Objects and Classes Advanced

Advanced Class Members

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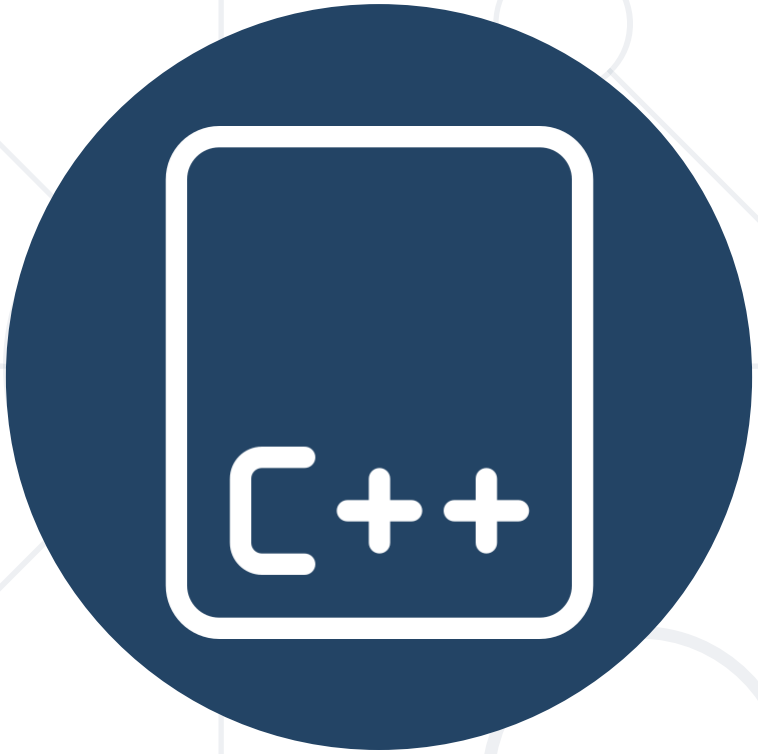
#cpp-oop



Namespaces

Organizing Code into Named Groups

Namespaces

- Named groups of variables, functions, classes, etc.

```
namespace GroupName { ... /*members*/ ... }
```

  - Members access each other normally

```
namespace SoftUni {
  namespace CppFundamentals {
    const int numLectures = 6
    std::string lectures[numLectures]{ "Basic Syntax", ... };
  }
  namespace CppAdvanced {
    using namespace std;
    vector<string> lectures{ "Pointers and References", ... };
  }
}
```

Namespaces

- Outside code uses group name followed by **operator::**

```
int main() {
  for (std::string s : SoftUni::CppFundamentals::lectures)
    std::cout << s << std::endl;
}
```

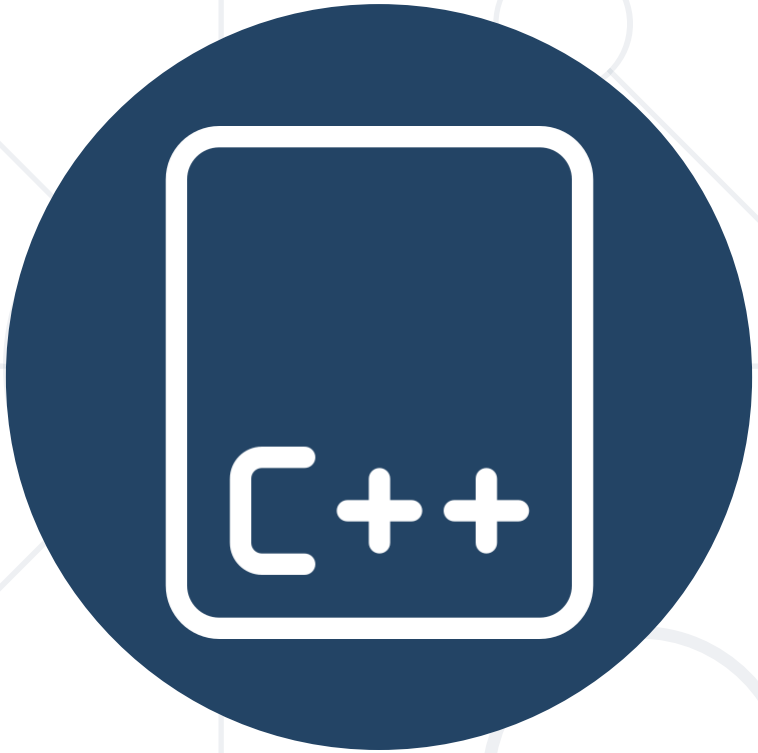
- **using** declarations tell compiler where to look "by default"
  - **using namespace std;**

```
int main() {
  using namespace SoftUni::CppFundamentals;
  for (std::string s : lectures)
    std::cout << s << std::endl;
}
```

