CSE 333
Lecture 10 - references, const, classes

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New exercise out today, due before class Wednesday

HW2 due a week from Thursday - how’s it look?

- Reminder: you can use our hw1/solution_binaries/libhw1.a instead of your own hw1 code if you’d like.

Midterm exam Fri. May 6, a week after HW2 due

Sections this week: C++, const / references / 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;
}
```
Reminder: pointers

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    *z += 1;  // sets y (and therefore *z) to 11
    return EXIT_SUCCESS;
}
```
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    *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;
}
```

```c
x 6
y 10
z 0xbff2d4
```
Reminder: pointers

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- you can change its value to change what it is pointing to
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```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;
}
```

```c
x 7
y 10
z 0xbff2d4
```
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

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int main(int argc, char **argv) {
    int x = 5, y = 10;
    int *z = &x;
    *z += 1;       // sets x to 6
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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;
}
```

pointer.cc
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 *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 | 0xbff2d0
```

pointer.cc
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

```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;
}
```

References: x, z

Values:
- 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

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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** | 6
---|---
**y** | 10
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
7
y
10
```
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
  
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```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;
}
```

```plaintext
x, z | 10
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
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```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;
}
```
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;
}
```

passbyreference.cc
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

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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

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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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```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

- client passes in an argument with normal syntax
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```c++
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

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;
}
```

passbyreference.cc
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;
}
```

passbyreference.cc
**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

cons’ts 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;
}
```

styleguide.cc
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 small structs/objects)
  ‣ 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
  ‣ 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
```cpp
#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;
}
```

```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()  << ", "  << p1.get_y()  << ")" << endl;

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

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

`usepoint.cc`
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

- common style convention: structs for simple bundles of data (maybe with convenience constructors); classes for abstractions with data + functions
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
Reading Assignment

Before next class: read sections in *C++ Primer* covering constructors, copy constructors, assignment (operator=), and destructors

- Ignore “move semantics” for now

- The table of contents and index are your friends…
See you on Wednesday!