CS 32 Intro to CS II

Week 2, Discussion 3A

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General Information

- Course info:

  http://web.cs.ucla.edu/classes/winter20/cs32/

  Midterms: 1/30 (Thu.) & 2/25 (Tue.); Final: 3/14 (Sat.)

- TA - Xiao (Steven) Zeng: stevennz@g.ucla.edu
- Discussion 3A:

  Fridays 12:00 pm - 1:50 pm, Boelter 5422

- Office hours:

  Mondays 11:30 am - 12:30 pm, 3:30 pm - 4:30 pm, Boelter 3256S

  Fridays 3:30 pm - 4:30 pm, Boelter 3256S

LA - Sidharth Ramanan

- Email: sidharthramanan@gmail.com
- Office hours: Mondays 4:00 pm to 4:30 pm and Thursdays 8:30 am to 10:00 am @ Boelter 3256S

Today’s Topics:

- Constructor & destructor
- Member initialization list
- Order of construction & destruction
- Copy constructor
- Assignment operator
- Worksheet
- Homework questions (tentative)

Constructor

A **constructor** is a special member function that automatically initializes **every new variable** we create of a class. It's called any time we **create a new variable** of a class.

A constructor is called **N times** when we create **an array of size N** (called for each array element). If a class variable is declared in a loop, it's newly constructed **in every iteration**.

```
// Circle.h

class Circle
{
  public:
    Circle(double x, double y, double r);
    void draw() const;
    bool scale(double factor);
    double radius() const;
  private:
    double m_x;
    double m_y;
    double m_r;
      // Class invariant:  m_r > 0
};

double area(const Circle& circ);
```

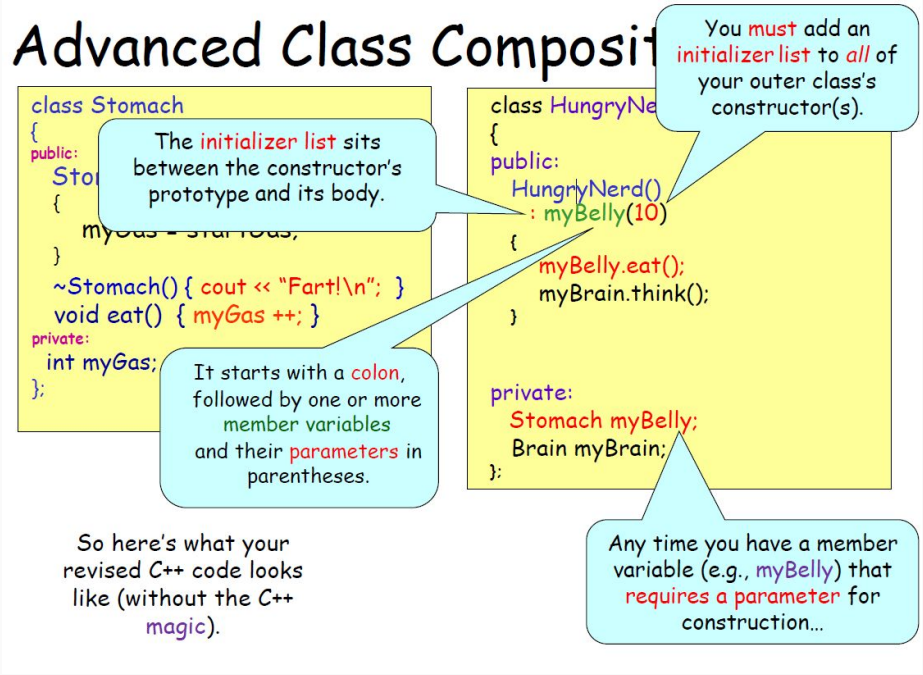
```
Circle::Circle(double x, double y, double r)
 : m_x(x), m_y(y), m_r(r)
{
    if (r <= 0)
    {
        cerr << "Cannot create a circle of radius " << r << endl;
        exit(1);
    }
}
```

