CS 162
Intro to Computer Science II

Lecture 13

Constructors

Shallow vs. Deep Copy

2/12/24

Oregon State University

Odds and Ends

- Assignment 3 posted
- Lab 6 posted
- Design 3 will be posted later today!
- Midterm Exam: Friday this week during lecture time

Review

- Abstraction vs. Encapsulation
  - Abstraction: hide unwanted details while giving out most essential details
    - i.e. 10,000 feet view
  - Encapsulation: hide the code and data into a single unit
  - In short, abstraction hides details at the **design** level, while encapsulation hides details at the **implementation** level
- Classes have member variables and functionality
- Contents are private by default
  - Traditionally member variables are private with member functions being public
  - Use accessors and mutators to work with private member variables
    - `get_grade(), get_location(), get_name()`
    - `set_grade(), set_location(), set_name()`
- Classes are typically written with their own header (.h) and implementation (.cpp) files

`this` Keyword

- Can be used inside any class functions as a **pointer** to the object with which the function was called
  - **“`this`” always points to the object being operated on**
- Using `this` can be helpful
  - Make sure we’re referring to the data members of a class, not to other variables that might be in scope.
  - E.g. when a function parameter has the same name as one of its data members

```
void Point::set_x(int  x){
        this->x =  x;
}
```

- Demo…

Const

- To prevent changes to an object being passed, put `const` the parameter listing
  - E.g. `bool is_greater (const Point& a, const Point& b);`
- If a function isn’t supposed to change anything, put a const at the end
  - e.g. `void print() const;`
  - `void Point::print() const {/* definition */}`
  - Will cause an error if the code in print changes anything
- ✳ If using const member variable, it has to be initialized in constructor(s) using initialization list
  - E.g. `Point::Point():z(5){} //where z is defined as a const int`
- Demo…

Today’s Topics:

- Constructors
  - Default vs. non-default

Implementing a Class

- Let’s use what we’ve learned so far to create a Course class
  - Create header and implementation files
  - Basic properties include:
    - course name
    - roster
    - current enrollment
    - instructor

  - Demo…

Implementing a class

- Now our Course class …
  - Has a name
  - Contains roster information with student names
  - Tracks number of enrolled students

- New question… how do we initialize the member variables?
  - Use mutators
  - Umm… calling each individual mutator function is cumbersome
  - Fortunately, we have a better way!

Introducing Constructor

- Constructor – a specially defined function
- Automatically called when the object is created
- Sets up (initializes) the object with appropriate values
  - Member variable values
  - Allocating memory for member variables
  - *Opening a file to read from or write to
- If a constructor is not provided by the programmer, one will be automatically generated (implicitly) but will not initialize any values

More details on Constructors

- **Must** have the same name as the class
- Not allowed to return anything
- May have parameters
  - If no parameters provided, referred to as default constructor
  - If parameters are provided, referred to as non-default constructor (a.k.a. parameterized constructor).
  - It can be defined in a couple ways:
    - Option 1: Use assignment statements

```
Point::Point (){
        this->x = -1;
        this->y = -1;
}
```

```
Point::Point (int a, int b){
        this->x = a;
        this->y = b;
}
```

    - Option 2: Use initialization list

```
Point::Point() : x(-1), y(-1) {}
Point::Point(int a, int b) : x(a), y(b) {}
```

- If using const member variable, it has to be initialized in constructor(s) using initialization list
  - E.g. `Point::Point():z(5){} //where z is defined as a const int`

More details on Constructors

- Each class may have **at most one** default constructor, and **any number** of non-default ones
- If you define any non-default constructors for a class, a default one is **likely needed**
- If constructors are explicitly defined for a class, the compiler will not generate one for you
    - Typical compile time error: a class has non-default constructors, but no default one. Create objects using default constructor → NoNo!!!
- Can't be called using the dot operator
- Can be called after the object is created

```
next_point = Point (3,3);
```

Today’s Topics:

