CSCI 200: Foundational Programming Concepts & Design Lecture 18

Objects and Functions

Previously in CSCI 200

- Use + - to denote public private

TyrannosaurusRex
- species : string - height : double - weight : double
+ run() : void + eat(Meat) : void + roar() : string + getSpecies() : string + getHeight() : double + setHeight(double) : void

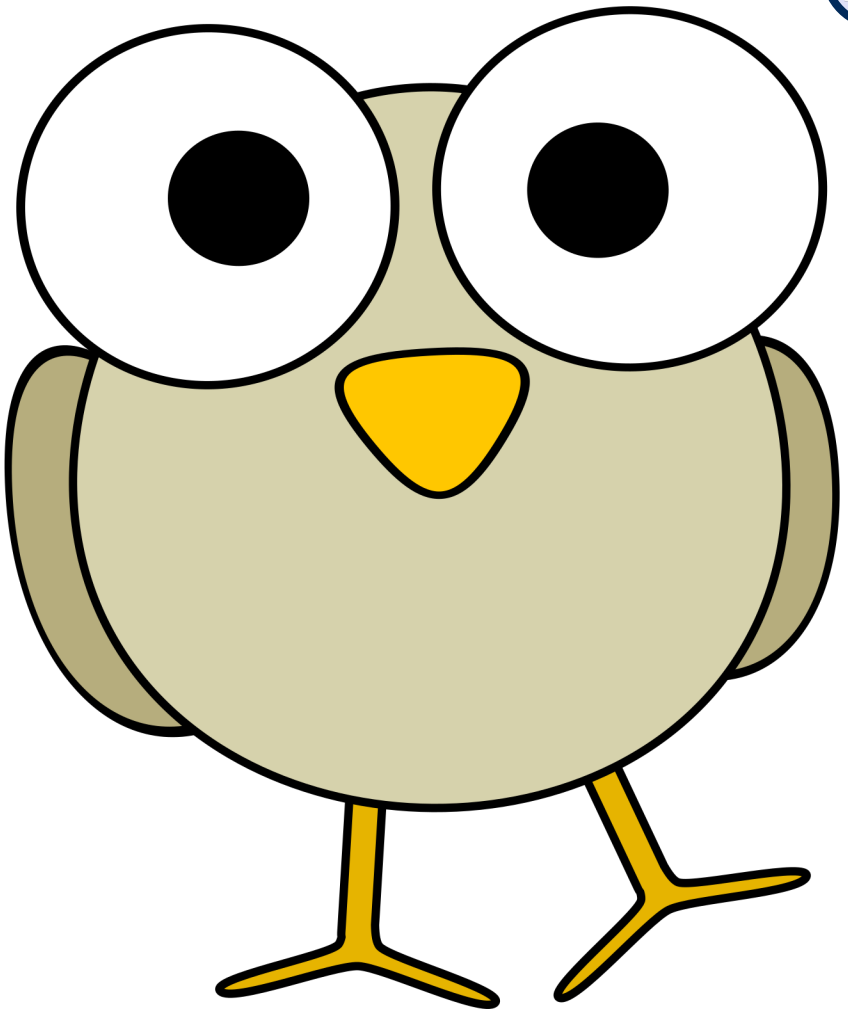
Previously in CSCI 200

```
// 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
```

Questions?



Learning Outcomes For Today

- Construct a program that accesses an element in a vector, returns the length of a vector, changes the length of the vector, and other vector operations.
- Construct a program that accesses an element in a string, returns the length of a string, changes the length of the string, and other string operations.
- Compare and contrast Procedural Programming with Object-Oriented Programming
- Explain the following terms and how they are used (1) dot operator / member access operator (2) data member (3) scope resolution operator
- Discuss the concept of scope within and outside a class & struct

On Tap For Today

- Collections of Objects
- Passing Objects to Functions
- Final Project
- Practice

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To Do: Create this Class

- Create a vector of courses

Course	
- enrollment: int - title: string	// initializes to zero

+ Course()
+ Course(string)
+ getTitle(): string
+ getEnrollment(): int
+ registerStudent(): void
+ withdrawStudent(): void
	// sets title to CSM101
	// sets title to param
	// returns title of course
	// returns enrollment of course
	// increments enrollment by 1
	// decrements enrollment by 1

