CSE 333 Section AB

Const, References & Make! (w/ Yifan & Travis)
Logistics

Due Friday:
Exercise 8 @ 11 am

Due Monday:
Exercise 9 @ 11 am

Due Thursday 10/24:
Homework 2 @ 9 pm
References & Const review
Example

Consider the following code:

```c
int x = 5;
int &refx = x;
int *ptrx = &x;
```

Similar in syntax to the `*` in pointer declarations.

Legend

Red Thing = “can’t change the box it’s next to”
Black = “writeable/readable”
Example

Consider the following code:

```c
int x = 5;
int &refx = x;
int *ptrx = &x;
const int &ro_refx = x;
const int *ro_ptr1 = &x;
int *const ro_ptr2 = &x;
```

“Const pointer to an int”

Tip: Read the declaration “right-to-left”

Legend

Red Thing = “can’t change the box it’s next to”
Black = “writeable/readable”
Example

Consider the following code:

```c
int x = 5;
int &refx = x;
int *ptrx = &x;
const int &ro_refx = x;
const int *ro_ptr1 = &x;
int *const ro_ptr2 = &x;
```

When would you prefer this...

```c
void func(int &arg);
```

...to this? Vice-Versa?

```c
void func(int *arg);
```

Legend

Red Thing = “can’t change the box it’s next to”
Black = “writeable/readable”
Example

Consider the following code:

```c
int x = 5;
int &refx = x;
int *ptrx = &x;
const int &ro_refx = x;
const int *ro_ptr1 = &x;
int *const ro_ptr2 = &x;
```

Which results in a compiler error?

- `bar(refx);`
- `bar(ro_refx);`
- `foo(refx);`

Legend

Red Thing = “can’t change the box it’s next to”
Black = “writeable/readable”
Example

Consider the following code:

```c
int x = 5;
int &refx = x;
int *ptrx = &x;
const int &ro_refx = x;
const int *ro_ptr1 = &x;
int *const ro_ptr2 = &x;
```

Which results in a compiler error?

```c
ro_ptr1 = (int*)0xDEADBEEF;
ptrx = &ro_refx;
ro_ptr2 = ro_ptr2 + 2;
*ro_ptr1 = *ro_ptr1 + 1;
```

Legend

Red Thing = “can’t change the box it’s next to”
Black = “writeable/readable”
What about “const” object methods?
#ifndef _POINT_H_
#define _POINT_H_

class Point {
  public:
    Point(const int x, const int y); // constructor
    int get_x() const { return x_; } // inline
    int get_y() const { return y_; } // inline
    double Distance(const Point& p) const;
    void SetLocation(const int x, const int y);
  
  private:
    int x_; // data member
    int y_; // data member
}; // class Point

#endif // _POINT_H_
Summary

● Pointers vs. References:

<table>
<thead>
<tr>
<th>Pointers</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can move to different data via reassignment/pointer arithmetic</td>
<td>References the same data for its entire lifetime</td>
</tr>
<tr>
<td>Can be initialized to NULL</td>
<td>No sensible “default reference”</td>
</tr>
<tr>
<td>“datatype *const ptr” is good style for output parameters within functions (Unchangeable pointers pointing to changeable data)</td>
<td>“const datatype &amp;ref” is good style for passing in input values to a function (Read-only values without copying memory)</td>
</tr>
</tbody>
</table>

