LOOPS AND FUNCTIONS

Announcements

- Office hours have been moved to MLH 301
- Also... new office hours on Tuesdays, 5:30 - 8 PM
- Sample code posted
- Homework 1 will be posted by class time on Wednesday!

Quick Review...

- variables, data types, expressions
  - declare an unsigned integer named **score**
  - declare a double-precision floating-point value named **distance** with an initial value of 43.523
- conditional statements
- print "hello" if both of these are true:
  - **distance** is less than 25.0
  - a bool named **running** is true or **score** is greater than 100

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

int main()
{
    int gazonk, foo = 2 * 5;
    int baz = 10 - foo;

    if( baz )
        if( foo )
            cout << "Alpha" << endl;
    else
        cout << "Beta" << endl;

    cout << "gazonk: " << gazonk << endl;

    return 0;
}
```

Quick Review 2...

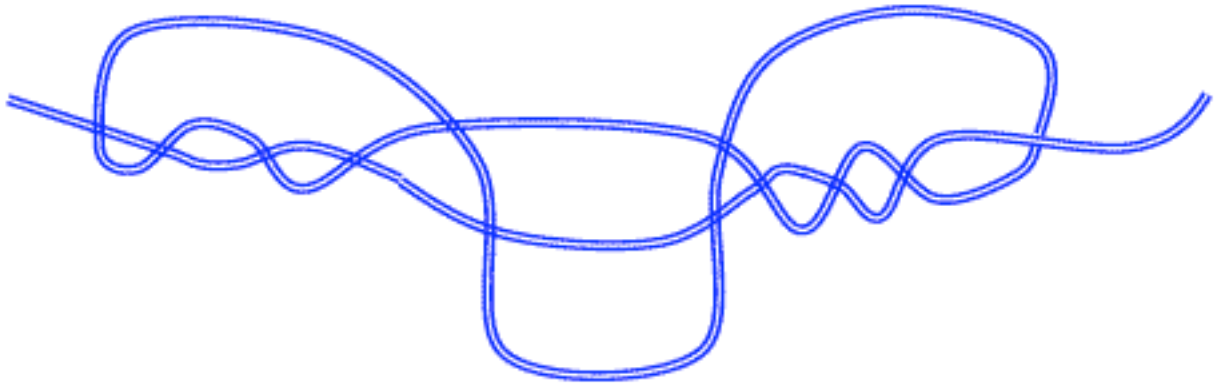
What is the output of this program?

Quick Review 3...

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

int main()
{
    double foo = (2.0 * 5.0) / 1.0;
    int baz = 10 - foo;

    if( baz )
        cout << "Alpha" << endl;

    return 0;
}
```

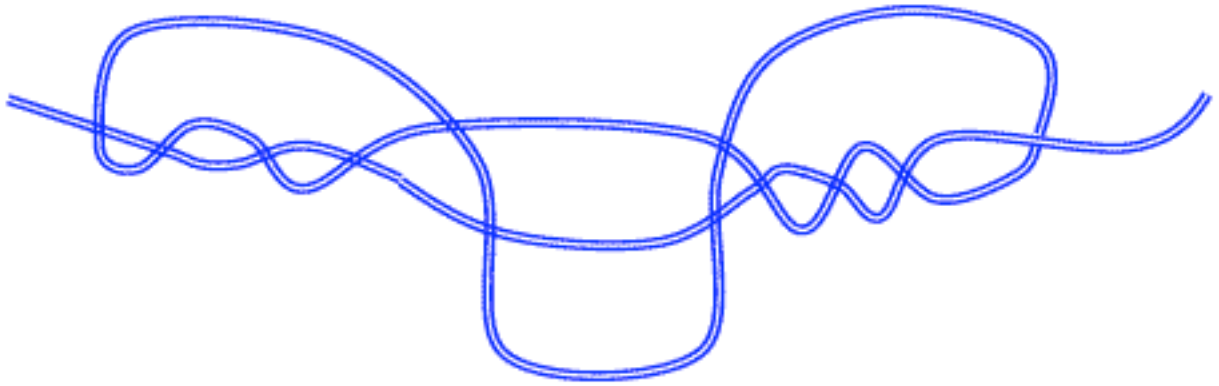
What is the output of this program?

