CS-202

C++ Classes – Inheritance (Pt.1)

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Course Week

Course , Projects , Labs:

Monday	Tuesday	Wednesday	Thursday	Friday
			Lab (4 Sections)	
	CLASS	RL – Session	CLASS	
PASS Session	PASS Session	**Project DEADLINE**	NEW Project	

Your 4th Project Deadline still stands for *next* Wednesday 2/28!

- PASS Sessions held Monday-Tuesday
- RL Session held Wednesday

} get all the help you may need!

- 24-hrs delay after Project Deadline incurs 20% grade penalty.
- Past that, NO Project accepted. Better send what you have in time!

Today's Topics

C++ Classes Cheatsheet

- Declaration
- Members, Methods, Interface
- Implementation – Resolution Operator (`::`)
- Instantiation – Objects
- Object Usage – Dot Operator (`.`)
- Object Pointer Usage – Arrow Operator (`->`)
- Classes as Function Parameters, Pass-by-Value, by-(`const`)-Reference, by-Address
- Protection Mechanisms – `const` Method signature
- Classes – Code File Structure
- Constructor(s), Initialization List(s), Destructor
- `static` Members – Variables / Functions
- Class `friend`(s)
- Keyword `this`
- Operator Overloading

Inheritance

Classes

Class Cheatsheet

Declaration:

```
class Car {
  public:
   float addGas(float gallons);
   float getMileage();
   char m_licensePlates[9];
  protected:
   float m_gallons;
   float m_mileage;
  private:
   bool setEngineTiming(double[16]);
   double m_engineTiming[16];
};
```

Class (Type) Name

- ➢ Type Name is up to you to declare!

- ➢ Members in Brackets
- ➢ Semicolon

Conventions:

- ➢ Begin with Capital letter.
- ➢ `camelCase` for phrases.
- ➢ General word for Class of Objects.

Class Cheatsheet

Declaration:

```
class Car  {
 public:
   float addGas(float gallons);
   float getMileage();
   char m_licensePlates[9];
 protected:
   float m_gallons;
   float m_mileage;
 private:
   bool setEngineTiming(double[16]);
   double m_engineTiming[16];
};
```

Access Specifiers

- ➢ Provide Protection Mechanism

Encapsulation - Abstraction:

- ➢ "Data Hiding"

Class Cheatsheet

Declaration:

```
class Car  {
  public:
   float addGas(float gallons);
   float getMileage();
   char m_licensePlates[9];
  protected:
   float m_gallons;
   float m_mileage;
  private:
   bool setEngineTiming(double[16]);
   double m_engineTiming[16];
};
```

Member Variables

- All necessary Data inside a single Code Unit.

Conventions:

- Begin with **m_<variable_name>**.

Encapsulation - Abstraction:

- Abstract Data Structure

Class Cheatsheet

Declaration:

```
class Car  {
  public:
   float addGas(float gallons);
   float getMileage();
   char m_licensePlates[9];
  protected:
   float m_gallons;
   float m_mileage;
  private:
   bool setEngineTiming(double[16]);
   double m_engineTiming[16];
};
```

Member Function / Class Methods

- All necessary Data & Operations inside a single Code Unit.

Conventions:

- Use **camelCase** (or **CamelCase**).

Encapsulation - Abstraction:

- Abstract Data Structure

Classes

Class Cheatsheet

Usual-case Class Interface Design:

```
class Car  {
public:
   float addGas(float gallons);
   float getMileage();
   bool setEngineTiming(double[16]);
private:
   char m_licensePlates[9];
   float m_gallons;
   float m_mileage;
   double m_engineTiming[16];
};
```

public Class Interface:
- ➢ Class Methods

private Class Access:
- ➢ Class Data

Class Interface to Member Data should "go through" Member Functions.

Classes

Class Cheatsheet

Class Implementation:

```
class Car  {
    …
    bool addGas(float gallons);
    float getMileage();
};

float Car::addGas(float gallons){
  /* actual code here */
}

float Car::getMileage(){
 /* actual code here */
}
```

An Implementation *needs* to exist for Class Methods

Scope Resolution Operator

(::)

- ➢ Indicates which Class Method this definition implements.

Classes

Class Cheatsheet

Class Instantiation - Implicit:

```
<type_name> <variable_name>;
```

```
Car myCar;
```

Object

Create (Construct) a variable of specific Class type.

Will employ "*Default Constructor*"

- ➢ Compiler will auto-handle *Member Variables*' initialization !

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Class Object Usage:

```
<variable_name>.<member_name>;
```

Dot Operator – Member-of

(.)

- Which Object this Member references.

```
Car myCar;
float mileage = myCar.getMileage();
strcpy(myCar.m_licensePlates,"Gandalf");
```

Member Variables &
Member Functions

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Class Object Pointers:

```
<type_name>* <variable_name_Pt>;

Car myCar;
```

Object

```
Car* myCar_Pt;
```

Pointer to Object

```
myCar_Pt = &myCar;
(*myCar_Pt).getMileage();
```

- ➢ Dereferencing to get to Object.

  Works the same as any pointer.

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Class Object Pointer Usage:

```
<variable_name_Pt>-><member_name>;
```

Arrow Operator – Member-access

(->)

- ➢ Structure (Class) Pointer Dereference

```
Car myCar;
Car* myCar_Pt = &myCar;

myCar_Pt->getMileage();
strcpy(myCar_Pt->m_licensePlates,"Gandalf");
```

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Class Object Pointer Usage:

```
<variable_name_Pt>-><member_name>;
```

Arrow Operator – Member-access

(->)

- ➢ Structure (Class) Pointer Dereference

Why?

Chaining Operator Precedence (. , ->)

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

```
(*(*(*topClass).subClass).subSubClass).method();
topClass->subClass->subSubClass->method();
```

Class Cheatsheet

Class Object in Function – By-Value:

```
Car myCar;
strcpy(myCar.m_licensePlates,"Gandalf");
printCapPlatesMileage(myCar);
cout << myCar.m_licensePlates;

void printCapPlatesMileage(Car car){
  char* lP = car.m_licensePlates;
  while (*lP = toupper(*lP)){ ++lP; }
  cout << car.m_licensePlates << endl;
  cout << car.getMileage() << endl;
}
```

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Note:
Will work with Local Object Copy !

Classes

Class Cheatsheet

Class Object in Function – By-Reference:

```
Car myCar;
strcpy(myCar.m_licensePlates,"Gandalf");
printModifyCapPlates(myCar);
cout << myCar.m_licensePlates;

void printModifyCapPlates(Car& car){
  char* lP = car.m_licensePlates;
  while (*lP = toupper(*lP)){ ++lP; }
  cout << car.m_licensePlates << endl;
}
```

```
class Car {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Note:

Will modify Object Data !

Class Cheatsheet

Class Object in Function – By-const-Reference:

```
Car myCar;
strcpy(myCar.m_licensePlates,"Gandalf");
printCapPlates(myCar);
cout << myCar.m_licensePlates;

void printCapPlates(const Car& car){
  char* lP = (char*)malloc(sizeof(
                  car.m_licensePlates));
  strcpy(lP,car.m_licensePlates);

  char* lP_0 = lP;
  while (*lP = toupper(*lP)){ ++lP; }

  cout << lP_0 << endl;
}
```

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Note:
Not allowed to modify Object Data !

Class Cheatsheet

Class Object in Function – By-Address:

```
Car myCar;
Car* myCar_Pt = &myCar;
strcpy(myCar_Pt->m_licensePlates,"Gandalf");
printModifyCapPlates(myCar_Pt);
cout << myCar.m_licensePlates;

void printModifyCapPlates(Car* car_Pt){
  char* lP = car_Pt->m_licensePlates;
  while (*lP = toupper(*lP)){ ++lP; }
  cout << car_Pt->m_licensePlates
       << endl;
}
```

```
class Car {
 public:
  float addGas(float gallons);
  float getMileage();
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Note:

Will modify Object Data !

