Class Members

CMSC 240 Software Systems Development

Today

- Constructors
- Enumerations
- Static members
- Operator overloading
- In-class activity

RICHMOND

Today

- Constructors
- Enumerations
- Static members
- Operator overloading
- In-class activity

RICHMOND

How do we design a class?

We must specify the **3 parts**:

1. Member variables: What variables make up this new type?

2. Member functions: What functions can you call on a variable of this type?

3. Constructor: What happens when you make a new instance of this type?

September 21, 2023

1. Member variables: What variables make up this new type?

2. Member functions: What functions can you call on a variable of this type?

3. Constructor: What happens when you make a new instance of this type?

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date(int yyyy, int mm, int dd);  // constructor
8       void add_day(int num);
9       int getYear() { return year; }   // inline method declarations
10      int getMonth() { return month; }
11      int getDay() { return day; }
12  private:
13      int year, month, day;
14      bool is_valid();
15  };
16
17  #endif
```

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date(int yyyy, int mm, int dd);  // constructor
8       void add_day(int num);
9       int getYear() { return year; }   // inline method declarations
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11      int getDay() { return day; }
12  private:
13      int year, month, day;
14      bool is_valid();
15  };
16
17  #endif
```
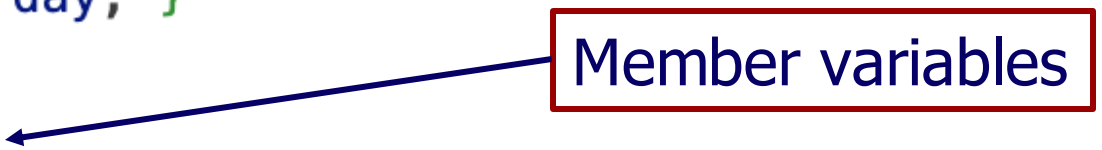



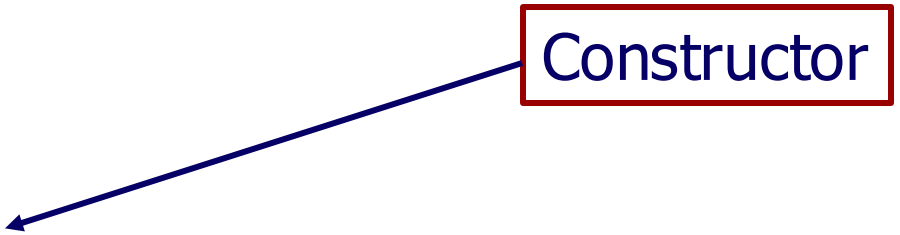
C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date(int yyyy, int mm, int dd);  // constructor
8       void add_day(int num);
9       int getYear() { return year; }   // inline method declarations
10      int getMonth() { return month; }
11      int getDay() { return day; }
12  private:
13      int year, month, day;
14      bool is_valid();
15  };
16
17  #endif
```

Member functions

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date(int yyyy, int mm, int dd);  // constructor
8       void add_day(int num);
9       int getYear() { return year; }   // inline method declarations
10      int getMonth() { return month; }
11      int getDay() { return day; }
12  private:
13      int year, month, day;
14      bool is_valid();
15  };
16
17  #endif
```



Date.cpp > ...

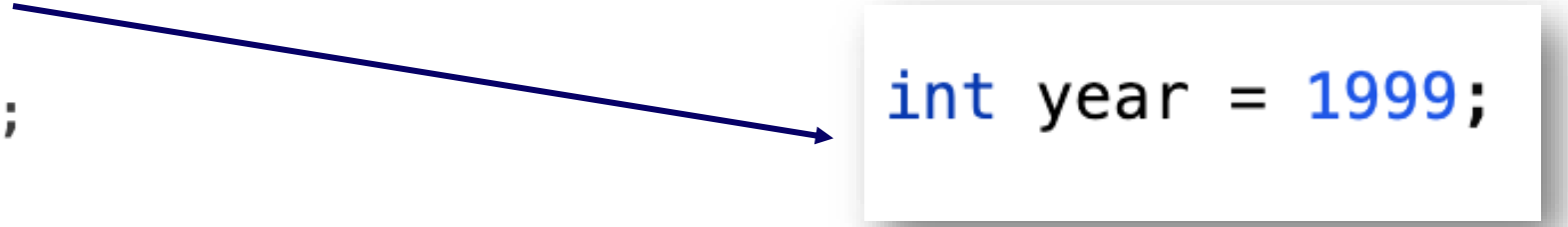
```cpp
#include "Date.h"

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}
```