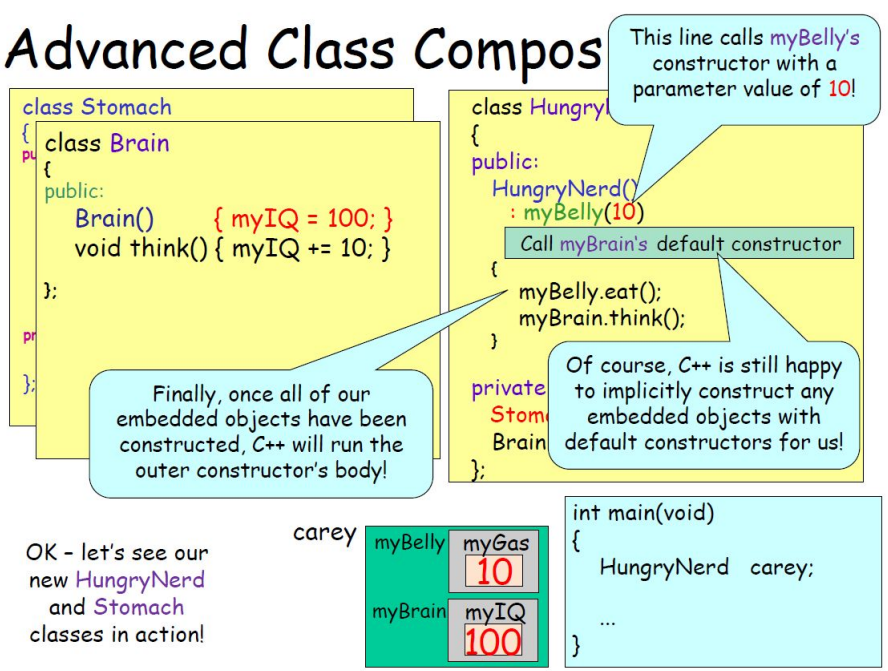
```
int main()
{
    Circle c(-2, 5, 10);
    c.scale(2);
    c.draw();
    cout << area(c);
}
```

Member Initialization List

An **initialization/initializer list** can initialize an embedded class object and/or primitive member variables with a constructor.

It's required for any class member variable that does not have default constructor!



