University of Southern California

Viterbi School of Engineering

SW Design

A Review: Classes, Structs, C++ Strings

Reference: Professor Mark Redekopp's Course Materials, Online Resources

Types and Instances

- A 'type' indicates how much memory will be required, what the bits mean (i.e. data vs. address), and what operations can be performed
  - int = 32-bits representing only integer values and supporting +,-,*,/,=,==,<,>, etc.
  - char* = 32-bit representing an address and supporting * (dereference),&,+,- (but not multiply and divide)
  - Types are like blueprints for what & how to make a particular 'thing'
- A variable or object is an actual instantiation (allocation of memory) for one of these types
  - int x, double z, char *str;

Abstract Data Types

- Often times we want to represent abstract things (beyond an integer, character, or double)
  - Examples:
    - A pixel, a circle, a student
- Often these abstract types can be represented as a collection of integers, character arrays/strings, etc.
    - A pixel (with R,G,B value)
    - A circle (center_x, center_y, radius)
    - A student (name, ID, major)
- Objects (realized as 'structs' in C and later 'classes' in C++) allow us to aggregate different type variables together to represent a larger 'thing' as well as supporting operations on that 'thing'
  - Can reference the collection with a single name (pixelA, student1)
  - Can access individual components (pixelA.red, student1.id)

Objects

- Objects contain:
  - Data members
    - Data needed to model the object and track its state/operation (just like structs)
  - Methods/Functions
    - Code that operates on the object, modifies it, etc.
- Example: Deck of cards
  - Data members:
    - Array of 52 entries (one for each card) indicating their ordering
    - Top index
  - Methods/Functions
    - Shuffle(), Cut(), Get_top_card()

Structs vs Classes

- Structs (originated in the C language) are the predecessors of classes (C++ language)
  - Though structs are still valid in C++
- Classes form the basis of 'object-oriented' programming in the C++ language
- Both are simply a way of aggregating related data together and related operations (functions or methods) to model some 'object'
- The majority of the following discussion applies both to structs and classes equally so pay attention now to make next lecture easier

Object-Oriented Programming

- Model the application/software as a set of objects that interact with each other
- Objects fuse data (i.e., variables) and functions (a.k.a methods) that operate on that data into one item (i.e., object)
  - Like structs but now with associated functions/methods
- Objects become the primary method of encapsulation and abstraction
  - Encapsulation
    - Hiding of data and implementation details (i.e. make software modular)
    - Only expose a well-defined interface to anyone wanting to use our object
  - Abstraction
    - How we decompose the problem and think about our design rather than the actual code

C++ STRINGS

C Strings

- In C, strings are:
  - Character arrays (char mystring[80])
  - Terminated with a NULL character
  - Passed by reference/pointer (char *) to functions
  - Require care when making copies
    - Shallow (only copying the pointer) vs.
      Deep (copying the entire array of characters)
  - Processed using C String library (<cstring>)

String Function/Library (cstring)

- int strlen(char *dest)

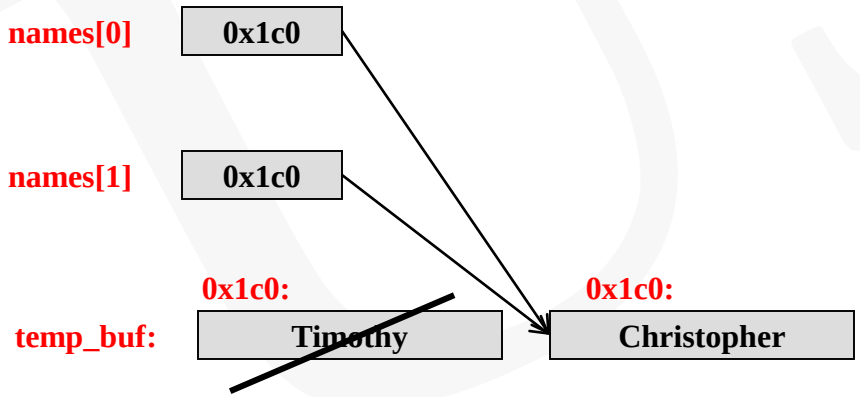
In C, we have to pass the C-String as an argument for the function to operate on it

- int strcmp(char *str1, char *str2);
  - Return 0 if equal, >0 if first non-equal char in str1 is alphanumerically larger, <0 otherwise
- char *strcpy(char *dest, char *src);
  - strncpy(char *dest, char *src, int n);
  - Maximum of n characters copied
- char *strcat(char *dest, char *src);
  - strncat(char *dest, char *src, int n);
  - Maximum of n characters concatenated plus a NULL
- char *strchr(char *str, char c);
  - Finds first occurrence of character ‘c’ in str returning a pointer to that character or NULL if the character is not found

```
#include <cstring>
using namespace std;

int main() {
  char temp_buf[5];
  char str[] = "Too much";

  strcpy(temp_buf, str);
  strncpy(temp_buf, str, 4);
  temp_buf[4] = '\0'

  return 0; }
```

Copying Strings/Character Arrays in C

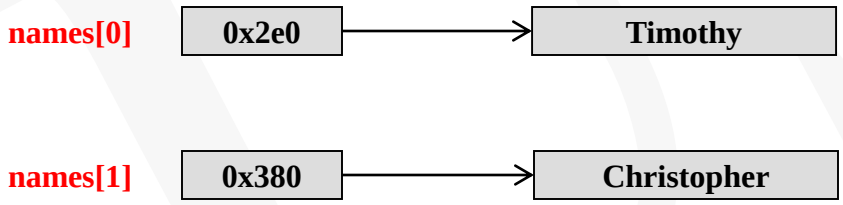
- Recall shallow vs. deep copies
- Can we just use the assignment operator, '=' with character arrays?
- No, must allocate new storage




```
#include <iostream>
#include <cstring>
using namespace std;

// store 10 user names of up to 80 chars
//   names type is still char **
char *names[10];


int main()
{
  char temp_buf[100];


  cin >> temp_buf;  // user enters "Timothy"
  names[0] = temp_buf;


  cin >> temp_buf;  // user enters "Christopher"
  names[1] = temp_buf;

  return 0;
}
```

Copying Strings/Character Arrays in C (cont.)

