CSE 333
Section 4

HW2 Overview, C++ Intro

Logistics

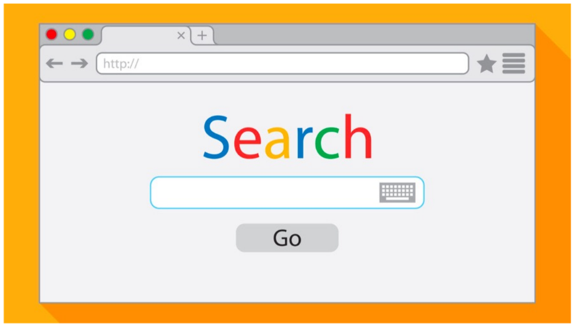
- Homework 2
  - Due next **Thursday, 5/1 @ 11:59pm**
  - Indexing files to allow for searching
- Exercise 9
  - Write a Vector class in C++
  - Out tomorrow morning, due **Monday @ 10:00am**

- TODO: read about copy ctr/op=/dtr in C++ Primer **before Friday class**

- Please look at your exercise feedback, even if you get a 3 (= "gold star"). That means no serious problems, but there often is feedback about things to fix in future work. We're seeing things recur that should be not happening over and over. Let's fix it!

Homework 2 Overview

Homework 2



- Main Idea: Build a search engine for a file system
  - It can **take in queries** and **output a list of files** in a directory that has that query
  - The query will be **ordered** based on the number of times the query is in that file
  - Should handle **multiple word queries** (*Note: all words in a query have to be in the file*)

- What does this mean?
  - Part A: **Parsing a file** and reading all of its contents into heap allocated memory
  - Part B: **Crawling a directory** (reading all regular files recursively in a directory) and building an index to query from
  - Part C: **Build a searchshell** (search engine) to query your index for results

Note: It will use the **LinkedList** and **HashTable** implementations from **HW1**!

Part A: File Parsing

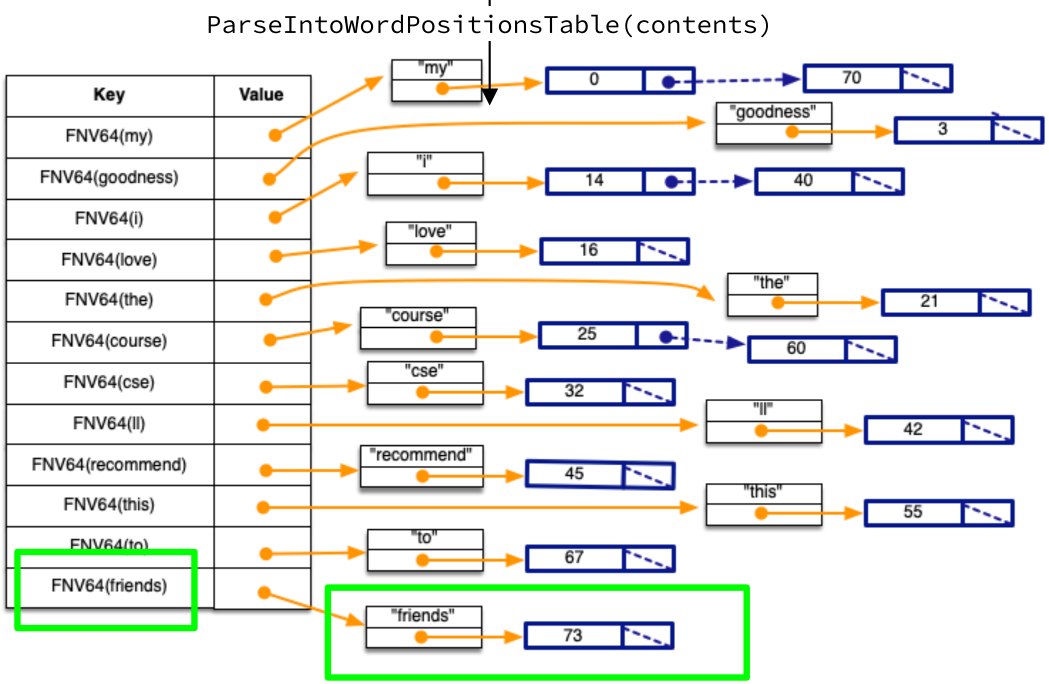
Read a file and generate a HashTable of WordPositions!