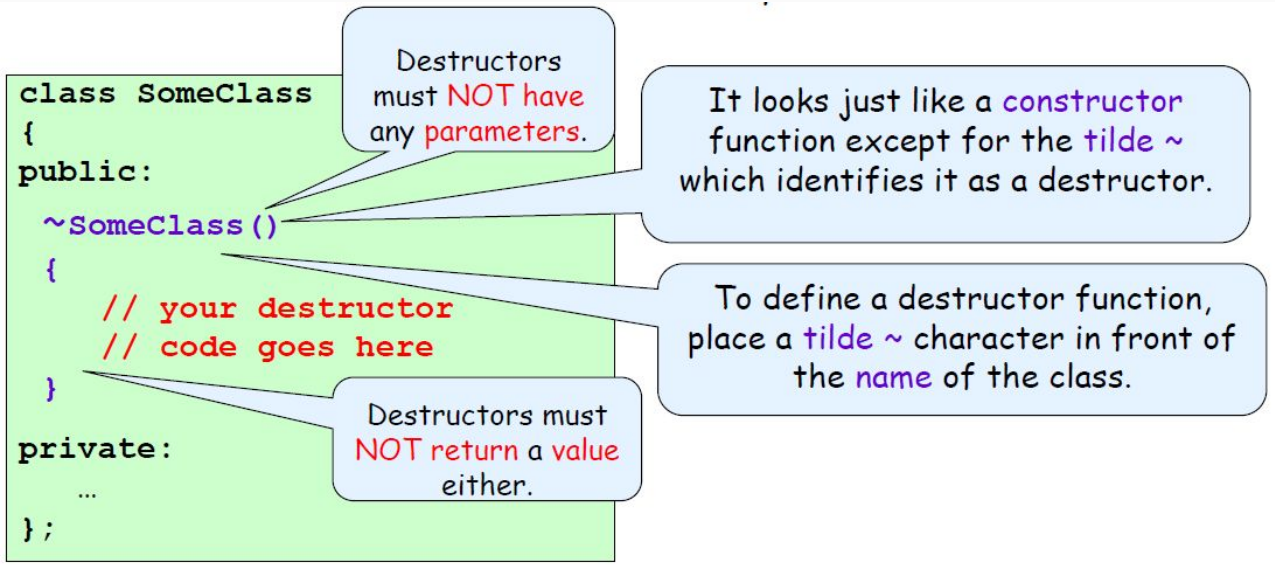


Destructor

A **destructor** de-initialize or destroy a class variable when it is goes away.

If we define an array of N items, a destructor is called **N times** when it goes away.

If we don't define a destructor for a class, compiler will create an implicit one for us. It works fine **unless we use dynamically allocated memory in our class** (will be discussed later).



Order of Construction & Destruction

When a class contain *a member variable of a class type*, it **construct** the member variable **first**, and **destruct** the member variable **last**.

Q: What's the output?

```
using namespace std;

class Tire
{
public:
    Tire() { cout << "T "; }
    ~Tire() { cout << "~T "; }
};

class Wheel
{
public:
    Wheel() { cout << "W "; }
    ~Wheel() { cout << "~W "; }
private:
    Tire m_tire;
};
```

```
class Motorcycle
{
public:
    Motorcycle() { cout << "M "; }
    ~Motorcycle() { cout << "~M "; }
private:
    Wheel m_wheels[2];
};

int main()
{
    Motorcycle m;
    cout << endl;
    cout << "====" << endl;
}
```

Try it out: https://repl.it/@BruinUCLA/Order-of-construction

Manage Resource

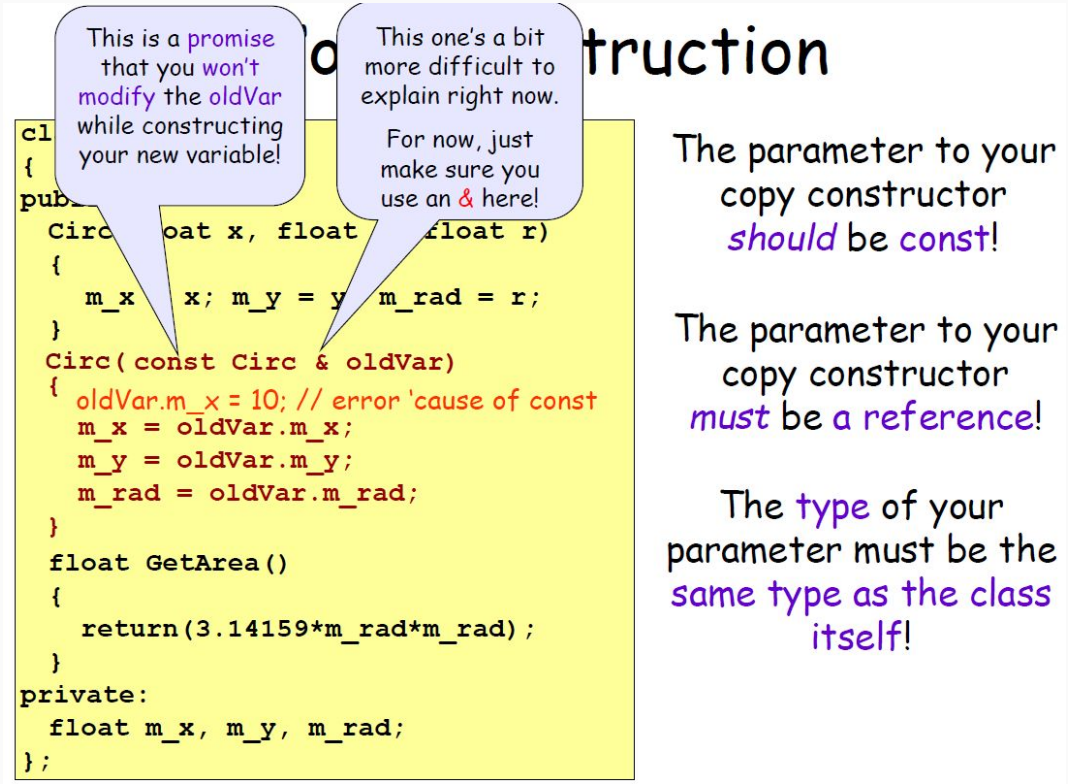
Determine the memory we need for a program during runtime is necessary sometimes (e.g., user inputs). In these cases, we use ***new*** and ***delete*** to dynamically allocate memory.

