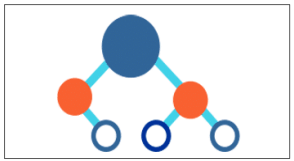
CSci 3081W: Program Design and Development

Lecture 03 - Classes

Roadmap for Today

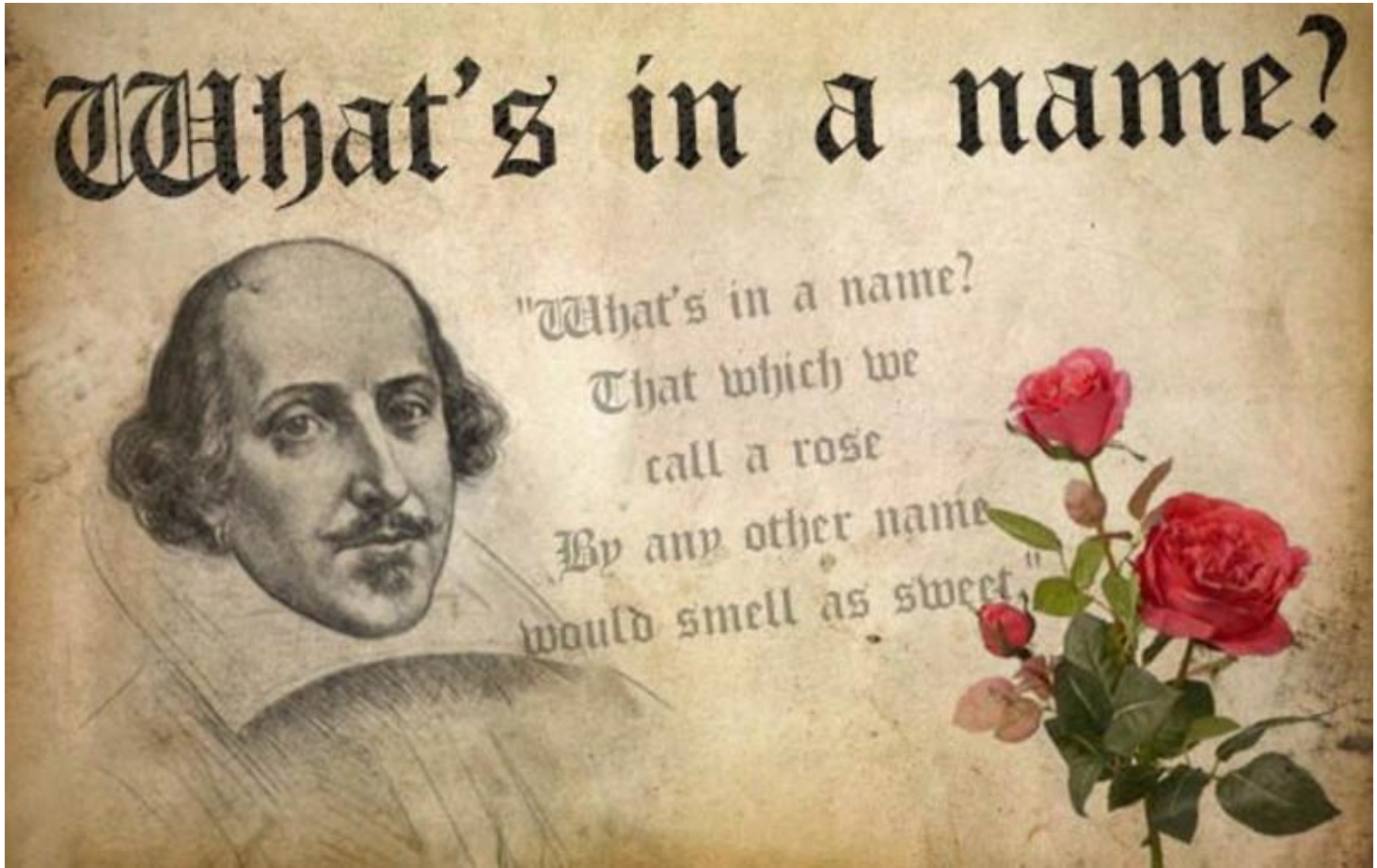
Motivation for Design: Namespaces



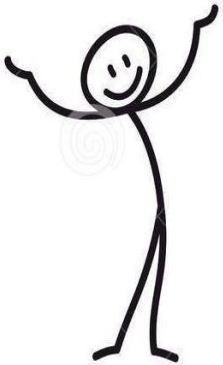
Design: Abstract Data Types

Development: C++ Classes

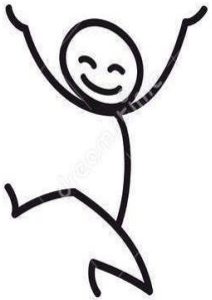
Motivating Example - Namespaces



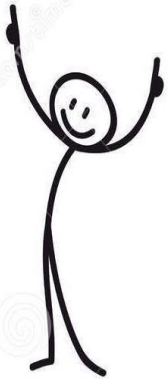
Daniel



Daniel

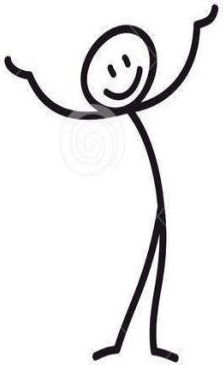


Daniel



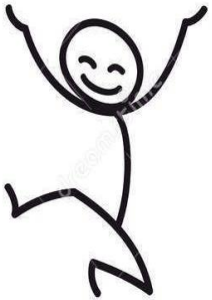
How do we distinguish between Dans?

