Hello, world!

Looks simple enough...

- compile with g++ instead of gcc:
  - g++ -Wall -g -std=c++11 -o helloworld helloworld.cc

- let’s walk through the program step by step
Hello, world!

```cpp
#include <iostream>
#include <cstdlib>

int main(int argc, char **argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

**iostream is part of the C++ standard library**

- note you don’t include a “.h” when you include C++ standard library headers
  - but you do for local headers (e.g., `#include "ll.h"`)

- `iostream` declares stream object instances, including `std::cin`, `std::cout`, `std::cerr`, in the “std” namespace
Hello, world!

cstdlib is the C standard library’s stdlib.h header

- (nearly) all C standard library functions are available to you
  - for header <foo.h>, you should #include <cfoo>
- we need it for EXIT_SUCCESS, as usual
Hello, world!

```cpp
#include <iostream>
#include <cstdlib>

int main(int argc, char **argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

std::cout is the “cout” object instance declared by iostream, living within the “std” namespace (C++’s name for stdout)

- std::cout is an object of class ostream
- used to format and write output to the console
- the entire standard library is in namespace std
Hello, world!

C++ distinguishes between objects and primitive types
- primitive types include all the familiar ones from C
  - char, short, int, unsigned long, float, double, long double, etc.
  - and, C++ defines “bool” as a primitive type (woohoo!)
Hello, world!

```
#include <iostream>
#include <cstdlib>

int main(int argc, char **argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

“<<” is an operator defined by the C++ language
- it’s defined by C as well; in C/C++, it bitshifts integers
- but, C++ allows **classes** to overload operators
  - the ostream class overloads “<<”
  - i.e., it defines methods that are invoked when an ostream is the LHS of the << operator
Hello, world!

```cpp
#include <iostream>
#include <cstdlib>

int main(int argc, char **argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

ostream has many different methods to handle `<<`
- the methods differ in the type of the RHS of `<<`
- if you do `std::cout << "foo";`
  - C++ invokes cout’s method to handle `"<<"` with RHS “char *”
Hello, world!

```cpp
#include <iostream>
#include <cstdlib>

int main(int argc, char **argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

the ostream class’s methods that handle “<<” return (a reference to) themselves

- so, when (std::cout << “Hello, World!”) is evaluated:
  - a method of the std::cout object is invoked
  - it buffers the string “Hello, World!” for the console
  - and, it returns (a reference to) std::cout
Hello, world!

```cpp
#include <iostream>
#include <cstdlib>

int main(int argc, char **argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```
	next, a method on std::cout to handle "<<" is invoked

- this time, the RHS is std::endl

- turns out this is a pointer to a “manipulator” function
  
  ▶ this manipulator function writes newline to the ostream it is invoked on, and then flushes the ostream’s buffer

  ▶ so, something is printed on the console at this point
Wow...

```c++
#include <iostream>
#include <cstdlib>

int main(int argc, char **argv) {
    std::cout << "Hello, World!" << std::endl;
    return EXIT_SUCCESS;
}
```

You should be surprised and scared at this point

- C++ makes it easy to hide a significant amount of complexity
  - it’s powerful, but really dangerous
  - once you mix together templates, operator overloading, method overloading, generics, and multiple inheritance, it gets really hard to know what’s actually happening!
Refining it a bit...

C++'s standard library has a `std::string` class!

- include the `<string>` header to use it
Refining it a bit...

The “using” keyword introduces part of a namespace, or an entire namespace, into the current region:

- using namespace std;  -- imports all names from std::
- using std::cout;  -- imports only std::cout
Refining it a bit...

We’re instantiating a `std::string` object on the stack

- passing the C string “Hello, World!” to its constructor method
  - `hello` is deallocated (and its destructor invoked) when main returns
Refining it a bit...