Date.cpp > ...

```cpp
#include "Date.h"

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}

//    Date::Date(int yyyy, int mm, int dd)  // constructor
//    {
//        year = yyyy;                      // initialize members
//        month = mm;
//        day = dd;
//
//        is_valid();
//    }
```

Date.cpp > ...

```cpp
#include "Date.h"

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}

//    Date::Date(int yyyy, int mm, int dd)  // constructor
//    {
//        year = yyyy;                      // initialize members
//        month = mm;
//        day = dd;
//
//        is_valid();
//    }
```



Date.cpp > ...

```
1    #include "Date.h"
2
3    Date::Date(int yyyy, int mm, int dd)  // constructor
4        : year{yyyy}, month{mm}, day{dd}  // member initializer list
5    {
6        is_valid();
7    }
8
9    //    Date::Date(int yyyy, int mm, int dd)  // constructor
10   //    {
11   //        year = yyyy;
12   //        month = mm;
13   //        day = dd;
14   //
15   //        is_valid();
16   //    }
```

```
int year = 1999;
```

```
int year;
    // ...
year = 1999;
```

```cpp
#include "Date.h"

int main()
{
    // Correct
    Date today1 = {2023, 9, 21};

    // Also correct
    Date today2{2023, 9, 21};

    // Also correct
    Date today3(2023, 9, 21);

    // Also correct
    Date today4 = Date{2023, 9, 21};

    // Also correct
    Date today5 = Date(2023, 9, 21);

    // Put the new Date object on the heap
    Date* todayPointer = new Date{2023, 9, 21};

    return 0;
}
```

Don’t forget to free your memory

```
20      // Put the new Date object on the heap
21      Date* todayPointer = new Date{2023, 9, 21};
22
23      delete todayPointer;
```

```cpp
#include "Date.h"

int main()
{
    Date today1;                    // Error: no default constructor exists

    Date today2{};                  // Error: empty initializer

    Date today3{2023};              // Error: too few arguments

    Date today4{1, 2, 3, 4};        // Error: to many arguments

    Date today5{2023, "sep", 21};   // Error: incorrect argument types

    return 0;
}
```

C Date.h > ...

```h
#ifndef DATE_H
#define DATE_H

class Date
{
public:
    Date();                             // default constructor
    Date(int yyyy, int mm, int dd);     // constructor
    void add_day(int num);
    int getYear() { return year; }      // inline method declarations
    int getMonth() { return month; }
    int getDay() { return day; }
private:
    int year, month, day;
    bool is_valid();
};

#endif
```

Date.cpp > ...

```cpp
#include "Date.h"

Date::Date()  // default constructor
    : year{2021}, month{1}, day{1}
{
}

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}
```

```cpp
#include "Date.h"

int main()
{
    Date today1;                    // It works...

    Date today2{};                  // It works...

    Date today3{2023};              // Error: too few arguments

    Date today4{1, 2, 3, 4};        // Error: to many arguments

    Date today5{2023, "sep", 21};   // Error: incorrect argument types

    return 0;
}
```

Ask a question

Today

- ~~Constructors~~
- Enumerations
- Static members
- Operator overloading
- In-class activity

RICHMOND

Enumerations

- An **`enum`** is a very simple user-defined type
  - Use them when you want a set of values as symbolic constants

```
1    enum class Month
2    {
3        jan=1, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec
4    };
```

The body of an enumeration is simply a list of enumerators.

