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.
~~`2001`~~`ASpaceOddysey;` ✘	Doesn't begin with a letter.
~~`while`~~`;` ✘	Reserved keyword.
`how`~~` exciting!`~~`;` ✘	Non-alphanumeric.
~~`iamaverylongvariablenameohmygoshyesiam`~~`;` ✘	
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	$\pm1.2\times10^{-38}$ to $\pm3.4\times10^{38}$
`double`	8 / 4	$\pm2.3\times10^{-308}$ to $\pm1.7\times10^{308}$ **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 RAM **OR** 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`.

Primitive Variable Types (cont)

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

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

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

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

Declaring

`struct strctName varName;`	A variable `varName` as structure type `strctName`.

Structures (cont)

`struct strctName *ptrName;`	A `strctName` structure type pointer, `ptrName`.
`struct strctName{ type a; type b; } varName;`	Shorthand for defining `strctName` and declaring `varName` as that structure type.
`struct strctName varName = { a, b };`	A variable `varName` as structure type `strctName` and initialising its members.

Accessing

`varName.x`	Member `x` of structure `varName`.
`ptrName->x`	Value of structure pointer `ptrName` member `x`.

Bit Fields

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

Array members can't be assigned bit fields.

Type Definitions

Defining

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

Declaring

`uint16 x = 65535;`	Variable `x` as type `uint16`.
`newType y = {0, 0};`	Structure `y` as type `newType`.

Unions

Defining

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

Declaring

`union uN vName;`	A variable `vName` as union type `uN`.

Accessing

`vName.y[int]`	Members cannot store values concurrently. Setting `y` will corrupt `x`.

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

Enumeration

Defining

`enum bool { false, true };`	A custom data type `bool` with two possible states: `false` or `true`.

Declaring

`enum bool varName;`	A variable `varName` of data type `bool`.

Assigning

`varName = true;`	Variable `varName` can only be assigned values of either `false` or `true`.

Evaluating

`if(varName == false)`	Testing the value of `varName`.

Pointers

Declaring

`type *x;`	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 type *y;`	A data structure pointer.
`type z[];`	An array/string name can be used as a pointer to the first 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 *)v`	Dereferencing a `void` pointer as a `type` pointer.

A pointer is a variable that holds a memory location.

Arrays

Declaring

`type name[int];`	You set array length.
`type name[int] = {x, y, z};`	You set array length and initialise elements.
`type name[int] = {x};`	You set array length and initialise all elements to `x`.
`type name[] = {x, y, z};`	Compiler sets array length based on initial 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) / sizeof(arrayType)`	Returns length of `array`. *(Unsafe)*
`sizeof(array) / sizeof(array[0])`	Returns length of `array`. *(Safe)*