- No, must allocate new storage




```
#include <iostream>
#include <cstring>
using namespace std;

// store 10 user names of up to 80 chars
//   names type is still char **
char *names[10];


int main()
{
  char temp_buf[100];


  cin >> temp_buf;  // user enters "Timothy"
  names[0] = new char[strlen(temp_buf)+1];
  strcpy(names[0], temp_buf);


  cin >> temp_buf;  // user enters "Christopher"
  names[1] = new char[strlen(temp_buf)+1];
  strcpy(names[1], temp_buf);


  return 0;
}
```

C++ Strings

- So you don't like remembering all these details?
  - You can do it! Don't give up
- C++ provides a 'string' class that abstracts all those worrisome details and encapsulates all the code to actually handle:
  - Memory allocation and sizing
  - Deep copy
  - etc.

Object Syntax Overview

- The following are objects
  - ifstream
  - string
- Can initialize at declaration by passing initial value in ( )
  - Known as a constructor
- Use the dot operator to call an operation (function) on an object or access a data value
- Some special operators can be used on certain object types (+, -, [], etc.) but you have to look them up

```
#include <iostream>
#include <string>
using namespace std;
int main(int argc, char *argv[])

{
  string s1("EE 590");// len will have 6
  int len = s1.size();

  // s2 will have "EE590"
  string s2 = s1.substr(3,3);

  // s3 will have "EE 590 is dr"
  string s3 = s1 + " is dr";

  // will print 'E'
  cout << s1[0] << endl;
  cout << s2 << endl;
  cout << s3 << endl;
  return 0;
}
```

String and Ifstreams are Examples of Objects

```
ifstream myfile(argv[1]);

myfile.fail();

myfile >> x;
```

String Examples

- **Must:**
  - #include <string>
  - using namespace std;
- **Initializations / Assignment**
  - Use initialization constructor
  - Use '=' operator
  - Can reassign and all memory allocation will be handled
- **Redefines operators:**
  - + (concatenate / append)
  - += (append)
  - ==, !=, >, <, <=, >= (comparison)
  - [] (access individual character)

```
#include <iostream>
#include <string>
using namespace std;
int main(int argc, char *argv[])

{
string s1("EE 590");
 cout << s1 << endl;

string s2="590";
 s2 = "EE " + s2;
 cout << s2 << endl;

 if (s1 == s2)
  cout << "s1 and s2 are the same" <<
endl;
  return 0;
}
```

http://www.cplusplus.com/reference/string/string/

More String Examples

- Size/Length of string
- Get C String (char *) equiv.
- Find a substring
  - Searches for occurrence of a substring
  - Returns either the index where the substring starts or string::npos
  - std::npos is a constant meaning 'just beyond the end of the string'...it's a way of saying 'Not found'
- Get a substring
  - Pass it the start character and the number of characters to copy
  - Returns a new string
- Others: replace, rfind, etc.

```
#include <iostream>
#include <string>
using namespace std;

int main(int argc, char *argv[]) {
  string s1("abc def");
  cout << "Len of s1: " << s1.size() << endl;

  char my_c_str[80];
  strcpy(my_c_str, s1.c_str() );
  cout << my_c_str << endl;

  if(s1.find("bc d") != string::npos)
    cout << "Found bc_d starting at pos=":
    cout << s1.find("bc_d") << endl;

  found = s1.find("def");
  if( found != string::npos){
    string s2 = s1.substr(found,3)
    cout << s2 << endl;
  }
}
```

Output:

```
Len of s1: 7
abc def
The string is: abc def
Found bc_d starting at pos=1
def
```

Exercises

- **Circ_shift**

Starting with data...

STRUCTS

Definitions and Instances (Declarations)

- **Objects must first be defined/declared (as a 'struct' or 'class')**
  - The declaration is a blue print that indicates what any instance should look like
  - Identifies the overall name of the struct and its individual component types and names
  - The declaration does not actually create a variable
  - Usually appears outside any function
- **Then any number of instances can be created/instantiated in your code**
  - *Instances* are actual objects created from the definition (blueprint)
  - Declared like other variables

```
#include<iostream>

using namespace std;

// struct definition
struct pixel {
  unsigned char red;
  unsigned char green;
  unsigned char blue;
};
// 'pixel' is now a type
//  just like 'int' is a type

int main(int argc, char *argv[])
{
  int i,j;
  // instantiations
  pixel pixela;
  pixel image[256][256];
  // make pixela red
  pixela.red = 255;
  pixela.blue = pixela.green = 0;
  // make a green image
  for(i=0; i < 256; i++){
    for(j=0; j < 256; j++){
      image[i][j].green = 255;
      image[i][j].blue = 0;
      image[i][j].red = 0;
  }  }
  return 0;
}
```

Membership Operator (.)

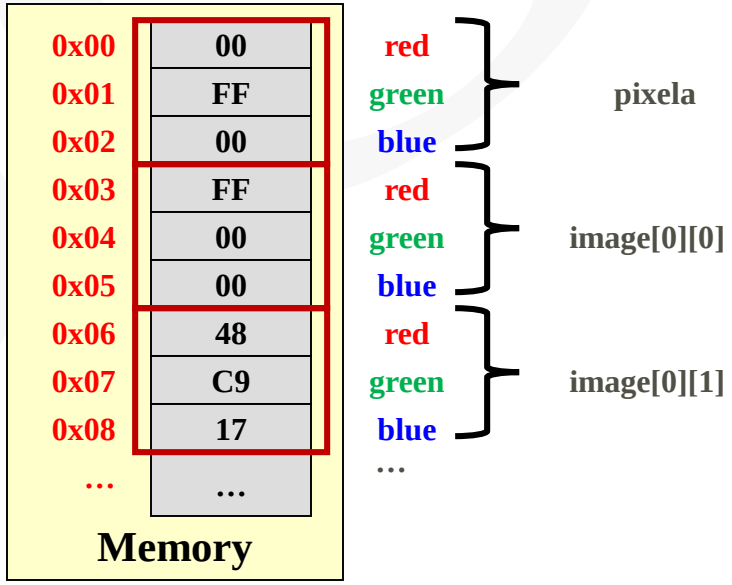
- Each variable (and function) in an object definition is called a 'member' of the object (i.e. struct or class)
- When declaring an instance/variable of an object, we give the entire object a name, but the individual members are identified with the member names provided in the definition
- We use the . (dot/membership) operator to access that member in an instance of the object
  - Supply the name used in the definition above so that code is in the form: instance_name.member_name

```
#include<iostream>
using namespace std;

enum {CS, CECS, EE};

struct student {
  char name[80];
  int id;
  int major;
};


int main(int argc, char *argv[])
{
  int i,j;
  // instantiations
  student my_student;

  // setting values
  strncpy(my_student.name,"Tom Trojan",80);
  my_student.id = 1682942;
  my_student.major = CS;
  if(my_student.major == CECS)
    cout << "You like HW" << endl;
  else
    cout << "You like SW" << endl;
  ...
  return 0;
}
```

