CSE 333
Lecture 10 - references, const, classes

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HW2 due a week from Thursday

New exercise out today, due before class Friday

Sections Thursday: 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;
}
```

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

```c
x  6
y  10
z  0xbfffd4
```
Reminder: pointers

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int main(int argc, char **argv) {
    int x = 5, y = 10;
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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;
}
```
Reminder: pointers

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}
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Reminder: pointers

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    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
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

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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 5
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 | 6 |
| y    | 10 |
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 | 7
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
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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;
}
```

```plaintext
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;
}
```

`passbyreference.cc`
Pass by reference

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  - 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;
}
```

```cpp
(main) a 5
(main) b 10
```
Pass by reference

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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
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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;
}
```
Pass by reference

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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;
}
```
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.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

```
#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 {
        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
#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_
```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
    std::cout << "p1 is: ("; 
    std::cout << p1.get_x() << " , " << p1.get_y() << " )";
    std::cout << std::endl;
    std::cout << "p2 is: ("; 
    std::cout << p2.get_x() << " , " << p2.get_y() << " )";
    std::cout << std::endl;
    std::cout << "dist : " std::endl;
    std::cout << p1.Distance(p2) << std::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!