

### 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.

### Variables (cont)

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.

~~iamave ryl ong var iab len ame ohm ygo shy esiam;~~  
✗

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
------	-------	-------------



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### Primitive Variable Types (cont)

char	1	unsigned <b>OR</b> signed
unsigned char	1	0 to $2^8-1$
signed char	1	$-2^7$ to $2^7-1$
int	2 / 4	unsigned <b>OR</b> signed
unsigned int	2 / 4	0 to $2^{16}-1$ <b>OR</b> $2^{31}-1$
signed int	2 / 4	$-2^{15}$ to $2^{15}-1$ <b>OR</b> $-2^{31}$ to $2^{32}-1$
short	2	unsigned <b>OR</b> signed
unsigned short	2	0 to $2^{16}-1$
signed short	2	$-2^{15}$ to $2^{15}-1$
long	4 / 8	unsigned <b>OR</b> signed
unsigned long	4 / 8	0 to $2^{32}-1$ <b>OR</b> $2^{64}-1$
signed long	4 / 8	$-2^{31}$ to $2^{31}-1$ <b>OR</b> $-2^{63}$ to $2^{63}-1$

### Primitive Variable Types (cont)

long long	8	unsigned <b>OR</b> 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)
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 $\pm 1.7 \times 10^{308}$ <b>OR</b> 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.)
------------	--



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### Primitive Variable Types (cont)

`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
<code>int8_t</code>	1	$-2^7$ to $2^7-1$
<code>uint8_t</code>	1	0 to $2^8-1$
<code>int16_t</code>	2	$-2^{15}$ to $2^{15}-1$
<code>uint16_t</code>	2	0 to $2^{16}-1$
<code>int32_t</code>	4	$-2^{31}$ to $2^{31}-1$
<code>uint32_t</code>	4	0 to $2^{32}-1$
<code>int64_t</code>	8	$-2^{63}$ to $2^{63}-1$
<code>uint64_t</code>	8	0 to $2^{64}-1$

#### From the `stdbool.h` Library

Type	Bytes	Value Range
------	-------	-------------



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### Extended Variable Types (cont)

`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 structName{ type x; type y; };
```

A structure type `struct` Name 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 structName varName;
```

A variable `varName` as structure type `struct` Name.

```
struct structName *ptrName;
```

A `structName` structure type pointer, `ptrName`.

```
struct structName{ type a; type b; } varName;
```

Shorthand for defining `structName` and declaring `varName` as that structure type.

### Structures (cont)

```
struct structName varName = { a, b };
```

A variable `varName` as structure type `structName` and initialising its members.

#### Accessing

`varName.x`

Member `x` of structure `varName`.

`xptrName->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 `newType` from a structure.



### Type Definitions (cont)

```
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.

```
void *v;
```

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



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### Pointers (cont)

<code>struct type *y;</code>	A data structure pointer.
<code>type z[];</code>	An array/string name can be used as a pointer to the first array element.
<b>Accessing</b>	
<code>x</code>	A memory address.
<code>*x</code>	Value stored at that address.
<code>y-&gt;a</code>	Value stored in structure pointer <code>y</code> member <code>a</code> .
<code>&amp;varName</code>	Memory address of normal variable <code>varName</code> .
<code>*(type *)v</code>	Dereferencing a void pointer as a type pointer.

A pointer is a variable that holds a memory location.

### Arrays

#### Declaring

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

### Arrays (cont)

<code>type name[int] = {x};</code>	You set array length and initialise all elements to <code>x</code> .
<code>type name[] = {x, y, z};</code>	Compiler sets array length based on initial elements.

*Size cannot be changed after declaration.*

#### Dimensions

<code>name[int]</code>	One dimension array.
<code>name[int][int]</code>	Two dimensional array.

#### Accessing

<code>name[int]</code>	Value of element <code>int</code> in array <code>name</code> .
<code>*(name + int)</code>	Same as <code>name[int]</code> .

*Elements are contiguously numbered ascending from 0.*

<code>&amp;name[int]</code>	Memory address of element <code>int</code> in array <code>name</code> .
<code>name + int</code>	Same as <code>&amp;name[int]</code> .

*Elements are stored in contiguous memory.*

#### Measuring

<code>sizeof(array) / sizeof(arrayType)</code>	Returns length of array. ( <i>Unsafe</i> )
--	--



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### Arrays (cont)

`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

### Escape Characters (cont)

\? 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.



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### Functions (cont)

`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/string 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 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 `n`.)*

`type funcName([args...])` Same type, `n` and `args...` respective function

`;` Semicolon instance function delimit



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### 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.

### Conditional (Branching) (cont)

```
if(a){ b; }else if(c){ d; }else{ e; }
```

#### switch, case, break

```
switch(a){ case b: c; }
```

```
switch(a){ default: b; }
```

```
switch(a){ case b: case c: d; }
```

```
switch(a){ case b: c; case d: e; default: f; }
```

```
switch(a){ case b: c; break; case d: e; break; default: f; }
```



### 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.

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)
```

### Iterative (Looping) (cont)

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.*



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### Console Input/Output

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

#### Characters

<code>getchar()</code>	Returns a single character's ANSI code from the input stream buffer as an <i>integer</i> . ( <i>safe</i> )
<code>putchar(int)</code>	Prints a single character from an ANSI code <i>integer</i> to the output stream buffer.