The C++ string library overloads the `<<` operator as well

- defines a function (not an object method) that is invoked when the LHS is an ostream and the RHS is a `std::string`

  ▶ http://www.cplusplus.com/reference/string/operator<<
Refining it a bit...

```
#include <iostream>
#include <cstdlib>
#include <string>

using namespace std;

int main(int argc, char **argv) {
  string hello("Hello, World!");
  cout << hello << endl;
  return EXIT_SUCCESS;
}
```

Note the side-effect of using namespace std;
- can now refer to std::string by string, std::cout by cout, and std::endl by endl
string concatenation

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

int main(int argc, char **argv) {
    string hello("Hello");
    hello = hello + " there";
    cout << hello << endl;
    return EXIT_SUCCESS;
}
```

The string class overloads the “+” operator
- creates and returns a new string that is the concatenation of LHS and RHS
string assignment

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

int main(int argc, char **argv) {
    string hello("Hello");
    hello = hello + " there";
    cout << hello << endl;
    return EXIT_SUCCESS;
}
```

The string class overloads the “=” operator

- copies the RHS and replaces the string’s contents with it
  - so, the full statement (i) “+” creates a string that is the concatenation of hello’s current contents and “ there”, and (ii) “=” creates a copy of the concatenation to store in hello. Without the syntactic sugar it is: `hello.operator=(hello.operator+(" there"));`
stream manipulators

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

int main(int argc, char **argv) {
    cout << "Hi! " << setw(4) << 5 << " " << 5 << endl;
    cout << hex << 16 << " " << 13 << endl;
    cout << dec << 16 << " " << 13 << endl;
    return EXIT_SUCCESS;
}
```

iomanip defines a set of stream manipulator functions
- pass them to a stream to affect formatting
stream manipulators

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

int main(int argc, char **argv) {
    cout << "Hi! " << setw(4) << 5 << " " << 5 << endl;
    cout << hex << 16 << " " << 13 << endl;
    cout << dec << 16 << " " << 13 << endl;
    return EXIT_SUCCESS;
}
```

setw(x) sets the width of the next field to x
- only affects the next thing sent to the output stream
stream manipulators

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

int main(int argc, char **argv) {
    cout << "Hi! " << setw(4) << 5 << " " << 5 << endl;
    cout << hex << 16 << " " << 13 << endl;
    cout << dec << 16 << " " << 13 << endl;
    return EXIT_SUCCESS;
}
```

**hex** sets the stream to output integers in hexadecimal

- stays in effect until you set the stream to some other base

- **hex**, **dec**, **oct** are your choices
You can still use printf, though

C is (roughly) a subset of C++

- Can mix C and C++ idioms if needed to work with existing code, but avoid mixing if you can - use C++(11)
Reading

std::cin is an object instance of class istream

- supports the >> operator for “extraction”
- cin also has a getline( ) method
References

C++: introduces references as part of the language

- a reference acts like an alias for some other variable

  - alias: another name that is bound to the aliased variable
  - mutating a reference is mutating the referenced variable

```cpp
int main(int argc, char **argv) {
    int x = 5, y = 10;
    int &z = x; // binds the name "z" to variable x
    z += 1; // sets z (and thus x) to 6
    x += 1; // sets x (and thus z) to 7
    z = y; // sets z (and thus x) to the value of y
    z += 1; // sets z (and thus x) to 11
    return EXIT_SUCCESS;
}
```
References

C++: introduces references as part of the language

- a reference is **an alias** for some other variable
  
  ‣ **alias**: another name that is bound to the aliased variable
  
  ‣ mutating a reference **is** mutating the referenced variable

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    int x = 5, y = 10;
    int &z = x;  // binds the name "z" to variable x

    z += 1;     // sets z (and thus x) to 6
    x += 1;     // sets x (and thus z) to 7

    z = y;      // sets z (and thus x) to the value of y
    z += 1;     // sets z (and thus x) to 11

    return EXIT_SUCCESS;
}
```

```plaintext
x, z  5
y     10
```
References

