CSCI 200: Foundational Programming Concepts & Design Lecture 17

Object-Oriented Programming:

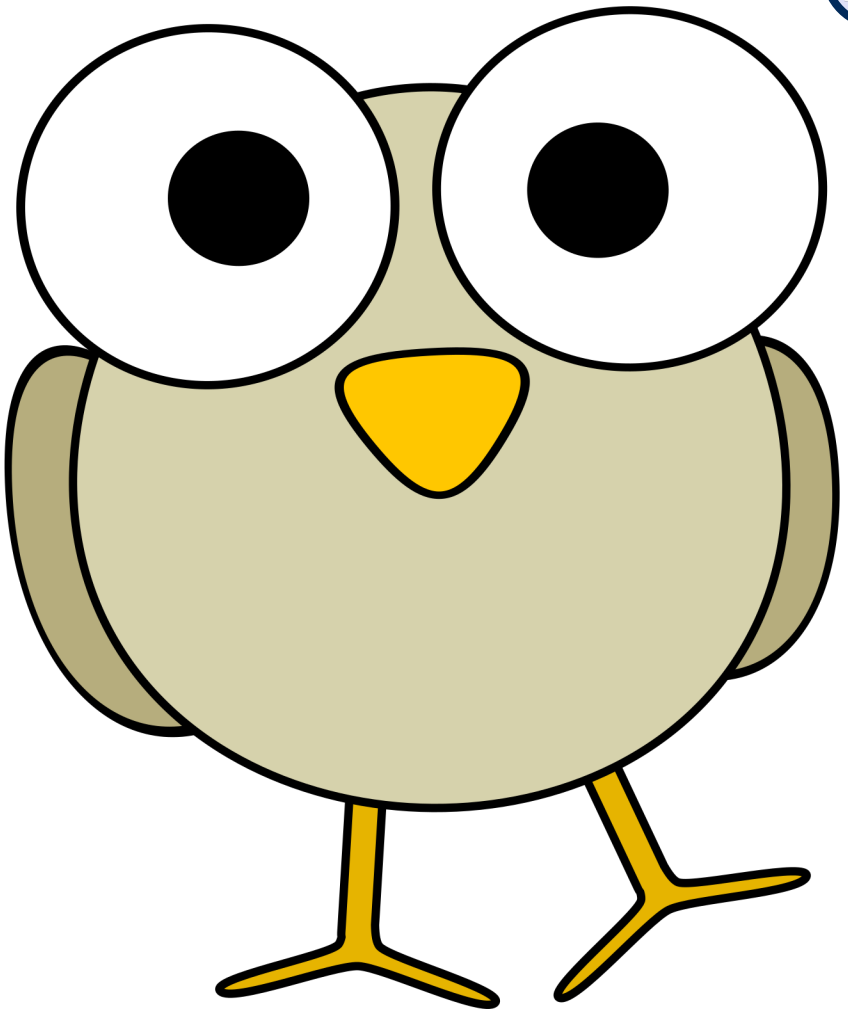
Managing & Encapsulating State

Previously in CSCI 200

- Vector implements dynamically sized list
- String implements dynamically sized character list

- Big O Notation describes runtime complexity of algorithm

Questions?



Learning Outcomes For Today

- Discuss the concept of encapsulation
- Draw a class diagram using UML to describe the structure of a class and its members
- Discuss the difference between a class and an object
- Create a class containing data members and member functions
- Compare and contrast Procedural Programming with Object-Oriented Programming

Learning Outcomes For Today

- Explain the following terms and how they are used
  - (1) dot operator / member access operator
  - (2) data member
  - (3) scope resolution operator
- Discuss the difference between
  - (1) a class and an object
  - (2) a class and a struct
- Explain and use the following terms
  - (1) constructors & destructors
  - (2) accessor modifiers
  - (3) accessor & mutator functions
- Discuss the concept of scope within and outside a class & struct

On Tap For Today

- Constructors
- Public & Private
  - Getters & Setters
- Practice

Class Declaration

- Place in its own header file ClassName.h

```
// inside Box.h
#ifndef BOX_H
#define BOX_H
class Box {
public:
    float height;
    float depth;
    float width;

};
#endif
```

Creating an Object

```
// inside main.cpp
#include "Box.h"

int main() {
    Box smallBox;
    smallBox.height = 4;
    smallBox.width = 4;
    cout << "Enter the box length: ";
    cin >> smallBox.depth;
    cout << "The volume is: ";
    cout << smallBox.width * smallBox.height * smallBox.depth << endl;
    return 0;
}
```

Class Declaration

- Place in its own header file ClassName.h

```
// inside Box.h
class Box {
public:
    float height;
    float depth;
    float width;
    float volume();
};
```

- Will get to implementation next

Class Definition

- Placed in a class implementation file ClassName.cpp

```
// inside Box.cpp
#include "Box.h"


float Box::volume() {
    return height * depth * width;
}
```