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++; ✘
```

`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

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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.

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File Input/Output (cont)

`fseek(fptr, offset, origin);`	Sets current file position. Returns *false* is 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(fptr)`	Tests end-of-file indicator.
`rename(strOldName, strNewName)`	Renames a file.
`remove(strName)`	Deletes a file.
Characters	
`fgetc(fptr)`	Returns character read or EOF if unsuccessful. *(safe)*
`fputc(int c, fptr)`	Returns character written or EOF if unsuccessful.
Strings	
`fgets(char *s, int n, fptr)`	Reads `n-1` characters from file `fptr` into string `s`. Stops at `EOF` and `\n`. *(safe)*
`fputs(char *s, fptr)`	Writes string `s` to file `fptr`. Returns non-negative on success, `EOF` otherwise.
Formatted Data	
`fscanf(fptr, format, [...])`	Same as `scanf` with additional file pointer parameter. *(unsafe)*
`fprintf(fptr, format, [...])`	Same as `printf` with additional file pointer parameter.
Alternative	

File Input/Output (cont)

`fgets(strName, length, fptr); sscanf(strName, "%d", &x);`	Uses `fgets` to limit the input length, then uses `sscanf` to read the resulting string in place of `scanf`. *(safe)*
Binary	
`fread(void *ptr, sizeof(element), number, fptr)`	Reads a `number` of `element`s from `fptr` to array `*ptr`. *(safe)*
`fwrite(void *ptr, sizeof(element), number, fptr)`	Writes a `number` of `element`s to file `fptr` 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
`%d` or `%i`	`-42`	Signed decimal integer.
`%u`	`42`	Unsigned decimal integer.
`%o`	`52`	Unsigned octal integer.
`%x` or `%X`	`2a` or `2A`	Unsigned hexadecimal integer.
`%f` or `%F`	`1.21`	Signed decimal float.
`%e` or `%E`	`1.21e+9` or `1.21E+9`	Signed decimal w/ scientific notation.
`%g` or `%G`	`1.21e+9` or `1.21E+9`	Shortest representation of `%f`/`%F` or `%e`/`%E`.
`%a` or `%A`	`0x1.207c8ap+30` or `0X1.207C8AP+30`	Signed hexadecimal float.
`%c`	`a`	A character.
`%s`	`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 <inbuilt.h>`	Replaces line with contents of a standard C header file.
`#include "./custom.h"`	Replaces line with contents of a custom header file. *Note dir path prefix & quotations.*
`#define NAME value`	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`

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C Reserved Keywords (cont)

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

C / POSIX Reserved Keywords

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

GNU Reserved Names

Header Reserved Keywords

Name	Reserved By Library
d_...	dirent.h
l_...	fcntl.h
F_...	fcntl.h
O_...	fcntl.h
S_...	fcntl.h
gr_...	grp.h
..._MAX	limits.h
pw_...	pwd.h
sa_...	signal.h
SA_...	signal.h
st_...	sys/stat.h
S_...	sys/stat.h
tms_...	sys/times.h
c_...	termios.h
V...	termios.h
I...	termios.h
O...	termios.h
TC...	termios.h
B[0-9]...	termios.h

GNU Reserved Names

Heap Space

#include <stdlib.h>

Allocating

malloc();	Returns a memory location if successful, NULL otherwise.
type *x; x = malloc(sizeof(type));	Memory for a variable.
type *y; y = malloc(sizeof(type) * length);	Memory for an array/string.
struct type *z; z = malloc(sizeof(struct type));	Memory for a structure.

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 identical otherwise.
return(*(int *)a - *(int *)b);	Negative result swaps b for a, positive result 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`. (~a)
`~a`	Binary ones complement (bitwise NOT) of `a`. (~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 × b)
`a / b;`	Quotient of dividend `a` and divisor `b`. Ensure divisor is non-zero. (a ÷ 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 × 2^b)
`a >> b;`	Right bitwise shift of `a` by `b` places. (a × 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 ≤ 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 ≥ b)
`a == b;`	Equality. True if `a` is equal to `b` and false otherwise. (a ⇔ b)
`a != b;`	Inequality. True if `a` is not equal to `b` and false otherwise. (a ≠ b)
`a & b;`	Bitwise AND of `a` and `b`. (a ∩ b)
`a ^ b;`	Bitwise exclusive-OR of `a` and `b`. (a ⊕ b)

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Binary Operators (cont)

`a	b;`	Bitwise inclusive-OR of `a` and `b`. (a $\bigcup$ b)
`a && b;`	Logical AND. True if both `a` and `b` are non-zero. (Logical AND) (a $\bigcap$ b)
`a || b;`	Logical OR. True if either `a` or `b` are non-zero. (Logical OR) (a $\bigcup$ 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 × b)
`a /= b;`	Assigns quotient of dividend `a` and divisor `b` to `a`. (a = a ÷ b)
`a %= b;`	Assigns remainder of *integers* dividend `a` and divisor `b` to `a`. (a = a mod 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 × 2^b)
`a >>= b;`	Assigns right bitwise shift of `a` by `b` places to `a`. (a = a × 2^{-b})
`a &= b;`	Assigns bitwise AND of `a` and `b` to `a`. (a = a $\bigcap$ 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 $\bigcup$ b)

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