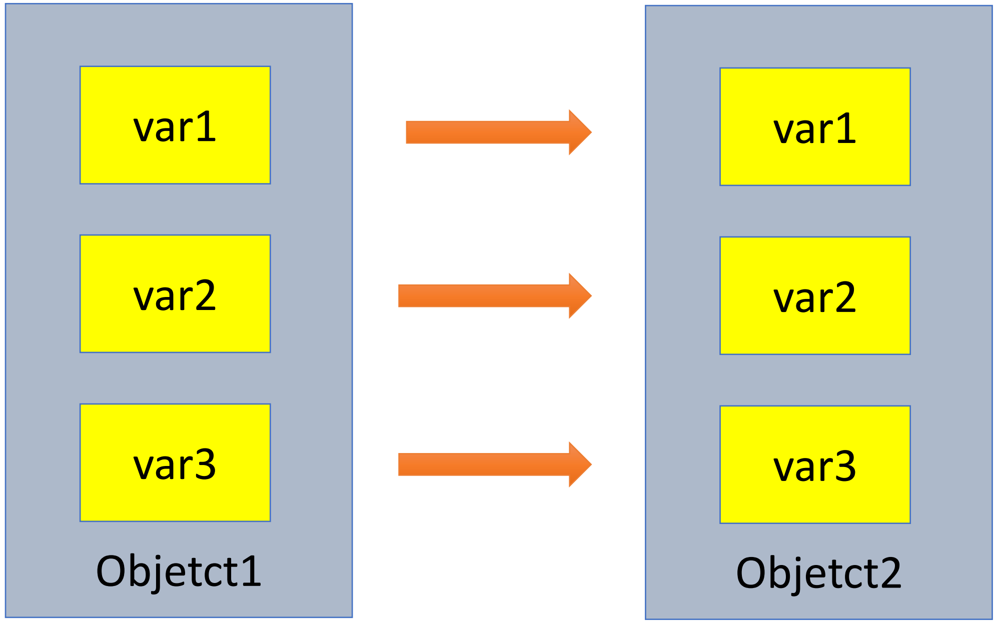
- Shallow vs. Deep copy
- Begin Big three

Destructor

- Special function which is called automatically when the object is destroyed
  - Happens when a statically allocated object goes out of scope or when a dynamically allocated object is freed with `delete`
- Think of this as the "opposite" of the constructor
- Generally used to clean up dynamic memory usage, file I/O handles, database connections, etc.
- To create a destructor, declare a public class function with no return type, with the same name as the class, preceded by a tilde (~):
  - E.g. `~Point();`
- Demo…