- Functions have access to ALL data members of a class

- :: is the **Scope Resolution operator**
  - Specifies which scope an identifier belongs to
- In our case, which class a function belongs to
  - Box::volume()
- Could have two classes with the same function name
  - Box::volume() Tube::volume()

Precedence	Operator	Associativity
1	Parenthesis: ( )	Innermost First
2	Scope Resolution: S::	Left to Right
3	Postfix Unary Operators: a++ a-- f()	
4	Prefix Unary Operators: ++a --a +a -a !a (type)a &a *p	Right to Left
5	Binary Operators: a*b a/b a%b	Left to Right
6	Binary Operators: a+b a-b	
7	Relational Operators: a<b a>b a<=b a>=b	
8	Relational Operators: a==b a!=b	
9	Logical Operators: a&&b	
10	Logical Operators: a||b	
11	Assignment Operators: a=b a+=b a-=b a*=b a/=b a%=b	Right to Left

Creating an Object

```
// inside main.cpp
#include "Box.h"

int main() {
    Box smallBox;
    smallBox.height = 4;
    smallBox.width = 4;
    cout << "Enter the box length: ";
    cin >> smallBox.depth;
    cout << "The volume is: ";
    cout << smallBox.volume() << endl;
    return 0;
}
```

What happens if...

```
// inside main.cpp
#include "Box.h"

int main() {
    Box smallBox;
    cout << "The volume is: ";
    cout << smallBox.volume() << endl; // what does it print?
    return 0;
}
```

On Tap For Today

- Constructors
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- Practice

Constructor

- A special function
- Named after the class name
- Has no return type

- Called automatically upon object creation
  - Used to setup/initialize/allocate object state

Creating a Constructor

```
// inside Box.h
class Box {
public:
    int height;
    int width;
    int depth;
    Box();

    int volume();
};
```

```
// inside Box.cpp
#include "Box.h"

Box::Box() {
    height = 1;
    width = 1;
    depth = 1;
}
```

Using a Constructor

```
// inside main.cpp
#include "Box.h"

int main() {
    Box smallBox;                    // use the default constructor implicitly
    Box squareBox = Box();           // use the default constructor explicitly
    Box myBox;                       // use the default constructor
    cout << smallBox.volume() << endl;  // prints 1
    myBox.height = 4;
    myBox.width = 6;
    myBox.depth = 8;
    cout << myBox.volume() << endl;     // prints 192
    return 0;
}
```

Overloading a Constructor

```
// inside Box.h
class Box {
public:
    int height;
    int width;
    int depth;
    Box();
    Box(int h, int w, int d);
    int volume();
};
```

```
// inside Box.cpp
#include "Box.h"

Box::Box() {
    height = 1;
    width = 1;
    depth = 1;
}

Box::Box(const int H,
         const int W,
         const int D) {
    height = H;
    width = W;
    depth = D;
}
```

Using a Constructor

```
// inside main.cpp
#include "Box.h"

int main() {
    Box smallBox;                   // use the default constructor
    Box squareBox = Box(2, 2, 2);  // explicit parameterized constructor
    Box myBox( 4, 6, 8 );           // implicit parameterized constructor
    cout << smallBox.volume() << endl;  // prints 1
    cout << myBox.volume() << endl;     // prints 192
    return 0;
}
```

Box Rules

- All dimensions must be positive

Rule Enforced!

```
// inside Box.h

class Box {
public:
    int height;
    int width;
    int depth;
    Box();
    Box( int h, int w, int d );
    int volume();
};
```

```
// inside Box.cpp
#include "Box.h"

Box::Box( int h, int w, int d ) {
    if(h > 0) height = h;
    else      height = 1;

    if(w > 0) width = w;
    else      width = 1;

    if(d > 0) depth = d;
    else      depth = 1;
}
```

```
// main.cpp

Box myBox(-5, -5, -5);
cout << myBox.volume() << endl;    // 1


Box yourBox(5, 5, 5);
cout << yourBox.volume() << endl; // 125
```

More Concerns

```
// inside Box.h

class Box {
public:
    int height;
    int width;
    int depth;
    Box();
    Box( int h, int w, int d );
    int volume();
};
```

```
// inside Box.cpp
#include "Box.h"

Box::Box( int h, int w, int d ) {
    if(h > 0) height = h;
    else      height = 1;

    if(w > 0) width = w;
    else      width = 1;

    if(d > 0) depth = d;
    else      depth = 1;
}
```

```
// main.cpp

Box myBox(-5, -5, -5);
cout << myBox.volume() << endl;    // 1


Box yourBox(5, 5, 5);
cout << yourBox.volume() << endl; // 125
yourBox.width = -5;
cout << yourBox.volume() << endl; // -125
```

Box Rules

- All dimensions must be positive

Rule violated!