Memory View of Objects

- Each instantiation allocates memory for all the members/components of the object (struct or class)

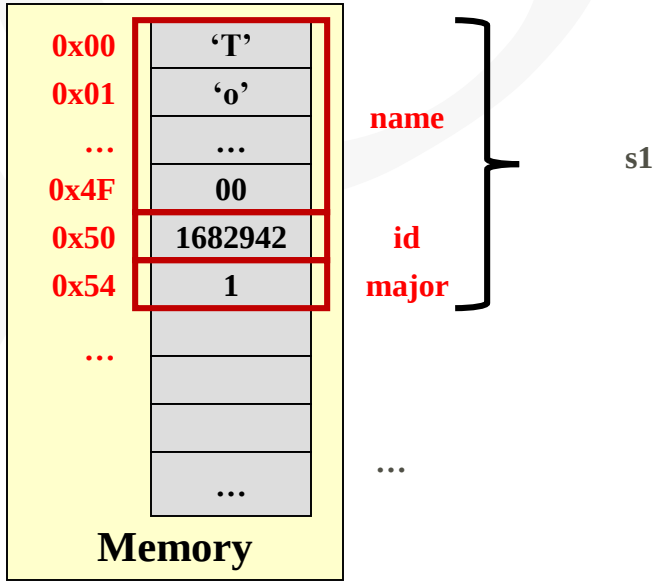
```
#include<iostream>

using namespace std;

struct pixel {
  unsigned char red;
  unsigned char green;
  unsigned char blue;
};

int main(int argc, char *argv[])
{
  int i,j;
  // instantiations
  pixel pixela;
  pixel image[256][256];
...
  return 0;
}
```



Memory View of Objects

- Objects can have data members that are arrays or even other objects

```
#include<iostream>

using namespace std;

struct student {
  char name[80];
  int id;
  int major;
};

int main(int argc, char *argv[])
{
  int i,j;
  // instantiations
  student s1;
  ...
  return 0;
}
```



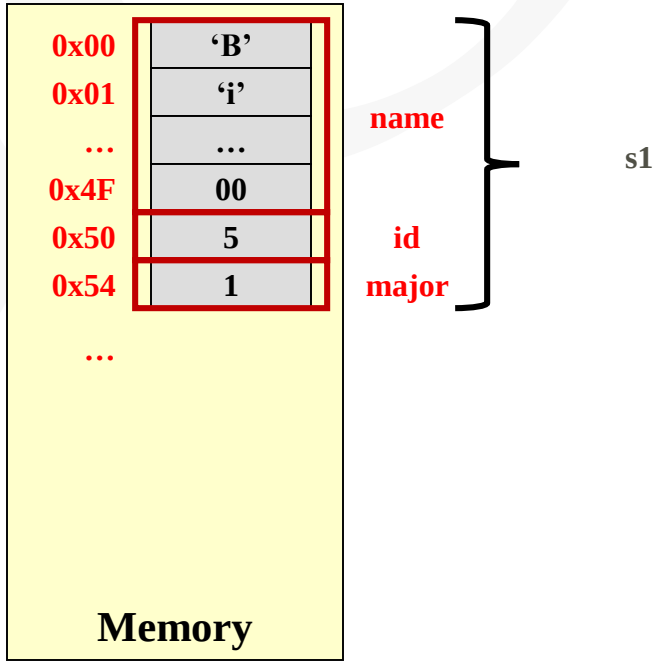
Assignment semantics and pointers to objects

IMPORTANT NOTES ABOUT OBJECTS

Object assignment

- Consider the following initialization of s1

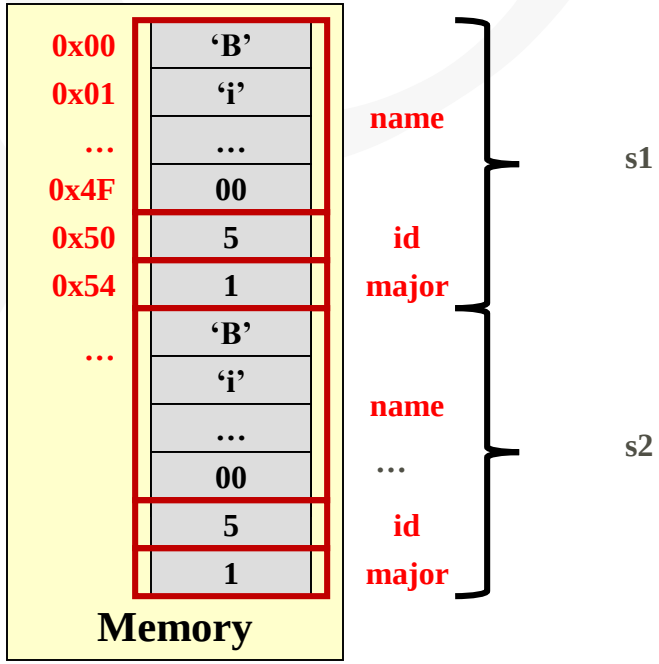
```
#include<iostream>
using namespace std;

enum {CS, CECS};

struct student {
  char name[80];
  int id;
  int major;
};

int main(int argc, char *argv[])
{
  student s1,s2;
  strncpy(s1.name,"Bill",80);
  s1.id = 5; s1.major = CECS;
```



Object assignment (cont.)

