Creating New Types

In data structures, we will be learning and creating new types of structures to store data. We will start simply – by the end, we will have types we built being the building blocks for new types!

Big Idea: Encapsulation

Our First Class – Cube:

<table>
<thead>
<tr>
<th>Cube.h</th>
<th>Cube.cpp</th>
</tr>
</thead>
</table>
| #pragma once | #include "Cube.h"
| class Cube { | double Cube::getVolume() {
|     public: |     return length_*
|         double getVolume(); |     length_* length_; |
| } | }

Public vs. Private:

<table>
<thead>
<tr>
<th>Situation</th>
<th>Protection Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cube functionality provided to client code</td>
<td></td>
</tr>
<tr>
<td>Variable containing data about the Cube</td>
<td></td>
</tr>
<tr>
<td>Helper function used in Cube</td>
<td></td>
</tr>
</tbody>
</table>

Hierarchy in C++:

There Cube class we’re building might not be the only Cube class. Large libraries in C++ are organized into...

<table>
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<tr>
<th>Cube.h</th>
<th>Cube.cpp</th>
</tr>
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</table>
| #pragma once | #include "Cube.cpp"
| namespace cs225 { | namespace cs225 {
|     class Cube { |     double Cube::getVolume() {
|         public: |         return length_*
|             double getVolume(); |     length_* length_; |
|     } | }

Default Constructor:

Every class in C++ has a constructor – even if you didn’t define one!

- Automatic/Implicit Default Constructor:

Custom Default Constructor:

Custom, Non-Default Constructors:

We can provide also create constructors that require parameters when initializing the variable:

<table>
<thead>
<tr>
<th>Cube.h</th>
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</thead>
</table>
| namespace cs225 { | namespace cs225 {
|     class Cube { |     double Cube::Cube(double length) {
|         public: |     }
|             Cube(double length); |     }
|         */ ... */ | }

Our First Program:

<table>
<thead>
<tr>
<th>main.cpp</th>
</tr>
</thead>
<tbody>
<tr>
<td>#include &quot;Cube.h&quot;</td>
</tr>
<tr>
<td>#include &lt;iostream&gt;</td>
</tr>
<tr>
<td>int main() {</td>
</tr>
<tr>
<td>cs225::Cube c;</td>
</tr>
<tr>
<td>std::cout &lt;&lt; &quot;Volume: &quot; &lt;&lt; c.getVolume() &lt;&lt; std::endl;</td>
</tr>
<tr>
<td>return 0;</td>
</tr>
<tr>
<td>}</td>
</tr>
</tbody>
</table>

...run this yourself: run make and ./main in the lecture source code.
However, our program is unreliable. **Why?**

**Default Constructor:**
Every class in C++ has a constructor – even if you didn’t define one!
- Automatic/Implicit Default Constructor:

<table>
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<tr>
<td>4 class Cube { 5 public:</td>
<td>3 Cube::Cube() { 4 Cube(); 5 /* ... */</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

- Custom Default Constructor:

```cpp
class Cube {
public:
    Cube();
    /* ... */
};
```

**Custom, Non-Default Constructors:**
We can provide also create constructors that require parameters when initializing the variable:

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<td>4 class Cube { 5 public: 6 Cube(double length);</td>
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<td>...</td>
<td>...</td>
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**Puzzle #1: How do we fix our first program?**

```cpp
...
8 cs225::Cube c;
9 cout << "Volume: " << c.getVolume() << endl;
...```

...run this yourself: run `make puzzle` and `./puzzle` in the lecture source code.

**Solution #1:**

**Solution #2:**

*The beauty of programming is both solutions work! There’s no one right answer, both have advantages and disadvantages!*

**Pointers and References**
Often, we will have direct access to our object:

```
Cube s1; // A variable of type Cube
```

Occasionally, we have a reference or pointer to our data:

```
Cube & r1 = s1; // A reference variable of type Cube
Cube * p1; // A pointer that points to a Cube
```

**Pointers**
Unlike reference variables, which alias another variable’s memory, pointers are variables with their own memory. Pointers store the memory address of the contents they’re “pointing to”.

Three things to remember on pointers:
1. 
2. 
3. 

```cpp
int main() {
    ... cs225::Cube c;
    std::cout << "Address storing 'c':" << &c << std::endl;
    ... cs225::Cube * p = &c;
    std::cout << "Addr. storing ptr: " << &p << std::endl;
    ... std::cout << "Contents of ptr: " << *p << std::endl;
    return 0;
}
```

**Indirection Operators:**

```
&v
*v
v->
```

**CS 225 – Things To Be Doing:**

1. Setup your computer
2. Join us on Discord