

References Revisited

CSE 333 Spring 2019

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Administrivia

- ❖ Midterm is Friday (5/10) @ 5-6:10 pm in KNE 130
 - No lecture on Friday!
 - 1 double-sided page of handwritten notes; reference sheet provided on exam
 - **Topics:** everything from lecture, exercises, project, etc. up *until* C++ templates
 - Old exams on course website, review in section next week
- ❖ Exercise 13 (smart pointers) and Mid-quarter survey posted on Friday
- ❖ Homework 3 – spec out now, files pushed on Friday
 - Spec overview
 - Demo

Lecture Outline

- ❖ **Smart Pointers Wrap-Up**
- ❖ References Revisited

Smart Pointer Methods (incomplete)

- ❖ `std::unique_ptr U;`
 - `U.get()` — return to stored pointer
 - `U.release()` — release stored pointer: return value & replace with NULL
 - `U.reset(q)` — delete the stored pointer, then replace with `q`
- ❖ `std::shared_ptr S;`
 - `S.get()` — return the stored pointer
 - `S.use_count()` — return the reference count (# of shared_ptr)
 - `S.unique()` — equivalent to `use_count() == 1`
- ❖ `std::weak_ptr W;`
 - `W.lock()` — return a shared_ptr with the same stored pointer
 - `W.use_count()` — return the reference count (shared_ptr only)
 - `W.expired()` — equivalent to `use_count() == 0`

GDB and Smart Pointers

- ❖ GDB demo
 - `sharedvec.cc` (from Lecture 16)
 - `weakcycle.cc` (from Lecture 16)

Lecture Outline

- ❖ Smart Pointers Wrap-Up
- ❖ **References Revisited**

Confusion About References

- ❖ When should they be used?
 - Particularly with parameters and return values
- ❖ When can using them cause trouble?

The Plan

- ❖ We'll go through a bunch of code examples
 - Try to come up with a response on your own first
 - Then discuss with your neighbor(s) and come to a consensus
 - Vote at <http://PollEv.com/justinh>
- A. **We must NOT use a reference**
- B. **It's OK but *discouraged* to use a reference**
- C. **It's OK and *encouraged* to use a reference**
- D. **We must use a reference**
- E. **We're lost...**

Parameters 1

param1.cc

```
#include <cstdlib>
#include <iostream>

using namespace std;

// SHOULD WE BE USING REFERENCES FOR PARAMETERS "a" AND "b"?
// (Answer: ?)
int LeastCommonMultiple(const int &a, const int &b) {
    for (int n=1; ; n++) {
        if ((n % a == 0) && (n % b == 0))
            return n;
    }
}

int main(int argc, char **argv) {
    int x = 12, y = 14;

    int lcm = LeastCommonMultiple(x, y);
    cout << "LCM(" << x << ", " << y << ") is " << lcm << endl;
    return EXIT_SUCCESS;
}
```

param1.cc

❖ B. It's OK but *discouraged* to use a reference

- A const reference to a small primitive type (e.g. `int`, `float`)
- We aren't changing the argument values (`const`), so it doesn't matter if we use a copy or not – reference is *optional*
- Correct behavior, but might have better performance with regular call-by-value

↪ no major benefit to preventing copy of small pieces of data

Parameters 2

param2.cc

```
#include <cmath>
#include <cstdlib>
#include <iostream>

#include "ThreeDPoint.h"

// SHOULD WE BE USING REFERENCES FOR PARAMETERS "a" AND "b"?
// (Answer: ?)
double Distance(const ThreeDPoint &a, const ThreeDPoint &b) {
    double dist = pow(a.x-b.x,2) + pow(a.y-b.y,2) + pow(a.z-b.z,2);
    return sqrt(dist);
}

int main(int argc, char **argv) {
    ThreeDPoint a(1,2,3), b(4,5,6);

    int dist = Distance(a, b);
    cout << "Distance(a,b) is " << dist << endl;
    return EXIT_SUCCESS;
}
```

param2.cc

❖ C. It's OK and *encouraged* to use a reference

- A const reference to a complex type (e.g. struct, object instance)
- We aren't changing the argument values (`const`), so it doesn't matter if we use a copy or not – reference is *optional*
- Correct behavior and likely performance benefit from not having to copy