- Assigning one object to another will perform an element by element copy of the source struct to the destination object

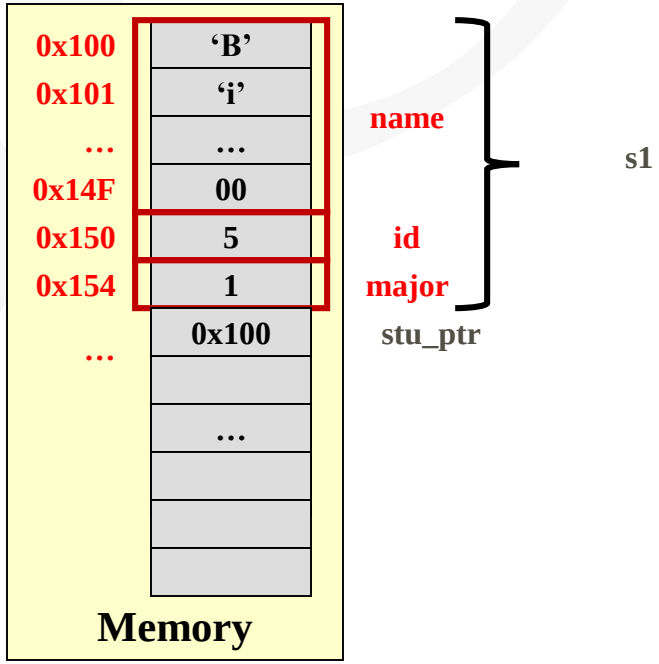
```
#include<iostream>
using namespace std;

enum {CS, CECS };

struct student {
  char name[80];
  int id;
  int major;
};

int main(int argc, char *argv[])
{
  student s1,s2;
  strncpy(s1.name,"Bill",80);
  s1.id = 5; s1.major = CECS;
  s2 = s1;
  return 0;
}
```



Pointers to Objects

- We can declare pointers to objects just as any other variable

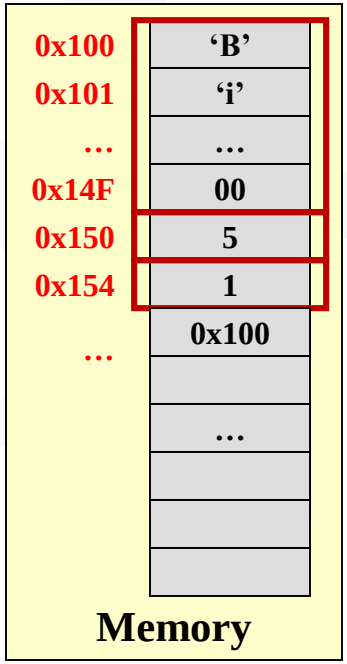
```
#include<iostream>
using namespace std;

enum {CS, CECS };

struct student {
  char name[80];
  int id;
  int major;
};

int main(int argc, char *argv[])
{
  student s1, *stu_ptr;
  strncpy(s1.name,"Bill",80);
  s1.id = 5; s1.major = CECS;
  stu_ptr = &s1;
  return 0;
}
```

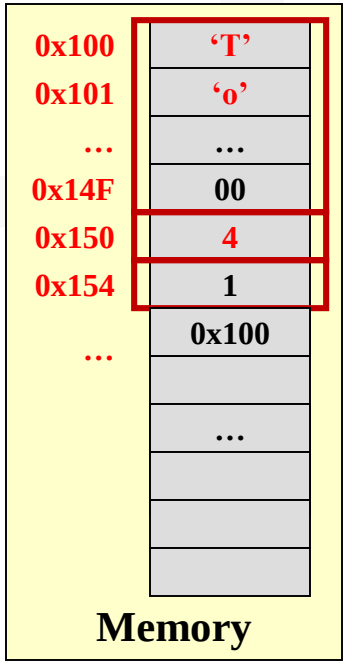


Accessing members from a Pointer

- Can dereference the pointer first then use the dot operator

```
#include<iostream>
using namespace std;

enum {CS, CECS };

struct student {
  char name[80];
  int id;
  int major;
};

int main(int argc, char *argv[])
{
  student s1,*stu_ptr;
  strncpy(s1.name,"Bill",80);
  s1.id = 5; s1.major = CECS;
  stu_ptr = &s1;
  (*stu_ptr).id = 4;
  strncpy( (*stu_ptr).name, "Tom",80);


  return 0;
}
```

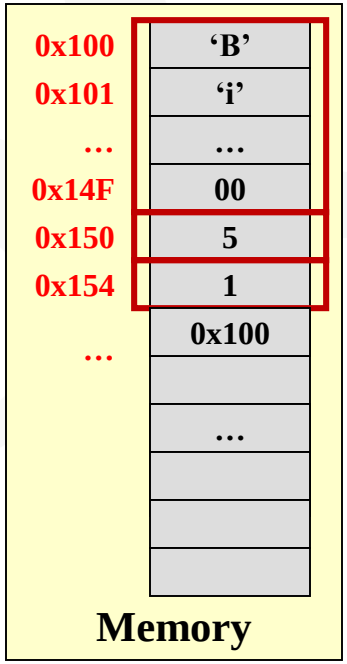


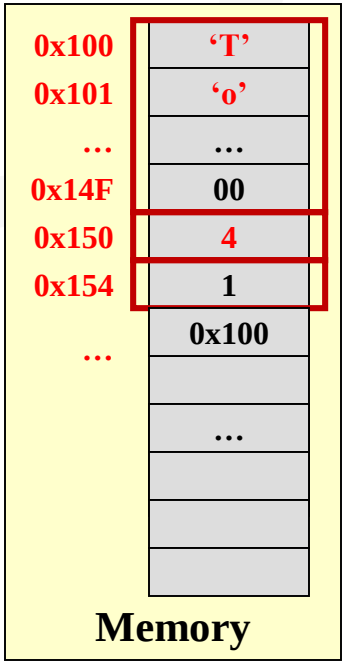


Arrow (->) operator

- Save keystrokes & have cleaner looking code by using the arrow (->) operator
  - `(*struct_ptr).member` equivalent to `struct_ptr->member`
  - Always of the form: `ptr_to_struct->member_name`

```
#include<iostream>
using namespace std;

enum {CS, CECS };

struct student {
  char name[80];
  int id;
  int major;
};

int main(int argc, char *argv[])
{
  student s1,*stu_ptr;
  strncpy(s1.name,"Bill",80);
  s1.id = 5; s1.major = CECS;
  stu_ptr = &s1;
  stu_ptr->id = 4;
  strncpy( stu_ptr->name, "Tom",80);
  ...
  return 0;
}
```