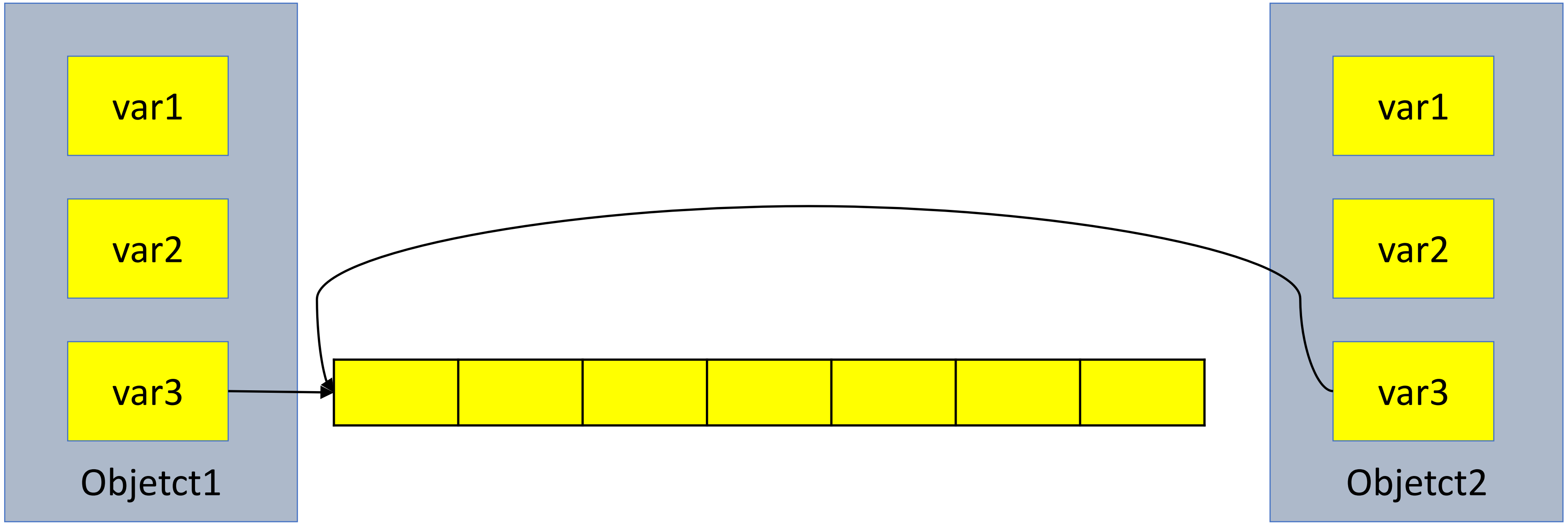
Shallow Copy vs. Deep Copy

- Shallow:
  - A.k.a.: member-wise copy
  - Copy the contents of member variables from one object to another
  - **Default behavior** when objects are copied or assigned



Shallow Copy vs. Deep Copy

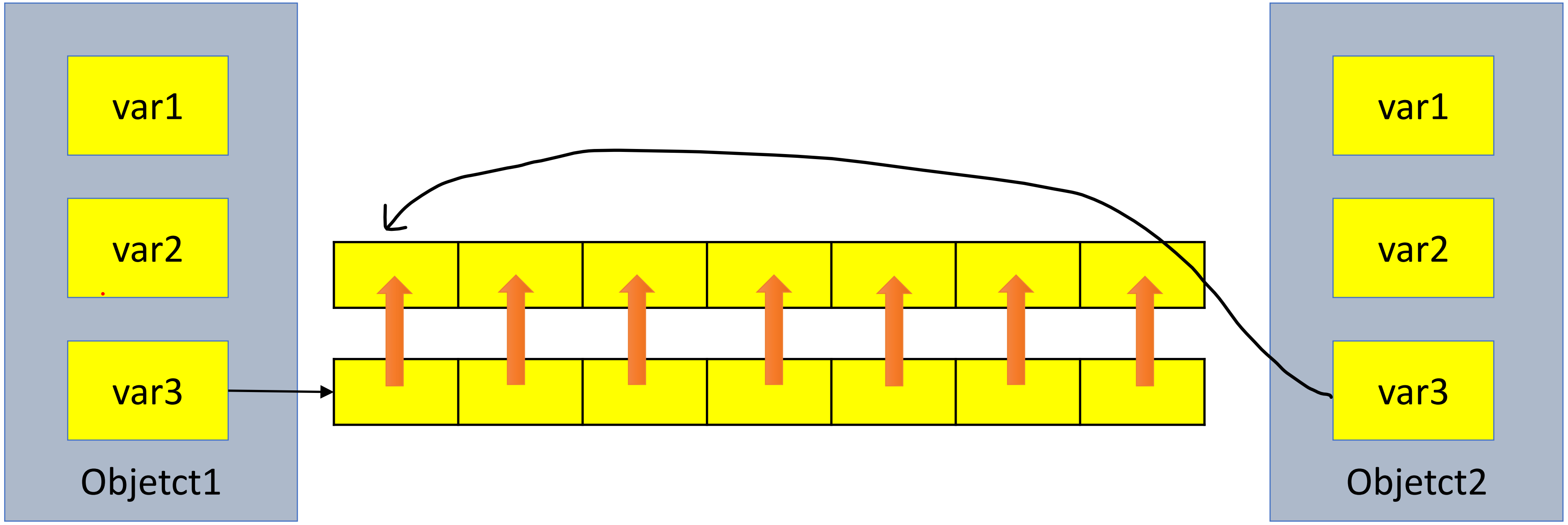
- Shallow:
  - What if the object has dynamic memory allocated?