- Allocate memory to a single element: *Ptr = new sometype*
- Allocate memory to a block (array) of elements: *Ptr = new sometype [# of elements]*
- Free memory containing a single element: *delete Ptr*
- Free memory containing a block (array) of elements: *delete **[]** Ptr*

We should write our own destructor if our class use dynamically allocated memory to **prevent memory leak** before the class instance is destroyed.

Copy Constructor

A **copy constructor** initializes an new object using an existing object of the **same class**.



The parameter to your copy constructor *should* be const!

The parameter to your copy constructor *must* be a reference!

The type of your parameter must be the same type as the class itself!

```
int main()
{
  Circ a(1,1,5);

  Circ b(a);


  cout << b.GetArea();
}
```

Note: C++ also allows you to write *Circ b = a*, instead of *Circ b(a)*.

Copy Constructor

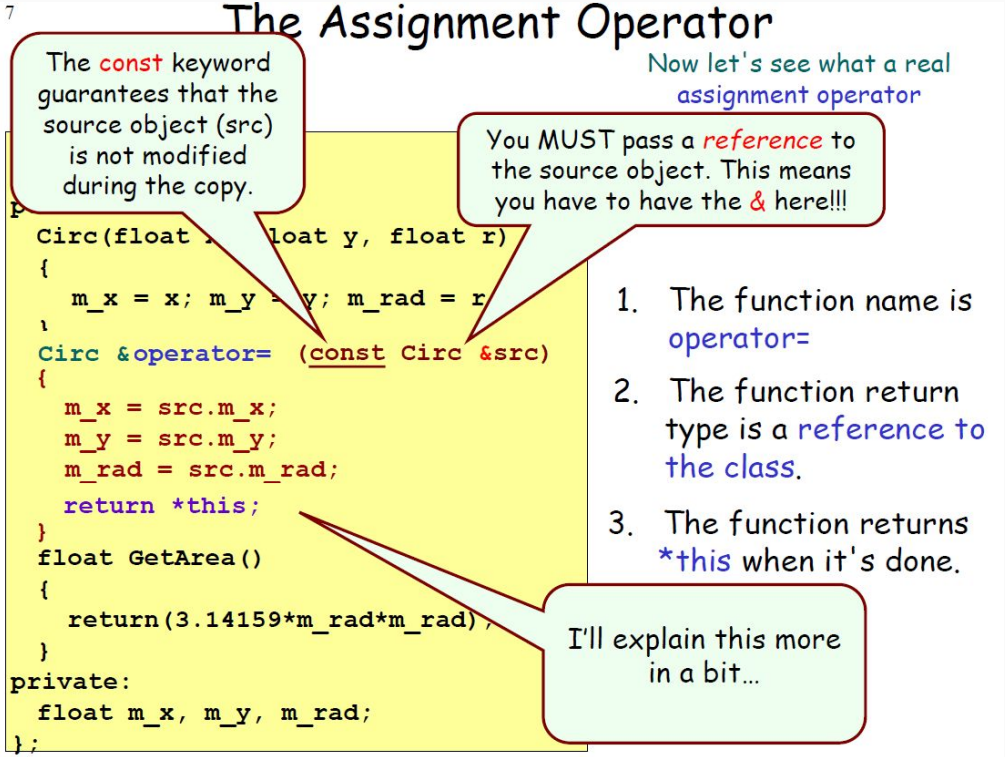
A default copy constructor provided by C++ just copies all member variables to the new object (**shallow copy**) and may cause problems. Thus in those cases we must define our owns copy constructor.