#### Strings

<code>gets(strName)</code>	Reads a line from the input stream into a string variable. ( <i>Unsafe, removed in C11.</i> )
----------------------------	---

#### Alternative

<code>fgets(strName, length, stdin);</code>	Reads a line from the input stream into a string variable. ( <i>Safe</i> )
---	--


<code>puts("string")</code>	Prints a string to the output stream.
-----------------------------	---------------------------------------

#### Formatted Data

### Console Input/Output (cont)

<code>scanf("%d", &amp;x)</code>	Read value/s (type defined by format string) into variable/s (type must match) from the input stream. Stops reading at the first whitespace. <i>&amp;</i> prefix not required for arrays (including strings.) ( <i>unsafe</i> )
<code>printf("I love %c %d!", 'C', 99)</code> <code>)</code>	Prints data (formats defined by the format string) as a string to the output stream.

#### Alternative

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### Console Input/Output (cont)

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

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.

### File Input/Output (cont)

Mode	Description
<code>String</code>	String containing file's directory path & name.
<code>mode</code>	String specifying the file access mode.
<code>"r" / "rb"</code>	Read existing text/binary file.
<code>"w" / "wb"</code>	Write new/over existing text/binary file.
<code>"a" / "ab"</code>	Write new/append to existing text/binary file.
<code>"r+" / "rb+" / "r+b"</code>	Read and write existing text/binary file.
<code>"w+" / "wb+" / "w+b"</code>	Read and write new/over existing text/binary file.
<code>"a+" / "ab+" / "a+b"</code>	Read and write new/append to existing text/binary file.

### Closing



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### File Input/Output (cont)

`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.

`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

### File Input/Output (cont)

`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



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### File Input/Output (cont)

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

### Binary

```
fread(void *ptr, sizeof(element), number, fptr)
```

```
fwrite(void *ptr, sizeof(element), number, fptr)
```

*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.

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

%u	Uses fge	42	Unsigned decimal integer.
%o	ts to limit	52	Unsigned octal integer.
%x or %X	the input length, then uses	2a or 2A	Unsigned hexadecimal integer.
%f or %F	scanf to	1.21	Signed decimal float.
%e or %E	read the resulting	1.21e+9 or 1.21E+9	Signed decimal w/ scientific notation.
%g or %G	string in place of s	1.21e+9 or 1.21E+9	Shortest representation of %f/%F or %e/%E.
%a or %A	scanf. (safe)	0x1.207c8ap+30 or 0X1.207C8AP+30	Signed hexadecimal float.
%c	Reads a n	a	A character.
%s	umber of	A String.	A character string.
%p	elements		A pointer.
%%	from fptr	%	A percent character.

to array \*  
ptr.  
(safe)

Writes a n  
umber of  
elements  
to file fpt  
r from  
array \*pt  
r.



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

`%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`.

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

#### 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.
- . \* 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.



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

j	Display a <code>intmax_t</code> integer.
t	Display a <code>ptrdiff_t</code> integer.

### Preprocessor Directives

<code>#include &lt;inbuilt.h&gt;</code>	Replaces line with contents of a standard C header file.
<code>#include "./custom.h"</code>	Replaces line with contents of a custom header file. <i>Note dir path prefix &amp; quotations.</i>
<code>#define NAME value</code>	Replaces all occurrences of <code>NAME</code> with <code>value</code> .

### 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

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



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### 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

### Header Reserved Keywords (cont)

#### GNU Reserved Names

### Heap Space

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

#### Allocating

```
malloc();
```

```
type *x; x = malloc(sizeof(type));
```

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

```
struct type *z; z = malloc(sizeof(struct type));
```

#### Deallocating

```
free(ptrName);
```

#### Reallocating



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### Heap Space (cont)