LOOPS



- Computers are very good at doing repetitive tasks
- Loops aid in doing repetitive work
- Nearly all complex programs will have loops

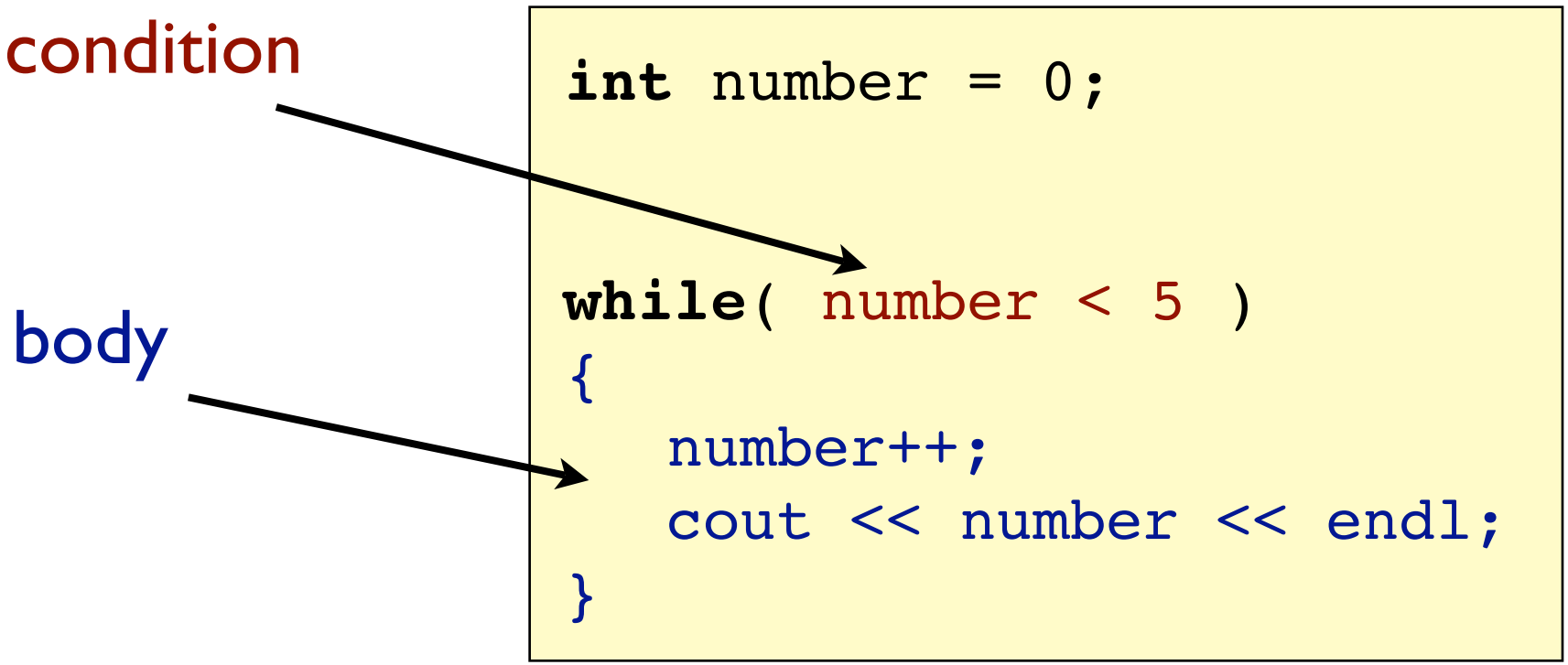
LOOPS



- C++ has three kinds of loops:
  - for loop
  - while loop
  - do-while loop
- Each of these work kind of like the if statement: they execute the single statement (or block of statements) that follows them

`while` Loop

- Condition is checked at the beginning of every iteration of the loop
- If the condition evaluates to true, the body of the loop is executed