Namespaces Application

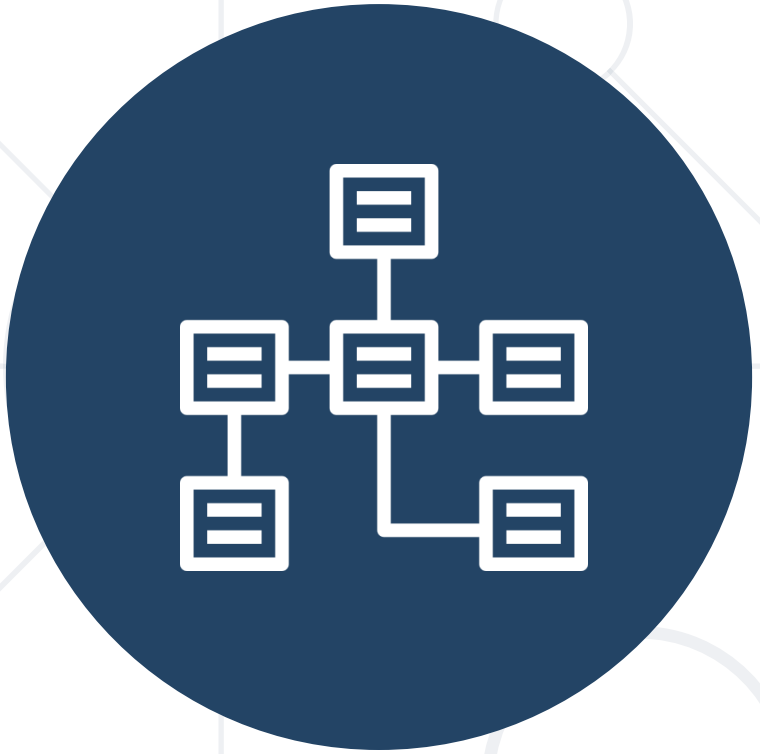
- Main purpose of namespaces – avoid name conflicts
- Example: a 2D Geometry library vs. C++ `std` library
  - `std::vector` – dynamic linear container
  - `geometry2d::vector` – a vector in 2D space (with `x`, `y`)
  - Namespaces prevent `vector` name conflict
- Avoid `using` declarations

```
using namespace std; using namespace Geometry2D;
vector v; // compilation error
```



Namespaces

LIVE DEMO



Members

`static`, `const`, `mutable`

Static Members in OOP

- Members NOT related to any specific object
  - Used without an object
- Access similar to identifiers in namespaces
  - class name and `operator::`

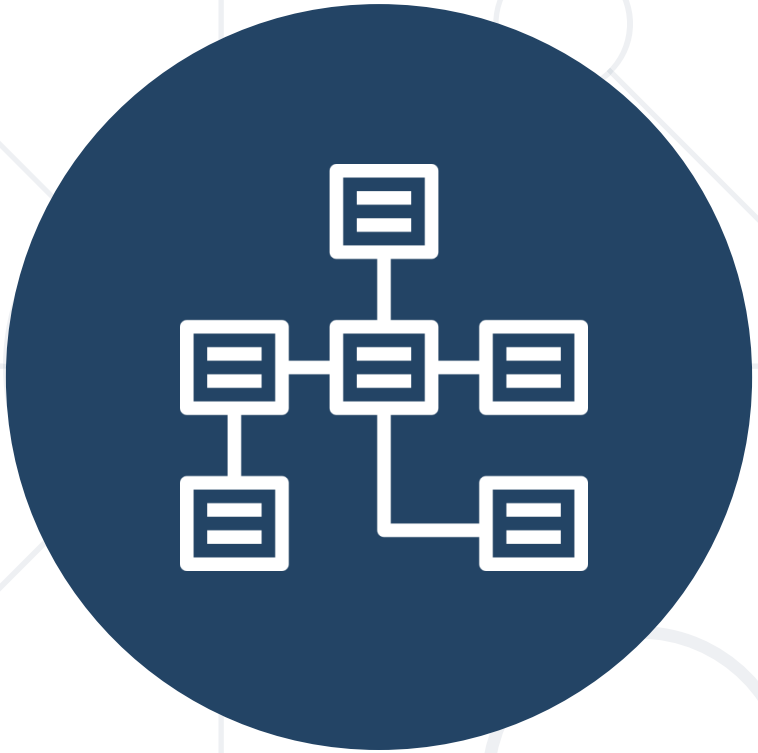
Static Members in OOP

```
class Company {
public:
  static const int ID_LENGTH = 8;
  string id;
  long long capitalDollars;
  ...
  static string generateId() {
    string id(ID_LENGTH, ' ');
    for (int i = 0; i < ID_LENGTH; i++)
      id[i] = 'A'+rand()%(1+'Z'-'A');
    return id;
  }
}
...
int main() {
  Company randomIdCompany{ Company::generateId(), 100 };
  Company z{ string(Company::ID_LENGTH, 'Z'), 1000 };
  ...
```