Word positions will include the word and LinkedList of its positions in a file.

```c
typedef struct WordPositions {
 char        *word;      // normalized word.  Owned.
 LinkedList  *positions; // list of DocPositionOffset_t.
} WordPositions;
```

somefile.txt

```
My goodness!  I love the course CSE333.\n
I'll recommend this course to my friends.\n
```



Note that the key is the hashed C-string of `WordPositions`

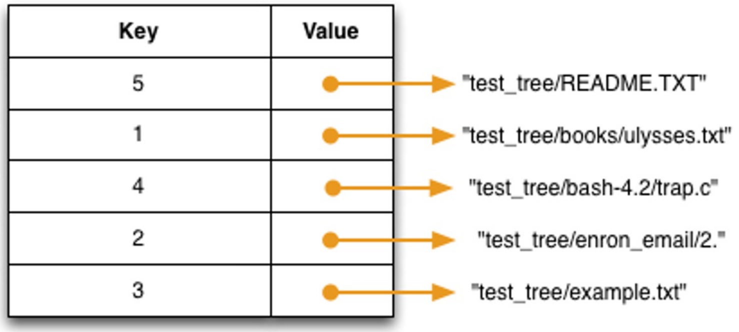
Part B: Directory Crawling – DocTable

Read through a directory in CrawlFileTree.c

For each file visited, build your DocTable and MemIndex!

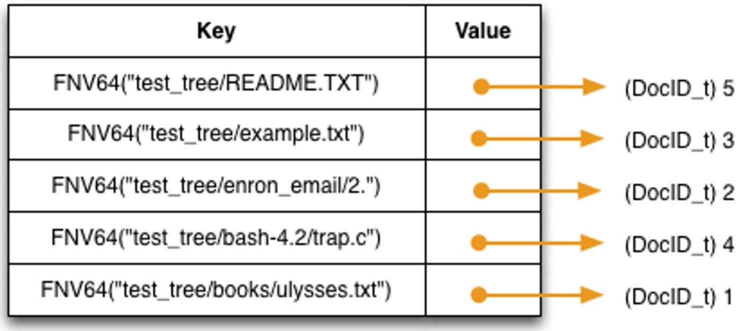
DocTable maps document names to IDs. FNV64 is a hash function.

```
struct doctable_st {
 HashTable *id_to_name;  // mapping doc id to doc name
 HashTable *name_to_id;  // mapping docname to doc id
 DocID_t    max_id;      // max docID allocated so far
};
DocID_t DocTable_Add(DocTable *table, char *doc_name);
```



Key	Value
5	"test_tree/README.TXT"
1	"test_tree/books/ulysses.txt"
4	"test_tree/bash-4.2/trap.c"
2	"test_tree/enron_email/2."
3	"test_tree/example.txt"

docid_to_docname



Key	Value
FNV64("test_tree/README.TXT")	(DocID_t) 5
FNV64("test_tree/example.txt")	(DocID_t) 3
FNV64("test_tree/enron_email/2.")	(DocID_t) 2
FNV64("test_tree/bash-4.2/trap.c")	(DocID_t) 4
FNV64("test_tree/books/ulysses.txt")	(DocID_t) 1