Enumerations

- An **`enum`** is a very simple user-defined type
  - Use them when you want a set of values as symbolic constants

```
1    enum class Month
2    {
3        jan=1, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec
4    };
```

For any other enumerator whose definition does not have an initializer, the associated value is the value of the previous enumerator plus one

Enumerations

- An **`enum`** is a very simple user-defined type
  - Use them when you want a set of values as symbolic constants

```
1    enum class Month
2    {
3        jan=1, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec
4    };
```

```
1    enum class Month
2    {
3        jan=1, feb=2, mar=3, apr=4, may=5, jun=6, jul=7, aug=8, sep=9, oct=10, nov=11, dec=12
4    };
```

Enumerations

- An **`enum`** is a very simple user-defined type
  - Use them when you want a set of values as symbolic constants

```
1    enum class Month
2    {
3        jan=1, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec
4    };
```

The **`class`** in **`enum class`** means that the enumerators are in the scope of the enumeration.

To refer to **`jan`** we have to say **`Month::jan`**

Enumerations

- An **`enum`** is a very simple user-defined type
  - Use them when you want a set of values as symbolic constants

```
1    enum class Day
2    {
3        mon, tue, wed, thr, fri, sat, sun
4    };
```

If we don't initialize the first enumerator, the count starts with 0.

Here **`mon`** is represented as **`0`** and **`sun`** is represented as **`6`**.

When to use an Enumeration

```
1   #include "Date.h"
2
3   int main()
4   {
5
6       // Supposed to by Year, Month, Day
7       // But we entered Year, Day, Month
8       Date notValid = {2023, 21, 9};
9
10      // Correct
11      Date today = {2023, 9, 21};
12  }
```

lecture8 > enums > C Date.h > ...

```h
#ifndef DATE_H
#define DATE_H

enum class Month
{
    jan=1, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec
};

class Date
{
public:
    Date(int yyyy, Month mm, int dd);  // constructor using enum
    void add_day(int num);
    int getYear() { return year; }
    int getMonth() { return int(month); }
    int getDay() { return day; }
private:
    int year;
    Month month;
    int day;
    bool is_valid();
};

#endif
```

lecture8 > enums > C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   enum class Month
5   {
6       jan=1, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec
7   };
8
9   class Date
10  {
11  public:
12      Date(int yyyy, Month mm, int dd);  // constructor using enum
13      void add_day(int num);
14      int getYear() { return year; }
15      int getMonth() { return int(month); }
16      int getDay() { return day; }
17  private:
18      int year;
19      Month month;
20      int day;
21      bool is_valid();
22  };
23
24  #endif
```

lecture8 > enums > C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   enum class Month
5   {
6       jan=1, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec
7   };
8
9   class Date
10  {
11  public:
12      Date(int yyyy, Month mm, int dd);  // constructor using enum
13      void add_day(int num);
14      int getYear() { return year; }
15      int getMonth() { return int(month); }
16      int getDay() { return day; }
17  private:
18      int year;
19      Month month;
20      int day;
21      bool is_valid();
22  };
23
24  #endif
```

lecture8 > enums > C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   enum class Month
5   {
6       jan=1, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec
7   };
8
9   class Date
10  {
11  public:
12      Date(int yyyy, Month mm, int dd);  // constructor using enum
13      void add_day(int num);
14      int getYear() { return year; }
15      int getMonth() { return int(month); }
16      int getDay() { return day; }
17  private:
18      int year;
19      Month month;
20      int day;
21      bool is_valid();
22  };
23
24  #endif
```

lecture8 > enums > C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
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4   enum class Month
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7   };
8
9   class Date
10  {
11  public:
12      Date(int yyyy, Month mm, int dd);  // constructor using enum
13      void add_day(int num);
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18      int year;
19      Month month;
20      int day;
21      bool is_valid();
22  };
23
24  #endif
```

