HW2 out now, due a week from Tuesday

New exercise out after class, due before class Monday
- Short C++ program without classes

Look at C++ Primer for details and explanations. We won’t have time in class to cover everything useful.
Today’s goals

Useful C++ features
- references, const

Introducing C++ classes
- defining, using them
Reminder: pointers

C: a pointer is a variable containing an address
- you can change its value to change what it is pointing to
- a pointer can contain the address of a different variable

```c
int main(int argc, char **argv) {
    int x = 5, y = 10;
    int *z = &x;

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

    z = &y;  // sets z to the address of y
    *z += 1; // sets y (and therefore *z) to 11

    return EXIT_SUCCESS;
}
```

```
x | 5
y | 10
z | ?
```

pointer.cc
Reminder: pointers

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    return EXIT_SUCCESS;
}
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    z = &y; // sets z to the address of y
    *z += 1; // sets y (and therefore *z) to 11

    return EXIT_SUCCESS;
}
```

x 6
y 10
z 0xbff2f2d4
Reminder: pointers

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    int x = 5, y = 10;
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}
```
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    *z += 1; // sets y (and therefore *z) to 11

    return EXIT_SUCCESS;
}
```

x | 7
---
y | 10
z | 0xbfff2d0
Reminder: pointers

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- you can change its value to change what it is pointing to
- a pointer can contain the address of a different variable

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int main(int argc, char **argv) {
    int x = 5, y = 10;
    int *z = &x;

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

    z = &y;  // sets z to the address of y
    *z += 1; // sets *z (and therefore y) to 11

    return EXIT_SUCCESS;
}
```

x 7
y 11
z 0xbfff2d0
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

```c
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;
}
```

### Variables: x, y
- **x**: 5
- **y**: 10

reference1.cc
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

```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;
}
```

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

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    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

reference1.cc
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  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   7
y      10
```
References

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  ‣ *alias*: another name that is bound to the aliased variable

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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 10

y 10
References

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    return EXIT_SUCCESS;
}
```
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;
}
```

(main) a 5

(main) b 10
Pass by reference

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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;
}
```

```plaintext
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;
}
```
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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 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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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;
}
```
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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

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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

```cpp
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 to pass input values
  - particularly for large values

use pointers to pass output parameters
  - input parameters first, then output parameters last

```c
#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 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
virality of const

- **OK to pass**
  - a pointer to non-const

- **not OK to pass**
  - a pointer to a const

- to a function that expects
  - a pointer to 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 {
  private:
    members;
  public:
    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
.h file

```c++
#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 functn
    
    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()

#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;
}
struct vs. class

in C

- a struct contains only fields
  ‣ cannot contain methods
  ‣ does not have public vs. private vs. protected

in C++

- struct and class are (nearly) the same
  ‣ both can contain methods
  ‣ both can have public vs. private vs. protected

- **struct**: default public, **class**: default private
Exercise 1

Write a C++ program that:

- has a class representing a 3-dimensional point
- has the following methods:
  - return the inner product of two 3d points
  - return the distance between two 3d points
  - accessors and mutators for the x, y, z coordinates
Exercise 2

Write a C++ program that:

- has a class representing a 3-dimensional box
  ‣ use your exercise 1 class representing 3d points to store the coordinates of the vertices that define it
  ‣ assume the box has right-angles only and its faces are parallel to the axes, so you only need two vertices to define it

- has the following methods:
  ‣ test if one box is inside another box
  ‣ return the volume of a box
  ‣ handles "<<", "=", and a copy constructor
  ‣ uses const in all the right places
See you on Monday!