docname_to_docid

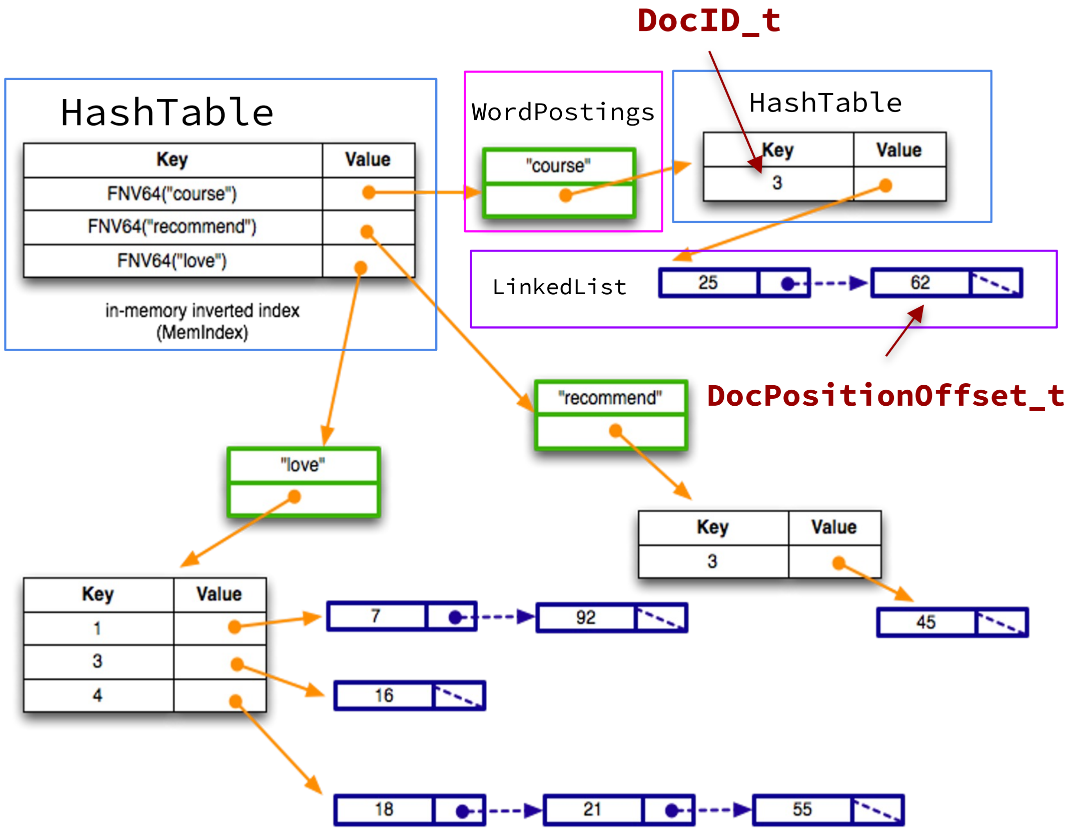
Part B: Directory Crawling – MemIndex

MemIndex is an index to view files.
It’s a HashTable of WordPostings.

```
typedef struct {
 char          *word;
 HashTable     *postings;
} WordPostings;
```

Let’s try to find what contains “course”:

- WordPostings’ postings has an element with `key == 3` (Only DocID 3 has “course in its file”)
- The value is the LinkedList of offsets the words are in DocID 3

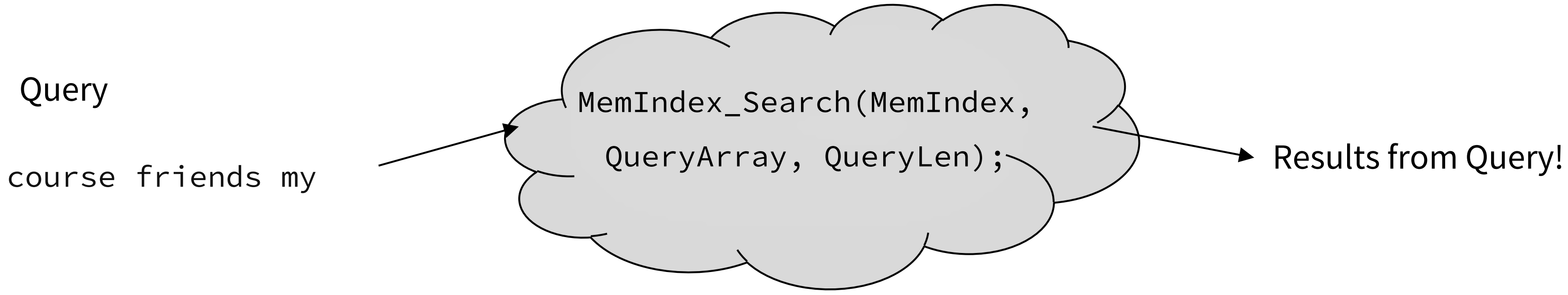


Part C: Searchshell

- Use queries to ask for a result!
  - Formatting should match example output
  - Exact implementation is up to you!

MemIndex.h

```
typedef struct SearchResult {
 uint64_t docid;  // a document that matches a search query
 uint32_t rank;   // an indicator of the quality of the match
} SearchResult, *SearchResultPtr;
```



Query

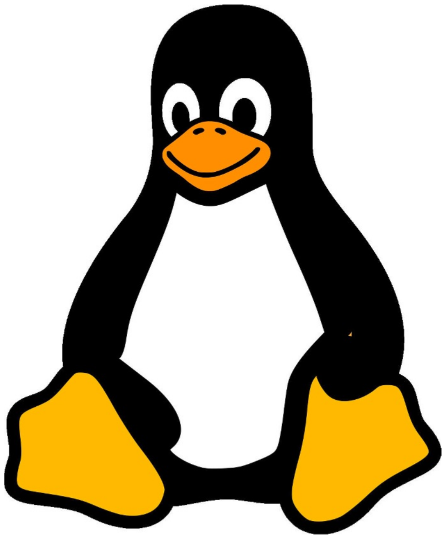
```
course friends my
```

```
MemIndex_Search(MemIndex,
  QueryArray, QueryLen);
```

Results from Query!