lecture8 > enums > Date.cpp > ...

```cpp
#include "Date.h"

Date::Date(int yyyy, Month mm, int dd)       // constructor
        : year{yyyy}, month{mm}, day{dd}     // member initializer list
{
    is_valid();
}
```

lecture8 > enums > Date.cpp > ...

```cpp
#include "Date.h"

Date::Date(int yyyy, Month mm, int dd)      // constructor
    : year{yyyy}, month{mm}, day{dd}    // member initializer list
{
    is_valid();
}
```

lecture8 > enums > TestDate.cpp > ...

```cpp
#include <iostream>
#include "Date.h"

int main()
{
    Date today = {2023, Month::sep, 21};

    std::cout << "year == " << today.getYear() << std::endl;
    std::cout << "month == " << today.getMonth() << std::endl;
    std::cout << "day == " << today.getDay() << std::endl;
}
```

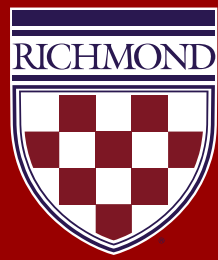
lecture8 > enums > TestDate.cpp > ...

```cpp
#include <iostream>
#include "Date.h"

int main()
{
    Date today = {2023, Month::sep, 21};

    std::cout << "year == " << today.getYear() << std::endl;
    std::cout << "month == " << today.getMonth() << std::endl;
    std::cout << "day == " << today.getDay() << std::endl;
}
```

C Toaster.h > ...

```
1   #ifndef TOASTER_H
2   #define TOASTER_H
3
4
5   class Toaster
6   {
7
8   public:
9       Toaster(int initialLevel);
10      void toast();
11      void cancel();
12      bool isOn();
13      int getLevel();
14      void setLevel(int newLevel);
15  private:
16      int heatLevel;
17      bool isToasting;
18      bool isValidLevel(int level);
19  };
20
21  #endif
```

Where could you add an enumeration to your design?



Today

- ~~Constructors~~
- ~~Enumerations~~
- Static members
- Operator overloading
- In-class activity

RICHMOND

Static Member Variables

- **Static member variables** can be accessed on the class itself, without creating an instance of the class
- Exists only once, regardless of how many instances of the class are created
- Shared among all instances of the class
- Value is set outside the class, typically in a source (.cpp) file, even if it's declared const (this is required to allocate storage for it)

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date();
8       Date(int yyyy, int mm, int dd);
9       void add_day(int num);
10      int getYear() { return year; }
11      int getMonth() { return month; }
12      int getDay() { return day; }
13      static int DEFAULT_YEAR;
14  private:
15      int year, month, day;
16      bool is_valid();
17  };
18
19  #endif
```

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date();
8       Date(int yyyy, int mm, int dd);
9       void add_day(int num);
10      int getYear() { return year; }
11      int getMonth() { return month; }
12      int getDay() { return day; }
13      static int DEFAULT_YEAR;
14  private:
15      int year, month, day;
16      bool is_valid();
17  };
18
19  #endif
```

Date.cpp > ...

```cpp
#include "Date.h"

Date::Date()  // default constructor
    : year{DEFAULT_YEAR}, month{1}, day{1}
{
}

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}

int Date::DEFAULT_YEAR = 2001;
```

Date.cpp > ...

```cpp
#include "Date.h"

Date::Date()  // default constructor
    : year{DEFAULT_YEAR}, month{1}, day{1}
{
}

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}

int Date::DEFAULT_YEAR = 2001;
```

TestDate.cpp > ...

```cpp
#include "Date.h"
#include <iostream>
using namespace std;

int main()
{
    cout << Date::DEFAULT_YEAR << endl;

    return 0;
}
```

TestDate.cpp > ...

```cpp
#include "Date.h"
#include <iostream>
using namespace std;

int main()
{
    cout << Date::DEFAULT_YEAR << endl;

    return 0;
}
```