Daniel



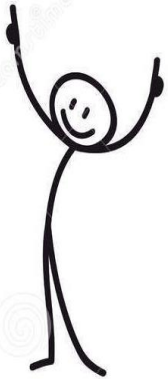
Dr. Daniel Keefe

Daniel



Daniel Orban

Daniel



Daniel O. (not Orban)

We use a namespace!

- Last Name

The same is true for programming in any language.

Consider the **vec3** in each of the following libraries:

vmmlib
A VECTOR AND MATRIX MATH LIBRARY

vec3

glm

vec3

Eigen

vec3

vec3

```
struct vec3 {
  float x, y, z;
};
```

Namespaces solve the problem of competing names.

Consider the **vec3** in each of the following libraries:

vmml::vec3

glm::vec3

eigen::vec3

csci3081::vec3

```
struct vec3 {
  float x, y, z;
};
```

Namespaces solve the problem of competing names.

Consider the **vec3** in each of the following libraries:

vmml::vec3

glm::vec3

eigen::vec3

csci3081::vec3

Declaring a namespace:

```
namespace csci3081 {
struct vec3 {
  float x, y, z;
};
}
```

Using a namespace:

(a)

```
using namespace csci3081;
vec3 v;
cout << v.x << endl;
```

(b)

```
csci3081::vec3 v;
cout << v.x << endl;
glm::vec3 v2;
cout << v2[0] << endl;
```

Use the std namespace when using the C++ standard library.

Using the namespace means we do not need the scope operator ::.

```
#include <iostream>
using namespace std;

int main()
{
   cout << "Hello World" << endl;
   return 0;
}
```

The scope operator :: allows us to use types without the using keyword.

```
#include <iostream>


int main()
{
   std::cout << "Hello World" << std::endl;
   return 0;
}
```

When would you use one or the other?

Design Principle: Naming is important even beyond namespaces.

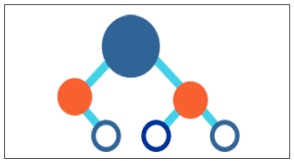
What happens if you don't name things correctly?

- float temp1;
- class GenericItem {...};
- class ManagerOfThings {...};
- class SortAlgorithm {...};
- struct MultiStructuredTemplateBuildingPlan {...};
- a.execute();
- duck1.operation5();

We need to think about **design** questions in this class.

Roadmap for Today

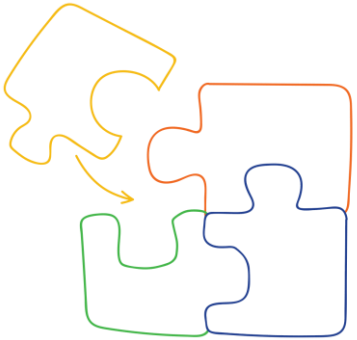
Motivation for Design: Namespaces



Design: Abstract Data Types

Development: C++ Classes

Design Exercise: What are some desirable characteristics for a good software design?



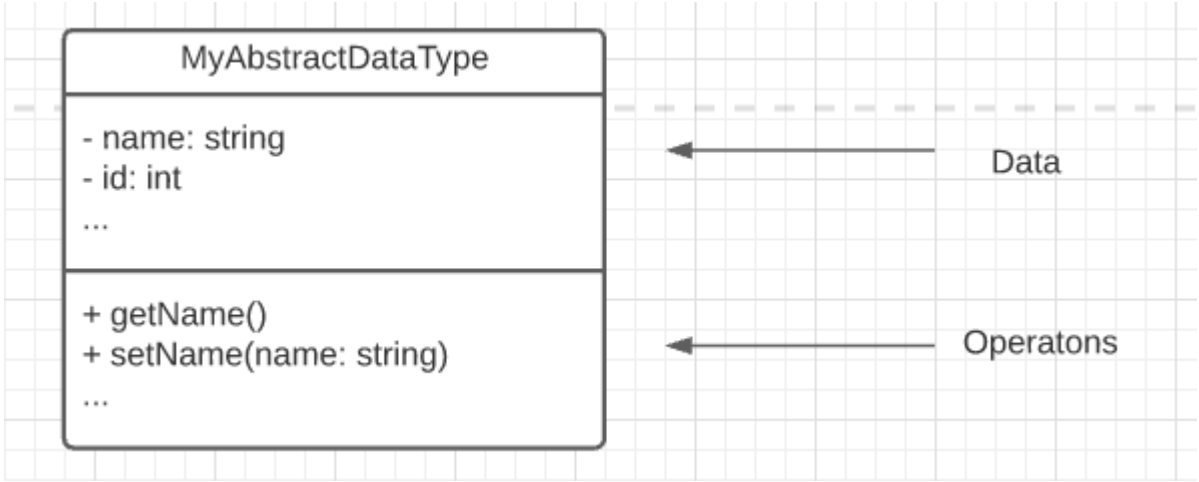
Design Exercise: What are some desirable characteristics for a good software design?