Class Cheatsheet

Protection Mechanisms – const Method signature:

A “promise” that Method doesn’t modify Object

```
Car myCar;
cout << myCar.getMileage() << endl;
cout << myCar.addGas(10.0F) << endl;

float Car::getMileage() const {
  return m mileage;
}
float Car::addGas(float gallons) {
  if (m_gallons += gallons > MAX_GALLONS)
    m_gallons = MAX_GALLONS;
  return m_gallons;
}
```

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage() const ;
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Protection Mechanisms – Access Specifiers:

public

Anything that has access to a ***Car*** Object (scope-wise) also has access to all **public** Member Variables and Functions.

- “Normally” used for Functions.
- Need to have at least one **public** Member.

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage() const ;
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Protection Mechanisms – Access Specifiers:

`private`

Members (Variables and Functions) that can ONLY be accessed by Member Functions of the `Car` Class.

- ➢ Cannot be accessed in `main()`, in other files, or by other functions.

- ➢ If not specified, Members default to `private`.
- ➢ Should specify anyway – good coding practices!

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage() const ;
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Protection Mechanisms – Access Specifiers:

`protected`

Members that can be accessed by:

- ➢ Member Functions of the ***`Car`*** Class.
- ➢ Member Functions of any *Derived* Class.

```
class Hybrid : Car  {
   …
   float gasToElectricRatio();
};

float Hybrid::gasToElectricRatio(){
    if (m_gallons < …){ return …; }
}
```

A *Derived* Class

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage() const ;
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Member Functions – Accessors (“Getters”)

Name starts with get, ends with Member name.
Allows retrieval of non-public Data Members.

```
float Car::getMileage() const {
  return m_mileage;
}
```

Note: Don’t generally take in arguments.

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage() const ;
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Member Functions – Mutators (“Setters”)

Name starts with **set**, ends with Member name.
Controlled changing of non-**public** Data Members.

```
bool Car::setEngineTiming(double t_in[16]){
  for (int i=0;i<16;++i){
    if (t_in[i]<… || t_in[i]>…){ return false; }
  }
  for (int i=0;i<16;++i){
    m_engineTiming[i]=t_in[i];
  }
  return true;
}
```

Note: In simple case, don’t **return** anything (**void**).
In controlled setting, return success/fail (**bool**).

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage() const ;
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Member Functions – Facilitators (“Helpers”)

Provide support for the Class’s operations.

```
float Car::addGas(float gallons) {
  if (m_gallons += gallons > MAX_GALLONS)
    m_gallons = MAX_GALLONS;
  return m_gallons;
}
```

Note:

public if generally called outside Function.

private/protected if only called by Member Functions.

```
class Car  {
 public:
  float addGas(float gallons);
  float getMileage() const ;
  char m_licensePlates[9];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[16];
};
```

Classes

Class Cheatsheet

Classes and Code File Structure

Class Header File: `Car.h`

```
#ifndef CAR_H
#define CAR_H

#define NUMVALVES 16

class Car  {
 public:
  float addGas(float gallons);
  float getMileage() const ;
  char m_licensePlates[9];
 protected:
  float m_gallons, m_mileage;
 private:
  bool setEngineTiming(double[16]);
  double m_engineTiming[NUMVALVES];
};

#endif
```

Class Source File: `Car.cpp`

```
#include <iostream>
#include "Car.h"

#define MAX_GALLONS 20.0

float Car::getMileage() const {
  return m_mileage;
}
float Car::addGas(float gallons) {
  if (m_gallons += gallons > MAX_GALLONS)
    m_gallons = MAX_GALLONS;
  return m_gallons;
}
bool Car::setEngineTiming(double t_in[16]){
  for (int i=0;i<16;++i){
    if (t_in[i]<… || t_in[i]>…) return false;
  }
  for (int i=0;i<16;++i){
    m_engineTiming[i]=t_in[i];
  }
  return true;
}
```

Class Cheatsheet

Classes and Code File Structure

Note: Compile all your source (.cpp) files together with

```
g++ car_program.cpp Car.cpp
```

Program File: `car_program.cpp`

```
#include <iostream>
#include <…>

#include "Car.h"

int main(){
  Car myCar;
  Car* myCar_Pt = &myCar;

  strcpy(myCar_Pt->m_licensePlates,"Gandalf");
  printCapPlates(myCar_Pt);
  cout << myCar.m_licensePlates << endl;

  cout << myCar.getMileage() << endl;
  cout << myCar.addGas(10.0F) << endl;
  return 0;
}
```

Classes

Class Cheatsheet

Constructor(s):

Special Function:

- ➢ Prototype is named same as Class.
- ➢ Have no **return** type.

"Constructors have no names and cannot be called directly."
"They are invoked when initialization takes place."
"They are selected according to the rules of initialization."

- ➢ Constructors that may be called without any argument are *Default* constructors.
- ➢ Constructors that take another Object of the same type as the argument are *Copy* and *Move* constructors.

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char m_licensePlates[PLT];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Classes

Class Cheatsheet

Default (empty) `ctor`:

➢ Function Prototype:

```
Car();
```

➢ Function Definition:

```
Car::Car(){
  strcpy(m_licensePlates, DFT_PLTS);
  m_gallons = DFT_GLNS;
  m_mileage = 0;
  m_engineTiming = _def_DFT_TIM;
}
```

Note:

➢ The compiler will (implicitly) provide a *Default* Constructor if none is specified.

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char m_licensePlates[PLT];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Class Cheatsheet

Overloaded (parametrized) `ctor`:

- Function Prototype (w/ Default Parameters):

```
Car(char licPlts[PLT],
    float glns=DFT_GLNS, float mlg=0,
    const double engTim[VLV]=DFT_TIM);
```

- Function Definition (no Default Parameters):

```
Car::Car(char licPlts[PLT], float glns,
    float mileage, const double engTim[VLV]){
  strcpy(m_licensePlates, licPlts);
  m_gallons = glns;
  m_mileage = mileage;
  for (int i=0; i<VLV; ++i)
    m_engineTiming[i] = engTim[i];
}
```

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char m_licensePlates[PLT];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Class Cheatsheet

Overloaded (parametrized) `ctor`:

- Function Prototype (w/ Default Parameters):

```
Car(char licPlts[PLT],
    float glns=DFT_GLNS, float mlg=0,
    const double engTim[VLV]=DFT_TIM);
```

- Function Definition (no Default Parameters):

```
Car::Car(char licPlts[PLT], float glns,
    float mileage, const double engTim[VLV]){
  /* num of args resolves implementation */
}
```

Note:
If you define an *Overloaded* Constructor the compiler will not automatically generate a *Default*.

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char m_licensePlates[PLT];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Class Cheatsheet

Overloaded (parametrized) **ctor**:

- ➢ Function Prototype (w/ Default Parameters):

```
Car(char licPlts[PLT],
    float glns=DFT_GLNS, float mlg=0,
    const double engTim[VLV]=DFT_TIM);
```

- ➢ Sequential Interpretation of Default Params:

```
   Car car("Gandalf", 5. ,0. , new double[VLV]
or     {0.,1.,2.,3.,…,3.,0.,1.,2.});
   Car car("Gandalf", 5. ,0.);
or
   Car car("Gandalf", 5.);
or
   Car car("Gandalf");
```

No Parameter skipping !

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char m_licensePlates[PLT];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Class Cheatsheet

Overloaded (parametrized) **ctor**:

- Function Prototype(s) of different versions must not produce same signatures:

```
Car(char licPlts[PLT], float glns);
Car(char[PLT], float);
```

```
Car(char licPlts[PLT], float mlg);
Car(char[PLT], float);
```

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char m_licensePlates[PLT];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Classes

Class Cheatsheet

Copy (class-object) `ctor`:

- Function Prototype:

```
Car(const Car &car);
```

- Function Definition:

```
Car::Car(const Car & car){
 strcpy(m_licensePlates,car.m_licensePlates);
  m_gallons = car.m_gallons;
  m_mileage = car.m_mileage;
  for (int i=0; i<VLV; ++i)
    m_engineTiming[i] = car.m_engineTiming[i];
}
```

Same Class:

- Access to `private` Members of input Object.

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char m_licensePlates[PLT];
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Classes

Class Cheatsheet

Copy (class-object) **`ctor`**:

- ➢ The compiler will (implicitly) provide a ***Shallow**-Copy* Constructor if none is specified.