- Will submit to Canvas 10/04 In Class Activity

Sample Class

```
class Course {
public:
  Course() {
        _enrollment = 0;
        _title = "CSM 101";
  }
  Course(const string TITLE) {
        _enrollment = 0;
        _title = TITLE;
  }
  string getTitle() { return _title; }
  int getEnrollment() { return _enrollment; }
  void registerStudent() { _enrollment++; }
  void withdrawStudent() { if(_enrollment > 0) _enrollment--; }
private:
  int _enrollment;
  string _title;
};
```

Consider V1

```
vector<Course> courseCatalog;
courseCatalog.push_back( Course("Prog. Concepts") );
courseCatalog.push_back( Course("Computer Graphics") );

// enroll students
for(size_t i = 0; i < courseCatalog.size(); i++) {
  courseCatalog.at(i).registerStudent();
  courseCatalog.at(i).registerStudent();

}

// print enrollments
for(size_t i = 0; i < courseCatalog.size(); i++) {
  cout << courseCatalog.at(i).getTitle() << " "
       << courseCatalog.at(i).getEnrollment() << endl;
}

// what does it print?
```

Consider V2

```
vector<Course> courseCatalog;
courseCatalog.push_back( Course("Prog. Concepts") );
courseCatalog.push_back( Course("Computer Graphics") );

// enroll students
for(size_t i = 0; i < courseCatalog.size(); i++) {
  Course currentCourse = courseCatalog.at(i);
  currentCourse.registerStudent();
  currentCourse.registerStudent();
}

// print enrollments
for(size_t i = 0; i < courseCatalog.size(); i++) {
  cout << courseCatalog.at(i).getTitle() << " "
       << courseCatalog.at(i).getEnrollment() << endl;
}

// what does it print?
```

Storing Objects on the Free Store

- Use a pointer!

```
int *pNumCars = new int;      //*pNumCars  initialized to 0
int *pNumCars2 = new int(5); //*pNumCars2 initialized to 5

Course *pCSM101 = new Course;// automatically calls constructor
pCSM101->setTitle("CSM 101");
Course *pCSCI200 = new Course("CSCI 200");
```

- **new** – "Computer, allocate enough memory in the free store for one object and tell me the starting address where the object will be stored. Initialize the object at that location."

Access Members of Object Pointers

- Must first dereference pointer before accessing

```
Course *pCSCI200 = new Course("CSCI 200");
(*pCSCI200).getEnrollment();
```

- But this gets ugly when members return pointers

```
vector<Course*> *pCourses = new vector<Course*>;
(*(*pCourses).at(0)).getEnrollment();
```

Use the Arrow Operator

- Dereference and access in one operation

```
Course *pCSCI200 = new Course("CSCI 200");
pCSCI200->getEnrollment();
```

- Much cleaner interface and denotes what type of thing we are working with at each level

```
vector<Course*> courses;
courses.at(0)->getEnrollment();
```

Precedence Table

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

Consider V2 - solved

```
vector<Course*> courseCatalog;
courseCatalog.push_back( new Course("Prog. Concepts") );
courseCatalog.push_back( new Course("Computer Graphics") );

// enroll students
for(size_t i = 0; i < courseCatalog.size(); i++) {
  Course* pCurrentCourse = courseCatalog.at(i);
  pCurrentCourse->registerStudent();
  pCurrentCourse->registerStudent();
}

// print enrollments
for(size_t i = 0; i < courseCatalog.size(); i++) {
  cout << courseCatalog.at(i)->getTitle() << " "
       << courseCatalog.at(i)->getEnrollment() << endl;
}

// what does it print?
```

To Do: Create this Class

- Submit your files to canvas 10/04 In Class Activity (if you haven't done so yet)

Course
- enrollment: int - title: string
+ getTitle(): string + getEnrollment(): int + registerStudent(): void + withdrawStudent(): void

```
// returns title of course
// returns enrollment of course
// increments enrollment by 1
// decrements enrollment by 1
```

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Passing Vectors/Strings to Function?

- Like any other single value: PBV or PBP

```
void print_vector_b_v( vector<int> vec ) {
  for( int i = 0; i < vec.size(); i++ )
    cout << vec.at(i) << endl;
}
void print_vector_b_p( vector<int> *pVec ) {
  for( int i = 0; i < pVec->size(); i++ )
    cout << pVec->at(i) << endl;
}
```

- Be aware of PBV / PBP implications. Concerns?