C++ static Fields

- Exist in the class, not in each object
- Defined and initialized outer class, in a `.cpp` file

```
class Company {
public:
static int CREATED_COMPANIES;
  ...
  Company(...) { CREATED_COMPANIES++; }
};
int Company::CREATED_COMPANIES = 0;
int main() {
  Company a{ ... }; Company b{ ... }; Company c{ ... };
  cout << Company::CREATED_COMPANIES; // prints 3
...
```



Static Members

LIVE DEMO

C++ const Fields

- Fields can be **const** – same as **const** variables
  - If non-static, initialized in constructor initializer list

```
class Company {
public:
  const std::string id;
  Company(std::string id, ...) : id(id), ... {}
}
```

```
const Company* c = new Company{ "GOOGINC.", ... };
cout << c.id << endl; // prints GOOGINC.
c.id = "thiswontcompile"; // compilation error
```

C++ const Methods

```
class Company {
  ...
  long long dollars; string id;
  void addCapital(long long dollars) {
    this->dollars += dollars;
  }

  void print() const {
    cout << this->id << " " << this->dollars;
  }
};
```

Method name

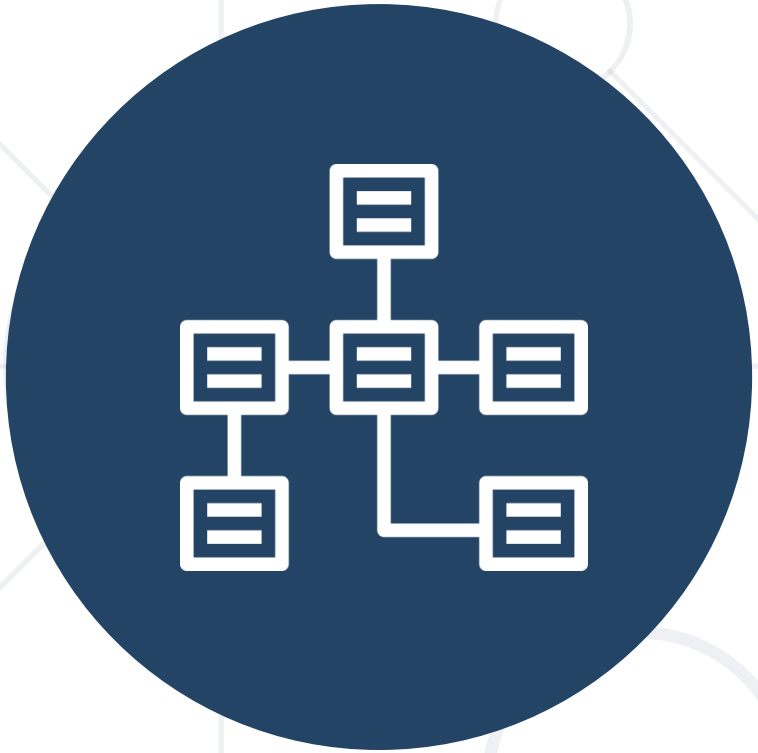
const

Return type

const methods can NOT change fields

const object/reference/pointer can only call const methods

```
Company c{ "GOOGINC.", 999 };
const Company& constRef = c;
constRef.print(); // GOOGINC. 999
c.addCapital(999999);
constRef.addCapital(999999); // compilation error
```



Constant Members

LIVE DEMO

Quick Quiz

- Which of the parts of code here will have compilation errors?

