow.



The Time Library

```
#include <time.h>
```

Variable Types

`time_t` Stores the calendar time.

`struct tm *x;` Stores a time & date breakdown.

tm structure members:

`int tm_sec` Seconds, 0 to 59.

`int tm_min` Minutes, 0 to 59.

`int tm_hour` Hours, 0 to 23.

`int tm_mday` Day of the month, 1 to 31.

`int tm_mon` Month, 0 to 11.

`int tm_year` Years since 1900.

`int tm_wday` Day of the week, 0 to 6.

`int tm_yday` Day of the year, 0 to 365.

`int tm_isdst` Daylight saving time.

Functions

`time (NULL)` Returns unix epoch time (seconds since 1/Jan/1970.)

`time (&time_t);` Stores the current time in a `time_t` variable.

`ctime (&time_t)` Returns a `time_t` variable as a string.

`x = localtime (&time_t);` Breaks `time_t` down into `struct tm` members.

Unary Operators

by descending evaluation precedence

`+a` Sum of 0 (zero) and a. ($0 + a$)

`-a` Difference of 0 (zero) and a. ($0 - a$)

`!a` Complement (logical NOT) of a. ($\sim a$)

`~a` Binary ones complement (bitwise NOT) of a. ($\sim a$)

`++a` Increment of a by 1. ($a = a + 1$)

`--a` Decrement of a by 1. ($a = a - 1$)

`a++` Returns a then increments a by 1. ($a = a + 1$)

Unary Operators (cont)

`a--` Returns a then decrements a by 1. ($a = a - 1$)

`(type)a` Typecasts a as `type`.

`&a;` Memory location of a.

`sizeof (a)` Memory size of a (or `type`) in bytes.

Binary Operators

by descending evaluation precedence

`a * b;` Product of a and b. ($a \times b$)

`a / b;` Quotient of dividend a and divisor b. Ensure divisor is non-zero. ($a \div b$)

`a % b;` Remainder of *integers* dividend a and divisor b.

`a + b;` Sum of a and b.

`a - b;` Difference of a and b.

`a << b;` Left bitwise shift of a by b places. ($a \times 2^b$)

`a >> b;` Right bitwise shift of a by b places. ($a \times 2^{-b}$)

`a < b;` Less than. True if a is less than b and false otherwise.

`a <= b;` Less than or equal to. True if a is less than or equal to b and false otherwise. ($a \leq b$)

`a > b;` Greater than. True if a is greater than than b and false otherwise.

`a >= b;` Greater than or equal to. True if a is greater than or equal to b and false otherwise. ($a \geq b$)

`a == b;` Equality. True if a is equal to b and false otherwise. ($a \Leftrightarrow b$)

`a != b;` Inequality. True if a is not equal to b and false otherwise. ($a \neq b$)

`a & b;` Bitwise AND of a and b. ($a \cap b$)

`a ^ b;` Bitwise exclusive-OR of a and b. ($a \oplus b$)

Binary Operators (cont)

`a | b;` Bitwise inclusive-OR of `a` and `b`. ($a \cup b$)

`a && b;` Logical AND. True if both `a` and `b` are non-zero. (Logical AND) ($a \cap b$)

`a || b;` Logical OR. True if either `a` or `b` are non-zero. (Logical OR) ($a \cup b$)

Ternary & Assignment Operators

by descending evaluation precedence

`x ? a : b;` Evaluates `a` if `x` evaluates as true or `b` otherwise. (`(if(x){ a; } else { b; })`)

`x = a;` Assigns value of `a` to `x`.

`a *= b;` Assigns product of `a` and `b` to `a`. ($a = a \times b$)

`a /= b;` Assigns quotient of dividend `a` and divisor `b` to `a`. ($a = a \div b$)

`a %= b;` Assigns remainder of *integers* dividend `a` and divisor `b` to `a`. ($a = a \bmod b$)

`a += b;` Assigns sum of `a` and `b` to `a`. ($a = a + b$)

`a -= b;` Assigns difference of `a` and `b` to `a`. ($a = a - b$)

`a <<= b;` Assigns left bitwise shift of `a` by `b` places to `a`. ($a = a \times 2^b$)

`a >>= b;` Assigns right bitwise shift of `a` by `b` places to `a`. ($a = a \times 2^{-b}$)

`a &= b;` Assigns bitwise AND of `a` and `b` to `a`. ($a = a \cap b$)

`a ^= b;` Assigns bitwise exclusive-OR of `a` and `b` to `a`. ($a = a \oplus b$)

`a |= b;` Assigns bitwise inclusive-OR of `a` and `b` to `a`. ($a = a \cup b$)

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