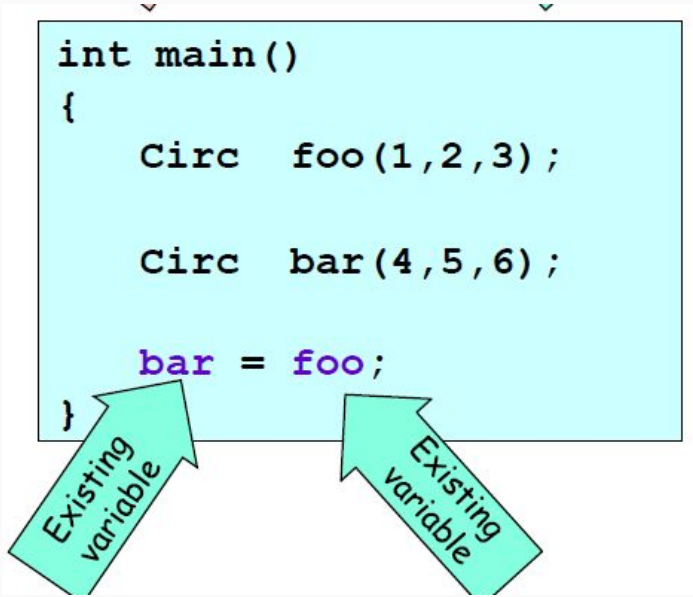
Q: What would a failure case be?

Try it out:
https://repl.it/@BruinUCLA/Copy-Constructor-Example?language=cpp11&folderId=

Assignment Operator (Operator=)

An assignment operator copies the value of an **existing** object to the value of another **existing** object with the **same class**. It does the copy job too without construction.





Assignment Operator (Operator=)

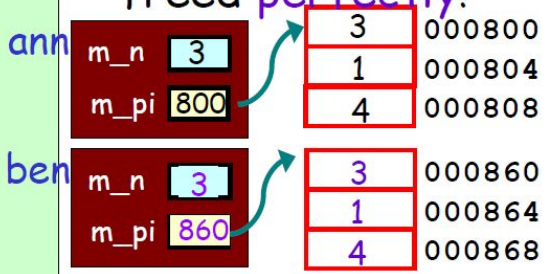
A default assignment operator provided by C++ does **shallow copy** too and may cause problems. Thus in those cases we must define our own assignment operator.

Another example:

```
class PiNerd
{
public:
  PiNerd(int n) { ... }
  ~PiNerd(){ delete[]m_pi; }

  // assignment operator:
  PiNerd &operator=(const PiNerd &src)
  {
    delete [] m_pi;
    m_n = src.m_n;
    m_pi = new int[m_n];
    for (int j=0;j<m_n;j++)
       m_pi[j] = src.m_pi[j];
    return *this;
  }
  void showOff() { ... }

private:
   int *m_pi, m_n;
};
```