`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),
```

`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 compFunc()` Function name unimportant.

`const void *a, const void *b` Argument names unimportant.

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

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



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### The Character Type Library

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

<code>tolower(char)</code>	Lowercase char.
<code>toupper(char)</code>	Uppercase char.
<code>isalpha(char)</code>	True if <code>char</code> is a letter of the alphabet, false otherwise.
<code>islower(char)</code>	True if <code>char</code> is a lowercase letter of the alphabet, false otherwise.
<code>isupper(char)</code>	True if <code>char</code> is an uppercase letter of the alphabet, false otherwise.
<code>isnumber(char)</code>	True if <code>char</code> is numerical (0 to 9) and false otherwise.
<code>isblank</code>	True if <code>char</code> is a whitespace character (' ', '\t', '\n') and false otherwise.

### The String Library

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

<code>strlen(a)</code>	Returns # of <code>char</code> in string <code>a</code> as an integer. Excludes <code>\0</code> . ( <i>unsafe</i> )
<code>strcpy(a, b)</code>	Copies strings. Copies string <code>b</code> over string <code>a</code> up to and including <code>\0</code> . ( <i>unsafe</i> )
<code>strcat(a, b)</code>	Concatenates strings. Copies string <code>b</code> over string <code>a</code> up to and including <code>\0</code> , starting at the position of <code>\0</code> in string <code>a</code> . ( <i>unsafe</i> )
<code>strcmp(a, b)</code>	Compares strings. Returns <i>false</i> if string <code>a</code> equals string <code>b</code> , <i>true</i> otherwise. Ignores characters after <code>\0</code> . ( <i>unsafe</i> )
<code>strstr(a, b)</code>	Searches for string <code>b</code> inside string <code>a</code> . Returns a pointer if successful, <code>NULL</code> otherwise. ( <i>unsafe</i> )

#### Alternatives

<code>strncpy(a, b, n)</code>	Copies strings. Copies <code>n</code> characters from string <code>b</code> over string <code>a</code> up to and including <code>\0</code> . ( <i>safe</i> )
-------------------------------	--



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### The String Library (cont)

<code>strncat(a, b, n)</code>	Concatenates strings. Copies <code>n</code> characters from string <code>b</code> over string <code>a</code> up to and including <code>\0</code> , starting at the position of <code>\0</code> in string <code>a</code> . ( <i>safe</i> )
<code>strncmp(a, b, n)</code>	Compares first <code>n</code> characters of two strings. Returns <i>false</i> if string <code>a</code> equals string <code>b</code> , <i>true</i> otherwise. Ignores characters after <code>\0</code> . ( <i>safe</i> )

*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

<code>time_t</code>	Stores the calendar time.
<code>struct tm *x;</code>	Stores a time & date breakdown.
<i>tm structure members:</i>	
<code>int tm_sec</code>	Seconds, 0 to 59.
<code>int tm_min</code>	Minutes, 0 to 59.
<code>int tm_hour</code>	Hours, 0 to 23.
<code>int tm_mday</code>	Day of the month, 1 to 31.

### The Time Library (cont)

<code>int tm_mon</code>	Month, 0 to 11.
<code>int tm_year</code>	Years since 1900.
<code>int tm_wday</code>	Day of the week, 0 to 6.
<code>int tm_yday</code>	Day of the year, 0 to 365.
<code>int tm_isdst</code>	Daylight saving time.

#### Functions

<code>time(NULL)</code>	Returns unix epoch time (seconds since 1/Jan/1970.)
<code>time(&amp;time_t);</code>	Stores the current time in a <code>time_t</code> variable.
<code>ctime(&amp;time_t)</code>	Returns a <code>time_t</code> variable as a string.
<code>x = localtime( &amp;time_t);</code>	Breaks <code>time_t</code> down into <code>struct tm</code> members.

### Unary Operators

*by descending evaluation precedence*

<code>+a</code>	Sum of 0 (zero) and <code>a</code> . ( <code>0 + a</code> )
<code>-a</code>	Difference of 0 (zero) and <code>a</code> . ( <code>0 - a</code> )
<code>!a</code>	Complement (logical NOT) of <code>a</code> . ( <code>~a</code> )



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### Unary Operators (cont)

<code>~a</code>	Binary ones complement (bitwise NOT) of <code>a</code> . ( <code>~a</code> )
<code>++a</code>	Increment of <code>a</code> by 1. ( <code>a = a + 1</code> )