a) The **`printOlder`** method and the **`Person`** ctor

b) The **`Person`** ctor

c) The **`printOlder`** method

d) None, the code is valid

```
class Person {
public:
  int age; const string name;
  Person(string name, int age) {
    this->name = name; this->age = age;
  }
int getAge() { return this->age; }
};
```

```
void printOlder(const Person& a, const Person& b) {
  if (a.getAge() >= b.getAge()) {
    cout << a.name;
} else cout << b.name;
```

```
Person a{ "joro", 26 };
Person b{ "ben dover", 46 };
printOlder(a, b);
```

C++ PITFALL: MISSING CONST ON GETTERS AND NOT SETTING CONST FIELDS IN INITIALIZER LIST

`const` fields can only be initialized in constructor initializer list. They can't be assigned in constructor body.

Getters should usually be marked **`const`** – they don't change the object, and outside code calling them may be doing so from const references/pointers.

The mutable Keyword

- Fields marked **mutable** can be changed by **const** methods
  - External code accesses **const**
  - Internal code changes state
  - Typically used for caching, logs, mutexes and other metadata

```
class Person {
  int age; const string name;
  mutable int ageChecks = 0;
public:
  Person(string name, int age)
  : name(name), age(age) {}

  int getAge() const {
    this->ageChecks++;
    return this->age;
  }
  int getAgeChecks() const {
    return this->ageChecks;
  }
};
```

```
const Person a{ "george", 26 };

a.getAge(); a.getAge(); a.getAge();

cout << a.getAgeChecks() << endl; // prints 3
```

Practice

Live Exercise in Class

Problem 1: Rolling Sticks

- You are given code that animates sticks
  - Represented on a line on the console
  - "roll" by changing their symbol and position on the line
  - Symbols: start from **_**, then ****, then **|**, then **/** and back to **_**
  - Position starts from **0**. When symbol becomes **|** – move to next
- The code already does the animation, you need to implement a **`Stick`** class that keeps and updates the state of a **`Stick`**
  - Implement the code in a **`Stick.h`** file **`include`**d by the **`RollingSticksMain.cpp`** file

Friend Functions and Classes

Sharing Access to Private Members

The `friend` Keyword

- Allows access to private members
  - Declared inside the "shared" class
  - The friend can access the "shared" class
- Can be **function** or **class**:

```
friend Type functionName();

friend classNAme;
```

Defining a friend function

Defining a friend class

- "Sharing" is one-way – from declaring a class to a friend

The C++ friend Usage

- Friend functions are often used for directly reading fields of a class
- Friends can usually be changed to members

```
class Company {
  private: string id; long long dollars;
  ...
  friend void getCompany(istream& in, Company& c);
};

void getCompany(istream& in, Company& c) {
  in >> c.id >> c.dollars;
}
```

```
Company c;
getCompany(std::cin, c);
```

Friend Functions and Classes

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Operator Overloading

Operator Overloading

- Redefining operators for user-defined classes
  - Almost all operators can be redefined (except `operator::`)
  - `+`, `-`, `*`, `/`, `++`, `--`, `<<`, `>>`, `<`, `>`, `=`, `operator bool`, …
- Operators are just specially-named functions/methods

```
Type operator+(...)
bool operator<(...)
...
```

- As members – first operand `this`, others are parameters
- As non-members – all operands are parameters

Member Operator Overload

- Syntax (replace **T** with the operator, e.g. **+**, **-**, **<**, ...)

```
ResultT operatorT(RighthandT r)     // binary
```

```
ResultT operatorT()                 // unary
```

```
class Price {
  int cents; string currency;
  ...
  Price operator+(const Price& other) const {
    string resultCurrency = ...;
    return Price{ this->cents + other.cents,
resultCurrency };
  }
};
```

```
Price a{ 499, "usd" };
Price b{ 1000, "usd" };


Price sum = a + b;
// sum is { 1499, "usd" }
```

Member Operator Overload

LIVE DEMO

Non-Member Operator Overload

- Syntax (replace **T** with the operator, e.g. **+**, **-**, **<**, ...)

```
ResultT operatorT(LefthandT l, RighthandT r)    // binary
```

```
ResultT operatorT(T operand)                    // unary
```

```
Price operator+(const Price& a, const Price& b) {
  string currency = ...;
  return Price(a.getCents() + b.getCents(), currency);
}
```

```
Price a{ 499, "usd" };
Price b{ 1000, "usd" };

Price sum = a + b; // sum is { 1499, "usd" }
```

