C++ Basics

I'm sorry, you're basic.
Announcements

Lab 1 this week!

Homework posted Friday (will be on gradescope)
Avoid errors

To remove your program of bugs, you should try to test your program on a wide range of inputs.

Typically it is useful to start with a small piece of code that works and build up rather than trying to program everything and then debug for hours.
Variables

Variables are objects in program

To use variables two things must be done:
  - Declaration
  - Initialization

See: uninitialized.cpp

Example if you forget to initialize:
  I am 0 inches tall.
  I am -1094369310 inches tall.
Variables

```c
int x, y, z;
```

```c
x = 2;
y = 3;
z = 4;
```

Same as:

```c
int x=2, y=3, z=4;
```

Variables can be declared anywhere (preferably at start)
Assignment operator

= is the assignment operator

The object to the right of the equals sign is stored into the object in the left

```cpp
int x, y;
y = 2;
x = y+2;
```

See: assignmentOp.cpp
Assignment operator

= is NOT a mathematic equals

x=3;
x=4;  // computer is happy!

This does not mean 3=4
Assignment operator

To the left of = needs to be a valid object that can store the type of data on the right

```java
int x;
x=2.6; // unhappy, 2.6 is not an integer

x+2 = 6; // x+2 not an object

2 = x; // 2 is a constant, cannot store x
```
Assignment operator

What does this code do?

```c
int x = 2, y = 3;
y = x;
x = y;
```

What was the intention of this code?
Increment operators

What does this code do?

```c
int x = 2;
x=x+1;
```
What does this code do?

```c
int x = 2;
x=x+1;
```

Same as:

```c
x+=1;
```
or

```c
x++;
```
Increment operators

Two types of increment operators:

x++;  // increments after command

vs

++x;  // increments before command
Complex assignments

The following format is general for common operations:

variable (operator)= expression
variable = variable (operator) expression

Examples:

\[ x += 2 \quad \leftrightarrow \quad x = x + 2 \]
\[ x *= y + 2 \quad \leftrightarrow \quad x = x * (y + 2) \]
Order of operations

Order of precedence (higher operations first):
- -, +, ++, -- and ! (unary operators)
* *, / and % (binary operators)
+ and - (binary operators)

% is remainder operator
(example later in simpleDivision.cpp)
Order of operations

Binary operators need two arguments
Examples: 2+3, 5/2 and 6%2

Unary operators require only one argument:
Examples: (see binaryVsUnaryOps.cpp) +x, x++, !x

(! is the logical inversion operator for bool)
Identifiers

Hello, my name is

Inigo Montoya
You killed my Father
Prepare to die
Identifiers

An identifier is the name of a variable (or object, class, method, etc.)

- Case sensitive
- Must use only letters, numbers or _
- Cannot start with a number
- (Some reserved identifiers, like main)
Identifiers

Already did this in week 1!
See: RuntimeError.cpp

```cpp
#include <iostream>
using namespace std;

int main()
{
    int number;
    cout << "What is your lucky number?" << endl;
    cin >> number;
    cout << "I like " << number << "!\n";
    return 0;
}
```
Identifiers

Which identifiers are valid?
1) james parker
2) BoByBoY
3) x3
4) 3x
5) x_______
6) ________x
7) Home.Class
8) Five%
9) x-1
Which identifiers are valid?

1) *james parker*
2) BoByBoY
3) x3
4) *3x*
5) x_______
6) _______x
7) *Home.Class*
8) *Five%*
9) x 1
Identifiers

(See: float.cpp)

```cpp
int main()
{
    float Float, fLoat, fl0at, FLOAt, FLOAT;
    Float = 1;
    fLoat = 2;
    fl0at = -3;
    FLOAT = 2;
    FLOAt = 4;
    cout << (-fLoat + floAT(fLoat*fLoat - FLOAt * Float * fl0at))/(FLOAT*FloAt);
    cout << (-fLoat - floAT(fLoat*fLoat - FLOAt * Float * fl0at))/(FLOAT*FloAt);
    return 0;
}
```
Identifiers
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:

```
int x;
```

You ask the computer for a variable called \textit{x}

Each variable actually has an associated \textit{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: intVSlon.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

double \texttt{x} = 2858291;

Computer's perspective:
\texttt{x} = 2.858291e6
or
\texttt{x} = 2.858291 \times 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>$0.010101010101$</td>
</tr>
<tr>
<td>$1/10 = 0.1$</td>
<td>$0.0001100110011$</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
You can use integers to represent `bool` also.

`false = 0`
`true = anything else`

(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
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

static_cast<double>(1)/2

7 ÷ 2 = 3 R 1

Remainder
You can also make a “constant” by adding `const` before the type

This will only let you set the value once

```cpp
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()`)
Functions

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)
Input and output

C:\> If you’re happy and you know it, syntax error!
Syntax error

C:\> If you’re happy and you know it, syntax error!
Syntax error

C:\> If you’re happy and you know it, and you really want to show it. If you’re happy and you know it, syntax error!
Syntax error

C:\> _
Strings and input

char can only hold a single letter/number, but one way to hold multiple is a string

string str;
cin >> str;

The above will only pull one word, to get all words (until enter key) use:

getline(cin, str);  (See: stringInput.cpp)
When showing doubles with cout, you can change how they are shown.

For example, to show a number as dollars and cents, you would type (before cout):

```cpp
cout.setf(ios::fixed);
cout.setf(ios::showpoint);
cout.precision(2);
```
More Output

There are two ways to get output to move down a line: `endl` and `"\n"

```cpp
    cout << endl;
```

... is the same as...

```cpp
    cout << "\n"
```

I will use both when coding
Madlibs

(see: madlibs.cpp)
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

If you cout this, “false” will be 0
and “true” will be 1 (anything non-zero is T)
Double trouble!

(See: doubleCompare.cpp)
Double trouble!

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

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

(doubles has about 16 digits of accuracy so you could go to \(10\times 10^{-15}\) if you want)

For comparing Strings, use: (0 if same)

\text{string1.compare(string2)}