

References Revisited

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Administrivia

- ❖ No exercise due Friday. Next exercise out Friday after midterm, due Monday before class (smart ptr exercise)
- ❖ Midterm: Friday in class
 - Closed book, no notes
 - Old exams and topic list on the course web now
 - Everything up through C++ classes, dynamic memory, templates & STL
 - Review in sections tomorrow
- ❖ Homework 3 – spec out now, files pushed by Friday
 - Spec overview & demo in class today

≡ 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
- ❖ For each example, we want to decide if it is appropriate to use references, and then chose one answer from this list:
 - 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

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?

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
 - Also, destructor is 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 variable
 - 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?

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?
 - Does it compile?
 - Does it “work”?
 - Does it do the “right thing”?

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)