TestDate.cpp > ...

```cpp
#include "Date.h"
#include <iostream>
using namespace std;

int main()
{
    // Update the default year in all
    // future instances of the Date class
    Date::DEFAULT_YEAR = 2023;

    cout << Date::DEFAULT_YEAR << endl;

    return 0;
}
```

TestDate.cpp > ...

```cpp
#include "Date.h"
#include <iostream>
using namespace std;

int main()
{
    // Update the default year in all
    // future instances of the Date class
    Date::DEFAULT_YEAR = 2023;

    cout << Date::DEFAULT_YEAR << endl;

    return 0;
}
```

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date();
8       Date(int yyyy, int mm, int dd);
9       void add_day(int num);
10      int getYear() { return year; }
11      int getMonth() { return month; }
12      int getDay() { return day; }
13      static const int DEFAULT_YEAR;
14  private:
15      int year, month, day;
16      bool is_valid();
17  };
18
19  #endif
```

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
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4   class Date
5   {
6   public:
7       Date();
8       Date(int yyyy, int mm, int dd);
9       void add_day(int num);
10      int getYear() { return year; }
11      int getMonth() { return month; }
12      int getDay() { return day; }
13      static const int DEFAULT_YEAR;
14  private:
15      int year, month, day;
16      bool is_valid();
17  };
18
19  #endif
```

Date.cpp > ...

```cpp
#include "Date.h"

Date::Date()  // default constructor
    : year{DEFAULT_YEAR}, month{1}, day{1}
{
}

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}

const int Date::DEFAULT_YEAR = 2001;
```

TestDate.cpp > ...

```cpp
#include "Date.h"
#include <iostream>
using namespace std;

int main()
{
    // Update the default year in all
    // future instances of the Date class
    Date::DEFAULT_YEAR = 2023;

    cout << Date::DEFAULT_YEAR << endl;

    return 0;
}
```

Error: Can not modify a `const` value.

Static Member Functions

- **Static member functions** can be called on the class itself, without creating an instance of the class
- It can only access static member variables or other static member functions directly
- It's often used as a utility function or to interact with static member variables.

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date();
8       Date(int yyyy, int mm, int dd);
9       void add_day(int num);
10      int getYear() { return year; }
11      int getMonth() { return month; }
12      int getDay() { return day; }
13      static int DEFAULT_YEAR;
14      static void setDefaultYear(int yearDefault);
15  private:
16      int year, month, day;
17      bool is_valid();
18  };
19
20  #endif
```

C Date.h > ...

```
1   #ifndef DATE_H
2   #define DATE_H
3
4   class Date
5   {
6   public:
7       Date();
8       Date(int yyyy, int mm, int dd);
9       void add_day(int num);
10      int getYear() { return year; }
11      int getMonth() { return month; }
12      int getDay() { return day; }
13      static int DEFAULT_YEAR;
14      static void setDefaultYear(int yearDefault);
15  private:
16      int year, month, day;
17      bool is_valid();
18  };
19
20  #endif
```

Date.cpp > ...

```cpp
#include "Date.h"

Date::Date()  // default constructor
    : year{DEFAULT_YEAR}, month{1}, day{1}
{
}

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}

int Date::DEFAULT_YEAR = 2001;

void Date::setDefaultYear(int yearDefault)
{
    DEFAULT_YEAR = yearDefault;
}
```

Date.cpp > ...

```cpp
#include "Date.h"

Date::Date()  // default constructor
    : year{DEFAULT_YEAR}, month{1}, day{1}
{
}

Date::Date(int yyyy, int mm, int dd)  // constructor
    : year{yyyy}, month{mm}, day{dd}  // member initializer list
{
    is_valid();
}

int Date::DEFAULT_YEAR = 2001;

void Date::setDefaultYear(int yearDefault)
{
    DEFAULT_YEAR = yearDefault;
}
```

TestDate.cpp > ...