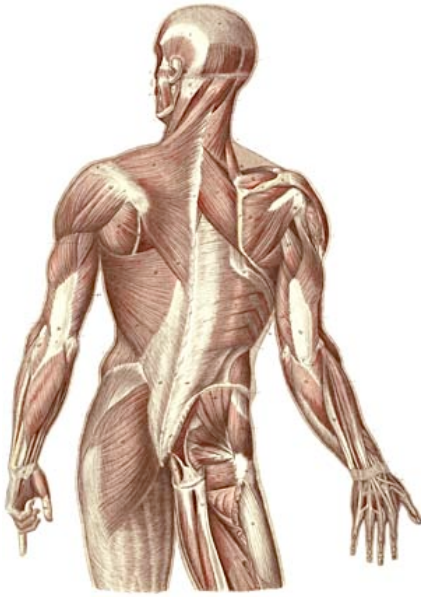
`while` Loop

- One way to think of this:
  - syntax and operation of a while loop is the same as a for loop...
  - ... except it will execute the body *until* the condition is true
- Again, watch out for stuff like this:

```
while( tired );
   sleep();
```

`do-while` Loops

- A while loop checks the condition *before* every iteration of the loop
  - so if the condition is never true, the loop will never execute
- A **`do-while`** loop checks the condition at the *end* of every iteration
  - side-effect: the body of the loop will always execute at least once, even if the condition is never true



Anatomy of a do-while

```
int number = 0;

do
{
    number++;
    cout << number << endl;
}
while( number < 5 );
```

do keyword
comes immediately before the body of the loop

body
again, single statement or block of statements

condition
checked *after* each iteration of the loop has executed

semicolon
the while is at the *end* of the loop, so it must be terminated by a semicolon

The `for` loop

- C-style for-loops are used in C, C++, Java, Perl, PHP, and a bunch of others
- The `for`-mat (heh heh) of a `for` loop:

```
for( initialization; condition; update )
{
   // body of loop
}
```

initialization: Executed first - just once. Used to setup any counter variables used in the loop.
ex: int i = 0; w = 4;

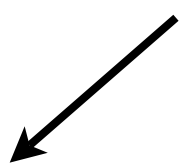
condition: Just like a `while`, `do-while`, or `if`. Checked *before* every iteration, as in a `while` loop.
ex: i < 20; w != 8;

update: Executed *after* each iteration, used to update variables (increment, decrement, etc).
ex: i++; q += 4; k *= 5

```
for( initialization; condition; update )
{
   // body of loop
}
```

FOR-LOOP EXAMPLES

```
for (int i=0; i<10; i++)
{
   cout << "i = " << i << endl;
}

for (int i=0; i<=10; i++)
{
   cout << "i = " << i << endl;
}

char i;
for (i ='a'; i<='z'; i++)
{
   cout << "i =" << i << endl;
}

for(char i='z'; i>='a'; i--)
{
   cout << "i = " << i << endl;
}
```



does this work?
why or why not?

what kind of loop would you use for...

- Printing out every even number between 0 and 100?
- Getting input from the user and making sure it is valid?
- Waiting for the time to be 10:00 AM before continuing?

Infinite Loops

- An infinite loop is a loop where the "condition" is always true, so the loop can never terminate
- Be careful of these!

```
int i = 0;
while( i < 10 )
{
}
```

```
for( ; ; )
{
}
```

```
while( true )
{
}
```

give me a

`break;`

- The break keyword breaks out of the current loop
- breaks out of the *current* loop only
- any problems with this?

```
while( true )
{
    while( true )
    {
        if( rand() % 10 == 5 )
            break;
    }
}
```

give me a

`break;`

`break` is useful but a bit ugly - it is usually a bit more elegant to rewrite the loop condition instead.