Class now contains raw Pointer Member (**`char*`**):

- ➢ Handle memory allocation for Member Data.

```
Car::Car(){
  m_licensePlates = (char*)malloc(PLT);
  /* rest of Default ctor statements */
}
Car::Car(const char* licPlts, float glns,
   float mileage, const double engTim[VLV]){
  m_licensePlates = (char*)malloc(PLT);
  /* rest of Overloaded ctor statements */
}
```

```
class Car  {
 public:
  Car();
  Car(const char * licPlts,
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);

  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char * m_licensePlates;
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

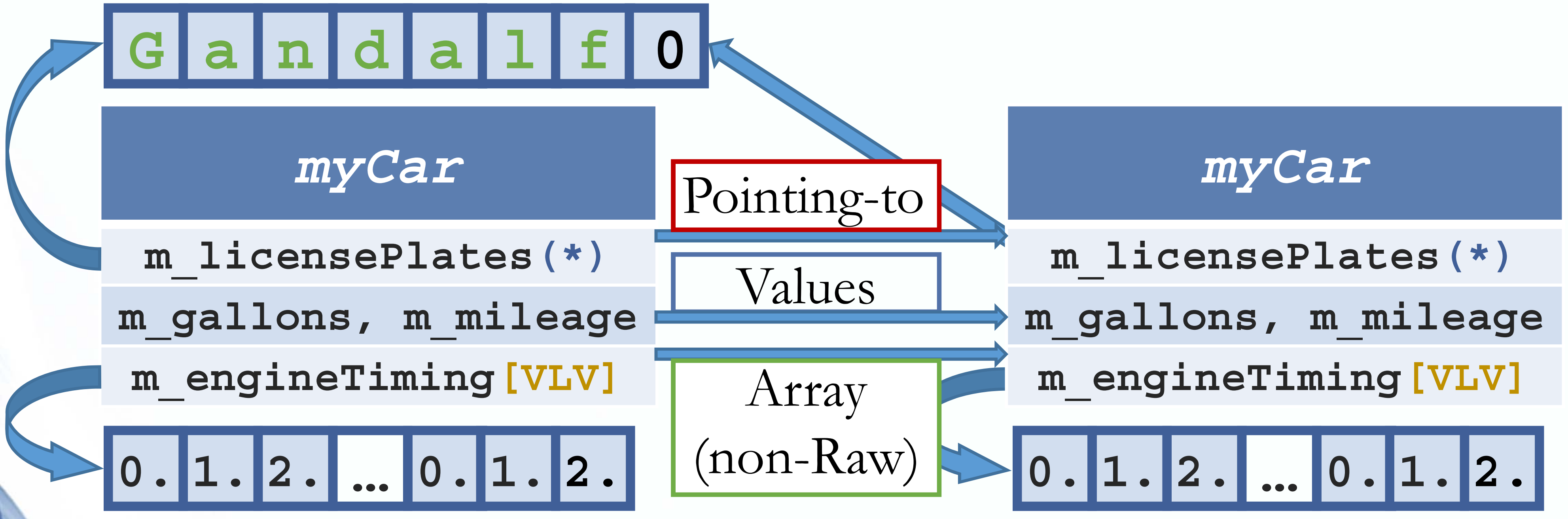
Class Cheatsheet

Copy (class-object) `ctor`:

- ➢ The compiler will (implicitly) provide a ***Shallow**-Copy* Constructor if none is specified.

***Shallow**-Copy* `ctor` copies raw Pointer, not Data!

```
Car myCar("Gandalf");
Car myCarCpy(myCar);
```



```
class Car  {
 public:
  Car();
  Car(const char * licPlts,
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);

  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char * m_licensePlates;
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Class Cheatsheet

Copy (class-object) **ctor**:

- Explictly Implement ***Deep**-Copy* Constructor.

***Deep**-Copy* **ctor** will allocate-&-copy Data!

Function Definition:

```
Car::Car(const Car &car){
  m_licensePlates = (char*)malloc(PLT);
  strcpy(m_licensePlates,car.m_licensePlates);
  m_gallons = car.m_gallons;
  m_mileage = car.m_mileage;
  for (int i=0; i<VLV; ++i)
    m_engineTiming[i] = car.m_engineTiming[i];
}
```

```
class Car  {
 public:
  Car();
  Car(const char * licPlts,
  float glns=DFT_GLNS, float mlg=0,
  const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char * m_licensePlates;
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
};
```

Classes

Class Cheatsheet

Copy (class-object) `ctor`:

```
Car myCar("Gandalf");
Car myCarCpy(myCar);
myCar.m_licensePlates[4] = 0;
cout << myCar.m_licensePlates << ","
     << myCarCpy.m_licensePlates << endl;
```

***Shallow**-Copy* `ctor` will only copy raw Pointer:

- Output: `Gand,Gand`

Explicit ***Deep**-Copy* `ctor` will allocate-copy Data:

- Output: `Gand,Gandalf`

Note:

- Always undesired? No, C++11 has *Move* `ctor`.
  However user-based raw Pointer solution(s) are unsafe !

```
class Car  {
public:
 Car();
 Car(const char * licPlts,
 float glns=DFT_GLNS, float mlg=0,
 const double engTim[VLV]=DFT_TIM);
 Car(const Car &car);
 float addGas(float gallons);
 float getGallons() const ;
 float getMileage() const ;
 char * m_licensePlates;
protected:
 float m_gallons;
 float m_mileage;
private:
 bool setEngineTiming(double[VLV]);
 double m_engineTiming[VLV];
};
```

Class Cheatsheet

Initialization List(s) (ctor Definition only):

- ➢ By-name Initialization of Data Members.
- ➢ Allows *Instantiation-time* Initialization.

```
Car::Car(const char * licPlts, float glns,
     float mlg, int fId,
     const double engTim[VLV]) :
   m_gallons( glns ) , m_mileage( mlg ) ,
   m_frameId( fId ) {
  // m_frameId = fId; wouldn't work (const)!
}
```

Note: With a const Member, needs to exist an *Initialization List* for *every* Constructor !

```
Car myCar("Gandalf",0,0,11000); //11000 years
```

```
class Car  {
 public:
  Car();
  Car(const char* licPlts,float glns
  =DFT_GLNS,float mlg=0,int fId=NO_F
  ,const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addGas(float gallons);
  float getGallons() const ;
  float getMileage() const ;
  char * m_licensePlates;
 protected:
  float m_gallons;
  float m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
  const int m_frameId;
};
```

Classes

Class Cheatsheet

Initialization List(s):

➢ Class-with-*Composistion* Initialization.

```
class Driver {
  public:
    Driver(){}
    Driver(char name[PLT], int fId);
  private:
    char m_name[PLT];
    Car m_car;
};

Driver::Driver(const char* name, int fId=NO_F) :
    m_name(name) , m_car(name,0,0,fId) {
  // Driver & m_car instantiated & initialized
}
```

ctor-in-ctor Call

Driver ctor Parameter re-used for Car ctor.

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],float glns
  =DFT_GLNS,float mlg=0,int fId=NO_F
  ,const double engTim[VLV]=DFT_TIM);
  Car(const Car & car);
  float addG/M(float gal/mil);
  float getG/M() const ;
  char m_licensePlates[PLT];
 protected:
  float m_gallons, m_mileage;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
  const int m_frameId;
};
```

Classes

Class Cheatsheet

Delegating Constructor (C++11):

- Can have one ctor invoke another ctor.