```cpp
#include "Date.h"
#include <iostream>
using namespace std;

int main()
{
    Date::setDefaultYear(2023);

    cout << Date::DEFAULT_YEAR << endl;

    return 0;
}
```

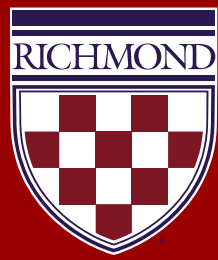
TestDate.cpp > ...

```cpp
#include "Date.h"
#include <iostream>
using namespace std;

int main()
{
    Date::setDefaultYear(2023);

    cout << Date::DEFAULT_YEAR << endl;

    return 0;
}
```

C Toaster.h > ...

```
1   #ifndef TOASTER_H
2   #define TOASTER_H
3
4
5   class Toaster
6   {
7
8   public:
9       Toaster(int initialLevel);
10      void toast();
11      void cancel();
12      bool isOn();
13      int getLevel();
14      void setLevel(int newLevel);
15  private:
16      int heatLevel;
17      bool isToasting;
18      bool isValidLevel(int level);
19  };
20
21  #endif
```

Where could you add static variables or methods to your design?



Today

- ~~Constructors~~
- ~~Enumerations~~
- ~~Static members~~
- Operator overloading

- In-class activity

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Method Overloading

C MathOperations.h > ...

```
1   class MathOperations {
2   public:
3       // Method to add two integers
4       int add(int a, int b) { return a + b; }
5
6       // Works: Method to add three integers
7       int add(int a, int b, int c) { return a + b + c; }
8
9       // Works: Method to add two doubles
10      double add(double a, double b) { return a + b; }
11
12      // Error: note: previous declaration
13      // The return type is NOT considered while differentiating the overloaded methods,
14      // so you cannot create an overloaded method just by changing the return type.
15      float add(double a, double b) { return a + b; }
16  };
```

You can reuse method names if the **parameters** in the method signature are different.

Operator Overloading

- **Operator overloading** is a feature in C++ that allows you to redefine the behavior of built-in operators (like +, -, *, etc.) for user-defined types like classes

- This enables you to use these operators in intuitive ways with objects of your custom types, making your code more readable and expressive

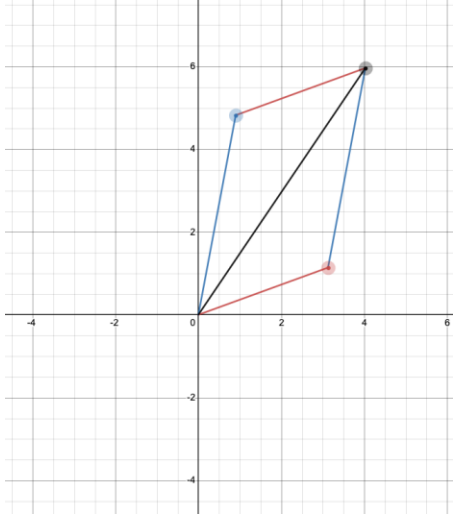
any of the following operators: `+` `-` `*` `/` `%` `^` `&` `|` `~` `!` `=` `<` `>` `+=` `-=` `*=` `/=` `%=` `^=` `&=` `|=`
`<<` `>>` `>>=` `<<=` `==` `!=` `<=` `>=` `<=>` (since C++20) `&&` `||` `++` `--` `,` `->*` `->` `( )` `[ ]`

Operator Overloading

- **Syntax**: Operator overloading is achieved by defining special member functions with the keyword `operator` followed by the operator symbol you wish to overload

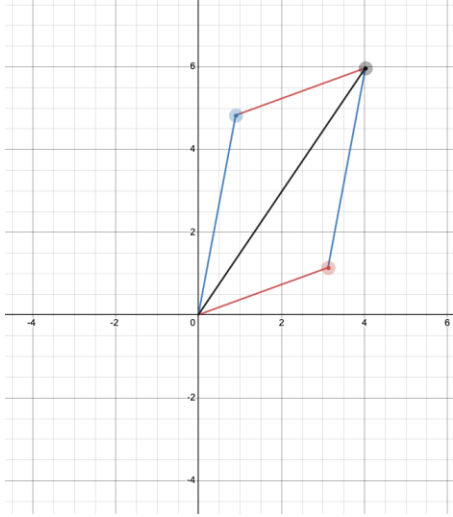
C Vector.h > ...