❖ Follow-up: Why not pass in a pointer instead?

can achieve all of the same behavior with a pointer as reference.

style → input parameters should be const ref
→ output parameters should be pointers

Return Value 1

ret1.cc

```
#include <cstdlib>
#include <iostream>

typedef struct Point_st {
    double x, y, z;
} Point;

// SHOULD WE BE USING A REFERENCE FOR THE RETURN VALUE?
// (Answer: ?)
Point &MakePoint(const int x, const int y, const int z) {
    Point retval = {x, y, z};
    return retval;
}

int main(int argc, char **argv) {
    Point p = MakePoint(1, 2, 3);
    std::cout << p.x << ", " << p.y << ", " << p.z << std::endl;
    return EXIT_SUCCESS;
}
```

ret1.cc

- ❖ **A. We must NOT use a reference**
 - A reference to a stack-allocated complex type
 - Never return a reference (or pointer to) a local variable
 - Destructor is also called on object when returning

Copy Constructor

Complex1.h

```
#ifndef _COMPLEX_H_
#define _COMPLEX_H_

#include <iostream>

namespace complex {

class Complex {
public:
    // Copy constructor -- should we pass a reference or not?
    // (Answer: ?)
    Complex(const Complex &copyme) {
        real_ = copyme.real_;
        imag_ = copyme.image_;
    }

private:
    double real_, imag_;
}; // class Complex

} // namespace complex

#endif // _COMPLEX_H_
```

Complex1.h

❖ D. We must use a reference

- A const reference to a complex type
- We aren't changing the argument's values so it doesn't matter if we use a copy or not, in theory
- A copy constructor *must* take a reference, otherwise it would need to call itself to make a (call-by-value) copy of the argument...

operator+

Complex2.h

```
#include <iostream>

namespace complex {

class Complex {
public:
    // Should operator+ return a reference or not?
    // (Answer: ?)
    Complex &operator+(const Complex &a) const {
        Complex tmp(0,0);
        tmp.real_ = this->real_ + a.real_;
        tmp.imag_ = this->imag_ + a.imag_;
        return tmp;
    }

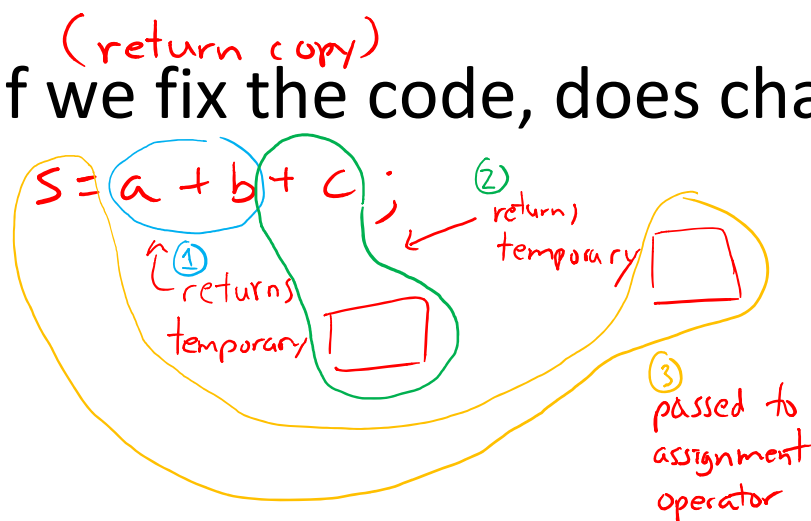
private:
    double real_, imag_;
}; // class Complex

} // namespace complex
```

Complex2.h

- ❖ **A. We must NOT use a reference**
 - A reference to a stack-allocated complex type
 - Never return a reference (or pointer to) a local variable
 - Destructor is also called on object when returning
- ❖ Follow-up: If we fix the code, does chaining work?