Hints

- Read the `.h` files for documentation about functions!
- Understand the high level idea and data structures before getting started
- Follow the suggested implementation steps given in the CSE 333 HW2 spec



Pointers, References, & Const

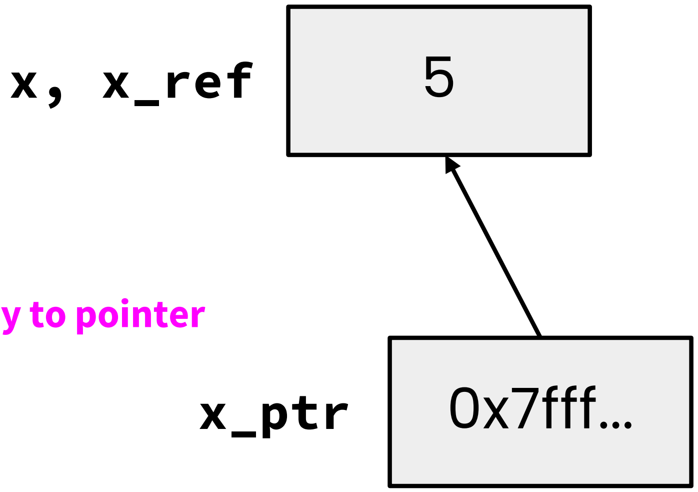
Example

Consider the following code:

```
int x = 5;
int& x_ref = x;
int* x_ptr = &x;
```

Note syntactic similarity to pointer declaration

Still the address-of operator!



What are some tradeoffs to using pointers vs references?

Pointers vs. References

Pointers

- Can move to different data via reassignment/pointer arithmetic
- Can be initialized to **NULL**
- Useful for output parameters:
  ```
  MyClass* output
  ```

References

- References the same data for its entire lifetime - *can’t reassign*
- No sensible “default reference,” must be an alias
- Useful for input parameters:
  ```
  const MyClass &input
  ```

Pointers, References, Parameters

- **`void func(int& arg)`** vs. **`void func(int* arg)`**
- Use references when you don't want to deal with pointer semantics
  - Allows real pass-by-reference
  - Can make intentions clearer in some cases
- **STYLE TIP:** use references for input parameters and pointers for output parameters, with the output parameters declared last
  - Note: A reference can't be `NULL`

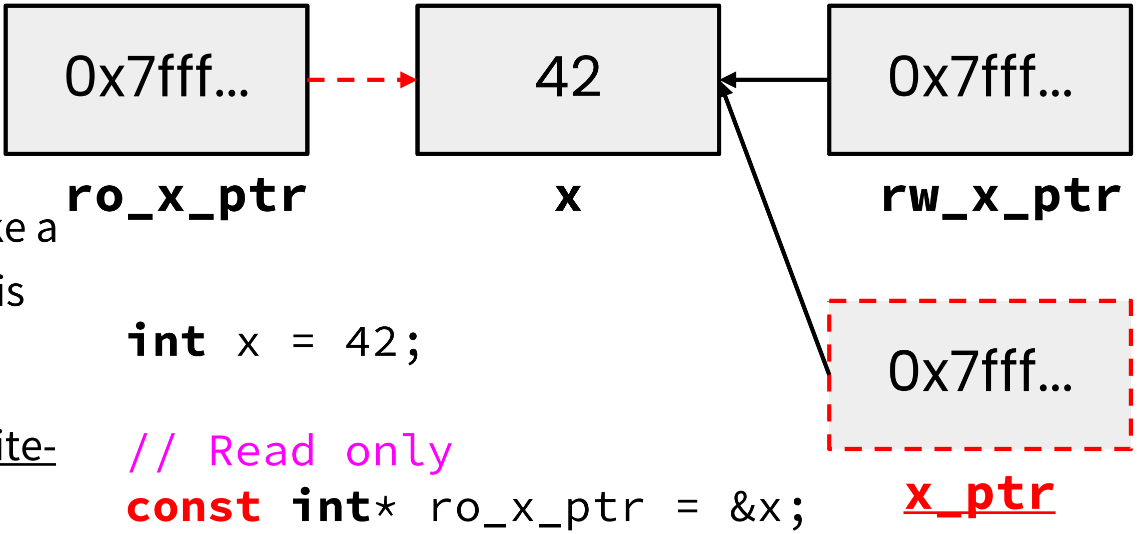
Const

- Mark a variable with `const` to make a compile time check that a variable is never reassigned
- Does not change the underlying write-permissions for this variable