- **Minimal complexity**
- **Ease of maintenance**
- **Loose coupling**
- **Extensibility**
- **Re-usability**
- High fan-in
- Low-to-medium fan-out
- Portability
- Leanness
- Stratification
  - McConnell (Code Complete - Ch. 5.2)

Object Oriented Design is one approach for meeting these criteria.

Abstract data types (ADTs) are the foundation for object-oriented programming.

UML - Unified Modeling Language



"An **abstract data type** is a collection of data and operations that work on the data"

- McConnell (Code Complete - Ch. 6.1)

Abstract data types (ADTs) are the foundation for object-oriented programming.

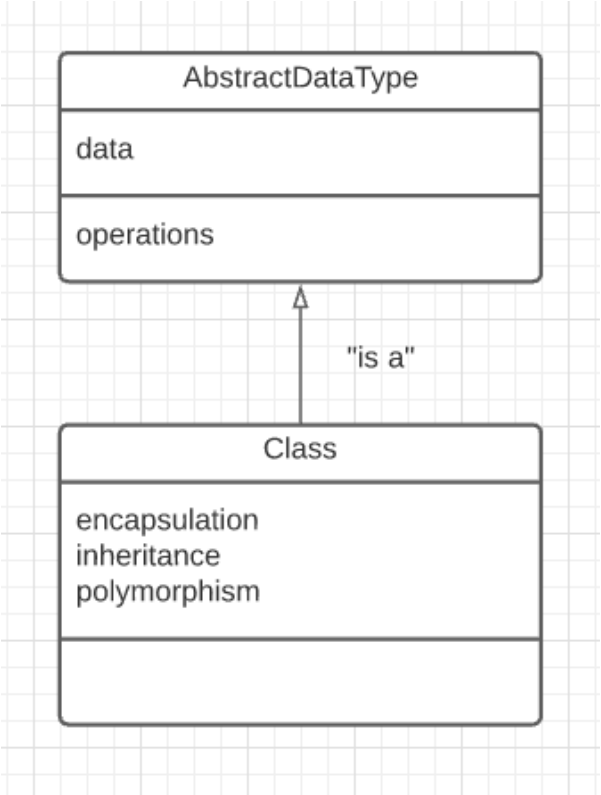
Examples:

Cruise Control	**Blender**	**Fuel Tank**
Set speed	Turn on	Fill tank
Get current settings	Turn off	Drain tank
Resume former speed	Set speed	Get tank capacity
Deactivate	Start "Insta-Pulverize"	Get tank status
	Stop "Insta-Pulverize"	
List		**Stack**
Initialize list	**Light**	Initialize stack
Insert item in list	Turn on	Push item onto stack
Remove item from list	Turn off	Pop item from stack
Read next item from list		Read top of stack

- McConnell (Code Complete - Ch. 6.1)

Notice that ADTs do not depend on a programming language.

What are classes?

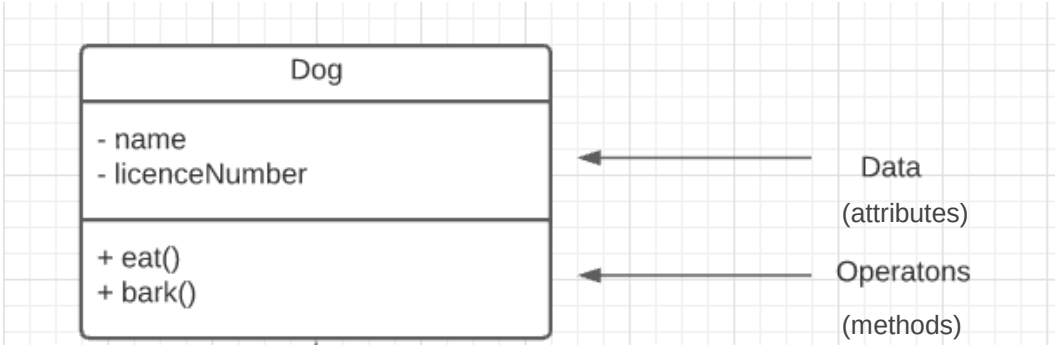


“One way of thinking of a class **is** as **a**n abstract data type plus inheritance and polymorphism.”

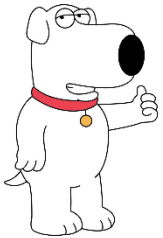
- McConnell (Code Complete - Ch. 6.1)

What is the difference between **Objects and Classes** in Object Oriented Programming?