```
1   #ifndef VECTOR_H
2   #define VECTOR_H
3
4   class Vector
5   {
6   public:
7       Vector(float x, float y);  // Constructor
8       Vector operator+(const Vector& other) const;  // Overload +
9       float getX() const { return x; }
10      float getY() const { return y; }
11  private:
12      float x;
13      float y;
14  };
15
16  #endif
```



C Vector.h > ...

```
1   #ifndef VECTOR_H
2   #define VECTOR_H
3
4   class Vector
5   {
6   public:
7       Vector(float x, float y);  // Constructor
8       Vector operator+(const Vector& other) const;  // Overload +
9       float getX() const { return x; }
10      float getY() const { return y; }
11  private:
12      float x;
13      float y;
14  };
15
16  #endif
```



Vector.cpp > ...

```cpp
#include "Vector.h"

Vector::Vector(float x, float y) : x(x), y(y) {}

Vector Vector::operator+(const Vector& other) const
{
    // Return an instance of Vector that is
    // this vector added to the other vector.
    return Vector(this->x + other.x, this->y + other.y);
}
```

Vector.cpp > ...

```cpp
#include "Vector.h"

Vector::Vector(float x, float y) : x(x), y(y) {}

Vector Vector::operator+(const Vector& other) const
{
    // Return an instance of Vector that is
    // this vector added to the other vector.
    return Vector(this->x + other.x, this->y + other.y);
}
```

TestVector.cpp > ...

```cpp
#include <iostream>
#include "Vector.h"
using namespace std;

int main()
{
    Vector v1(1, 2);
    Vector v2(3, 4);

    Vector v3 = v1 + v2;  // Uses the overloaded + operator

    // Print out the vector.
    cout << "v1 == [" << v1.getX() << ", " << v1.getY() << "]" << endl;
    cout << "v2 == [" << v2.getX() << ", " << v2.getY() << "]" << endl;
    cout << "v3 == [" << v3.getX() << ", " << v3.getY() << "]" << endl;
}
```

TestVector.cpp > ...

```cpp
#include <iostream>
#include "Vector.h"
using namespace std;

int main()
{
    Vector v1(1, 2);
    Vector v2(3, 4);

    Vector v3 = v1 + v2;  // Uses the overloaded + operator

    // Print out the vector.
    cout << "v1 == [" << v1.getX() << ", " << v1.getY() << "]" << endl;
    cout << "v2 == [" << v2.getX() << ", " << v2.getY() << "]" << endl;
    cout << "v3 == [" << v3.getX() << ", " << v3.getY() << "]" << endl;
}
```

TestVector.cpp > ...

```cpp
#include <iostream>
#include "Vector.h"
using namespace std;

int main()
{
    Vector v1(1, 2);
    Vector v2(3, 4);

    Vector v3 = v1 + v2;  // Uses the overloaded + operator

    // Print out the vector.
    cout << "v1 == [" << v1.getX() << ", " << v1.getY() << "]" << endl;
    cout << "v2 == [" << v2.getX() << ", " << v2.getY() << "]" << endl;
    cout << "v3 == [" << v3.getX() << ", " << v3.getY() << "]" << endl;
}
```

```
v1 == [1, 2]
v2 == [3, 4]
v3 == [4, 6]
```

TestVector.cpp > main()

```cpp
#include <iostream>
#include "Vector.h"
using namespace std;

ostream& operator<<(ostream& out, const Vector& v)
{
    out << "[" << v.getX() << ", " << v.getY() << "]";
    return out;
}

int main()
{
    Vector v1(1, 2);
    Vector v2(3, 4);