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  - **alias**: another name that is bound to the aliased variable
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```c
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    int x = 5, y = 10;
    int &z = x;  // binds the name "z" to variable x
    z += 1;     // sets z (and thus x) to 6
    x += 1;     // sets x (and thus z) to 7
    z = y;      // sets z (and thus x) to the value of y
    z += 1;     // sets z (and thus x) to 11
    return EXIT_SUCCESS;
}
```

**x, z** 6

**y** 10
References

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    z = y; // sets z (and thus x) to the value of y
    z += 1; // sets z (and thus x) to 11

    return EXIT_SUCCESS;
}
```

x, z | 7
---|---
y | 10

reference1.cc
References

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    int x = 5, y = 10;
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    x += 1;      // sets x (and thus z) to 7
    z = y;       // sets z (and thus x) to the value of y
    z += 1;      // sets z (and thus x) to 11

    return EXIT_SUCCESS;
}
```
References

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    x += 1;  // sets x (and thus z) to 7
    z = y;   // sets z (and thus x) to the value of y
    z += 1;  // sets z (and thus x) to 11
    return EXIT_SUCCESS;
}
```

\[x, z \rightarrow 11\]

\[y \rightarrow 10\]
Pass by reference

C++ allows you to truly pass-by-reference

- client passes in an argument with normal syntax
  - function uses reference parameters with normal syntax
  - modifying a reference parameter modifies the caller’s argument

```cpp
void swap(int &x, int &y) {
    int tmp = x;
    x = y;
    y = tmp;
}

int main(int argc, char **argv) {
    int a = 5, b = 10;

    swap(a, b);
    cout << "a: " << a << " b: " << b << endl;
    return EXIT_SUCCESS;
}
```

Pass by reference.cc
Pass by reference

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```cpp
void swap(int &x, int &y) {
    int tmp = x;
    x = y;
    y = tmp;
}

int main(int argc, char **argv) {
    int a = 5, b = 10;

    swap(a, b);
    cout << "a: " << a << "; b: " << b << endl;
    return EXIT_SUCCESS;
}
```

passbyreference.cc
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    int tmp = x;
    x = y;
    y = tmp;
}

int main(int argc, char **argv) {
    int a = 5, b = 10;

    swap(a, b);
    cout << "a: " << a << " b: " << b << endl;
    return EXIT_SUCCESS;
}
```

passbyreference.cc
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    int tmp = x;
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    y = tmp;
}

int main(int argc, char **argv) {
    int a = 5, b = 10;
    swap(a, b);
    cout << "a: " << a << " b: " << b << endl;
    return EXIT_SUCCESS;
}
```

passbyreference.cc
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    int a = 5, b = 10;

    swap(a, b);
    cout << "a: " << a << " b: " << b << endl;
    return EXIT_SUCCESS;
}
```

passbyreference.cc
Pass by reference

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```cpp
void swap(int &x, int &y) {
    int tmp = x;
    x = y;
    y = tmp;
}

int main(int argc, char **argv) {
    int a = 5, b = 10;

    swap(a, b);
    cout << "a: " << a << " b: " << b << endl;
    return EXIT_SUCCESS;
}
```

passbyreference.cc
Pass by reference

C++ allows you to truly pass-by-reference

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```cpp
void swap(int &x, int &y) {
    int tmp = x;
    x = y;
    y = tmp;
}

int main(int argc, char **argv) {
    int a = 5, b = 10;

    swap(a, b);
    cout << "a: " << a << "; b: " << b << endl;
    return EXIT_SUCCESS;
}
```
**const**

