

PHY 250

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Winter 2024, Week 3

C++: Objects-Recap

Two main types of objects in C++, `struct` and `class`. They are identical.

Three access qualifiers `private`, `protected`, and `public`.

```
1  class MyClass {  
2  private:  
3  
4  public:  
5  
6  };
```

C++: Objects

```
1  class Engine {  
2  private:  
3  
4  public:  
5      Engine();  
6      ~Engine();  
7  
8  };
```

The **Engine()** is the constructor, This is the code we want to run we we create a new Engine instance.

The **~Engine()** is the destructor, This is the code we want to run we we destroy an Engine instance.

C++: Objects

```
1  class Engine {  
2  private:  
3      float RPM;  
4  public:  
5      Engine();  
6      ~Engine();  
7  
8      void Set_RPM(float HowMuch);  
9      float Get_RPM();  
10 };
```

The `float` RPM is a `private` member. Private members can only be accessed by the class instance.

We can safely access `private` members with `public` Getters and Setters.

C++: Objects

Last class we wrote a class for a 1D float array called fArray.

```
1  class fArray{
2  private:
3      int m_num_el = 0;
4      float* m_vals = NULL;
5      bool is_init = false;
6  public:
7      fArray();
8      ~fArray();
9
10     void INIT(int num);
11     float* Get_Vals();
12     int Get_Num();
13 };
```

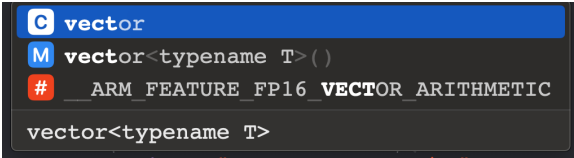
C++: Objects

A more common name for this class would be a vector.

```
1  class vector{
2  private:
3      int m_num_el = 0;
4      float* m_vals = NULL;
5      bool is_init = false;
6  public:
7      vector();
8      ~vector();
9
10     void INIT(int num);
11     float* Get_Vals();
12     int Get_Num();
13 };
```

C++: Objects

With this class name auto-complete gives me



A screenshot of an IDE's auto-completion menu for the C++ `vector` class. The menu is displayed against a dark background. The first item, `vector`, is highlighted with a blue background and a white 'C' icon. Below it are two other items: `vector<typename T>()` with a blue 'M' icon, and `__ARM_FEATURE_FP16_VECTOR_ARITHMETIC` with a red '#' icon. At the bottom of the menu, the text `vector<typename T>` is visible.

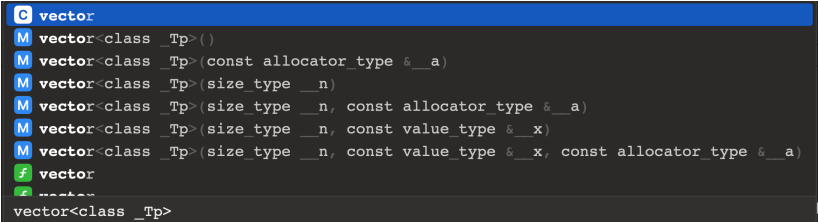
```
C vector
M vector<typename T>()
# __ARM_FEATURE_FP16_VECTOR_ARITHMETIC
vector<typename T>
```

C++: Objects

However, if I include these lines in my main file

```
1 #include <vector>
2 using namespace std;
```

I get

A screenshot of a C++ IDE showing the definition of the `vector` class. The code is displayed in a dark-themed editor with a blue header bar. The header bar contains the text "C vector". The code itself is as follows:

```
M vector<class _Tp>()
M vector<class _Tp>(const allocator_type &__a)
M vector<class _Tp>(size_type __n)
M vector<class _Tp>(size_type __n, const allocator_type &__a)
M vector<class _Tp>(size_type __n, const value_type &__x)
M vector<class _Tp>(size_type __n, const value_type &__x, const allocator_type &__a)
f vector
f ~vector
vector<class _Tp>
```

This would get very confusing

C++: Namespaces

We can fix this problem by using a namespace.

```
1 namespace PHY{
2
3 class vector{
4 private:
5     int m_num_el = 0;
6     float* m_vals = NULL;
7     bool is_init = false;
8 public:
9     vector();
10    ~vector();
11    void INIT(int num);
12    float* Get_Vals();
13    int Get_Num();
14 };
15 }
```

