CSE 333

Lecture 10 - references, const, classes

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Yet another exercise out today, due before class Friday

Section this week: C++, const / references / classes
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;
}
```

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;
}
```

```plaintext
x  5
y  10
z  0xbfff2d4
```
Reminder: pointers

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    you can change its value to change what it is pointing to
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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 6
y 10
z 0xbfffd4
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    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;
}
```

```bash
  x  7
  y  10
  z  0xbfffd2d4
```

pointer.cc
Reminder: pointers

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    int x = 5, y = 10;
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    x += 1;   // sets x (and therefore *z) to 7
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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 0xbfffd2d0
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;
}
```

```plaintext
x 5
y 10
```
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    z += 1; // sets z (and thus x) to 11
    return EXIT_SUCCESS;
}
```

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

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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
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}
```

x, z 6

y 10
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}
```

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 | 10 |
| y   | 10 |
References

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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 += 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  11
y  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;
}
```

(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;
}
```

(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;
}
```

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

| (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
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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

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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

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

```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 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 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 {
    public:
        members;
    private:
        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 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;
}
```
.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
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
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…
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!