CSE 333
Lecture 10 - references, const, classes

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HW2 due a week from tomorrow

New exercise out today after class, due before class Friday

Sections tomorrow: 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

```cpp
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      ?
```
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pointer.cc
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    *z += 1; // sets *z (and therefore y) to 11

    return EXIT_SUCCESS;
}
```

`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

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    z += 1;     // sets z (and thus x) to 11
    return EXIT_SUCCESS;
}
```

| x, z | 5 |
| y    | 10 |

reference1.cc
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` = 6
- `y` = 10

reference1.cc
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;
}
```

```plaintext
x, z  7
y     10
```
References

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    z += 1;    // sets z (and thus x) to 11
    return EXIT_SUCCESS;
}
```

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

reference1.cc
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 | 11
    
y   | 10
```

reference1.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;
}
```
Pass by reference

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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;
}
```

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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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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
| (swap) tmp | 5 |
| (main) a   | 5 |
| (swap) x   | 5 |
| (main) b   | 10|
| (swap) y   | 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;
}
```

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;
}
```
Pass by reference

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  - modifying a reference parameter modifies the caller’s argument

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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;
}
```

```
(main) a 10
(main) b 5
```
const

**const**: cannot be changed

- used much more in C++ than in C

```cpp
template
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

```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 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
  - 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)

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

class member definition syntax  (in a .cc file)

```cpp
returntype classname::methodname(parameters) {
  statements;
}
```

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

- typically name them Classname.cc, Classname.h
#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

#define _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;
}
```
#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
- typical style convention: structs for simple bundles of data; 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
See you on Friday!