```
Car(char lP[PLT], int fId) :
 Car(lP, DFT_GLNS,0, fId, DFT_TIM)
{  /* delegating ctor body … */   }
```

Default Member Initialization (C++11):

- Can set default Member values in Declaration.
- Any *Initialization List* appearance of the member will have precedence over this default.

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],float glns
  =DFT_GLNS,float mlg=0,int fId=NO_F
  ,const double engTim[VLV]=DFT_TIM);
  Car(char lP[PLT], int fId) :
Car(lP,DFT_GLNS,0,fId,DFT_TIM){ … }
  float addG/M(float gal/mil);
  float getG/M() const ;
  char m_licensePlates[PLT] = "Gdf";
 protected:
  float m_gallons = DFT_GLNS;
  float m_mileage = 0;
 private:
  bool setEngineTiming(double[VLV]);
  double m_engineTiming[VLV] = {…};
  const int m_frameId;
};
```

Classes

Class Cheatsheet

static Data Members:

- Class state properties, not bound to an Object.
- Manipulated via the Class or an Object (if not private).

```
Car::Car(){ s_carFactoryCnt++; } //dflt ctor

cout << Car::s_carFactoryCnt;     //via class
Car myCar1; //call dflt ctor, increment cnt
cout << myCar1.s_carFactoryCnt;   //via object
```

static Member Function:

- Can only manipulate & address static Data Members and static Member Functions.

```
Car myCar2; //call dflt ctor, increment cnt
cout << Car::getCarFactoryCnt() << "==" <<
     << myCar1.getCarFactoryCnt() << "==" <<
     << myCar2.getCarFactoryCnt() ;   //2==2==2
```

```
class Car  {  //Class Header
 public:
  Car();
  Car(char licPlts[PLT],float glns
  =DFT_GLNS,float mlg=0,int fId=NO_F
  ,const double engTim[VLV]=DFT_TIM);
  …
  static int getCarFactoryCnt();
 private:
  // declaration of static member
  static int s_carFactoryCnt;
};
```

```
#include <Car.h> //Class Source

// definition of static member
int Car::s_carFactoryCnt = 0;
int Car::getCarFactoryCnt(){
  return Car::s_carFactoryCnt;
} …
```

Class Cheatsheet

static Local Variables in Class Methods:

- ➢ Statically allocated data.
- ➢ Initialized the first time Class Function block is entered.
- ➢ Lifetime until program exits!

```
float Car::addG(float gallons){
  static int refill_cnt = 0;
  cout<<"Refilled "<< ++refill_cnt <<" times"<<endl;
  m_gallons += gallons;
}

Car myCar1, myCar2;
myCar1.addG(10.0);
myCar2.addG(10.0);
```

Output: `Refilled 1 times`

Output: `Refilled 2 times`

Notes (Why is it usually such a "bad" design choice):

- ➢ Aliasing! The same variable is referenced within a member function that is to be called by different Calling Objects!
- ➢ Visible only in Function block (of no use to Class) !

```
class Car  {
 public:
  Car();
  Car(char licPlts[PLT],float glns
  =DFT_GLNS,float mlg=0,int fId=NO_F
  ,const double engTim[VLV]=DFT_TIM);
  Car(const Car &car);
  float addG/M(float gallons);
  float getG/M() const ;
  static int getCarFactoryCnt();
  char m_licensePlates[PLT];
 protected:
  float m_gallons, m_mileage;
 private:
  bool getEngineTiming(double[VLV]);
  double m_engineTiming[VLV];
  const int m_frameId;
  static int s_carFactoryCnt;
};
```

Classes

Class Cheatsheet

Operator Overloading – **non-Member** of Class.

- **Unary** Operator(s):

```
const Money operator-(const Money& mn)
{ return Money(-mn.getD(),-mn.getC()); }
Money myMoney(99,25), notMyMoney = - myMoney;
```

- **Binary** Operator(s):

```
bool operator==(const Money& mn1, const Money& mn2)
{ return mn1.getD()==mn2.getD() && mn1.getC() == mn2.getC(); }

const Money operator+(const Money& mn1, const Money& mn2)
{ return Money(mn1.getD()+mn2.getD(),mn1.getC()+mn2.getC()); }
Money myMoney(99,25), yourMoney(0,75);
bool ourMoneyEqual = myMoney == yourMoney;
Money ourMoney = myMoney + yourMoney;
```

`return`: a `const` *Unnamed* Class Object

```
class Money{
 public:
  Money();
  Money(int dollars,
          int cents=0);
  Money(const Money &m);
  void setD/C(int dc);
  int getD/C() const;
 private:
  int m_dollars;
  int m_cents;
};
```

Note:
Operator(s) should handle Class specifications (e.g. prevent ***m_cents*** rollover)

Class Cheatsheet

Operator Overloading – **Class Member** Function.

- **Assignment** Operator (half the story, the rest for later) :

```
void Money::operator=(const Money& mn)
{ m_dollars = mn.m_dollars; m_cents = mn.m_cents; }
Money myMoney(99,25), myMoneyAgain = myMoney;
```

A Class method, like saying: `myMoneyAgain.operator=(myMoney);`

Note: If none specified, compiler creates a default Assignment Operator (***Member**-Copy)* for Class Objects. *Remember*: ***Shallow***-Copy vs ***Deep***-Copy.

- **Binary** Operator(s):

```
const Money Money::operator+(const Money& mn) const
{ return Money(m_dollars+mn.m_dollars, m_cents+mn.m_cents); }
Money myMoney(99,25), yourMoney(0,75);
Money ourMoney = myMoney + yourMoney;
```

Calling Object is like 1st parameter: `myMoney.operator+(yourMoney);`

```
class Money{
 public:
  Money();
  Money(int dollars,
          int cents=0);
  Money(const Money &m);
  void Money operator=
 (const Money& m);
  const Money operator+
 (const Money& m) const;

  void setD/C(int dc);
  int getD/C() const;

 private:
  int m_dollars;
  int m_cents;
  char* m_owner;
};
```

Classes

Class Cheatsheet

➢ Operator Overloading – Both versions (*Ambiguous*):

```
const Money operator+(const Money&a,const Money&b)
{  return Money(1);  }  //non-Member
const Money Money::operator+(const Money&b) const
{  return Money(2);  } //Class Member
warning: ISO C++ says that these are ambiguous …
Money m1,m2, m3 = m1 + m2;
Money m4 = m1 .operator+ ( m2 );
```

Result: 1

Result: 2

➢ Operator Overloading – Both versions (*Different Calls*):

```
const Money operator-(const Money &mn)
{ return Money(-mn.getD(), -mn.getC()); }
const Money operator-(const Money& m) const
{ return Money(m_dollars-mn.m_dollars, m_cents-mn.m_cents); }
Money m5 = - m1 ;      //Unary call
Money m6 = m1 - m2 ;   //Binary call
```

```
class Money{
 public:
  Money();
  Money(int dollars,
        int cents=0);
  Money(const Money &m);
const Money operator+
(const Money& m) const;
const Money operator-
(const Money& m) const;

  void setD/C(int dc);
  int getD/C() const;

 private:
  int m_dollars;
  int m_cents;
};
```

Classes

Class Cheatsheet

Operator Overloading

- Return by-const-Value

```
const Money Money::operator+(const Money& mn)const{
  return Money(m_dollars + mn.m_dollars,
               m_cents   + mn.m_cents);
}
```

Why const-Value ?

```
Money a(4, 50), b(3, 25), c(2, 10);
```

```
(a + b);
```

Evaluates to: *Unnamed* Object

```
c = (a + b);
```

OK…

```
(a + b) = c;
```

No !!!

Prevents (&protects) us from altering the returned value…

```
class Money{
 public:
  Money();
  Money(int dollars,
        int cents=0);
  Money(const Money &m);
  void Money operator=
(const Money& m);
  const Money operator+
(const Money& m) const;
  void setD/C(int dc);
  int getD/C() const;
 private:
  int m_dollars;
  int m_cents;
};
```

Classes

Class Cheatsheet

Operator Overloading

➢ Return by-const-Reference (?)

```
const Money& Money::operator+(const Money& mn) const
{ return Money(m_dollars + mn.m_dollars,
               m_cents   + mn.m_cents);   }
```

```
warning: returning reference to temporary.
```

➢ Makes a temporary Object, goes out of scope!

```
Money a(4, 50), b(3, 25);
const Money* ab_Pt = &(a + b);
cout << ab_Pt->getD()
<<","<< ab_Pt->getC();
```

```
 7
75
```

No !
This is UNSAFE !

Function return does not guarantee an immediate *Stack* frame wipe!