Passing Objects as Arguments

- In C, arguments must be a single value [i.e. a single data object / can't pass an entire array of data, instead pass a pointer]
- Objects are the exception…you can pass an entire struct 'by value'
  - Will make a copy of the struct and pass it to the function
- Of course, you can always pass a pointer [especially for big objects since pass by value means making a copy of a large objects]

```
#include<iostream>

using namespace std;

struct Point {
  int x;
  int y;
};

void print_point(Point myp)
{
  cout << "(x,y)=" << myp.x << "," << myp.y;
  cout << endl;
}

int main(int argc, char *argv[])
{
  Point p1;
  p1.x = 2; p1.y = 5;
  print_point(p1);
  return 0;
}
```

Returning Objects

- Can only return a single struct from a function [i.e. not an array of objects]
- Will return a *copy* of the struct indicated
  - i.e. 'return-by-value'

```
#include<iostream>

using namespace std;
struct Point {
  int x;
  int y;
};
void print_point(Point *myp)
{
  cout << "(x,y)=" << myp->x << "," << myp->y;
  cout << endl;
}
Point make_point()
{
  Point temp;
  temp.x = 3; temp.y = -1;
  return temp;
}
int main(int argc, char *argv[])
{
  Point p1;
  p1 = make_point();
  print_point(&p1);
  return 0;
}
```

CLASSES

Object-Oriented Programming

- Model the application/software as a set of objects that interact with each other
- Objects fuse data (i.e., variables) and functions (a.k.a methods) that operate on that data into one item, i.e., object
  - Like structs but now with associated functions/methods
- Objects become the primary method of encapsulation and abstraction
  - Encapsulation
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  - Abstraction
    - How we decompose the problem and think about our design rather than the actual code

Objects

- Objects contain:
  - Data members
    - Data needed to model the object and track its state/operation (just like structs)
  - Methods/Functions
    - Code that operates on the object, modifies it, etc.
- Example: Deck of cards
  - Data members:
    - Array of 52 entries (one for each card) indicating their ordering
    - Top index
  - Methods/Functions
    - Shuffle(), Cut(), Get_top_card()

C++ Classes

- Classes are the programming construct used to define objects, their data members, and methods/functions
- Similar idea to structs
- Steps:
  - Define the class' data members and function/method prototypes
  - Write the methods
  - Instantiate/Declare object variables and use them by calling their methods
- Terminology:
  - Class = Definition/Blueprint of an object
  - Object = Instance of the class, actual allocation of memory, variable, etc.

poker.cpp

```
#include <iostream>
using namespaces std;
class Deck {
 public:
   Deck();   // Constructor
   int get_top_card();
 private:
   int cards[52];
   int top_index;
};

// member function implementation
Deck::Deck()
{
  for(int i=0; i < 52; i++)
    cards[i] = i;
}
int Deck::get_top_card()
{
   return cards[top_index++];
}
// Main application
int main(int argc, char *argv[]) {
  Deck d;
  int hand[5];
  d.shuffle();
  d.cut();
  for(int i=0; i < 5; i++){
    hand[i] = d.get_top_card();
  }
  ...
```

C++ Classes (cont.)

deck.h

```
class Deck {
 public:
   Deck();    // Constructor
   ~Deck();   // Destructor
   void shuffle();
   void cut();
   int get_top_card();
 private:
   int cards[52];
   int top_index;
};
```

deck.cpp

```
#include<iostream>
#include "deck.h"

// Code for each prototyped method
```

poker.cpp

```
#include<iostream>
#include "deck.h"

int main(int argc, char *argv[]) {
  Deck d;
  int hand[5];

  d.shuffle();
  d.cut();
  for(int i=0; i < 5; i++){
    hand[i] = d.get_top_card();
  }
}
```

Class Definition

- class *name* { ... };
- Each function or data member can be classified as public, private, or protected
  - These classifications support encapsulation by allowing data/method members to be inaccessible to code that is not a part of the class (i.e. only accessible from within a public class method)
  - Ensure that no other programmer writes code that uses or modifies your object in an unintended way
  - Private: Can call or access only by methods/functions that are part of that class
  - Public: Can call or access by any other code
  - Protected: More on this later
- Everything private by default so you must use "public:" to make things visible
- Make the interface public and the guts/inner-workings private

deck.h

```
class Deck {
 public:
   Deck();    // Constructor
   ~Deck();   // Destructor
   void shuffle();
   void cut();
   int get_top_card();
 private:
   int cards[52];
   int top_index;
};
```

deck.cpp

```
#include<iostream>
#include "deck.h"

// Code for each prototyped method
```

poker.cpp

```
#include<iostream>
#include "deck.h"

int main(int argc, char *argv[]) {
  Deck d;
  int hand[5];

  d.shuffle();
  d.cut();

  d.cards[0] = ACE; //won't compile
  d.top_index = 5;  //won't compile
}
```

Constructors / Destructors

- Constructor is a function of the same name as the class itself
  - It is called automatically when the object is created (either when declared or when allocated via 'new')
  - Use to initialize your object (data members) to desired initial state
  - Returns nothing
- Destructor is a function of the same name as class itself with a '~' in front
  - Called automatically when object goes out of scope (i.e. when it is deallocated by 'delete' or when scope completes)
  - Use to free/delete any memory allocated by the object
  - Returns nothing
  - [Note: Currently we do not have occasion to use destructors; we will see reasons later on in the course for when to use these]

deck.h

```
class Deck {
 public:
   Deck();    // Constructor
   ~Deck();   // Destructor
   ...
};
```

deck.cpp

```
#include<iostream>
#include "deck.h"

Deck::Deck() {
  top_index = 0;
  for(int i=0; i < 52; i++){
    cards[i] = i;
  }
}
Deck::~Deck() {
}
```

poker.cpp

```
#include<iostream>
#include "deck.h"

int main(int argc, char *argv[]) {
  Deck d;  // Deck() is called
  ...
  return 1;
  // ~Deck() is called since
  // function is done
}
```