Passing Vectors to Function

- Like any other single value: PBV or PBP

```
void add_to_vector_b_v( vector<int> vec ) {
  vec.push_back( 100 );
}
void add_to_vector_b_p( vector<int> *pVec ) {
  pVec->push_back( 200 );
}
// ...
vector<int> myVec;
add_to_vector_b_v(  myVec ); cout << myVec.size() << endl;
add_to_vector_b_p( &myVec ); cout << myVec.size() << endl;
```

String Parameter Beware

```
void string_func1( string str ) {...}
void string_func2( string *pStr ) {...}


...
string word = "does this work?";
string_func1( word );
string_func2( &word );
string_func1( "does this work?" );
string_func2( "does this work?" );
```

String Parameter Beware

```
void string_func1( string str ) {...}
void string_func2( string *pStr ) {...}


...
string word = "does this work?";
string_func1( word );                    // YES
string_func2( &word );                   // YES
string_func1( "does this work?" );       // YES
string_func2( "does this work?" );       // NO!
```

How Much Memory Used?

```
void string_func1( string str ) {...}

void string_func2( string *pStr ) {...}


...

string word = "does this work?";

string_func1( word );

string_func2( &word );

string_func1( "does this work?" );
```

How Much Memory Used?

```
void string_func1( string str ) {...}
void string_func2( string *pStr ) {...}


...
string word = "does this work?";
string_func1( word );                    // 2 copies
string_func2( &word );                   // 1 copy
string_func1( "does this work?" );       // 1 copy
```

When To Use PBV or PBP?

```
void string_func1( string str ) {...}
void string_func2( string *pStr ) {...}


...
string word = "does this work?";
string_func1( word );                    // 2 copies
string_func2( &word );                   // 1 copy
string_func1( "does this work?" );       // 1 copy
```

How About Vectors?

- Memory Usage? Runtime?

```
void vector_func1( vector<int> vec ) {...}

void vector_func2( vector<int> *pVec ) {...}


...

vector<int> numbers = {...};

vector_func1( numbers );

vector_func2( &numbers );
```

How About Vectors?

- Memory Usage? Runtime?

```
void vector_func1( vector<int> vec ) {...}

void vector_func2( vector<int> *pVec ) {...}


...

vector<int> numbers = {...};

vector_func1( numbers );        // 2 copies - O(n)

vector_func2( &numbers );       // 1 copy - O(1)
```

Vector Operations

- Element Access – $O(1)$
- Vector Traversal – $O(n)$

- (Will continue to add to)

How About Vectors?

- Use PBP

```
// RW
void vector_func1( vector<int> *pVec ) {...}
// R only
void vector_func2( const vector<int> * const P_VEC )
{...}
...
vector<int> numbers = {...};
vector_func1( &numbers );      // 1 copy - O(1)
vector_func2( &numbers );      // 1 copy - O(1)
```

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Final Project

- Requirements
  - W Oct 11 – PDF to Canvas
    - Project Proposal
  - R Dec 07– zip to Canvas
    - Project Code
    - Project Paper
- Note: R Dec 07 – last day for all submissions!

Project Proposal

- Title
- Program Description (one paragraph)
- Data Description
  - Class UML Diagrams (Pseudocode) → NO code
  - List Data Structure
  - File I/O
- Procedural Description
  - Pseudocode → NO code
- Concerns / Needs

Project Code

- Has at least one original class
  - Private data/functions
  - Well defined Public interface
  - Written in separate files
  - More functionality than just getters/setters
- Has at least one array/linked list/queue/stack
  - List within class OR list of objects in main
- Uses File I/O
- Uses functions & constants when appropriate
- LOTS of comments
- Must follow style guidelines & best practices

Project Paper

- Title
- Program Description (one paragraph)
- Documentation
  - How to run and use your program
- Why was class structured as such?
- Why was data structure chosen?
- Why was File I/O used?
- Reflections

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To Do For Next Time

- Quiz 3 on Monday
  - File I/O + vector & string
- Set3 due Tuesday
- Final Project Proposal due Wednesday
- Submit class code to Canvas now