Note: Especially if the return type is a const-Reference ! (…)

```
class Money{
public:
 Money();
 Money(int dollars,
       int cents=0);
 Money(const Money &m);
 void Money operator=
(const Money& m);
 const Money& operator+
(const Money& m) const;
 void setD/C(int dc);
 int getD/C() const;
private:
 int m_dollars,m_cents;
};
```

Classes

Class Cheatsheet

Operator Overloading

- Return by-Reference – Operator ([])

Returned: <type_id>&, internal Member Reference.

```
int& Money::operator[](const int index)
{ return m_transID [ index ]; }
```

- Accessing (private) Data Member by-Reference:

```
Money hugeCheck(1000000);
int transCnt = 0;
hugeCheck [ transCnt++ ] = BANK_TRANS;
hugeCheck [ transCnt++ ] = BRIBE_TRANS;
hugeCheck [ transCnt++ ] = BANK_TRANS;
if (hugeCheck [ 1 ] == BRIBE_TRANS)
{ cout << "Illegal Activity!"; }
```

Write-to

Read-from

```
class Money{
 public:
  Money();
  Money(int dollars,
        int cents=0);
  Money(const Money &m);
  int& operator[](const
                  int index);
  const Money& operator+
 (const Money& m) const;

  void setD/C(int dc);
  int getD/C() const;
 private:
  int m_dollars,m_cents;
  int m_transID[T_HIST];
};
```

Class Cheatsheet

Operator Overloading w/ Cascading

- Return by-Reference – Operator(s) (`<<`) , (`>>`)

Returned: `<i/o>stream&`, Reference to passed 1st Parameter.

```
ostream& operator<<(ostream& os, const Money& mn){
   os << "$" << mn.m_dollars << "." << mn.m_cents;
   return os;
}

istream& operator>>(istream& is, Money& mn){
   char dollar, point;
   is >> dollar >> mn.m_dollars >> point  >> mn.m_cents;
   return is;
}
```

Note: Non-Member `friend` functions granted `private` Data access.

```
class Money{
 public:
  Money();
  Money(int dollars,
        int cents=0);
  Money(const Money &m);
  friend ostream&
  operator<<(ostream& os
  , const Money& m);
  friend istream&
  operator>>(istream& is
  , Money& m);
  void setD/C(int dc);
  int getD/C() const;
 private:
  int m_dollars,m_cents;
};
```

Example: `Money myMoney;`

`cin >> myMoney;`

w\ Cascading: `cout << "I have: " << myMoney << "right now";`

Classes

Class Cheatsheet

Operator Overloading w/ Cascading

➢ Return by-Reference – Assignment Operator (=)

Returned: `<class_type>&`, Reference to Calling Object.

```
Money& Money::operator=(const Money& m){
  this->m_dollars = m.m_dollars;
  this->m_cents = m.m_cents;
  this->output();
  return *this;
}
```

this : A pointer to the Calling Object inside a Member Function

Example:

```
Money moneyPack1,moneyPack2, moneyPack3(49,99);
moneyPack1 = moneyPack2 = moneyPack3;
```

Chaining Assignment Operator by returning Calling Object Reference

```
Output: $49.99
        $49.99
```

```
class Money{
 public:
  Money();
  Money(int dollars,
        int cents=0);
  Money(const Money &m);
  Money& operator=(const
              Money& m);

  void output();

  void setD/C(int dc);

  int getD/C() const;
 private:
  int m_dollars,m_cents;
};
```

Classes

Class Cheatsheet

Overloading Pre-Increment Operator(s) (++) , (- -):

- ➤ No arguments (for compiler *disambiguation*).

```
Money& Money::operator++(){
  m_cents++; … //mutates calling object
  return *this;
}
```

Note:
Modifies calling Object and returns a Reference to it.
No Object Copy operation!

```
Money myMoney(0,99);
Money myMoreMoney = ++ myMoney;
                {100,0}          {100,0}
```

```
class Money{
 public:
  Money();
  Money(int d, int c=0);
  Money(const Money &m);
  Money& operator++();
  Money& operator--();
  Money operator++(int);
  Money operator--(int);
  void setD/C(int dc);
  int getD/C() const;
 private:
  int m_dollars,m_cents;
};
```

Classes

Class Cheatsheet

Overloading Post-Increment Operator(s) (++) , (--):

- A dummy `int` argument (for compiler *disambiguation*).

```
Money Money::operator++(int dummy){
  Money moneyCopy(*this);
  this->m_cents++; … //mutates calling object
  return moneyCopy;
}
```

Note: Keeps a Copy of calling Object to **return** and then modifies calling Object (same as before).

```
Money myMoney(0,99);
Money mySameMoney = myMoney ++;
         {99,0}            {100,0}
```

```
class Money{
 public:
  Money();
  Money(int d, int c=0);
  Money(const Money &m);

  Money& operator++();
  Money& operator--();
  Money operator++(int);
  Money operator--(int);

  void setD/C(int dc);
  int getD/C() const;

 private:
  int m_dollars,m_cents;
};
```

Classes

Keyword this

Checking if the Calling Object is *exactly* the same as the Object passed as argument!

```
bool Money::thisCheck(const Money& m){
  if (this == &m)
    return true;
  else
    return false;
}
```

- Usual Application: Protect from self-Assignment

```
Money& Money::operator=(const Money& m){
  if (this != &m){ //check if trying to assign from self
    //perform assignment from m to calling object
    //only if other object m is a separate object
  }
  return *this;  //return calling object by-Reference
}
```

```
class Money{
 public:
  Money();
  Money(int d, int c=0);
  Money(const Money &m);
  Money& operator=(const
                 Money& rhs);
  bool thisCheck(const
                   Money& m);
  void setD/C(int dc);
  int getD/C() const;
 private:
  int m_dollars,m_cents;
};
```

Inheritance

Code Reuse

Important to successful coding

- ➢ Efficiency: No need to reinvent the wheel.
- ➢ Error free: If code already used/tested (not guaranteed, but more likely).

Ways to reuse code?

- ➢ Functions
- ➢ Classes
- ➢ Aggregation:

  `RentalAgency` *"has-a"* `RentalCar`
- ➢ Inheritance!

Inheritance

Object Relationships

"*Uses a*" relationship:

- ➢ `ObjectA` "*uses an*" `ObjectB`

  `Car` refuels from a `GasStation`

"*Has a*" – Composition or Aggregation

- ➢ `ObjectA` "*has an*" `ObjectB`

  `Car` incorporates a `Sensor`

"*Is a*" or "*Is a kind of*" – Inheritance

- ➢ `ObjectA` "*is a*" `ObjectB`

  `Car` is a `Vehicle`

Inheritance

Inheritance Relationship

What is Inheritance?

- A `Car` "*is a*" `Vehicle`

Code reuse by sharing related Set-Methods:

- Specific classes "Inherit" methods from general classes.

The `Car` Class Inherits from the `Vehicle` Class:

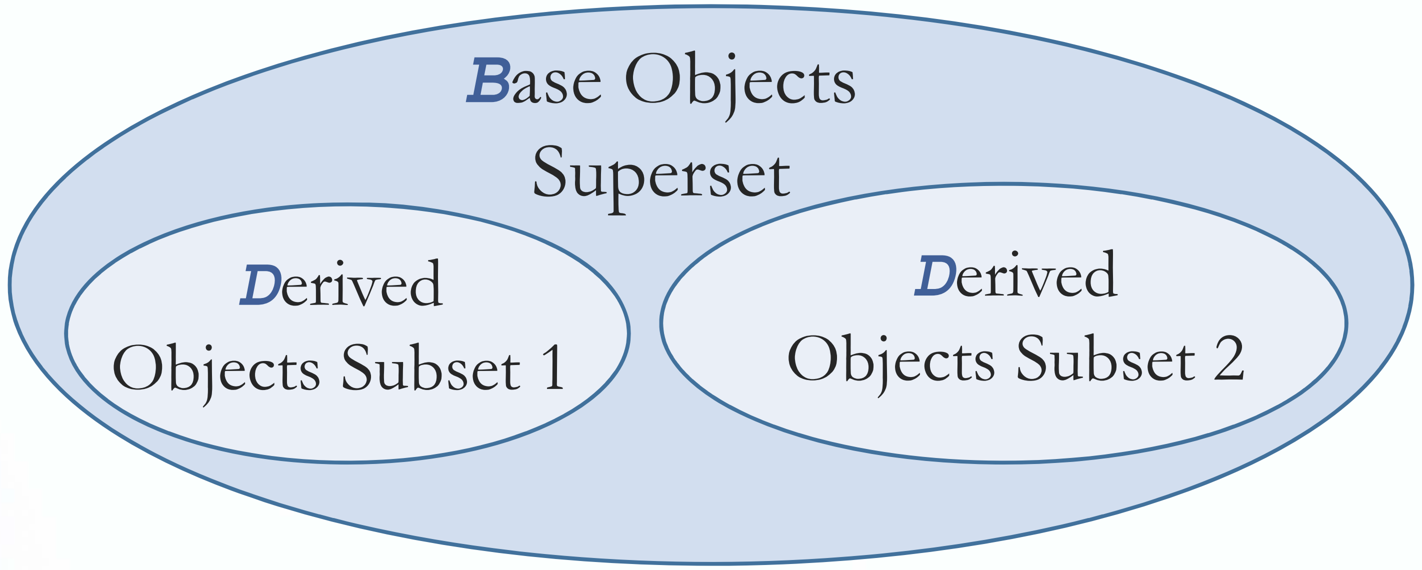
- `Vehicle` is the general class, or the *Base* Class.
- `Car` is the specialized class, or *Derived* Class, that Inherits from `Vehicle`.