  - This could be problematic as if we make any changes to the array in object 1, object 2 will be affected as well…

Shallow Copy vs. Deep Copy

- Deep:
  - Copy what each member variable is pointing to so that you get a separate but identical copy
  - Has to be programmer-specified



Assignment Operator (=) Overload

- Predefined assignment operator returns a reference
  - Allows us to chain assignments together: `a = b = c`
    - First set “`b = c`” and return a reference to `b`. Then set “`a = b`”
    - Need to make sure the assignment operator returns something of the same type as its left hand side
- Overloading assignment operator
  - Must be a member of the class

Copy Constructor

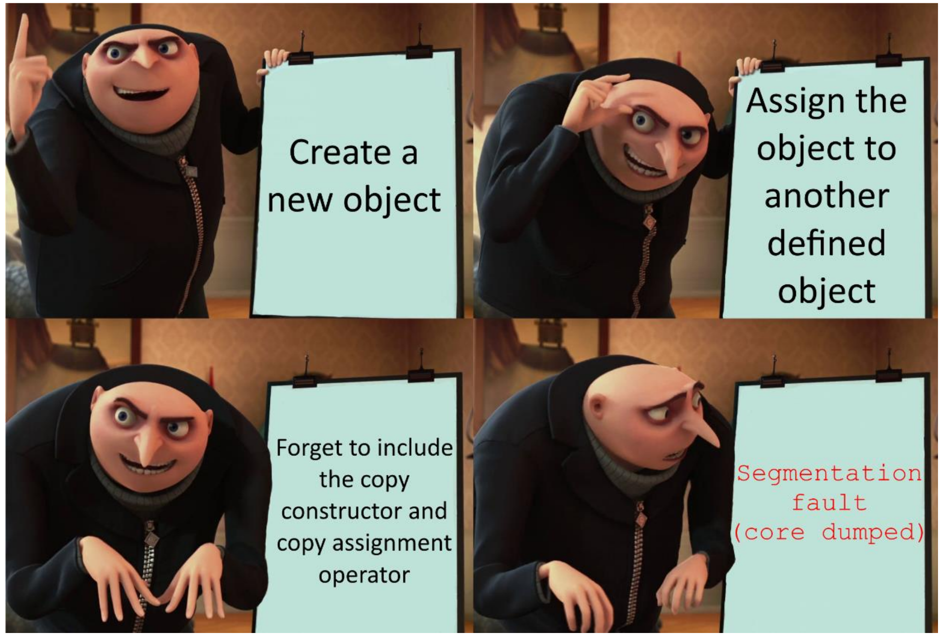
- Constructor that has one parameter that is of the same type as the class
  - Has to accept reference as parameter (normally `const`)
  - Allows for distinct copies, changes to one does not impact the other
  - Called automatically in three cases:
    - When a class object is being declared and initialized by another object of same type
    - Whenever an argument of the class type is “plugged in” for a call by value parameter
    - When a function returns a value of the class type

Destructor

- Delete the object
- Will be automatically created if one is not supplied
    - Will not handle dynamic memory
- `~Class_name();//no return type, no parameters, only one allowed`
- Called when the object goes out of scope
    - When the function ends
    - When the program ends
    - A block containing local variables ends
    - A `delete` operator is called

The Big Three

- If you implement either a **Destructor**, a **Copy Constructor**, or an **Overloaded Assignment Operator**, you should ensure that all 3 are defined
- If you needed one, you probably need all of them
- This rule of thumb goes by several names:
  - The Big Three
  - The Rule of Three
  - The Law of The Big Three
- *C++11 has an expanded version: The Big 5
  - We won't cover this yet


Create a new object
Assign the object to another defined object
Forget to include the copy constructor and copy assignment operator
Segmentation fault (core dumped)

Big Three Activity

Function	Prototype	Job	When is it called	Default Behavior if not defined?

Constructor	ClassName();
	ClassName(w/ params)
		Build the object	Default is called when object is declared with no parameters and no “=“ sign. Nondefault is called if parameters are given	The compiler will provide a default one. It will initialize all variables with garbage values, will not set up pointers

Copy Constructor				
Assignment Operator Overload				
Destructor				

Passing Objects

- Can be passed the same way as any other variable
- Traditionally pass by reference
  - Generally more efficient
  - Pass by value makes two copies → requires the copy constructor at least once
  - Pass by reference only uses the one variable, no copies
  - Can be problematic since changes to references persist

Class Composition

- Class Composition – a fundamental concept in OOP
  - Describes a class that “**has**” one or more objects of other classes.
- Allows to model a “**has-a**” relationship between objects.

- i.e. In assignment 3, `Shop` “has a” `Menu`, and a `Menu` “has a” `Coffee`
- (Well, in fact, a Menu has an array of Coffee objects, but you get the idea ☺)