Legend

Red = can’t change box it’s next to

Black = read and write

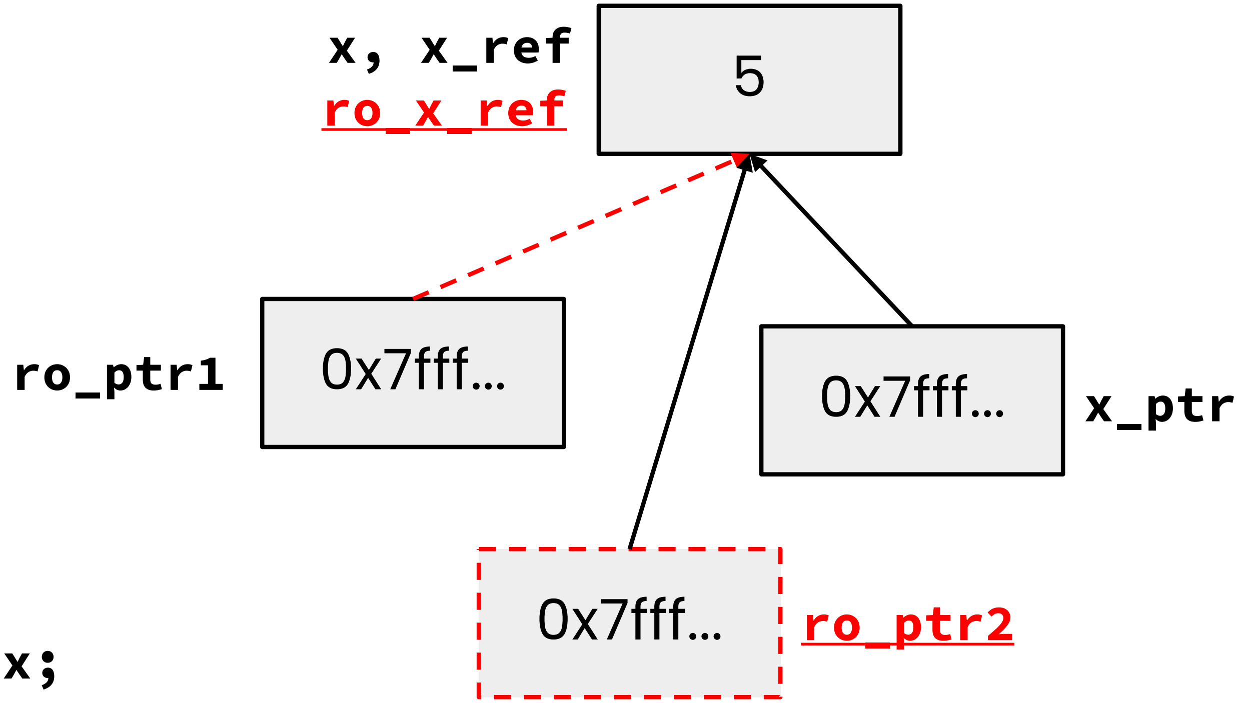


```
int x = 42;

// Read only
const int* ro_x_ptr = &x;

// Can still modify x with
rw_x_ptr!
int* rw_x_ptr = &x;

// Only ever points to x
int* const x_ptr = &x;
```

Exercise 1

Exercise 1

```
int x = 5;

int& x_ref = x;
int* x_ptr = &x;
const int& ro_x_ref = x;
const int* ro_ptr1 = &x;
int* const ro_ptr2 = &x;
```



“Pointer to a const int”

“Const pointer to an int”

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

Legend

Red = can’t change box it’s next to

Black = read and write

Exercise 1

When would you prefer void Func(int &arg); to void Func(int *arg);? Expand on this distinction for other types besides int.