How could we rewrite this?

```
// class algorithm
while( !classOver )
{
   stareAtClock();

   if( reallyBored )
      break;
}

doFunStuff();
```

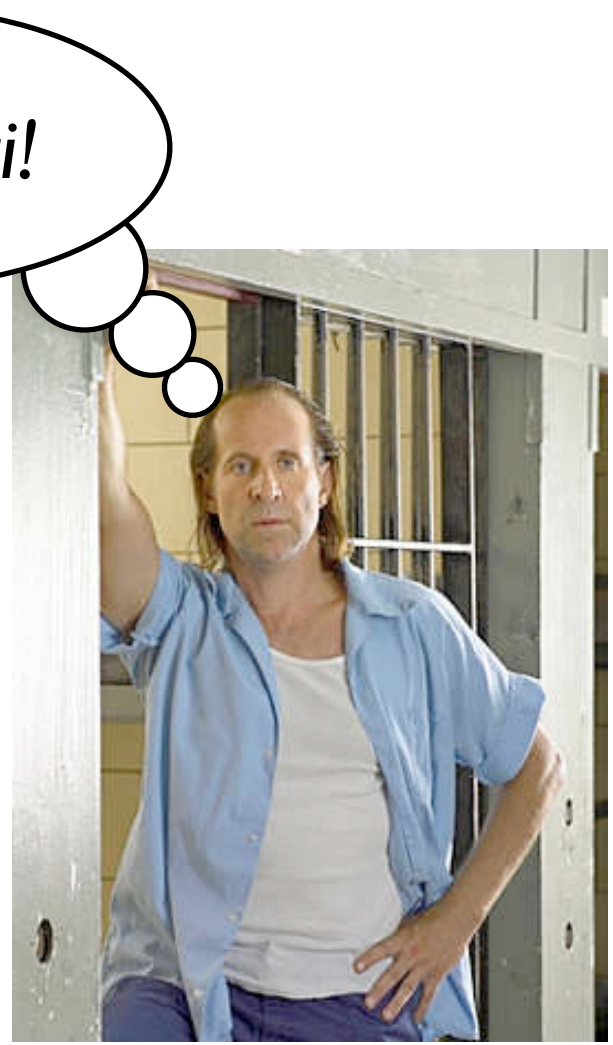
`continue;`

`...` skips the rest of the loop body and moves straight onto the next iteration.

```
// print grades
for( int i = 0; i < numStudents; i++ )
{
   if( student[i].droppedClass )
      continue;

   cout << student[i].name << endl;
   cout << student[i].grade << endl;
   cout << student[i].classRank << endl;
}
```

In-class programming exercise

Let's make a program that prints out the Fibonacci sequence.



$$F_n := F(n) := \begin{cases} 0 & \text{if } n = 0; \\ 1 & \text{if } n = 1; \\ F(n-1) + F(n-2) & \text{if } n > 1. \end{cases}$$

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89...

Functions

- Functions are a way to group chunks of code together so they can be reused later
  - ... otherwise you end up with huge, hard-to-maintain chunks of code
- Enables you to structure a program in a more modular way
- Functions in programming are similar to functions in mathematics.

Functions, cont.

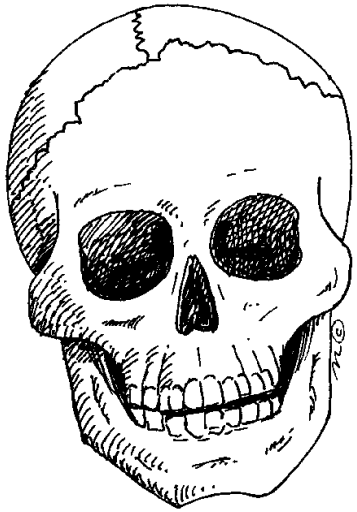
- Each function has its own code - just like the code in the main function
- Each function can access its own variables, but *not* the variables from any other function
- Functions can also access *global variables* - variables declared outside of any function, including the main function

Function Calls

- Function calls cause the following to happen:
  - The currently executing function is suspended
  - Program control is passed to the the function being invoked
  - When the function has finished executing, the suspended calling function resumes execution

useless example!