Some Notes

- A constructor function is declared just like a regular member function, but with a name that matches the class name
- Neither the constructor nor the destructor can have any return type (not even void)
- Constructors are executed once, when a new object of the corresponding class is created
- Constructors cannot be treated as regular member functions: constructors cannot be called explicitly
- Functions can overloaded and constructors are no exception. Multiple constructors with different number and/or type of parameters can co-exist
- The compiler chooses among the constructors, the whose argument matches the given parameters in the calling function
- The destructor can not take arguments

Example 1

```
#include <iostream>
#include <cassert>
class IntArray
{
private:
        int *m_array;
        int m_length;
public:
        IntArray(int length)
        {//constructor
            assert(length > 0);
m_array = new int[length];
            m_length = length;
        }
~IntArray() // destructor
        {// Dynamically delete
//array we allocated earlier
              delete[] m_array ;   }
        void setValue(int index, int value) { m_array[index] = value; }
        int& getValue(int index) { return m_array[index]; }

        int getLength() { return m_length; }
};
int main()
{
    IntArray ar(10); // allocate 10 integers
    for (int count=0; count < 10; ++count)
        ar.setValue(count, count+1);

    std::cout << "The value of element 5 is: " << ar.getValue(5);

    return 0;
}   // ar is destroyed here,
    //so the ~IntArray() destructor function is called here
```

Result: The value of element 5 is: 6

Example 2

```
class Simple
{
private:
    int m_nID;
public:
    Simple(int nID)
    {
        std::cout << "Constructing Simple " << nID << '\n';
        m_nID = nID;
    }
    ~Simple()
    {
      std::cout << "Destructing Simple" << m_nID << '\n';
    }
    int getID() { return m_nID; }
};
```

```
int main()
{
    // Allocate a Simple on the stack
    Simple simple(1);
    std::cout << simple.getID() << '\n';

    // Allocate a Simple dynamically
    Simple *pSimple = new Simple(2);
    std::cout << pSimple->getID() <<
'\n';
    delete pSimple;

    return 0;
} // simple goes out of scope here
```

Result:
Constructing Simple 1
1
Constructing Simple 2
2
Destructing Simple 2
Destructing Simple 1

Writing Member Functions

- When writing member functions, the compiler somehow needs to know that the function is a member of a particular class and that the function has inherent access to data members (w/o declaring them). Thus we must 'scope' our functions
- Include the name of the class followed by '::' just before name of function
- This allows the compiler to check access to private/public variables
  - Without the scope operator [i.e. void shuffle() rather than void Deck::shuffle()] the compiler would think that the function is some outside function (not a member of Deck) and thus generate an error when it tried to access the data members, i.e. cards array and top_index

deck.h

```
class Deck {
 public:
   Deck();    // Constructor
   ~Deck();   // Destructor
   ...
};
```

deck.cpp

```
#include<iostream>
#include "deck.h"

Deck::Deck() {
  top_index = 0;
  for(int i=0; i < 52; i++){
    cards[i] = i;
  }
}

Deck::~Deck()
{
}

void Deck::shuffle()
{
  cut(); //calls cut() for this object
  ...
}

int Deck::get_top_card()
{
  top_index++;
  return cards[top_index-1];
}
```

Calling Member Functions

- Member functions are called by preceding their name with the specific object that it should operate on
- d1.shuffle() indicates the code of shuffle() should be operating implicitly on d1's data member vs. d2 or any other Deck object

d1

cards[52]	0	1	2	3	4	5	6	7
top_index	0							

d2

cards[52]	0	1	2	3	4	5	6	7
top_index	0							

```
#include<iostream>
#include "deck.h"

int main(int argc, char *argv[]) {
  Deck d1, d2;
  int hand[5];

  d1.shuffle();
  // not Deck.shuffle() or
  // shuffle(d1), etc.

  for(int i=0; i < 5; i++){
    hand[i] = d1.get_top_card();
  }
}
```

d1

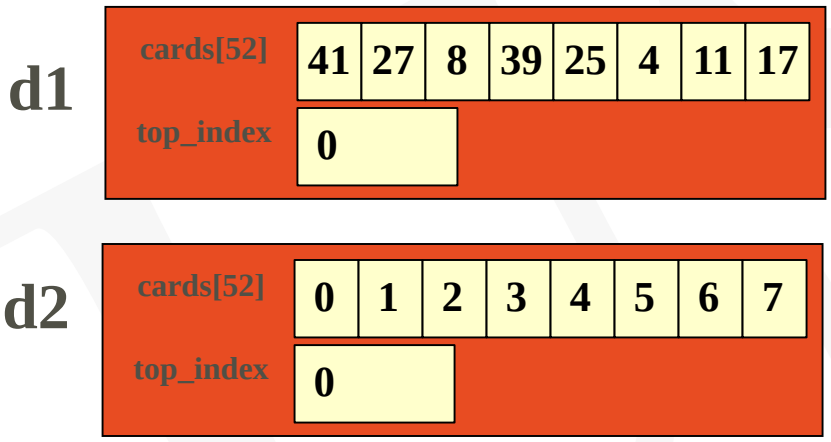
cards[52]	41	27	8	39	25	4	11	17
top_index	1							

Calling Member Functions (cont.)

- Within a member function we can just call other member functions directly

d1's data will be modified (shuffled and cut)

d1 is implicitly passed to shuffle()



Since shuffle was implicitly working on d1's data, d1 is again implicitly passed to cut()

poker.cpp

```
#include<iostream>
#include "deck.h"

int main(int argc, char *argv[]) {
  Deck d1, d2;
  int hand[5];

  d1.shuffle();
  ...
}
```

