CSE 333
Lecture 10 - references, const, classes

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HW2 out today, due in two weeks

New exercise out today, 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

```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
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
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}
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pointer.cc
Reminder: pointers

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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 0xbfff2d4
```
Reminder: pointers

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    *z += 1;    // sets x to 6
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    return EXIT_SUCCESS;
}
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    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;
}
```

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

```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;
}
```
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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 | 6

y  | 10
```

reference1.cc
References

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  z += 1;    // sets z (and thus x) to 11

  return EXIT_SUCCESS;
}
```

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

reference1.cc
References

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

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

```
x, z | 10
  y  | 10
```

reference1.cc
References

C++: introduces references as part of the language

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

  ▶ mutating a reference **is** mutating the referenced 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 | 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;
}
```

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

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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.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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    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
#include <iostream>

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);
    std::cout << "a: " << a << "; b: " << b << std::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;
}
```
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;
}
```
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 for input values
- particularly for large values

use pointers for 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 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 {
  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
```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;
}
```

Point.cc
#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!