<code>--a</code>	Decrement of <code>a</code> by 1. ( <code>a = a - 1</code> )
<code>a++</code>	Returns <code>a</code> then increments <code>a</code> by 1. ( <code>a = a + 1</code> )
<code>a--</code>	Returns <code>a</code> then decrements <code>a</code> by 1. ( <code>a = a - 1</code> )
<code>(type)a</code>	Typecasts <code>a</code> as <code>type</code> .
<code>&amp;a;</code>	Memory location of <code>a</code> .
<code>sizeof(a)</code>	Memory size of <code>a</code> (or <code>type</code> ) in bytes.

### Binary Operators

*by descending evaluation precedence*

<code>a * b;</code>	Product of <code>a</code> and <code>b</code> . ( <code>a × b</code> )
<code>a / b;</code>	Quotient of dividend <code>a</code> and divisor <code>b</code> . Ensure divisor is non-zero. ( <code>a ÷ b</code> )
<code>a % b;</code>	Remainder of <i>integers</i> dividend <code>a</code> and divisor <code>b</code> .
<code>a + b;</code>	Sum of <code>a</code> and <code>b</code> .
<code>a - b;</code>	Difference of <code>a</code> and <code>b</code> .

### Binary Operators (cont)

<code>a &lt;&lt; b;</code>	Left bitwise shift of <code>a</code> by <code>b</code> places. ( <code>a × 2<sup>b</sup></code> )
<code>a &gt;&gt; b;</code>	Right bitwise shift of <code>a</code> by <code>b</code> places. ( <code>a × 2<sup>-b</sup></code> )
<code>a &lt; b;</code>	Less than. True if <code>a</code> is less than <code>b</code> and false otherwise.
<code>a &lt;= b;</code>	Less than or equal to. True if <code>a</code> is less than or equal to <code>b</code> and false otherwise. ( <code>a ≤ b</code> )
<code>a &gt; b;</code>	Greater than. True if <code>a</code> is greater than <code>b</code> and false otherwise.
<code>a &gt;= b;</code>	Greater than or equal to. True if <code>a</code> is greater than or equal to <code>b</code> and false otherwise. ( <code>a ≥ b</code> )
<code>a == b;</code>	Equality. True if <code>a</code> is equal to <code>b</code> and false otherwise. ( <code>a ↔ b</code> )
<code>a != b;</code>	Inequality. True if <code>a</code> is not equal to <code>b</code> and false otherwise. ( <code>a ≠ b</code> )
<code>a &amp; b;</code>	Bitwise AND of <code>a</code> and <code>b</code> . ( <code>a ∧ b</code> )
<code>a ^ b;</code>	Bitwise exclusive-OR of <code>a</code> and <code>b</code> . ( <code>a ⊕ b</code> )



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### Binary Operators (cont)

<code>a   b;</code>	Bitwise inclusive-OR of <code>a</code> and <code>b</code> . ( <code>a   b</code> )
<code>a &amp;&amp; b;</code>	Logical AND. True if both <code>a</code> and <code>b</code> are non-zero. (Logical AND) ( <code>a &amp; b</code> )
<code>a    b;</code>	Logical OR. True if either <code>a</code> or <code>b</code> are non-zero. (Logical OR) ( <code>a   b</code> )

### Ternary & Assignment Operators

*by descending evaluation precedence*

<code>x ? a : b;</code>	Evaluates <code>a</code> if <code>x</code> evaluates as true or <code>b</code> otherwise. ( <code>(if(x){ a; } else { b; })</code> )
<code>x = a;</code>	Assigns value of <code>a</code> to <code>x</code> .
<code>a *= b;</code>	Assigns product of <code>a</code> and <code>b</code> to <code>a</code> . ( <code>a = a * b</code> )
<code>a /= b;</code>	Assigns quotient of dividend <code>a</code> and divisor <code>b</code> to <code>a</code> . ( <code>a = a / b</code> )
<code>a %= b;</code>	Assigns remainder of <i>integers</i> dividend <code>a</code> and divisor <code>b</code> to <code>a</code> . ( <code>a = a mod b</code> )
<code>a += b;</code>	Assigns sum of <code>a</code> and <code>b</code> to <code>a</code> . ( <code>a = a + b</code> )

### Ternary & Assignment Operators (cont)

<code>a -= b;</code>	Assigns difference of <code>a</code> and <code>b</code> to <code>a</code> . ( <code>a = a - b</code> )
<code>a &lt;&lt;= b;</code>	Assigns left bitwise shift of <code>a</code> by <code>b</code> places to <code>a</code> . ( <code>a = a * 2<sup>b</sup></code> )
<code>a &gt;&gt;= b;</code>	Assigns right bitwise shift of <code>a</code> by <code>b</code> places to <code>a</code> . ( <code>a = a * 2<sup>-b</sup></code> )
<code>a &amp;= b;</code>	Assigns bitwise AND of <code>a</code> and <code>b</code> to <code>a</code> . ( <code>a = a &amp; b</code> )
<code>a ^= b;</code>	Assigns bitwise exclusive-OR of <code>a</code> and <code>b</code> to <code>a</code> . ( <code>a = a ^ b</code> )
<code>a  = b;</code>	Assigns bitwise inclusive-OR of <code>a</code> and <code>b</code> to <code>a</code> . ( <code>a = a   b</code> )

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