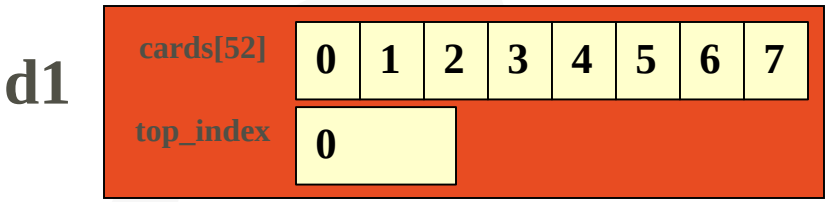
deck.cpp

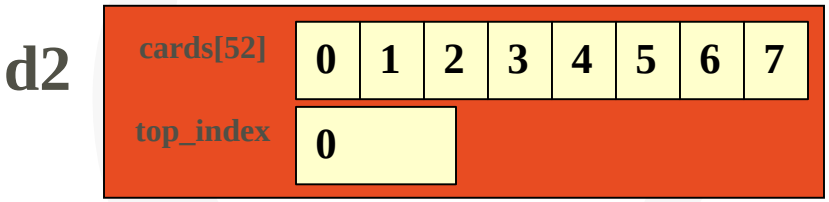
```
#include<iostream>
#include "deck.h"

void Deck::shuffle()
{
  cut(); // calls cut()
         // for this object
  for(i=0; i < 52; i++){
    int r = rand() % (52-i);
    int temp = cards[r];
    cards[r] = cards[i];
    cards[i] = temp;
  }
}
void Deck::cut()
{
  // swap 1st half of deck w/ 2nd
}
```

Class Pointers

- Can declare pointers to these new class types
- Use '->' operator to access member functions or data



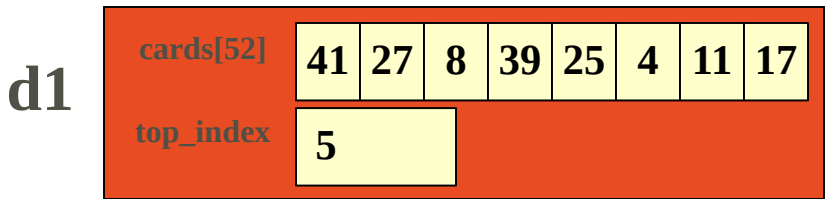



```
#include<iostream>
#include "deck.h"

int main(int argc, char *argv[]) {
  Deck *d1;
  int hand[5];

  d1 = new Deck;

  d1->shuffle();
  for(int i=0; i < 5; i++){
    hand[i] = d1->get_top_card();
  }
}
```



Multiple Constructors

- Can have multiple constructors with different argument lists

deck.h

```
class Student {
 public:
   Student();    // Constructor 1
   Student(string name, int id, double gpa);
                 // Constructor 2
   ~Student();  // Destructor
   string get_name();
   int get_id();
   double get_gpa();

   void set_name(string name);
   void set_id(int id);
   void set_gpa(double gpa);
 private:
   string _name;
   int _id;
   double _gpa;
};
```

deck.cpp

```
Student::Student()
{
  _name = "", _id = 0; _gpa = 2.0;
}

Student::Student(string name, int id, double
gpa)
{
  _name = name; _id = id; _gpa = gpa;
}
```

```
#include<iostream>
#include "deck.h"

int main()
{
  Student s1;  // calls Constructor 1
  string myname;
  cin >> myname;
  s1.set_name(myname);
  s1.set_id(214952);
  s1.set_gpa(3.67);

  Student s2(myname, 32421, 4.0);
              // calls Constructor 2

}
```

Public / Private and Structs vs Classes

- In C++ the only difference between structs and classes is structs default to public access, classes default to private access
- Thus, other code (non-member functions of the class) *cannot* access private class members directly

student.h

```
class Student {
 public:
   Student();    // Constructor 1
   Student(string name, int id, double gpa);
                 // Constructor 2
   ~Student();   // Destructor
   ...
 private:
   string _name;
   int _id;
   double _gpa;
};
```

grades.cpp

```
#include<iostream>
#include "student.h"

int main()
{
  Student s1;  string myname;
  cin >> myname;
  s1._name = myname; //compile error

  ...

}
```

Accessor / Mutator Methods

- Define public "get" (accessor) and "set" (mutator) functions to let other code access desired private data members
- Use 'const' after argument list for accessor methods

student.h

```
class Student {
 public:
   Student();    // Constructor 1
   Student(string name, int id, double gpa);
                 // Constructor 2
   ~Student();   // Destructor
   string get_name() const;
   int get_id() const;
   double get_gpa() const;

   void set_name(string s);
   void set_id(int i);
   void set_gpa(double g);
 private:
   string _name;
   int _id;
   double _gpa;
};
```

student.cpp

```
string Student::get_name()
{   return _name; }
int Student::get_id()
{   return _id; }
void Student::set_name(string s)
{   _name = s;   }

void Student::set_gpa(double g)
{   _gpa = g; }
```

```
#include<iostream>
#include "deck.h"

int main()
{
  Student s1;  string myname;
  cin >> myname;
  s1.set_name(myname);

  string another_name;
  another_name = s1.get_name();

  ...

}
```

Example: Basic Clock

- What members does it need?
- What operations might it have?
- How would we test it?
- Let's write some code...

Example: Basic Clock (cont.)

- What members does it need?
  - int hours, int minutes, int seconds
- What operations might it have?
  - get/set time
  - Print the time
  - Increment hours, minutes or seconds
  - Compare two clock times for equality
- Let's write some code...

C++ Classes: Example

```
#ifndef CLOCK_H
#define CLOCK_H

class Clock
{
 private:
  int hours;
  int minutes;
  int seconds;
 public:
  Clock();
  Clock(int h, int m, inst s);
  void print() const;
};

#endif
```

clock.h

```
#include "clock.h"

Clock::Clock()
{ hours = 12; minutes = 0;
  seconds = 0;
}
Clock::Clock(int h, int m, inst s)
{  hours = h; minutes = m;
   seconds = s;
}

void Clock::print() const
{ cout << hours << ":" ;
  cout << minutes << ":" ;
  cout << seconds;

}
```

clock.cpp

UML (Unified Modeling Language)