Classes are type definitions



Objects are specific realizations / instances / items



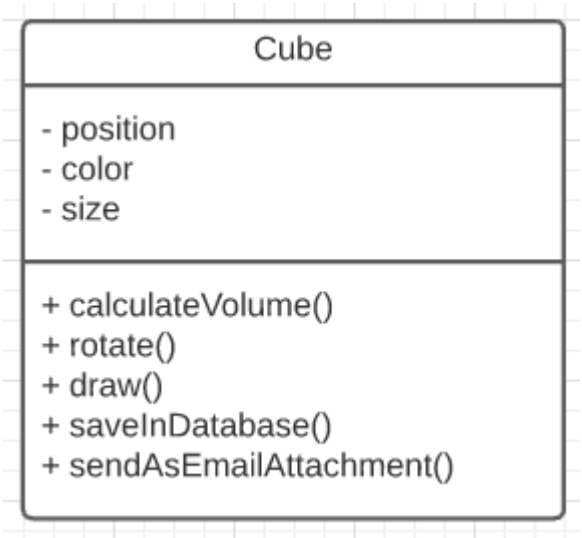
Brian

Scooby-Doo

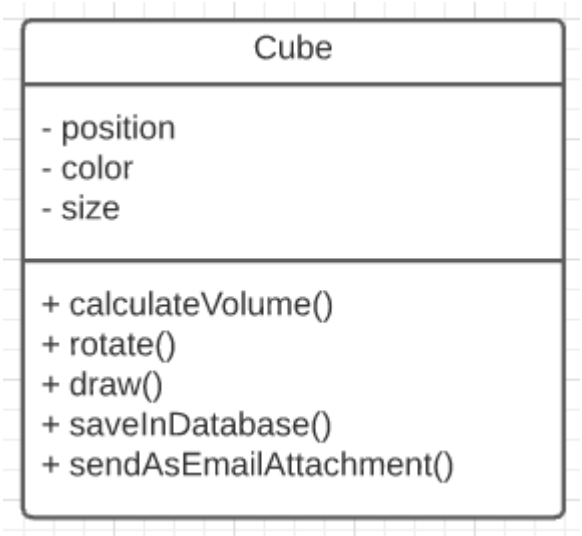
Marley

Bow & Wow

What is wrong with this Abstract Data Type (ADT)?



Design Principle: Low cohesion makes code hard to change and overly complex.



- draw()
  - UI code in a mathematical object
  - Specific graphics implementation.
- saveInDatabase()
  - Complex database logic inside of cube
- sendAsEmailAttachment()

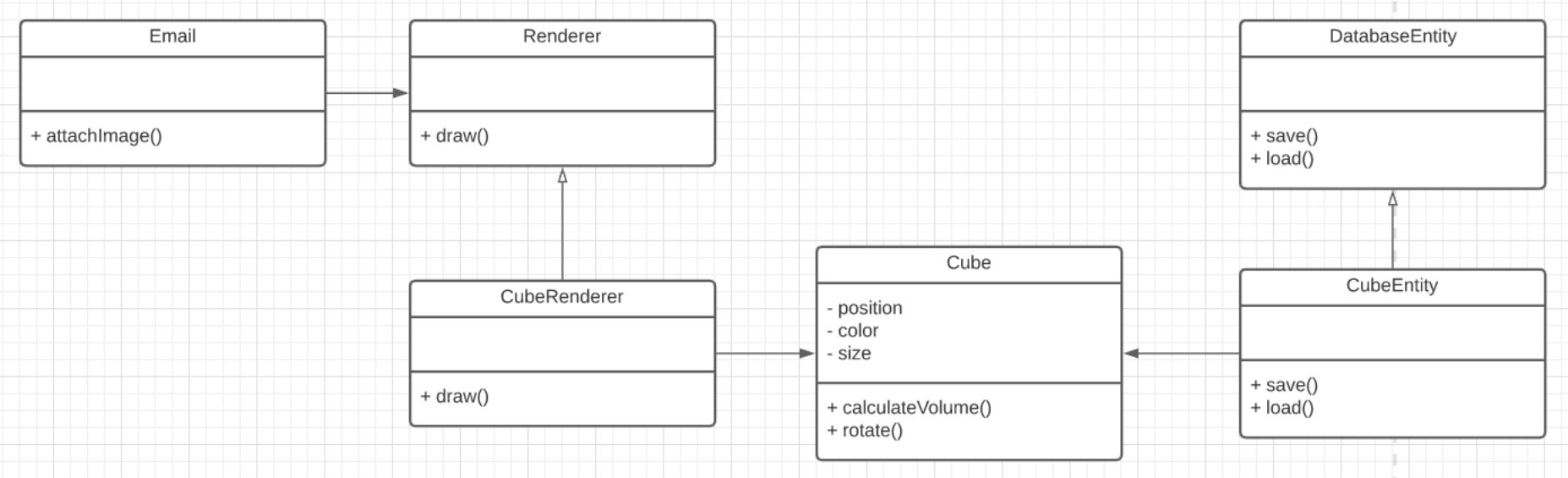
Need sender, recipient, subject, and message

  - What if we wanted a different type of attachment?

“**Cohesion** refers to how closely all the routines in a class or all the code in a routine support a central purpose—how focused the class is.” - McConnel (Ch 5.3)

Design Principle: High cohesion makes code simpler, extensible, and reusable.

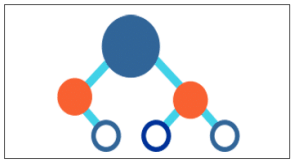
All operations must match the purpose of the class.



(i.e. utility methods are considered problematic).