Yes.



Assignment Operator

Complex3.h

```
#include <iostream>

namespace complex {

class Complex {
public:
    // Should the assignment operator return a reference?
    // (Answer: ?)
    Complex &operator=(const Complex &a) {
        if (this != &a) {
            this->real_ = a.real_;
            this->imag_ = a.imag_;
        }
        return *this;
    }

private:
    double real_, imag_;
}; // class Complex

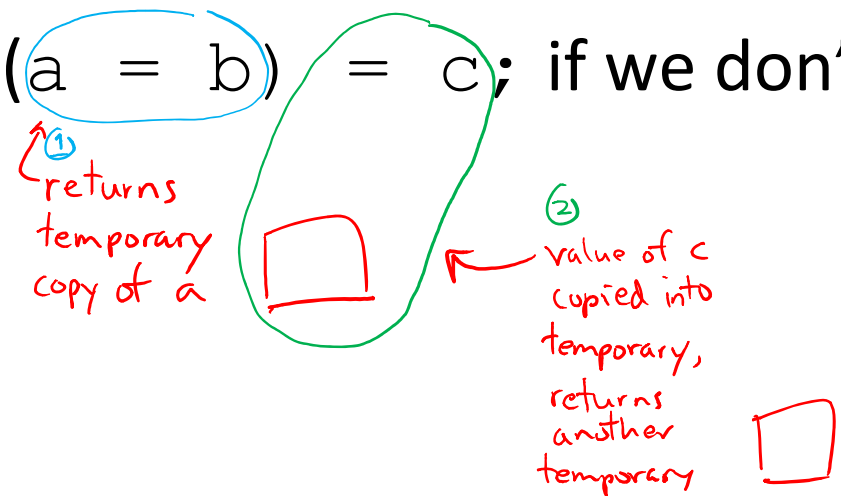
} // namespace complex
```

Complex3.h

❖ D. We must use a reference

- A reference to `*this`, the object this method was called on
- All of the “work” is done in the method body; the return value is only there for chaining (but *required* for chaining to work correctly)

❖ Follow-up: What happens in $(a = b) = c$; if we don't use a reference?



operator+=

Complex4.h

```
#include <iostream>

namespace complex {

class Complex {
public:
    // Should += return a reference?
    // (Answer: ?)
    Complex &operator+=(const Complex &a) {
        this->real_ += a.real_;
        this->imag_ += a.imag_;
        return *this;
    }

private:
    double real_, imag_;
}; // class Complex

} // namespace complex
```

Complex4.h

❖ D. We must use a reference

- A reference to `*this`, the object this method was called on
- All of the “work” is done in the method body; the return value is only there for chaining (but *required* for chaining to work correctly)
- You hardly see people chain `+=`, but it is allowed by the primitive data types, so we follow suit
 - Style/code quality: overloaded operators should have similar semantics to basic definitions to avoid programmer surprises

operator<<

Complex5.h

```
#include <iostream>

namespace complex {

class Complex {
public:
    double real() const { return real_; };
    double imag() const { return imag_; };

private:
    double real_, imag_;
}; // class Complex

} // namespace complex

// Should operator<< return a reference?
// (Answer: ?)
std::ostream &operator<<(std::ostream &out,
                        const complex::Complex &a) {
    out << "(" << a.real() << " + " << a.imag() << "i)";
    return out;
}
```

Complex5.h

❖ D. We must use a reference

- A reference to `out`, the ostream object provided as an reference argument
- The return value is only there for chaining (but *required* for chaining to work correctly)
- Copying of streams is disallowed (and doesn't make sense)