**const**: cannot be changed

- used much more in C++ than in C

```cpp
void BrokenPrintSquare(const int &i) {
    i = i*i;    // Compiler error here!
    std::cout << i << std::endl;
}

int main(int argc, char **argv) {
    int j = 2;
    BrokenPrintSquare(j);
    return EXIT_SUCCESS;
}
```

brokenpassbyrefconst.cc
const

const’s syntax is confusing

```c
int main(int argc, char **argv) {
  int x = 5; // x is an int
  const int y = 6; // y is a (const int)
y++; // compiler error

  const int *z = &y; // z is a (variable pointer) to a (const int)
  *z += 1; // compiler error
  z++; // ok

  int *const w = &x; // w is a (const pointer) to a (variable int)
  *w += 1; // ok
  w++; // compiler error

  const int *const v = &x; // v is a (const pointer) to a (const int)
  *v += 1; // compiler error
  v++; // compiler error

  return EXIT_SUCCESS;
}
```

constmadness.cc
style guide tip

use const reference parameters for input values
- particularly for large values
use pointers for output parameters
input parameters first, then output parameters last

```cpp
#include <cstdlib>

void CalcArea(const int &width, const int &height,
               int *const area) {
    *area = width * height;
}

int main(int argc, char **argv) {
    int w = 10, h = 20, a;

    CalcArea(w, h, &a);
    return EXIT_SUCCESS;
}
```

When to use references?

A stylistic choice

- not something mandated by the C++ language

Google C++ style guide suggests:

- input parameters:
  - either use values (for primitive types like int)
  - or use const references (for complex structs / object instances)

- output parameters
  - use const pointers (i.e., unchangeable pointers referencing changeable data – see previous slide)
virality of const

- **OK to pass**
  - a pointer to non-const
  - to a function that expects
    - a pointer to const

- **not OK to pass**
  - a pointer to a const
  - to a function that expects
    - a pointer to a non-const

```cpp
#include <iostream>

void foo(const int *y) {
    std::cout << *y << std::endl;
}

void bar(int *y) {
    std::cout << *y << std::endl;
}

int main(int argc, char **argv) {
    const int a = 10;
    int b = 20;

    foo(&b);   // OK
    bar(&a);   // not OK

    return 0;
}
```
Classes

class declaration syntax  (in a .h file)

class Name {
    public:
        members;
    private:
        members;
};

class member definition syntax  (in a .cc file)

    returnType classname::methodname(parameters) {
        statements;
    }

You can name your .cc, .h file anything (unlike Java)

- typically name them Classname.cc, Classname.h
```cpp
#ifndef _POINT_H_
#define _POINT_H_

class Point {
    public:
        Point(const int x, const int y); // constructor
        int get_x() const { return x_; } // inline member function
        int get_y() const { return y_; } // inline member function
        double Distance(const Point &p) const; // member function
        void SetLocation(const int x, const int y); // member function

    private:
        int x_; // data member
        int y_; // data member
}; // class Point

#endif // _POINT_H_
```

Point.h
#include <cmath>
#include "Point.h"

Point::Point(const int x, const int y) {
    x_ = x;
    this->y_ = y;  // "this->" is optional, unless names conflict
}

double Point::Distance(const Point &p) const {
    // We can access p’s x_ and y_ variables either through the
    // get_x(), get_y() accessor functions, or the x_, y_ private
    // member variables directly, since we’re in a member
    // function of the same class.
    double distance = (x_ - p.get_x()) * (x_ - p.get_x());
    distance += (y_ - p.y_) * (y_ - p.y_);
    return sqrt(distance);
}

void Point::SetLocation(const int x, const int y) {
    x_ = x;
    y_ = y;
}
.cc file with main()

```cpp
#include <iostream>
#include "Point.h"

using namespace std;

int main(int argc, char **argv) {
    Point p1(1, 2); // stack allocate a new Point
    Point p2(4, 6); // stack allocate a new Point

    cout << "p1 is: (" << p1.get_x() << ", ";
    cout << p1.get_y() << ")" << endl;

    cout << "p2 is: (" << p2.get_x() << ", ";
    cout << p2.get_y() << ")" << endl;

    cout << "dist : " << p1.Distance(p2) << endl;
    return 0;
}
```

usepoint.cc