Roadmap for Today

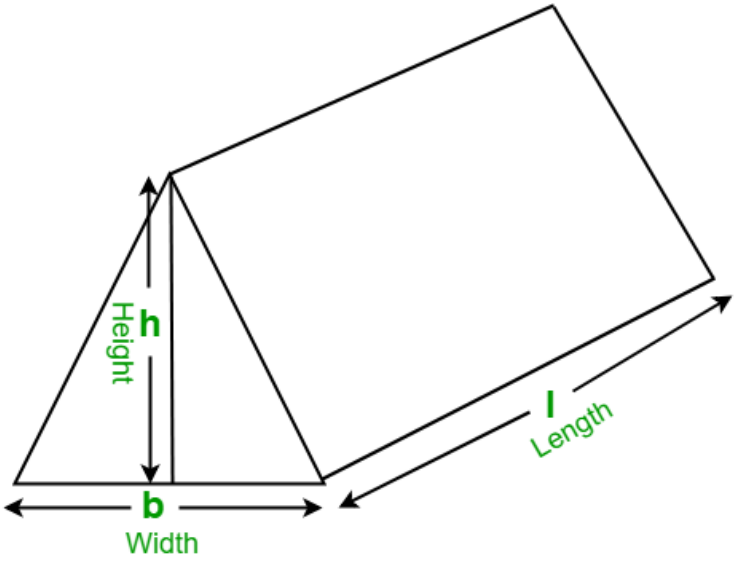
Motivation for Design: Namespaces

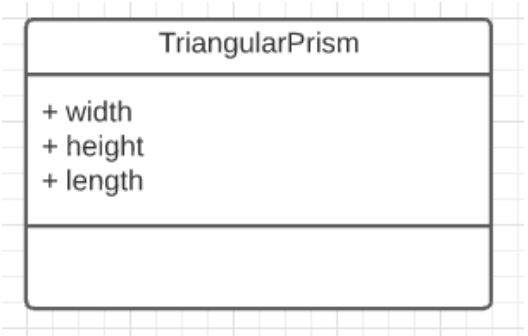


Design: Abstract Data Types

Development: C++ Classes

How can we represent a triangular prism ADT below in C/C++?





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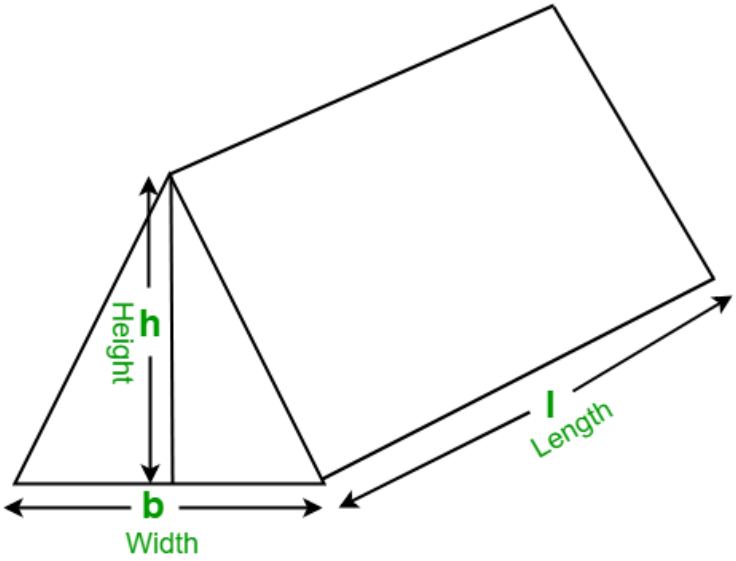
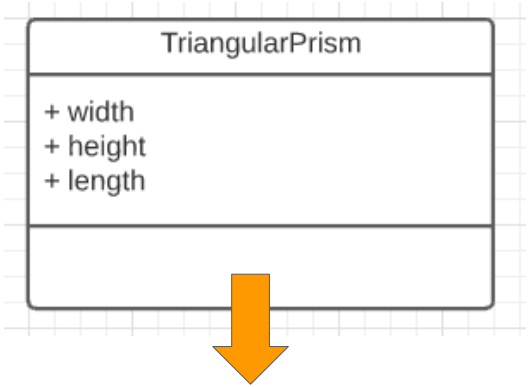
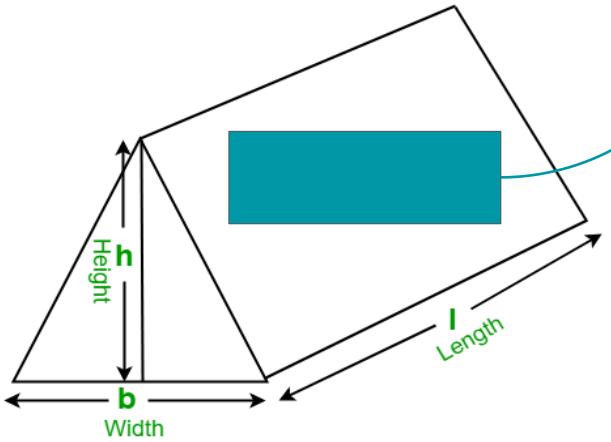





```
struct TriangularPrism {
  float height;
  float width;
  float length;
};
```

What if we wanted to add a color?