C++: Namespaces

By encapsulating our vector class in a namespace it has a unique definition so it won't be confused with any other definition of vector. More importantly it won't override any other defined objects.

```
1  int main(){  
2  
3      PHY::vector vec1;  
4      std::vector vec2;  
5      vec1 != vec2;  
6  
7      return 0;  
8  }
```

C++: Lab 3

1. Add the following to your MyClass.hpp file.

```
1   fArray();  
2   fArray(int num);  
3   ~fArray();
```

And in your .cpp file

```
1   fArray::fArray(int num){  
2       INIT(num);  
3   }
```

C++: Lab 3

4. In your myclass.hpp define a namespace with whatever name you choose. Keep in mind you will have to type this many times.
5. Encapsulate your fArray class in your namespace.
6. rename your fArray class to vecN, and add the following to your .hpp file.
7. Go through your myclass.cpp and change `vecN` \rightarrow `<your namespace>::vecN` ;
8. Create an instance using the new constructor of `<your namespace>::vecN` in main to make sure it works.

```
1 int main(){
2     int rows = 10;
3     YourNameSpace::vecN vec(rows);
4     return 0;
5 }
```

C++: Operators

Something we have all used many times

```
1  int main(){  
2  
3      int a = 3;  
4      int b = 1;  
5      int c = a + b;  
6  
7      return 0;  
8  }
```

Have you ever asked yourself what this really means?

C++: Operators

In C/C++ we need to declare a type for all variables, why?

```
1  int main(){  
2  
3      int a = 3;  
4  
5  return 0;  
6  }
```

`int` a; what does this do?

1. find 4 bytes of continuous memory and assign it to a.
2. define the type assigned to this block of memory to data type `int`.

Both of these are important but I want to focus on the second.

C++: Operators

The reason the data type assignment is important is due to operations.

```
1  int main(){  
2  
3      int a = 3;  
4      int b = 1;  
5      int c = a + b;  
6  
7  return 0;  
8  }
```

Let's look at the last line of code.

C++: Operators

```
int c = a + b;
```

We created a block of 4 bytes with data type `int` with variable reference "c".

Because `c` is an `int`, using the `=` operator means that we telling the compiler to copy the value of the `int` on the RHS of the `=` to the location of `c`.

This restricts what we can have on the RHS.

C++: Operators

```
1  int main(){  
2  
3      char val1[10] = "3";  
4      char val2[10] = "1";  
5      int val3 = val1 + val2;  
6  
7      return 0;  
8  }
```

This is an error because `val1 + val2` does not return an `int`.

C++: Operators

The `+` operator performs different actions depending on the data type it is operating on.

```
1  int rows = 10;
2  int cols = 10;
3  int sum1 = rows + cols;
4
5  std::string val1 = "10";
6  std::string val2 = "10";
7  std::string sum2 = val1 + val2;
8
9  char a = '1'; char b = '2';
10 char sum3 = a + b;
```

sum1 = 20

sum2 = 1010

sum3 = c

C++: Operators + Objects

In C++ all user defined classes, e.g. our vector class, have one operator predefined, `=`.

This is called the copy constructor, it allows us to copy over the contents of one class instance to another.

```
1  int main(){
2      int a = 10;
3      int b = a;
4
5      PHY::vector vec1;
6      PHY::vector vec2 = vec1;
7
8      return 0;
9  }
```

C++: Operators + Objects

```
1  int main(){
2      int a = 10;
3      int b = a;
4
5      PHY::vector vec1;
6      PHY::vector vec2 = vec1;
7
8      return 0;
9  }
```

C++: Operators + Objects

Copy over the following into your main() replacing PHY with <your namespace>;

```
1  int main(){
2      int rows = 10;
3      PHY::vecN vec(rows);
4      float* vals = vec.Get_Vals();
5      for(int i=0; i<rows; i++){
6          printf("vec[%d] = %.1f\n",i,vals[i]);
7      }
8      return 0;
9  }
```

C++: Operators + Objects

You should get the following output;