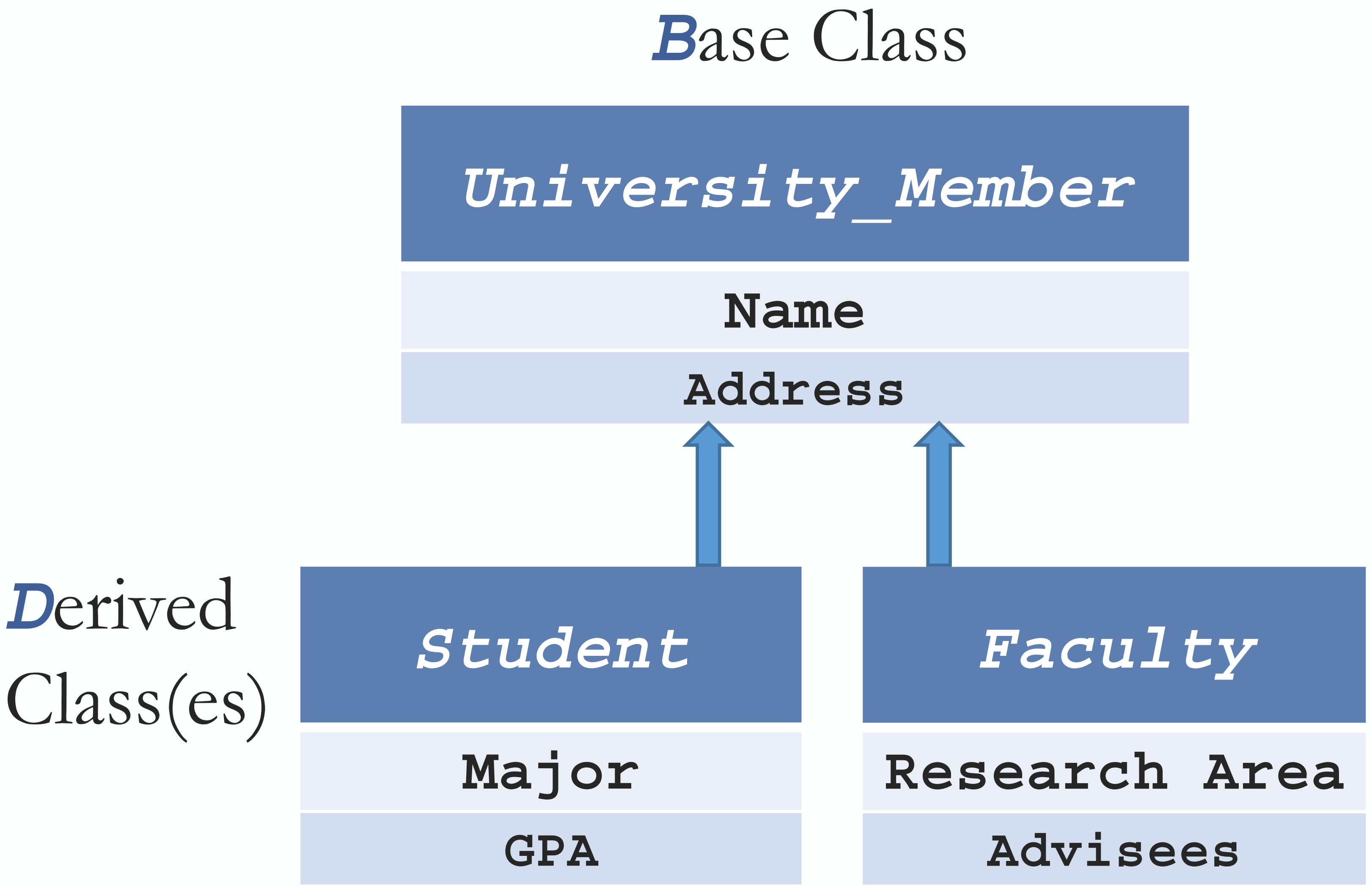
Inheritance

Inheritance Relationship

Inheritance Example:

- Every ***D*** is a ***B***
- Not every ***Di*** is a ***Dj***
- Some ***B***s are ***D***s





Inheritance

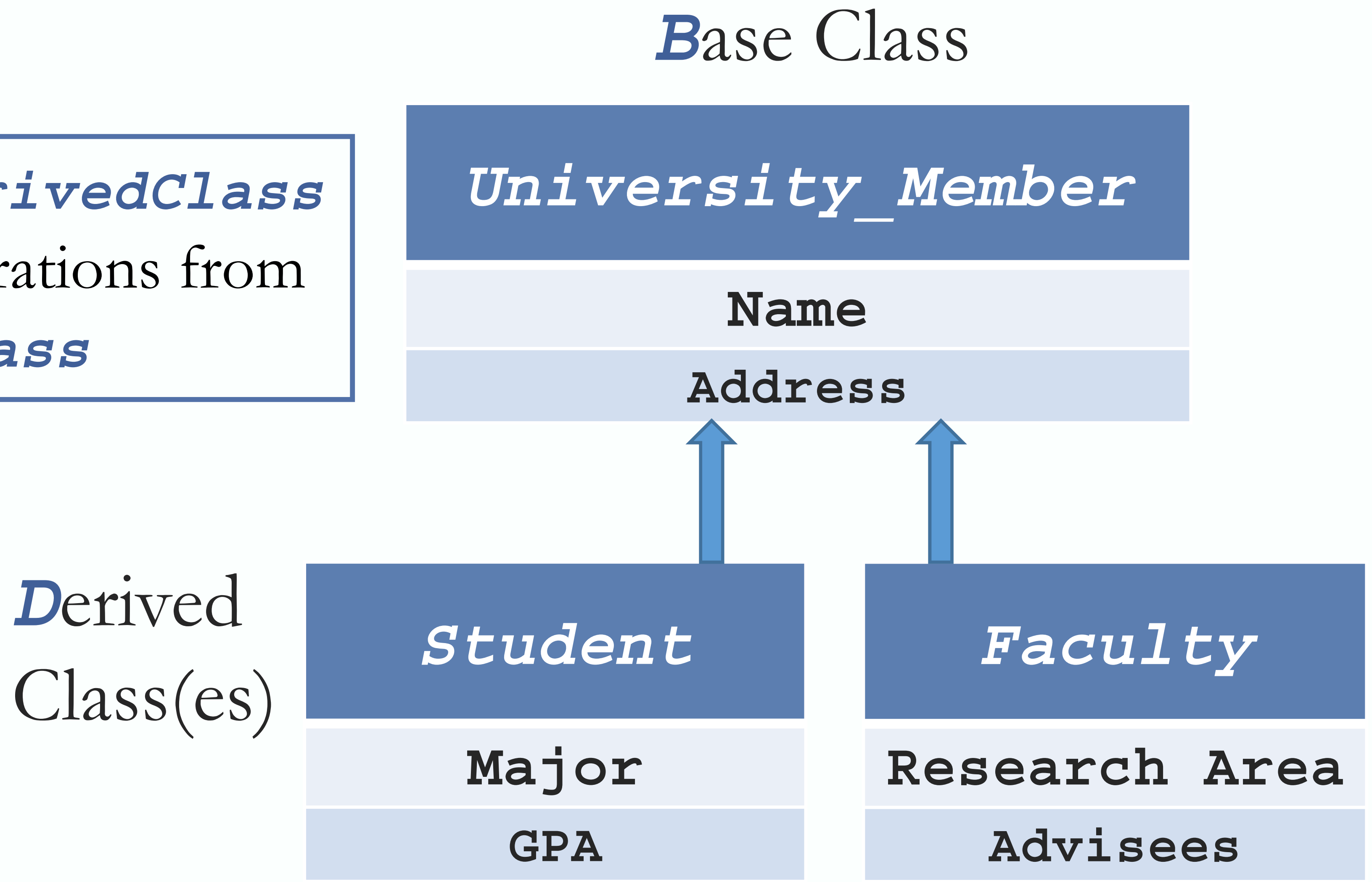
Inheritance Relationship

Inheritance Syntax:

```
class BaseClass {
    public:
        //operations
    private:
        //data
};
```