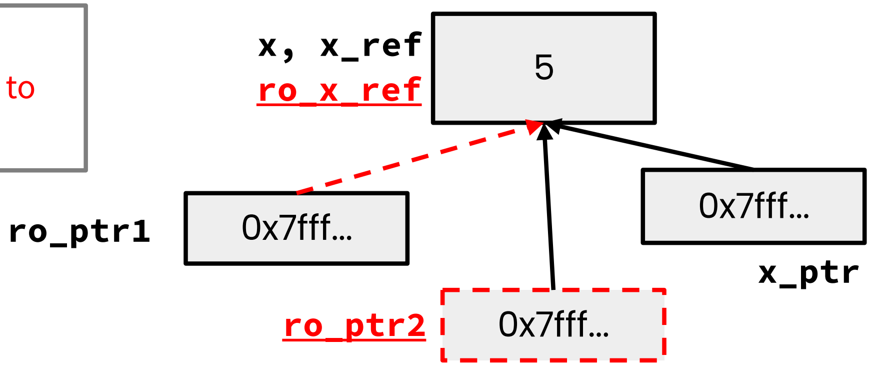
- When you don’t want to deal with pointer semantics, use references
- When you don’t want to copy stuff over (doesn’t create a copy, especially for parameters and/or return values), use references
- Style wise, we want to use **references for input parameters** and **pointers for output parameters**, with the output parameters declared last

Exercise 1

Legend

Red = can't change box it's next to

Black = "read and write"



x, x_ref

ro_x_ref

5

ro_ptr1

0x7fff...

ro_ptr2

0x7fff...

0x7fff...

x_ptr

```
void foo(const int& arg);
void bar(int& arg);

int x = 5;
int& x_ref = x;
int* x_ptr = &x;
const int& ro_x_ref = x;
const int* ro_ptr1 = &x;
int* const ro_ptr2 = &x;
```

Which lines result in a compiler error?

✓ OK ✗ ERROR

✓ `bar(x_ref);`

✗ `bar(ro_x_ref);` ro_x_ref is const

✓ `foo(x_ref);`

✓ `ro_ptr1 = (int*) 0xDEADBEEF;`

✗ `x_ptr = &ro_x_ref;` ro_x_ref is const

✗ `ro_ptr2 = ro_ptr2 + 2;` ro_ptr2 is const

✗ `*ro_ptr1 = *ro_ptr1 + 1;` (*ro_ptr1) is const

Objects and `const` Methods

```
#ifndef POINT_H_
#define POINT_H_

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

 private:
  int  x_;
  int  y_;
};  // class Point

#endif  // POINT_H_
```

Cannot mutate the object it's called on.

Trying to change x_ or y_ inside will produce a compiler error!

A **const** class object can only call member functions that have been declared as **const**

Exercise 2

Exercise 2

Which *lines* of the snippets of code below would cause compiler errors?

✓ OK ✗ ERROR

```
class MultChoice {
  public:
    MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
    int get_q() const { return q_; }
    char get_resp() { return resp_; }
    bool Compare(MultChoice &mc) const;  // do these MultChoice's match?

  private:
    int  q_;     // question number
    char resp_;  // response: 'A','B','C','D', or 'E'
};  // class MultChoice
```

```
✓   const MultChoice m1(1,'A');
✓   MultChoice m2(2,'B');
✗   cout << m1.get_resp();
✓   cout << m2.get_q();
```

```
✓   const MultChoice m1(1,'A');
✓   MultChoice m2(2,'B');
✓   m1.Compare(m2);
✗   m2.Compare(m1);
```

What would you change about the class declaration to make it better?

```
class MultChoice {
  public:
    MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
    int get_q() const { return q_; }
    char get_resp() { return resp_; }
    bool Compare(MultChoice &mc) const;  // do these MultChoice's match?

  private:
    int  q_;     // question number
    char resp_;  // response: 'A','B','C','D', or 'E'
};  // class MultChoice
```

```
class MultChoice {
  public:
    MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
    int get_q() const { return q_; }
    char get_resp() const { return resp_; }
    bool Compare(const MultChoice &mc) const;  // do these match?

  private:
    int  q_;     // question number
    char resp_;  // response: 'A','B','C','D', or 'E'
};  // class MultChoice
```

- Make get_resp() const
- Make the parameter to Compare() const
- Stylistically:
    - Add a setter method and default constructor
    - Disable copy constructor and assignment operator

Exercise 3a

Which *lines* of the snippets of code below would cause compiler errors?

✓ OK ✗ ERROR

```
✓     int z = 5;
✓     const int* x = &z;
✓     int* y = &z;
✓     x = y;
✗     *x = *y;
```

```
✓     int z = 5;
✓     int* const w = &z;
✓     const int* const v = &z;
✗     *v = *w;
✓     *w = *v;
```