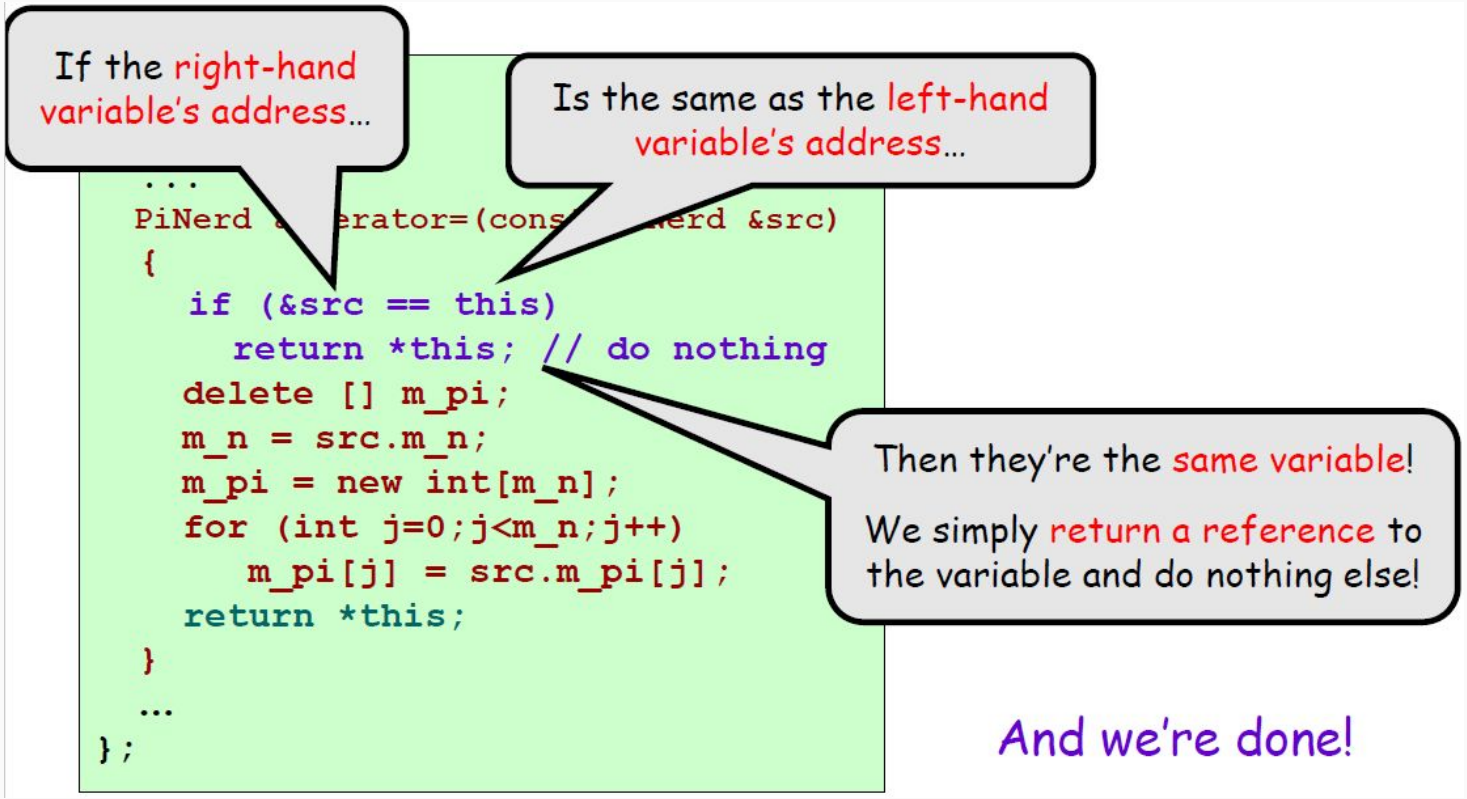
```
int main()
{
  PiNerd ann(3);
  PiNerd ben(4);

  ben = ann;

}// ann's d'tor called, then ben's
```

... and everything is freed perfectly!



Assignment Operator (Operator=)

We must also check to see if a variable is being assigned to itself , and if so do nothing:



A More Elegant Way of Assignment Operator

In real world, issues like exception safety (won't cover in CS32) make the classic way of implementing an assignment operator problematic. A more elegant modern approach is using **copy-and-swap idiom** to implement Operator=.

We give our class a swap function that swaps the values of two Strings. Then implement assignment operator using a copy constructor and swap function:

```
void String::swap(String& other)
{
    ... // exchange the m_len and other.m_len ints
    ... // exchange the m_text and other.m_text pointers
}
```

```
String& String::operator=(const String& rhs)
{
    if (this != &rhs)
    {
        String temp(rhs);
        swap(temp);
    }
    return *this;
}
```

Questions?

- You can find code examples used by Prof. Smallberg on course website “Lecs. 2&3 (Smallberg)” section.
- My slides take the following materials as references:
  - Prof. Smallberg’s code examples
  - Prof. Nachenberg’s lecture slides
  - Jack Gong’s discussion slides
  - Mark Edmonds’ website about CS32 from previous years - https://mjedmonds.com/CS32/CS32.html

Worksheet!