global variables

Variables declared outside any function are available to all functions
They are called *external* variables or *global* variables

```
int g = 12;

void f(void) {
    printf("The value of g is %d\n", g); // prints 12
    g = 42;
}

int main(void) {
    f();
    printf("The value of g is %d\n", g); // prints 42
    return 0;
}
```

global variables

- Avoid global variables - **NOT** needed in COMP1511
- make concurrency (threads) problematic
- creating hidden depenencies between parts of program
- make code reuse harder
- pollute the namespace - create a valid name everywhere you might accidentally use
- generally reduce readability
- global variable can be useful for "meta"-purposes
  e.g turning on-off debug logging through your program

static functions

- functions are shared between files by default
- this is undesirable in large programs
  because name clashes become likely
- name clashes also make code reuse difficult
- **static** keyword makes function visible only within file
  in other words **static** limits function's *scope*
- if a function doesn't need to be visible declare it static, e.g:

```
static double helper_function(int x, double y);
```

- allows files to be *de facto* modules in C
- similarly **static** makes global variables visible only within file
- beware **static** different meaning for local (function) variables

Static Function Variables

- when a function is called its variables are created
- when a function returns its variables are destroyed
- **static** changes *lifetime* of a function (local) variable
- value preserved between function calls
- static variables make concurrency difficult and programs harder to reader and understand
- rarely good reason to use static variables
- do **NOT** use in COMP1511
- note very different meaning to using **static** oustide functions poor language design

Static Variables

For example, here is a function that coutns how many times its has been called

```
void count(void) {
   static int call_count = 0;
   call_count++;
   printf("I have been called %d times\n", call_count);
}
```

More C Operators

C provides some additional operators, which allow for shorter statements which can make your code a little more readable, or a lot less readable.

- pre/post-increment: `++i, i++` same as `i = i + 1`
- pre/post-decrement: `--i, i--` same as `i = i - 1`
- compound assignment operators:
  - `a += b` same as `a = a + b`
  - `a -= 5` same as `a = a - 5`
  - `a *= -10` same as `a = a * -10`
  - `a /= 2` same as `a = a / 2`
  - `a %= b` same as `a = a % b`

Increment and Decrement Operators In Expressions

++ and -- can be used in in expressions
NOT recommended in COMP1511

They can be used *after* the variable:

```
k = 7;
n = k--;  // assign k to n, then decrement k by 1
printf("%d %d", k, n) // k=6, n=7
```

They can be used *before* the variable:

```
k = 7;
n = --k; // decrement k by 1, then assign k to n
printf("%d %d", k, n) // k=6, n=6
```

The *for* loop

There is also a construct called the *for* Loop:

```
for (expr1; expr2; expr3) {
    statements;
}
```

- *expr1* is evaluated before the loop starts.
- *expr2* is evaluated at the beginning of each loop;
  if it is non-zero, the loop is repeated.
- *expr3* is evaluated at the end of each loop.

Example of *for* loop

```
for (x = 1; x <= 10; x++) {
   printf("%d\n", x * x);
}
```

Can declare variable if used only within for loop:

```
for (int x = 1; x <= 10; x++) {
   printf("%d\n", x * x);
}
```

for loops and *while* loops

These two are equivalent:

```
for (expr1; expr2; expr3) {
    statements;
}
```

```
expr1;
while (expr2) {
    statements;
    expr3;
}
```

Counting Down to Zero

Any of the 3 expressions in the *for* loop may be omitted
';' must still be present. For example:

```
printf("Enter starting number for Countdown: ");
scanf("%d", &n); // initial value entered by user
for (; n >= 0; n--) {
   printf("%d\n", n );
}
printf("Blast Off!\verb|\n|");
```

for Loop expressions

Although **NOT recommended**, the comma operator ',' can be used to squeeze multiple statements into *expr1* and *expr3*. For example,

```
for (int x=0, y=2; x < MAX; x++, y++) {
    ...
}
```

break and *continue*

- *break* causes a loop to terminate; no more iterations are performed, and execution moves to whatever comes after the loop.
- *continue* causes the *current* iteration of the loop to terminate; execution moves to the next iteration.
  - with *while* and *do* loops, the conditional expression is tested before moving to the next iteration
  - with *for* loops, *expr3* is executed, then *expr2* is tested before moving to the next iteration
- *break* and *continue* used sparingly can make code more readable
- overuse of *break* and *continue* can make code incomprehensible

break and *continue*

Here is a typical use of *break*:

```
for (int i = 0; i < LIMIT; i++) {

  // lots of complex things happens here

  if (/* need to stop loop immediately */) {
     break; // exit loop immediately
  }

  // lots more complex things happens here
}
```

break and *continue* Statement

Here is a typical use of *continue*:

```
for (int i = 0; i < LIMIT; i++) {

  // lots of complex things happens here

  if (/* this is not what is wanted */) {
     continue; // got next loop iteration
  }

  // lots more complex things happens here
}
```

Exiting A Program

- In main **return** will terminate program
- **stdlib.h** provides a function useful outside main::

```
void exit(int status);
```

- status passed to exit same a return value of main
- **stdlib.h** defines **EXIT_SUCCESS** and **EXIT_FAILURE**
- **EXIT_SUCCESS** program executed successfully
- **EXIT_FAILURE** program stopped due to an error
- **EXIT_SUCCESS** == 0 on unix-like and almost all other systems

Implicit Type Conversions

Recall that C supports ‘hybrid’ arithmetic operations involving certain types, in a way that mirrors our expectations. For example:

```
3 + 5.8
```

An integer is added to a double, giving a double result. However, at the machine level floating point addition requires two double arguments and is a distinct operation from integer addition.

Implicit Type Conversions

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Implicit Conversions

The compiler steps in and performs an automatic conversion, known as a *cast*, from integer to double.

```
double d = 3;  // 3 is converted to double
int i = 5;
d = d + i;     // i is converted to double
```

Implicit Type Conversions

Implicit conversions are generally performed when considered 'safe', e.g., numeric types are converted to other numeric types with larger capacity. But sometimes unsafe implicit conversions are also performed, a common criticism of C. Consider:

```
int i = 1000;
char c1 = 100;  // statically checked, OK
char c2 = 1000; // statically checked, warning
char c3 = i;    // no warning
```

NB

You should be mindful of implicit conversions, often they make coding easier, but sometimes they can mask programming errors!

Explicit Type Conversions

C allows us to perform our own, explicit type casts, using the syntax `(`*type*`)`. For example:

```
double d1 = 1 / 2;
double d2 = 1 / (double) 2;
```

Will the values of `d1` and `d2` be different?

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double d1 = 1 / 2;
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```

Will the values of `d1` and `d2` be different? Yes!

It is good programming style to identify potentially unsafe implicit conversions and make them explicit:

```
#include <limits.h>
#include <assert.h>
...
assert(i >= CHAR_MIN && i <= CHAR_MAX);
char c = (char) i;  // for some int i
```

Explicit Type Conversions

NB

When using explicit casts the compiler will often assume that you know what you are doing and not issue warnings even when a cast is very likely unsafe!

For example:

```
int i = 1000;
char c = (char) i;
int *ip = (int *) i;
int nums[] = {0};
printf("%c\n", (char) i);
printf("%s\n", (char *) &i);
printf("%s\n", (char *) nums);
```

Casts are used here to view one type as another, often dangerous!