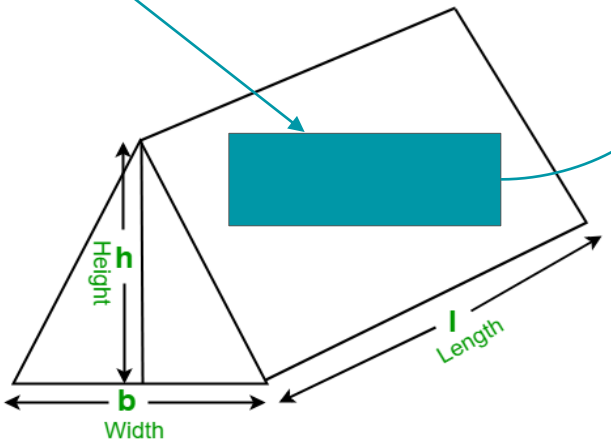


- Height - float
- Width - float
- Length - float
- Color - ???

```
struct TriangularPrism {
  float height;
  float width;
  float length;
  ??? color;
};
```

What if we wanted to add a color?

```
struct RGBColor {
  int red;
  int green;
  int blue;
};
```



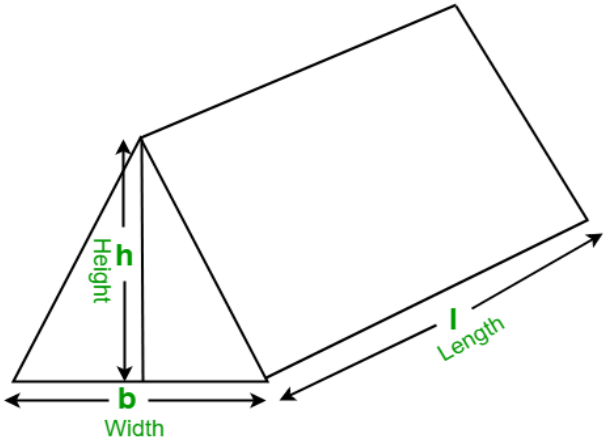
- Height - float
- Width - float
- Length - float
- Color - RGBColor

```
struct TriangularPrism {
  float height;
  float width;
  float length;
  RGBColor color;
};
```

Structs allow us to build self-contained complex data structures.

```
#include <iostream>
using namespace std;

struct TrianglularPrism {
float width;
float height;
float length;
};

int main()
{
TrianglularPrism prism;
prism.width = 1.0;
prism.height = 2.0;
prism.length = 4.0;

cout << "Prism: " << prism.width << " " <<
prism.height << " " << prism.length << endl;
return 0;
}
```

- Declaration
- Usage



Poll: What are the differences between a **struct** and **class** in C++?

```
struct TriangularPrism {
float height;
float width;
float length;
};
```

```
class TriangularPrism {
float height;
float width;
float length;
};
```

The major difference between C and C++ is **Object Oriented Programming**.

	Encapsulation	Inheritance	Polymorphism
C	No	No	No
C++	Yes	Yes	Yes

We will talk about Encapsulation today.

Encapsulation allows us to control access to variables.

```
struct TriangularPrism {
public:
   float width;
private:
   float height;
   float length;

public:
   float volume() {
      return 0.5*width, height, length;
   }
};

int main() {
   TriangularPrism prism1;
   prism1.width = 20;
   TriangularPrism prism2;
   prism1.width = 10;
   prism1.height = 30;

   cout << (prism1.volume() - prism2.volume()) << endl;
   return 0;
}
```

What is wrong with the following code?

Encapsulation allows us to control access to variables.

```
struct TriangularPrism {
public:
   float width;
private:
   float height;
   float length;

public:
   float volume() {
      return 0.5*width, height, length;
   }
};

int main() {
   TriangularPrism prism1;
   prism1.width = 20;
   TriangularPrism prism2;
   prism1.width = 10;
   prism1.height = 30;

   cout << (prism1.volume() - prism2.volume()) << endl;
   return 0;
}
```

We can only access attributes and actions that have been declared public.

Why in the world would we want this?

What could go wrong here without encapsulation?

```
struct BankAccount {
   int accNum;
   float balance;
};

struct Bank {
   BankAccount accounts[50];
   float totalAmount;

   BankAccount& getAccount(int id) {
      return accounts[id];
   }

   void deposit(BankAccount& account, float amount) {
      accounts[account.accNum].balance += amount;
      totalAmount += amount
   }

   float withdraw(BankAccount& account, amount) {
      accounts[account.accNum].balance -= amount;
      totalAmount -= amount;
      return amount
   }
}
```

```
int main() {
   Bank bank;
   BankAccount& acc = bank.getAccount(10);
   bank.deposit(acc, 20);
   bank.withdraw(acc, 10);
   return 0;
}
```

What could go wrong here without encapsulation?

```
struct BankAccount {
   int accNum;
   float balance;
};

struct Bank {
   BankAccount accounts[50];
   float totalAmount;

   BankAccount& getAccount(int id) {
      return accounts[id];
   }

   void deposit(BankAccount& account, float amount) {
      accounts[account.accNum].balance += amount;
      totalAmount += amount
   }

   float withdraw(BankAccount& account, amount) {
      accounts[account.accNum].balance -= amount;
      totalAmount -= amount;
      return amount
   }
}
```

```
int main() {
   Bank bank;
   BankAccount& acc = bank.getAccount(10);
   bank.deposit(acc, 20);
   bank.withdraw(acc, 10);

   // We can give banks money
   bank.totalAmount = 100000.0;

   // We can change our account number
   acc.accNum = 10;

   // We can give ourselves money
   acc.balance += 100;

   // We can create a new account with an overflow
   Bank.accounts[500].balance = 50000000000.0;

   return 0;
}
```