    Vector v3 = v1 + v2;  // Uses the overloaded + operator

    // Print out the vector.
    cout << "v1 == " << v1 << endl;
    cout << "v2 == " << v2 << endl;
    cout << "v3 == " << v3 << endl;
}
```

TestVector.cpp > main()

```cpp
#include <iostream>
#include "Vector.h"
using namespace std;

ostream& operator<<(ostream& out, const Vector& v)
{
    out << "[" << v.getX() << ", " << v.getY() << "]";
    return out;
}

int main()
{
    Vector v1(1, 2);
    Vector v2(3, 4);

    Vector v3 = v1 + v2;  // Uses the overloaded + operator

    // Print out the vector.
    cout << "v1 == " << v1 << endl;
    cout << "v2 == " << v2 << endl;
    cout << "v3 == " << v3 << endl;
}
```

Why pass and return ostream&

- There are several reasons, but the primary is that one would like to ”chain” calls to operator<<
- First, why pass an ostream&
  - Because you want to avoid the copy that would be required for if you pass by value. Moreover, the copy constructor for std::ostream is disabled (this sounds cryptic, but it’s not).
- But if you’re passing by reference, why not return void instead of ostream&
  - This is where the chaining comes in (see next slide).

Thanks StackOverflow: https://stackoverflow.com/questions/47466358/what-is-the-spaceship-three-way-comparison-operator-in-c and https://stackoverflow.com/questions/30272143/why-does-overloading-ostreams-operator-need-a-reference

Why pass and return ostream&

- Consider the following:

```
std::cout << "Hello " << "Prof S";

operator <<( operator <<( std::cout, "Hello" ), "Prof S" );
           ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
           ^
            returns reference to std::cout
```

- The bottom line is equivalent to the top line, in which you are "chaining" calls to operator<<

TestVector.cpp > main()

```cpp
#include <iostream>
#include "Vector.h"
using namespace std;

ostream& operator<<(ostream& out, const Vector& v)
{
    out << "[" << v.getX() << ", " << v.getY() << "]";
    return out;
}

int main()
{
    Vector v1(1, 2);
    Vector v2(3, 4);

    Vector v3 = v1 + v2;  // Uses the overloaded + operator

    // Print out the vector.
    cout << "v1 == " << v1 << endl;
    cout << "v2 == " << v2 << endl;
    cout << "v3 == " << v3 << endl;
}
```

TestVector.cpp > main()

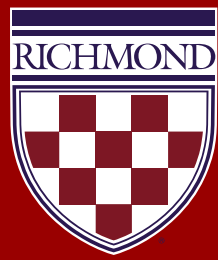
```cpp
#include <iostream>
#include "Vector.h"
using namespace std;

ostream& operator<<(ostream& out, const Vector& v)
{
    out << "[" << v.getX() << ", " << v.getY() << "]";
    return out;
}

int main()
{
    Vector v1(1, 2);
    Vector v2(3, 4);

    Vector v3 = v1 + v2;  // Uses the overloaded + operator

    // Print out the vector.
    cout << "v1 == " << v1 << endl;
    cout << "v2 == " << v2 << endl;
    cout << "v3 == " << v3 << endl;
}
```

```
v1 == [1, 2]
v2 == [3, 4]
v3 == [4, 6]
```

C Toaster.h > ...

```
1   #ifndef TOASTER_H
2   #define TOASTER_H
3
4
5   class Toaster
6   {
7
8   public:
9       Toaster(int initialLevel);
10      void toast();
11      void cancel();
12      bool isOn();
13      int getLevel();
14      void setLevel(int newLevel);
15  private:
16      int heatLevel;
17      bool isToasting;
18      bool isValidLevel(int level);
19  };
20
21  #endif
```

Where could you use operator overloading in your design?



Today

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- In class activity

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Visibility

- private
+ public
# protected