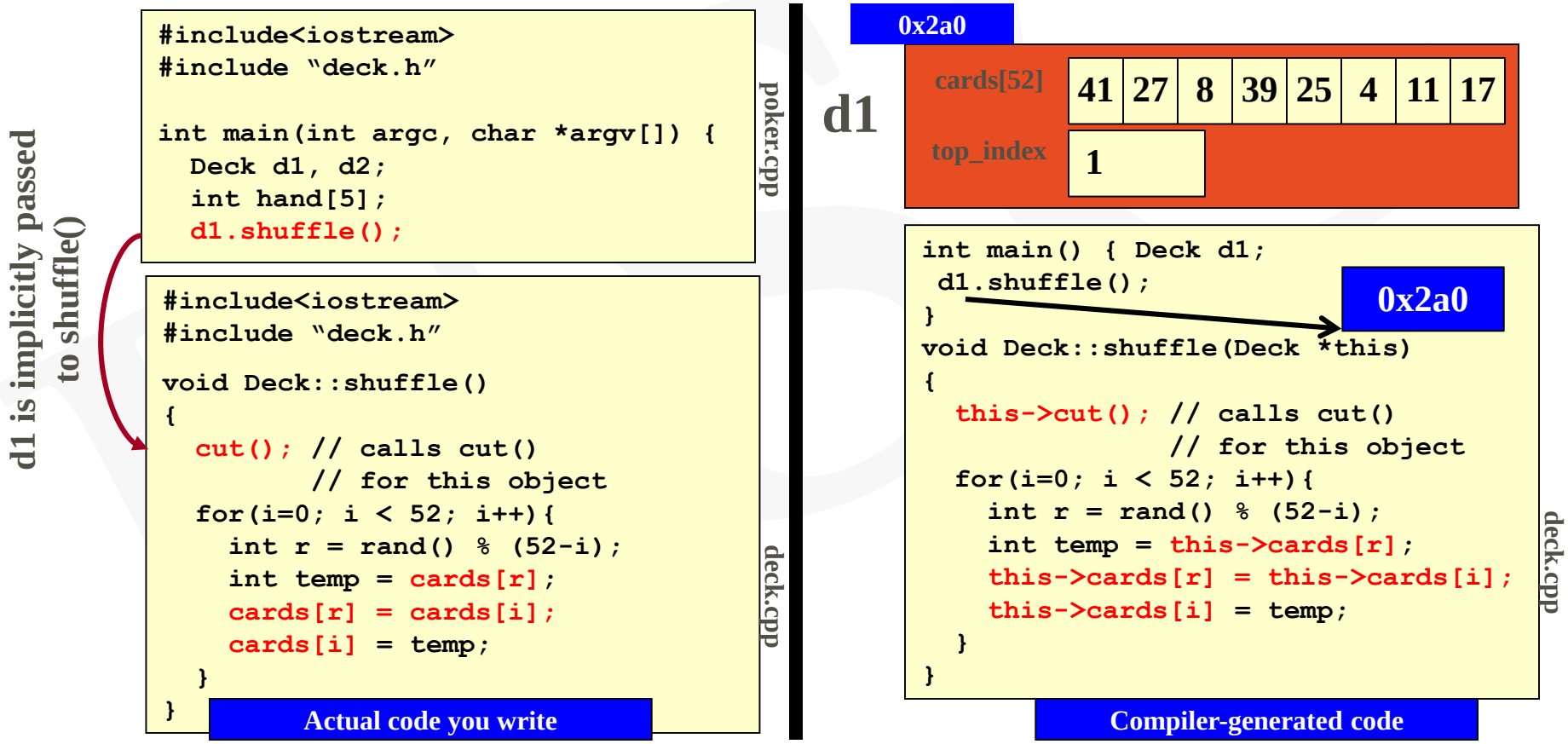
- Shows class definitions in a language-agnostic way
- Shows class hierarchy (inheritance, etc.)
- Each class shown in one box with 3 sections
  - Class Name, Member functions, then Data members
  - Precede function/data member with:
    + (public), - (private), # (protected)
  - Functions show *name with arguments* : *return type*
  - Data members show *name* : *type*

class name (e.g. Deck)
Member functions + shuffle() : void + cut() : void + getTop() : int
Member data - cards[52] : int - top_index : int

```
class Deck {
 public:
   Deck();    // Constructor
   ~Deck();   // Destructor
   void shuffle();
   void cut();
   int getTop();
 private:
   int cards[52];
   int top_index;
};
```

this Pointer

- How do member functions know which object's data to be operating on?
- D1 is implicitly passed via a special pointer call the '**this**' pointer



CLASS DESIGN NOTES

Class Notes

- Remember data members live on from one member function call to the next and can be access within ANY member function

```
#include <iostream>
#include <vector>
using namespace std;

class ABC
{
  public:
   ABC();
   void add_score(int s);
   int get_score(int loc);
private:
   vector<int> scores;
};

// A change to scores here
void ABC::add_score(int s){
  scores.push_back(s);
}

// would be seen by subsequent
//  calls to member functions
int ABC::get_score(int loc){
  return scores[loc];
}

int main(){
  ABC a;
  a.add_score(95);
  a.get_score(0);
}
```

Class Design

- Class names should be 'nouns'
- To decide what objects/classes you need use
  - Object discovery: Based on the requirements of description of the problem look for the nouns/object
  - Object invention: Objects that simplify management or help glue together the primary objects
- Method/Function names should be 'verbs'

```
class GradeBook
{
  public:
   computeAverage();
   int* getScores();
  private:
   int scores[20];
   int _size, _tail;
};

bool GradeBook::computeAverage(){
  double sum = 0.0;
  for(int i=0; i < _size; i++){
   sum += scores[i];
  }
  return sum / _size;
}


int main()
{
  GradeBook gb;
  int* myscores = gb.getScores();
  double sum = 0.0;
  for(int i=0; i < _size; i++){
   sum += myscores[i];
  }
  ...
}
```

http://www.cprogramming.com/tutorial/class_design.html

Class Design (cont.)

- Keep the computation where the data is, i.e., in the appropriate class member functions

```
class GradeBook
{
  public:
   computeAverage();
   int* getScores();
   int size() { return _size; }
  private:
   int scores[20];
   int _size, _tail;
};

bool GradeBook::computeAverage(){
  double sum = 0.0;
  for(int i=0; i < _size; i++){
   sum += scores[i];
  }
  return sum / _size;
}


int main()
{
  GradeBook gb;
  int* myscores = gb.getScores();
  double sum = 0.0;
  for(int i=0; i < gb.size(); i++){
   sum += myscores[i];
  }
  ...
}
```

Exercise

- Write the class definitions (and maybe eventually the whole program) for a card game
  - Form groups of 2 or 3
  - Choose BlackJack unless you'd really like to do something else

Part 1

- Write out the rules in Word, Google Docs, etc.
  - Put a box around the nouns…
  - Circle the action verbs
- Use the nouns and verbs to define the classes and member functions at a general level