What could go wrong here without encapsulation?

```
struct BankAccount {
   int accNum;
   float balance;
};

struct Bank {
   BankAccount accounts[50];
   float totalAmount;

   BankAccount& getAccount(int id) {
      return accounts[id];
   }

   void deposit(BankAccount& account, float amount) {
      accounts[account.accNum].balance += amount;
      totalAmount += amount
   }

   float withdraw(BankAccount& account, amount) {
      accounts[account.accNum].balance -= amount;
      totalAmount -= amount;
      return amount
   }
}
```

```
int main() {
   Bank bank;
   BankAccount& acc = bank.getAccount(10);
   bank.deposit(acc, 20);
   bank.withdraw(acc, 10);

   // We can give banks money
   bank.totalAmount = 100000.0;

   // We can change our account number
   acc.accNum = 10;

   // We can give ourselves money
   acc.balance += 100;

   // We can create a new account with an overflow
   Bank.accounts[500].balance = 50000000000.0;

   return 0;
}
```

Encapsulation is the future!

Enter center stage: **Classes**

```
struct BankAccount {
int accNum;
float balance;

public:
void deposit(float amount) {
                balance += amount;
}

float withdraw(amount) {
                balance -= amount;
                return amount
}
};
```

```
class BankAccount {
int accNum;
float balance;

public:
void deposit(float amount) {
                balance += amount;
}

float withdraw(amount) {
                balance -= amount;
                return amount
}
};
```

What is the difference between a **struct** and a **class**?

The only difference between a struct and a class is classes are **private** by default and structs are **public** by default.

```
struct BankAccount {
// public: (by default)
int accNum;
float balance;

public:
void deposit(float amount) {
                balance += amount;
}

float withdraw(amount) {
                balance -= amount;
                return amount
}
};
```

```
class BankAccount {
// private: (by default)
int accNum;
float balance;

public:
void deposit(float amount) {
                balance += amount;
}

float withdraw(amount) {
                balance -= amount;
                return amount
}
};
```

When should we use a struct vs a class?

Complex objects / everything else
(want to control variables and logic)

```
struct BankAccount {
int accNum;
float balance;
};
```

```
class BankAccount {
private:
int accNum;
float balance;

public:
void deposit(float amount) {
                balance += amount;
}

float withdraw(BankAccount& account, amount) {
                balance -= amount;
                return amount
}
};
```

When should we use a struct vs a class?

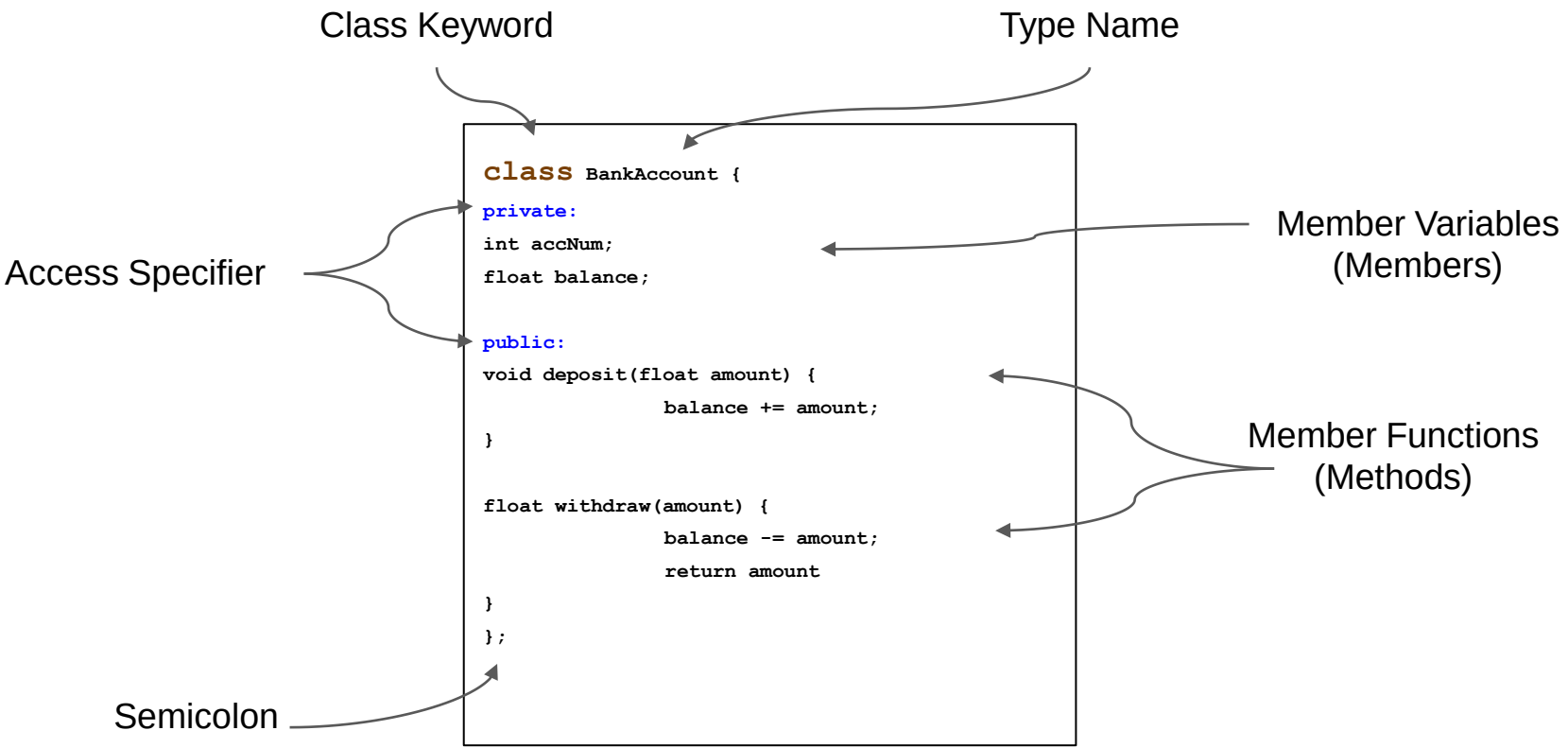
Classes protect the developer(s) from potentially doing something silly.