● Const:
  ○ **Tip:** Read the declaration “right-to-left”.
  ○ Prevent yourself (and clients) from changing data that doesn’t make sense to change!
Worksheet Time
2) What does the following program print out? **Hint:** box-and-arrow diagram!

```c
int main(int argc, char** argv) {
    int x = 1;  // assume &x = 0x7ff...94
    int& rx = x;
    int* px = &x;
    int*& rpx = px;

    rx = 2;
    *rpx = 3;
    px += 4;
    cout << "  x: " << x << endl;
    cout << "  rx: " << rx << endl;
    cout << "*px: " << *px << endl;
    cout << "&x: " << &x << endl;
    cout << "rpx: " << rpx << endl;
    cout << "*rpx: " << *rpx << endl;

    return 0;
}
```
2) What does the following program print out?  

```c
int main(int argc, char** argv) {
    int x = 1;   // assume &x = 0x7ff...94
    int& rx = x;
    int* px = &x;
    int*& rpx = px;

    rx = 2;
    *rpx = 3;
    px += 4;
    cout << " x: " << x << endl;   // x: 3
    cout << " rx: " << rx << endl;  // rx: 3
    cout << "*px: " << *px << endl;  // *px: ??? (garbage)
    cout << " &x: " << &x << endl;   // &x: 0x7ff...94
    cout << "rpx: " << rpx << endl;  // rpx: 0x7ff...a4
    cout << "*rpx: " << *rpx << endl; // *rpx = *px: ??? (garbage)

    return 0;
}
```
```cpp
struct Thing {
    int a;
    bool b;
};

void PrintThing(const Thing & t) {
    cout << boolalpha << "Thing: " << t.a << ", " << t.b << endl;
}

int main() {
    Thing foo = {5, true};
    cout << "(0) ";
    PrintThing(foo);

    cout << "(1) ";
    __???__(foo); // mystery 1
    PrintThing(foo);

    cout << "(2) ";
    __???__(&foo); // mystery 2
    PrintThing(foo);

    cout << "(3) ";
    __???__((foo); // mystery 3
    PrintThing(foo);

    return 0;
}
```

Possible Functions:
- void f1(Thing t);
- void f2(Thing &t);
- void f3(Thing *t);
- void f4(const Thing & t);
- void f5(const Thing t);

Program Output:
(0) Thing: 5, true
(1) Thing: 6, false
(2) Thing: 3, true
(3) Thing: 3, true
struct Thing {
    int a;
    bool b;
};

void PrintThing(const Thing& t) {
    cout << boolalpha << "Thing: " << t.a << ", " << t.b << endl;
}

int main() {
    Thing foo = {5, true};
    cout << "(0) ";
    PrintThing(foo);
    cout << "(1) ";
    // mystery 1: f2
    __???__(foo);
    PrintThing(foo);
    cout << "(2) ";
    // mystery 2: f3
    __???__(&foo);
    PrintThing(foo);
    cout << "(3) ";
    // mystery 3: f1, f2, f4, or f5
    __???__(foo);
    PrintThing(foo);
    return 0;
}
Makefiles, how do they work?

MakeFile Format:

```
target: src1 src2 ... srcN
command/commands
```

Can type “make <target>” it will attempt to build the target.

// attempts to build by running the supplied commands

- If the target file doesn’t exist, it is rebuilt.
- If a sources are “older” than the target, it will not be rebuilt.
- If a source doesn’t exist or has been updated, target is rebuilt.
- Make will recursively check that sources are up to date.
**Makefiles, Phony targets**

**MakeFile Format:**

```
target:  src1 src2 ... srcN
command/commands
```

**Phony Target:** If we list a target, but the command provided doesn’t make a file with the target’s name

```
all: <List all executables>
    // no need to provide a command
```

```
clean:
    rm <all files we want to delete>
```
Makefiles

**MakeFile Format:**

```
target: src1 src2 ... srcN
    command/command
```

The most important part is drawing the dependencies

- `.cc` files and `.h` are sources, should not be targets
- `.o` files are compiled from `.cc` files, depend on the source `.cc` and included `.h` files
- Executables need intermediate `.o` files if using multiple source `.cc` files
  Otherwise, can be compiled directly from sources.
<table>
<thead>
<tr>
<th></th>
<th>Point.h</th>
<th>UsePoint.cc</th>
<th>Point.cc</th>
<th>Thing.h</th>
<th>UseThing.cc</th>
<th>Alone.cc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>class Point { ... }</td>
<td></td>
<td>#include &quot;Point.h&quot;</td>
<td>struct Thing { ... }</td>
<td></td>
<td>int main( ... ) { ... }</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#include &quot;Thing.h&quot;</td>
<td></td>
<td>// full struct def here</td>
<td>int main( ... ) { ... }</td>
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