Types

There are only 10 types of people in this world; those who understand binary and those who don't.
Variables

We (hopefully) know that if you say:

```c
int x;
```

You ask the computer for a variable called `x`.

Each variable actually has an associated type describing what information it holds (i.e. what can you put in the box, how big is it, etc.).
Fundamental Types

- **bool** - true or false
- **char** - (character) A letter or number
- **int** - (integer) Whole numbers
- **long** - (long integers) Larger whole numbers
- **float** - Decimal numbers
- **double** - Larger decimal numbers

See: intVSLong.cpp
int vs long?

**int** - Whole numbers in the approximate range: -2.14 billion to 2.14 billions ($10^9$)

**long** - Whole numbers in the approximate range: -9.22 quintillion to 9.22 quintillion ($10^{18}$)

Using **int** is standard (unless you really need more space, for example scientific computing)
float vs double?
float vs double?

**float** is now pretty much obsolete.

**double** takes twice as much space in the computer and 1) has wider range and 2) is more precise

Bottom line: use **double** (unless for a joke)
float and double

Both stored in scientific notation

```c
double x = 2858291;
```

Computer's perspective:

```c
x = 2.858291e6
  or
x = 2.858291 * 10^6
```
Welcome to binary

<table>
<thead>
<tr>
<th>Decimal:</th>
<th>Binary:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1/2 = 0.5$</td>
<td>0.1</td>
</tr>
<tr>
<td>$1/3 = 0.3333333$</td>
<td>0.0101010101010101</td>
</tr>
<tr>
<td>$1/10 = 0.1$</td>
<td>0.00011001100110011</td>
</tr>
</tbody>
</table>

*double* is often just an approximation!
Numerical analysis

Field of study for (reducing) computer error

See: subtractionError.cpp

Can happen frequently when solving system of linear equations
bool

bool - either true or false

You have the common math comparisons:
> (greater than), e.g. 7 > 2.5 is true
== (equals), e.g. 5 == 4 is false
<= (less than or eq), e.g. 1 <= 1 is true

Note: double equals ( == ) asks a question, a single equals ( = ) changes values
bool

You can use integers to represent bool also.

false = 0
true = anything else (1 is what is stored)

(You probably won't need to do this)
int or double?

If you are counting something (money), use `int`

If you are dealing with abstract concepts (physics), use `double`

`int` doesn't make “rounding” mistakes
Double trouble!

(See: doubleTrouble.cpp)
Double trouble!

When comparing doubles, you should use check to see if relative error is small:

\[ \text{fabs}((x-y)/x) < 10E-10 \]

\textit{(double} has about 16 digits of accuracy so you could go to 10E-15 if you want)\textit{)}

For comparing Strings, use: (0 if same)
\texttt{string1.compare(string2)}
Primitive type hierarchy

bool < int < long < float < double

If multiple primitive types are mixed together in a statement, it will convert to the largest type present

Otherwise it will not convert type
Primitive type hierarchy

```
int x;
double y;

x+y

Converted to double
```

```
int x;
int y;

x/y

Not converted (still int)
```
Integer division

See: simpleDivision.cpp
Can be fixed by making one a double:
\[ 1/2.0 \]
or
\[ \text{static
cast<double>}(1)/2 \]
You can also make a “constant” by adding `const` before the type.

This will only let you set the value once.

```plaintext
const double myPI = 3.14;
myPI = 7.23;  // unhappy computer!
```
Functions

Functions allow you to reuse pieces of code (either your own or someone else's)

Every function has a return type, specifically the type of object returned

sqrt(2) returns a double, as the number will probably have a fractional part

The “2” is an argument to the sqrt function
Functions

Functions can return **void**, to imply they return nothing (you should not use this in an assignment operation)

The return type is found right before the functions name/identifier.

```c
int main() { ... means main returns an int type, which is why we always write return 0 and not return 'a' (there is no char main())
```
A wide range of math functions are inside `<cmath>` (get it by `#include <cmath>;` at top).

We can use these functions to compute Snell's Law for refraction angle.

(See: `math.cpp`)