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

int timesTwo( int input )
{
   int output = input * 2;
   return output;
}

int main()
{
   cout << “two times two is: “
        << timesTwo(2) << endl;

   return EXIT_SUCCESS;
}
```



Anatomy of a Function

function name

parameters
(each parameter needs a type and a name)

return type
(can be any C++ type or an object)

```
int add( int x, int y )
{
    int result;
    result = x + y;
    return result;
}
```

code

return
(function must return an integer)

function return types

- A function has to have *some* return type declared
- Return types can be any basic C++ data type
- Can also be any object type (that bit comes later)
- If a function doesn't return a type, the return type is **void**
  - with a void return type, returning anything causes a compiler error

Function Parameters

- Parameters are how we provide input to the function (return value is the output)
- Each parameter has a type and a name... no two names can be the same. (why not?)

```
int add( int x, int y )
{
}
```

`int x, int y` are the parameters, indicating this function will need to be called with two integers as input.

How to call functions

- You call a function using its name, followed by the parameters in parenthesis, separated by commas

```
int max = maximum( 3, 50 );
```

- Even if a function has *no* parameters, you still need to follow the function name with ()

```
int ans = UltimateAnswer();
```

- The compiler makes sure you call a function with the correct number of arguments:

```
int max = maximum();
```

simpleinterest.cpp:6: too few arguments to function `int maximum(int, int)

- The compiler also performs type-checking on the different arguments.

```
float var1 = 12.3;
float var2 = 10.5;
int max = maximum( var1, var2 );
```

simpleinterest.cpp:35: warning: passing `float' for argument passing 1 of `int maximum (int, int)
simpleinterest.cpp:35: warning: passing `float' for argument passing 2 of `int maximum (int, int)

Why is this a warning and not an error?

quick detour: type conversion

- Often the compiler can automatically convert one type to another - this is called an ***implicit type conversion***
- When this can be done without losing data, the compiler will usually just do it quietly
  - int to float: 32 becomes 32.0, etc.
- Some types can be converted but not without changing the value
  - float to int: 56.8 gets truncated; becomes 56
  - The compiler will issue a warning here

quick detour: type conversion

- You can also do an ***explicit type conversion***, in which you force the compiler to convert the type, regardless of consequences

```
float baz = 38.6;

// these are all equivalent
int foo = (int)baz;
int foo = (int)(baz);
int foo = int(baz);
```

- This lets the compiler know that the conversion was intended, and usually makes the warnings go away

Question:

```
int mystery( int x, int y, int z)
{
   int value = x;

   if( y > value )
      value = y;

   if( z > value )
      value = z;

   return value;
}
```

what is the output the following statement?

```
cout << mystery(6, 2, 5) << endl;
```

(Another) Question:

```
int main()
{
   cout << meaningOfLife() << endl;
   return EXIT_SUCCESS;
}

int meaningOfLife()
{
   return 42;
}
```

Will this work? Why or why not?

Answer: No.

```
int main()
{
     cout << meaningOfLife()
     << endl;
     return EXIT_SUCCESS;
}

int meaningOfLife()
{
     return 42;
}
```

compiler output:

```
prototype.cpp: In function `int main()':
prototype.cpp:8: `meaningOfLife' undeclared (first use this function)
prototype.cpp:8: (Each undeclared identifier is reported only once for each
function it appears in.)
prototype.cpp: In function `int meaningOfLife()':prototype.cpp:13: `int
meaningOfLife()' used prior to declaration
```

C++ files are compiled from top-to-bottom; the compiler doesn't "know" about meaningOfLife() because it hasn't "seen" it yet.

Function Prototypes

- Functions need to be either defined above the point at which they are called, or...
- There needs to be a **function prototype** above where that function is called.
- A function prototype is identical to the first line in the function body... just without a body, and followed by a semicolon.

```
int meaningOfLife();
```

```
int meaningOfLife( bool isFun, int, int );  // prototype

int main()
{
    cout << meaningOfLife() << endl;
    return EXIT_SUCCESS;
}

int meaningOfLife( bool isExciting, int b, int c )
{
    return 42;
}
```

- A prototype requires a return value, a name, and argument types. It can also have argument names - these are optional.
- The argument names can be *different* than those used in the function.
- Everything else must be exactly the same!