On Tap For Today

- Constructors
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  - Getters & Setters
- Practice

Public Access

```
// inside Box.h

class Box {
public:
    int height;
    int width;
    int depth;
    Box();
    Box( int h, int w, int d );
    int volume();
};
```

```
// inside Box.cpp
#include "Box.h"

Box::Box( int h, int w, int d ) {
    if(h > 0) height = h;
    else      height = 1;

    if(w > 0) width = w;
    else      width = 1;

    if(d > 0) depth = d;
    else      depth = 1;
}
```

```
// main.cpp
Box myBox(5, 5, 5);
cout << myBox.volume() << endl; // 125

myBox.width = -5;
cout << myBox.volume() << endl; // -125

myBox.height = -5;
cout << myBox.volume() << endl; // 125
```

Private Access

```
// inside Box.h

class Box {
public:
    Box();
    Box( int h, int w, int d );
    int volume();
private:
    int height;
    int width;
    int depth;
};
```

```
// inside Box.cpp
#include "Box.h"

Box::Box( int h, int w, int d ) {
    if(h > 0) height = h;
    else      height = 1;

    if(w > 0) width = w;
    else      width = 1;

    if(d > 0) depth = d;
    else      depth = 1;
}
```

```
// main.cpp
Box myBox(5, 5, 5);
cout << myBox.volume() << endl; // 125

myBox.width = -5;               // compiler error!
cout << myBox.volume() << endl;

myBox.height = -5;              // compiler error!
cout << myBox.volume() << endl;
```

Private Access

```
// inside Box.h

class Box {
public:
    Box();
    Box( int h, int w, int d );
    int volume();
private:
    int _height;
    int _width;
    int _depth;
};
```

```
// inside Box.cpp
#include "Box.h"

Box::Box( int h, int w, int d ) {
    if(h > 0) _height = h;
    else      _height = 1;

    if(w > 0) _width = w;
    else      _width = 1;

    if(d > 0) _depth = d;
    else      _depth = 1;
}
```

```
// main.cpp
Box myBox(5, 5, 5);
cout << myBox.volume() << endl;   // 125

myBox._width = -5;                // compiler error!
cout << myBox.volume() << endl;

myBox._height = -5;               // compiler error!
cout << myBox.volume() << endl;
```

Private Access

```
// inside Box.h

class Box {
public:
    Box();
    Box( int h, int w, int d );
    int volume();
private:
    int _height;
    int _width;
    int _depth;
};
```

```
// inside Box.cpp
#include "Box.h"

Box::Box( int h, int w, int d ) {
    if(h > 0) _height = h;
    else      _height = 1;

    if(w > 0) _width = w;
    else      _width = 1;

    if(d > 0) _depth = d;
    else      _depth = 1;
}
```

```
// main.cpp
Box myBox(5, 5, 5);

cout << myBox.volume() << endl; // 125
cout << myBox._height << " "    // compiler error!
     << myBox._width  << " "    // compiler error!
     << myBox._depth  << endl;  // compiler error!

myBox._height = 10;             // compiler error!
```

On Tap For Today

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Accessor Methods

- Aka “getters”
- A member function used to provide managed access to data members
- Allows a user to get (access) the value of a data member

Mutator Methods

- Aka “setters”
- A member function used to provide managed access to data members
- Allows a user to set (mutate) the value of a data member

Getters & Setters

```
// inside Box.h
class Box {
public:
    Box();
    Box( int h, int w, int d );
    int volume();
    int getHeight();
    void setHeight(const int H);
    // others for width & depth
private:
    int _height;
    int _width;
    int _depth;
};
```

```
// inside Box.cpp
#include "Box.h"

int Box::getHeight() {
    return _height;
}


void Box::setHeight(const int H) {
  if(H > 0) _height = H;
}


// others for width & depth
```

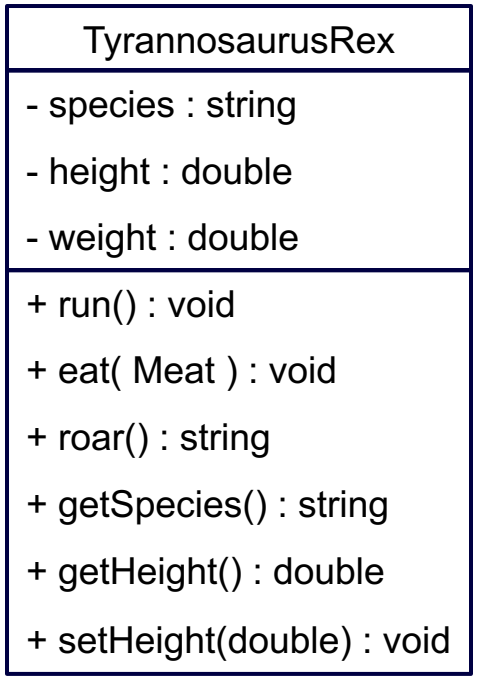
```
// main.cpp
Box myBox(5, 5, 5);
cout << myBox.volume() << endl; // 125

myBox.setWidth(-5);
cout << myBox.volume() << endl; // 125

myBox.setHeight(10);
cout << myBox.volume() << endl; // 250
```

UML Diagrams

- Use + - to denote public private



On Tap For Today

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To Do For Next Time

- Today: complete 10/2 Post Class Survey
- Can formally start A3
  - Set3 due Tue Oct 10