Specifics of Non-Member Overload

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- Non-member overloads allow any **left-hand** class
- Can be used to define operators for other types

```
string operator+(const string& s, const Price& p) {
  ostringstream out;
  out << s << p.getCents() << " " << p.getCurrency();
  return out.str();
}
```

```
Price a{ 499, "usd" };
Price b{ 1000, "usd" };
Price sum = a + b;
cout << std::string("Sum is ") + sum << endl;
```

Overloading Stream Read/Write

- `ostream` and `istream` use operators for output/input
  - `operator<<` and `operator>>` respectively
  - Defined for primitive types and `string`
  - Our classes contain primitives/`string`
- Overloading read/write for our classes
  - Read/write each field from/to the stream
  - Return the stream to enable chaining
  - Left operand stream, a right operand user object

Overloading Stream Read/Write

- Overriding read from `istream` – `friend` if fields private

```
class Price {... friend istream& operator>>(istream& in, Price& p); ... };
```

```
istream& operator>>(istream& in, Price& p) {
  return in >> p.cents >> p.currency;
}
```

```
Price a, b; cin >> a >> b;
```

- Overriding write to `ostream`

```
ostream& operator<<(ostream& out, const Price& p) {
  return out << p.getCents() << " " << p.getCurrency();
}
```

```
std::cout << a + b << std::endl;
```

Non-Member Operator Overload

LIVE DEMO

Quick Quiz

- What will the following code do?

```
istream& operator>>(istream& in, Price& p) {
  in >> p.cents >> " " >> p.currency;
}
ostream& operator<<(ostream& out, const Price& p) {
  out << p.getCents() << " " << p.getCurrency();
}
```

```
Price a, b; cin >> a >> b;
std::cout << a + b << std::endl;
```