`vec[0] = 0.0`

`vec[1] = 1.0`

`vec[2] = 2.0`

`vec[3] = 3.0`

`vec[4] = 4.0`

`vec[5] = 5.0`

`vec[6] = 6.0`

`vec[7] = 7.0`

`vec[8] = 8.0`

`vec[9] = 9.0`

C++: Operators + Objects

Now insert the additional part as shown;

```
1  int main(){
2      int rows = 10;
3      PHY::vecN vec(rows);
4      {
5          vec = PHY::vecN(rows);
6      }
7      float* vals = vec.Get_Vals();
8      for(int i=0; i<rows; i++){
9          printf("vec[%d] = %.1f\n",i,vals[i]);
10     }
11     return 0;
12 }
```

C++: Operators + Objects

Here is what I get;

```
vec[0] = -4270243677537828864.0
```

```
vec[1] = 0.0
```

```
vec[2] = 0.0
```

```
vec[3] = 0.0
```

```
vec[4] = 0.0
```

```
vec[5] = 0.0
```

```
vec[6] = 0.0
```

```
vec[7] = 0.0
```

```
vec[8] = 0.0
```

```
vec[9] = 0.0
```

This is **VERY BAD!!!!**.

C++: Operators + Objects

In the line

1

```
vec = PHY::vecN(rows);
```

On the RHS we are creating a new instance of `vecN` that has a `float*` that gets dynamically allocated using `new`. Then when the scope ends, i.e. `}}`, that instance of `vecN` gets destroyed and the `float*` is `delete`.

When we copy the new `vecN` to our `vec` using the `=` operator we are assigning the `float*` of the new `vecN` to our `vec`.

Which means that we `delete` the `float*` of the new `vecN` we are also deleting the `float*` that is assigned to old `vec`.

So then what happens to the memory we allocated for the first `vecN`?... **NOTHING!** it remains on the heap and does not get released until the program exits.

C++: Operators + Objects

This issue needs to be fixed. Let's redefine the `=` operator for our `vecN` class. As a public member add the following to the `.hpp` file.

```
1  vecN& operator=(const vecN& other);
```

and the in your `.cpp` file

```
1  PHY::vecN& PHY::vecN::operator=(const PHY::vecN& other){
2      this->m_num_el = other.m_num_el;
3      this->INIT(m_num_el);
4
5      for(int i=0; i<m_num_el; i++) {
6          this->m_vals[i] = other.m_vals[i];
7      }
8      return *this;
9  }
```

C++: Operators + Objects

This should have fixed the problem we had earlier. $\text{vec}[0] = 0.0$

$\text{vec}[1] = 1.0$

$\text{vec}[2] = 2.0$

$\text{vec}[3] = 3.0$

$\text{vec}[4] = 4.0$

$\text{vec}[5] = 5.0$

$\text{vec}[6] = 6.0$

$\text{vec}[7] = 7.0$

$\text{vec}[8] = 8.0$

$\text{vec}[9] = 9.0$

Looks Good!

C++: Operators + Objects = Power

This is the Power of C++. we get complete control over how we want operators to defined for our data types.

lets add a few more useful operators.

```
1 //Operators to make our lives easy
2 vecN& operator=(const vecN& other);
3 float& operator[](const int index);
4 vecN operator+(vecN& other);
```

C++: Operators + Objects = Power

This is why it works to add numpy arrays but not python lists.
This can be used to make our lives very easy

```
1  struct Vec3{
2      float x,y,z;
3      Vec3();
4      Vec3(float s);
5      Vec3(float e_x, float e_y, float e_z);
6
7      Vec3 add(const Vec3& other) const;
8      float& operator[](const int index);
9      float* get();
10
11     float dot(const Vec3& other) const;
12     Vec3 cross(const Vec3& other) const;
13     float len() const;
14
```

C++: Operators + Objects = Power

```
1  Vec3 operator+(const Vec3& other) const;
2  Vec3 operator-(const Vec3& other) const;
3  Vec3& operator=(const Vec3& other);
4  Vec3& operator=(const Quat& other);
5  Vec3 operator*(const Vec3& other) const;
6  Vec3 operator/(float div) const;
7  Vec3 operator+=(const Vec3& other);
8  Vec3 operator*=(float scale);
9
10 bool operator==(const Vec3& other) const;
11 bool Is_Parallel(const Vec3& other) const;
12 void Rotate_Quaternion(const Vec3& axis, float ang);
13 void Reset();
14 void print();
15 void Normalize();
16 void Vround(int decimals);
17
```