Complex objects / everything else
(want to control variables and logic)

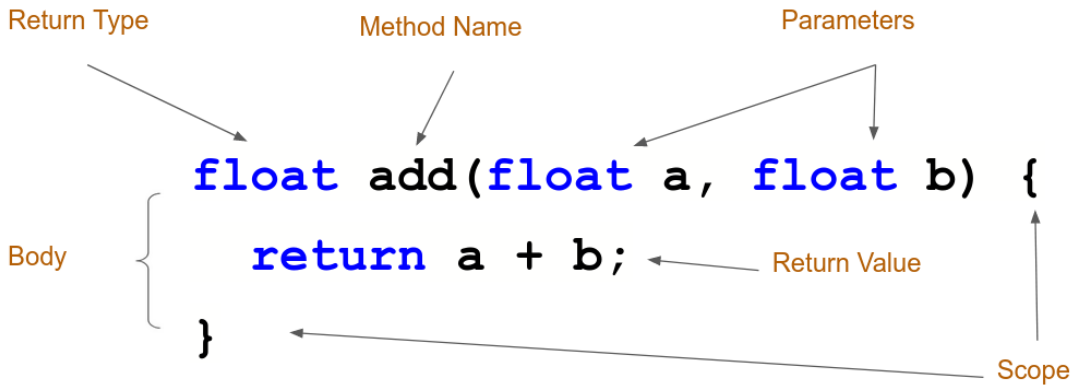
```
struct BankAccount {
int accNum;
float balance;
};
```

```
class BankAccount {
int accNum;
float balance;

public:
void deposit(float amount) {
                balance += amount;
}

float withdraw(BankAccount& account, amount) {
                balance -= amount;
                return amount
}
};
```

Classes and objects are the way we will work going forward. Classes are defined as follows:



User Defined Functions (& Class Methods) allow programs to reuse calculations.



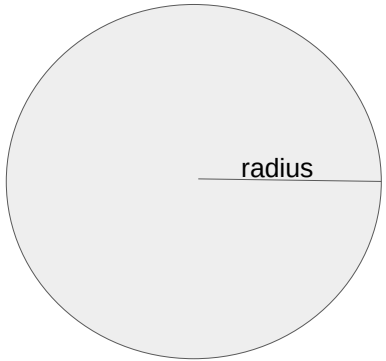
We can create classes and use their members / methods with the “.” operator.

```
class BankAccount {
private:
int accNum;
float balance;

public:
void getBalance() {
                return balance;
}
void setBalance(float amount) {
                balance = amount;
}

void deposit(float amount) {
                balance += amount;
}

float withdraw(amount) {
                balance -= amount;
                return amount
}
};
```

```
int main() {
// Create new account
BankAccount myAccount;

// set initial balance
myAccount.setBalance(100.0);

// withdraw and deposit
myAccount.withdraw(20.0);
myAccount.withdraw(20.0);
myAccount.deposit(10.0);
myAccount.withdraw(20.0);

// output final balance
cout << myAccount.getBalance() << endl;

// Cannot use the following
// cout << myAccount.balance << endl;

return 0;
}
```

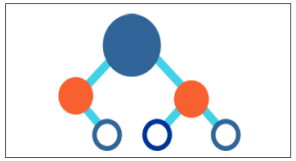
In-Class Exercise: Create a simple circle class using C++.

Write a class called Circle that has methods to calculate the area of the circle, the diameter and the circumference. Also provide the necessary getters/setters that are needed.



Feel free to use knowledge from previous classes.
(e.g. constructors, getters and setters, etc...).

Summary



Design Principles

- Naming is important.
- Classes are Abstract Data Types with inheritance and polymorphism.
- Low cohesion makes code hard to change and overly complex.
- High cohesion makes code simpler, extensible, and reusable.

Development

- C++ Namespaces
- C++ Class Basics
- Encapsulation