a) Print the sum of two prices read from the console

b) Give a compilation error

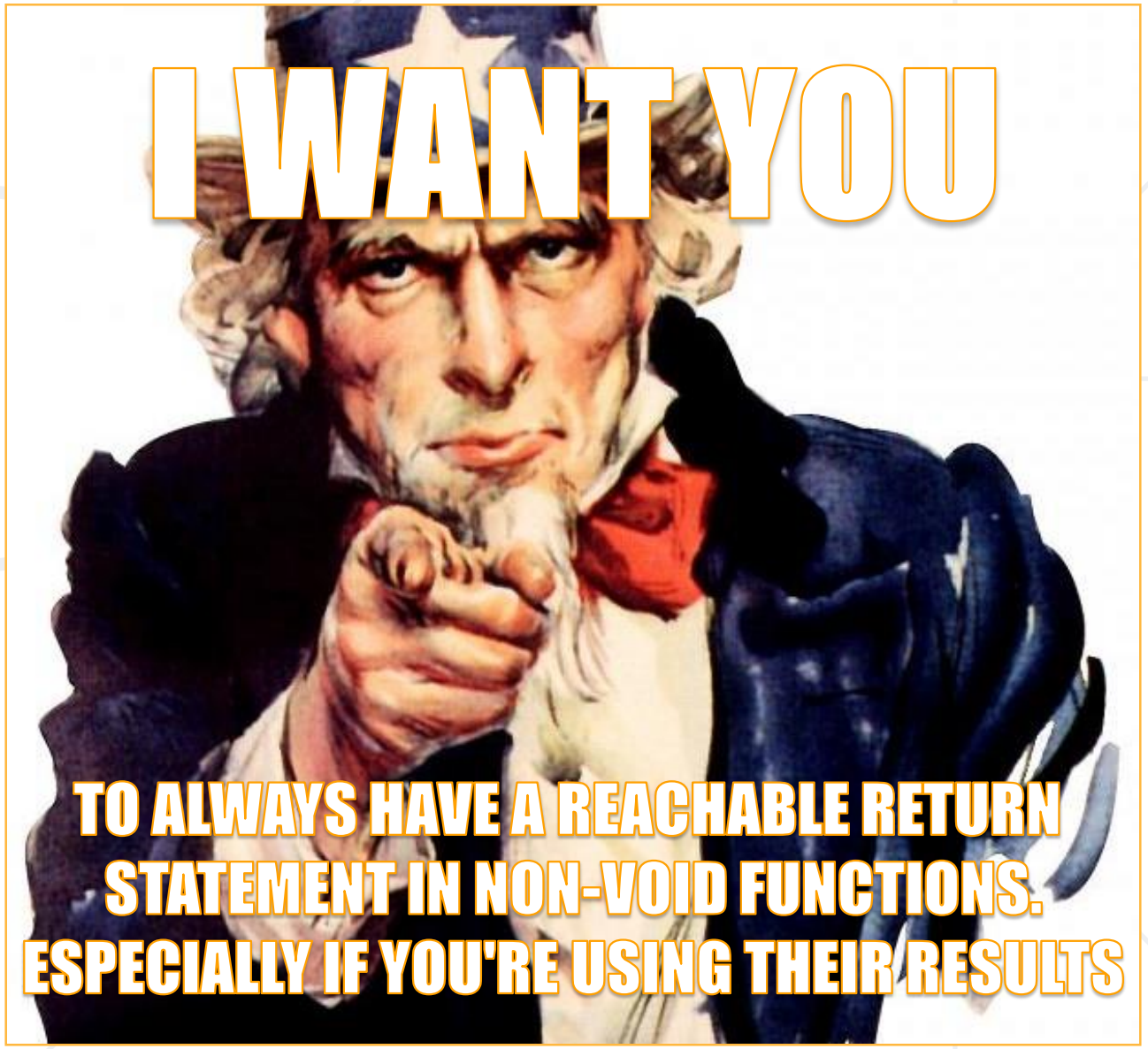
c) Behavior is undefined

Some compilers DO give compilation errors, but this is not required by the standard

C++ PITFALL: MISSING RETURN STATEMENT ON STREAM OPERATOR OVERLOAD, USED IN CHAINING

Notice the return statement is missing – hence the operator result is undefined (C++ does not give compilation errors here)

We use that undefined result in the chaining (i.e. `cin >> a >> b`, read **a** then read **b** with the resulting stream)



Comparison Operator Overload

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- Comparison operators return `bool` and are binary
- `operator<` overloading is of special interest

```
class Fraction {
  int num; int denom;
public:
  Fraction(int num, int denom)
  : num(num), denom(denom) {}
  ...
  bool operator<(const Fraction& other) const {
    return this->num * other.denom < other.num * this->denom; }
};
...
set<Fraction> fractions{
  Fraction{1, 3}, Fraction{2, 10}, Fraction{2, 6}
}; // fractions will contain 2/10 and 1/3 in that order
```

Comparison Operator Overload

LIVE DEMO

Quick Quiz

- What will the following code do?

```
class Fraction {
  ...
  bool operator<(Fraction& other) {
    return this->num * other.denom < other.num * this->denom;
  }
};
```

```
set<Fraction> fractions{

  Fraction{1, 3},
  Fraction{2, 10},
  Fraction{2, 6}
};
```

a) Create a set with 2 Fractions

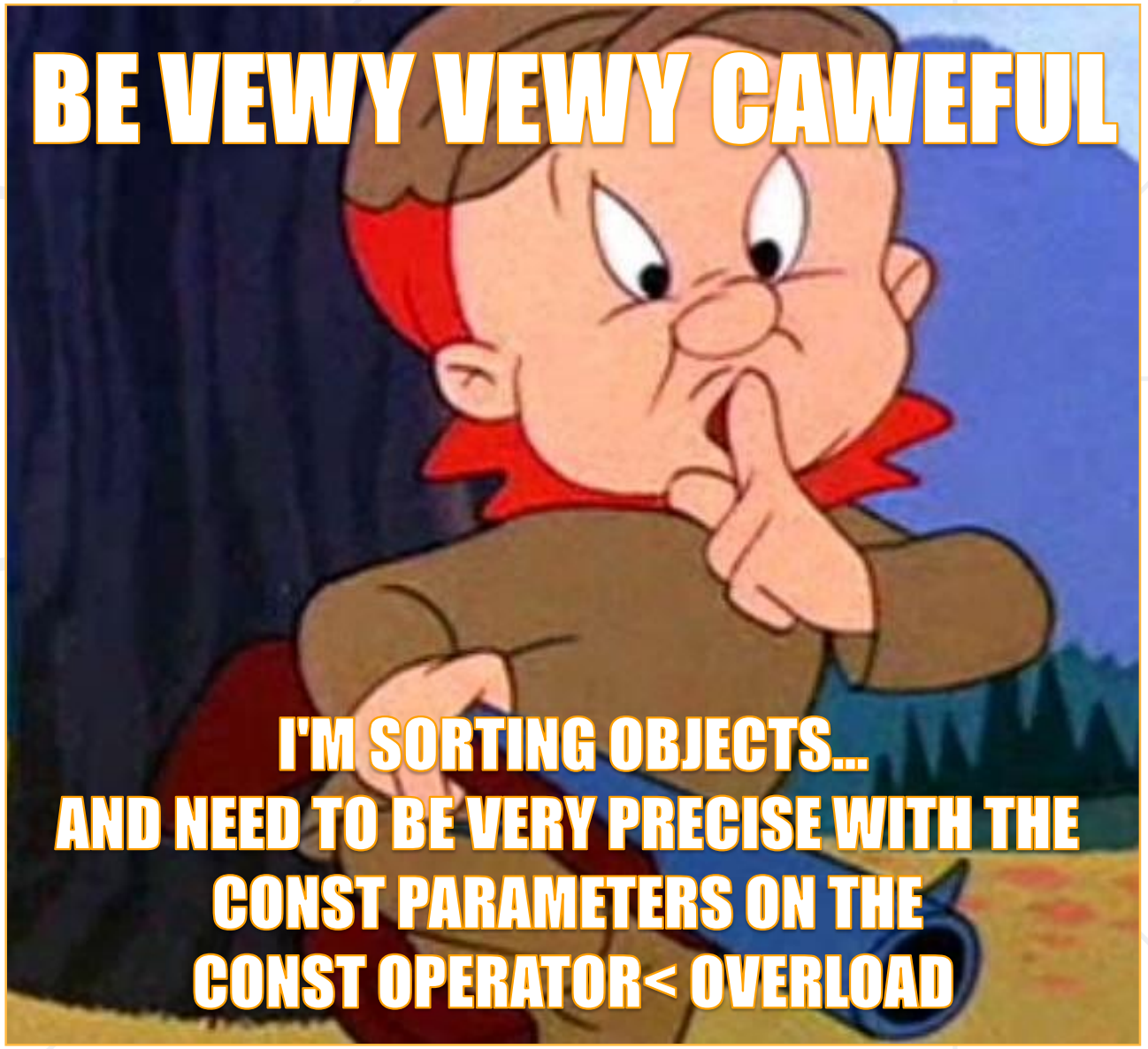
b) Give a compilation error

c) Behavior is undefined

C++ PITFALL: MISSING CONST ON PARAMETER AND/OR CONST ON OPERATOR METHOD WHEN USING WITH STL

All **`operator<`** usages in STL require the operator to be a const method with const reference parameters.

If they are not, we get a compilation error due to mismatch in parameters



Practice

Live Exercise in Class

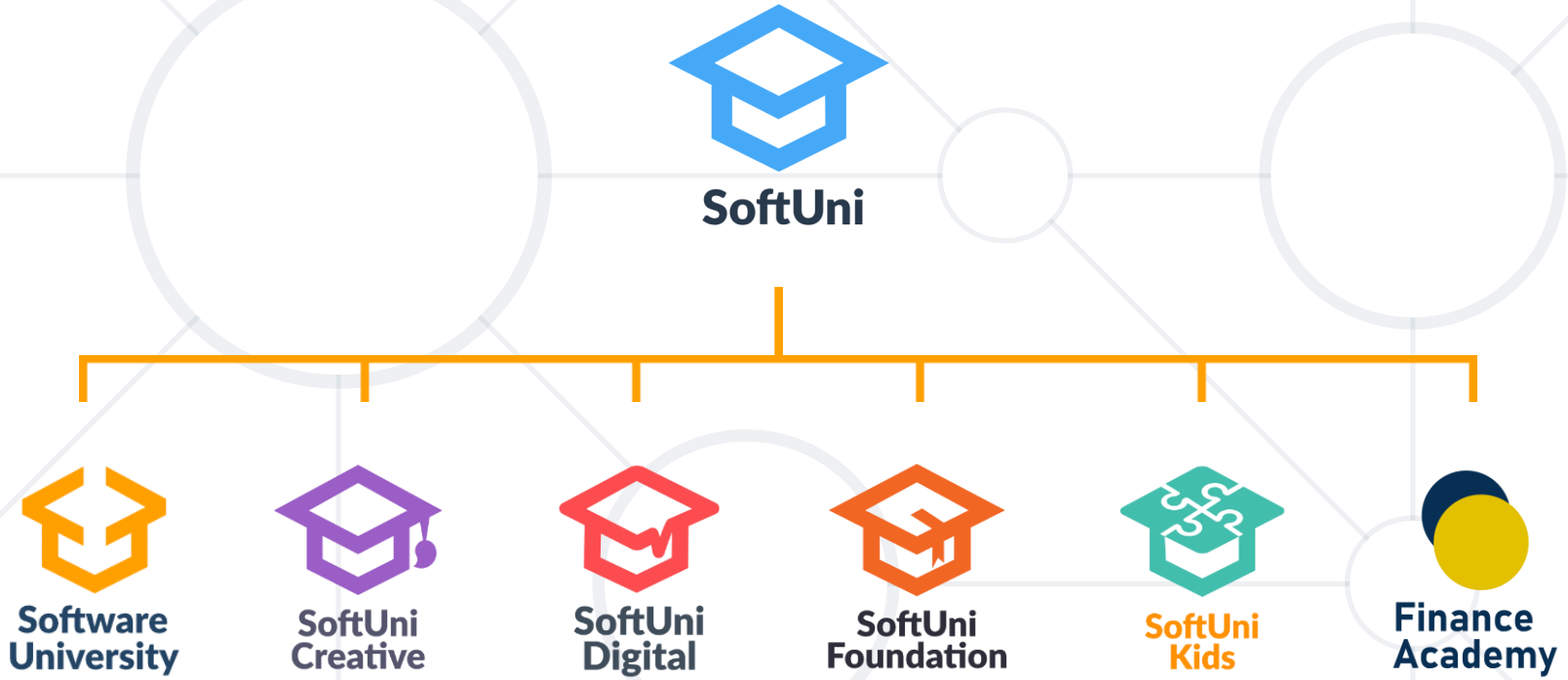
Problem 2: Fraction Class

- Expand the Fraction class from the last examples
  - Equality comparison
  - Addition and subtraction
  - Direct **`cout`** usage
  - Direct **`cin`** usage
  - Automatically reduce (2/4 should initialize as 1/2)
  - **`operator++`** incrementation by 1

Summary

- **Namespaces** organize code and avoid name conflicts
- Static members are "global" class members
- **Friend classes/functions** can access private members
- **Operators** are just methods with special names
  - Can be overloaded by user code
  - Non-member overloads allow overloads for any class
- Don't overuse overloading – code has to be readable

Questions?



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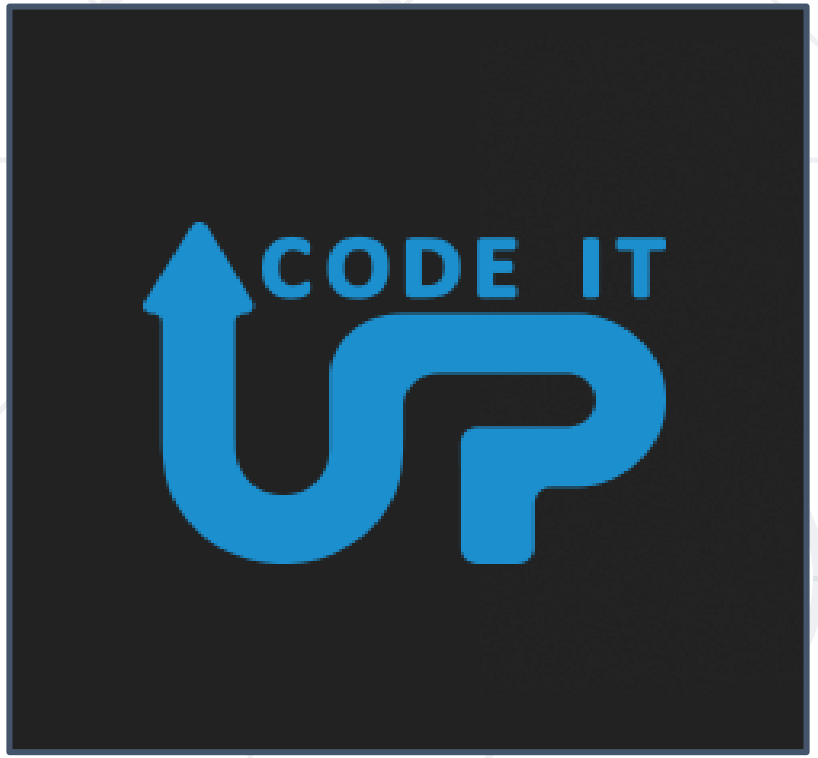

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