Indicates that this *DerivedClass* Inherits data and operations from this *BaseClass*

```
class DerivedClass : public BaseClass {
    public:
        //operations
    private:
        //data
};
```



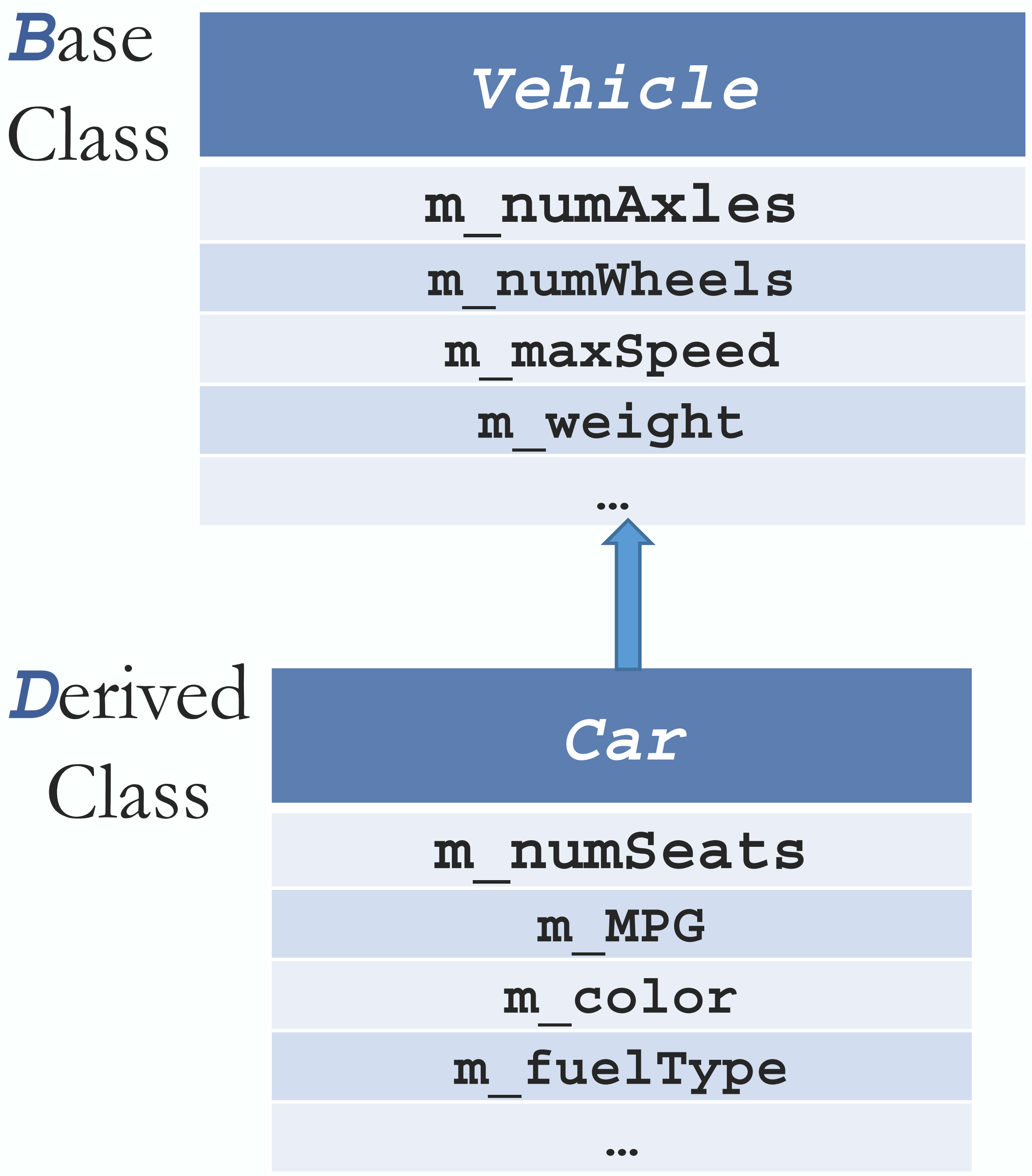
Inheritance

Inheritance Relationship

Indicative Code example:

```
class Vehicle {
  public:
    // functions
  private:
    // data
    int    m_numAxles;
    int    m_numWheels;
    int    m_maxSpeed;
    double m_weight;
} ;
```

All *Vehicle*s have axles, wheels, a max speed, and a weight



Inheritance

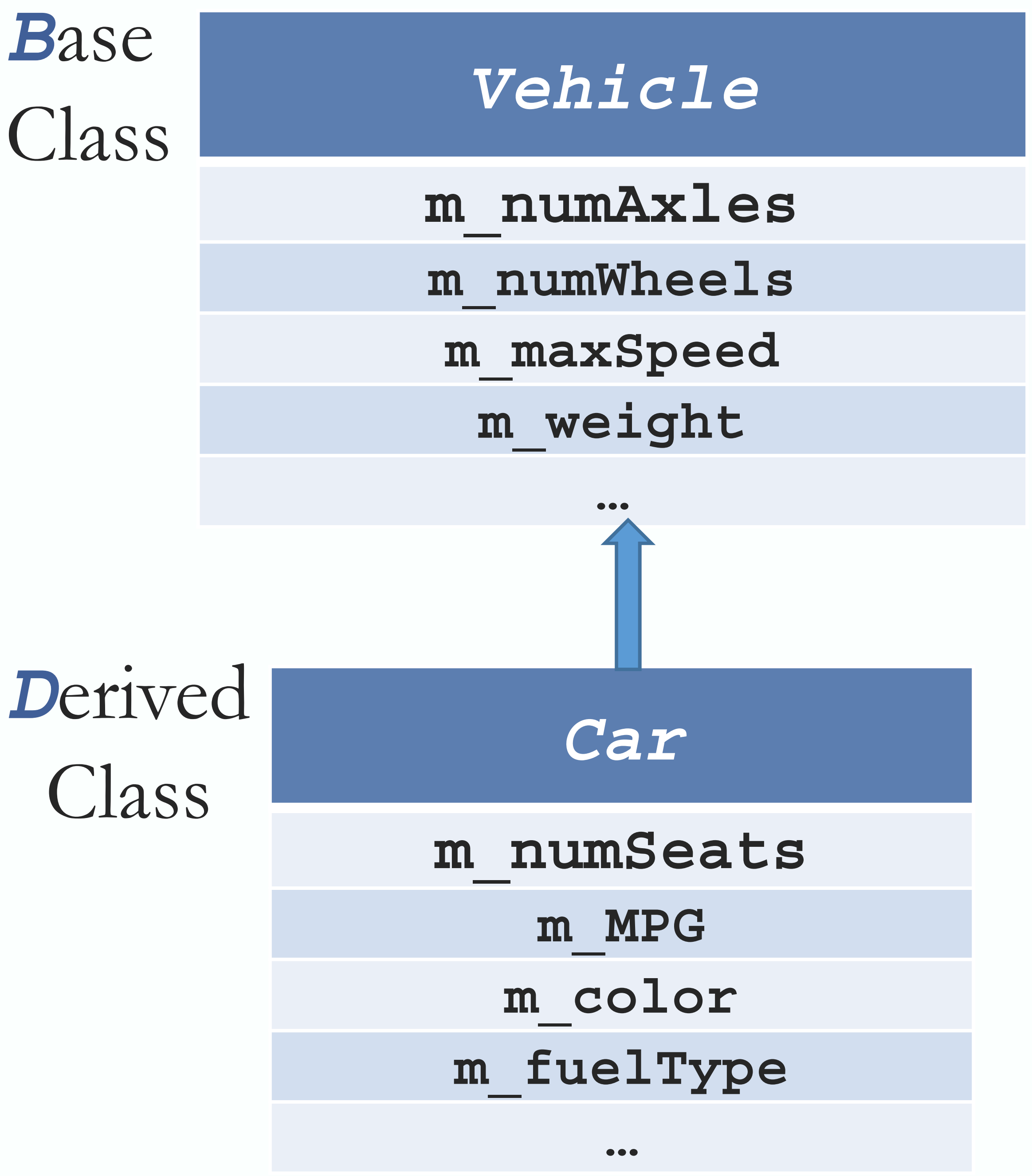
Inheritance Relationship

Indicative Inheritance Code example:

- Colon in Declaration indicates Inheritance.

```
class Car : public Vehicle {
  public:
    // functions
  private:
    // data
    int    m_numSeats;
    double m_MPG;
    string m_color;
    string m_fuelType;
} ;
```

All Cars have a number of seats, a MPG value, a color, and a fuel type



Base Class

Vehicle
m_numAxles
m_numWheels
m_maxSpeed
m_weight
…

Derived Class

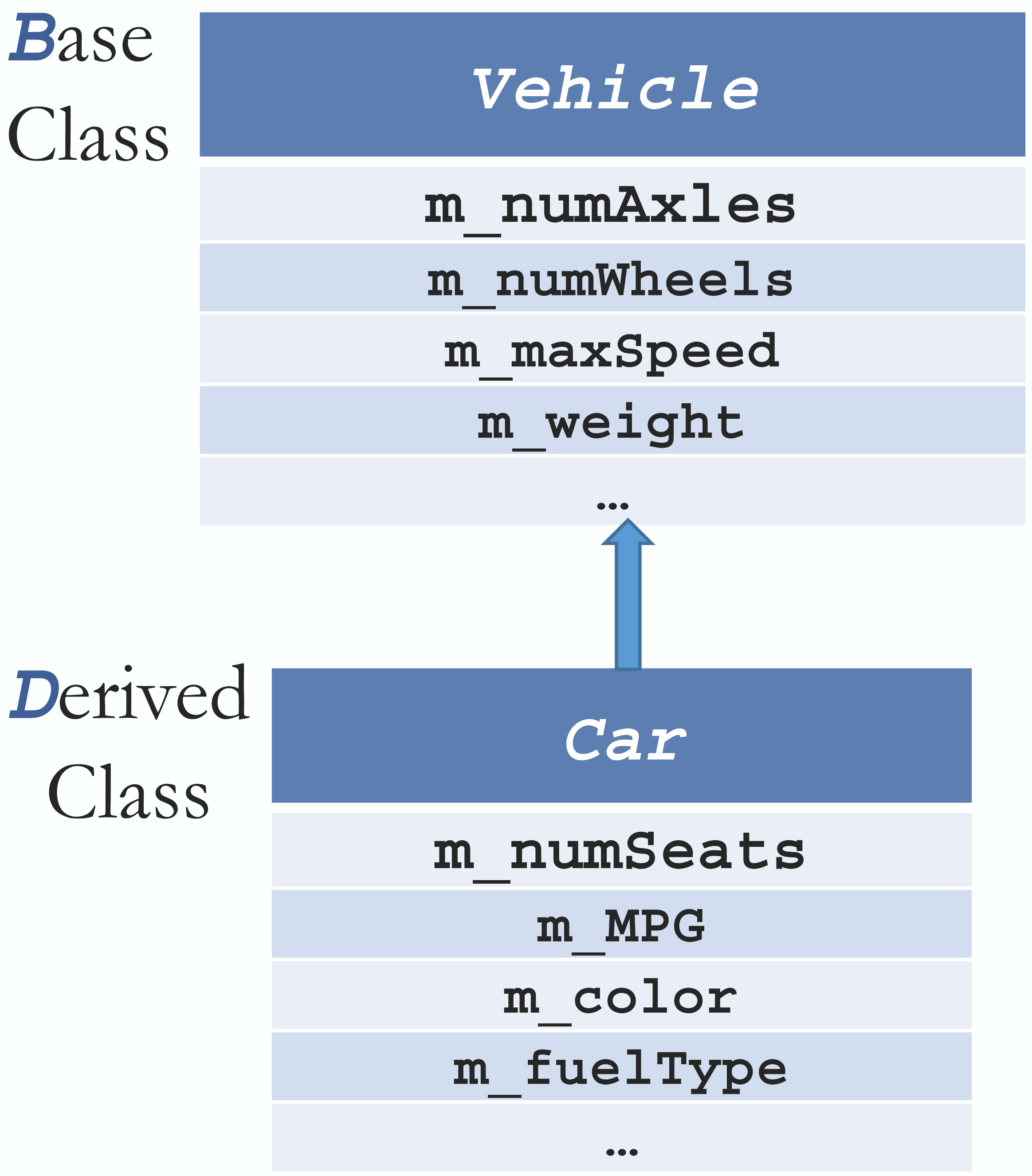
Car
m_numSeats
m_MPG
m_color
m_fuelType
…

Inheritance

Inheritance Relationship

Indicative Inheritance Code example:

```
class Car :
  public Vehicle { /*etc*/ };
class Plane :
  public Vehicle { /*etc*/ };
class SpaceShuttle :
  public Vehicle { /*etc*/ };
class BigRig :
  public Vehicle { /*etc*/ };
```



Base Class

Vehicle

m_numAxles

m_numWheels

m_maxSpeed

m_weight

…

Derived Class

Car

m_numSeats

m_MPG

m_color

m_fuelType

…

Composition

Composition Relationship

What is Composition?

- A `Car` *"is made of a/ incorporates a"* `Chassis`

The `Car` Class contains a Class Object of type `Chassis`.

A `Chassis` Object is part of the `Car` Class:

- A `Chassis` cannot "live" out of context of a `Car`.
- If the `Car` is destroyed, the `Chassis` is also destroyed!

Composition

Composition Relationship

Indicative Code example:

- No Inheritance for ***Chassis***:

```
class Chassis {
  public:
    // functions
  private:
    // data
    char m_material[MAT_LENGTH];
    double m_weight;
    double m_maxLoad;
} ;
```

```
class Car : public Vehicle {
  public:
    // functions
  private:
    // made-with (composition)
    Chassis m_chassis;
} ;
```

Aggregation

Aggregation Relationship

What is Aggregation?

- A `Car` *"has a/ uses a"* `Driver`

The `Car` Class is linked to an Object of type `Driver`.

`Driver` Class is not directly related to the `Car` Class.

- A `Driver` can live out of context of a `Car`.
- A `Driver` must be "contained" in the `Car` object *via a Pointer* to a `Driver` Object.

Aggregation

Aggregation Relationship

Indicative Code example:

➢ **Driver** Inherits from *Base* Class **Person**:

```
class Driver: public Person {
  public:
    // functions
  private:
    // data
    Date m_licenseExpire;
    char m_licenseType[LIC_MAX];
} ;
```

```
class Car : public Vehicle {
  public:
    // functions
  private:
    // has-a (aggregation)
    Driver *m_driver;
} ;
```

Inheritance

Inheritance (detailed)

Why Inheritance?

Abstraction for sharing similarities while retaining differences.

Group classes into related families:

- Share common operations and data.

Multiple Inheritance(s) is possible:

- Inherit from multiple Base Classes

```
class Car : public Vehicle ,
            public DMVRegistrable { … };
```

Promotes code reuse

- Design general Class once.
- Extend implementation(s) through Inheritance.

Inheritance

Inheritance (detailed)

Access Specifier(s)

Inheritance can be `public`, `private`, or `protected`.

- Our focus will be `public` Inheritance.

`Public`

- Everything that is aware of Base and Derived/Child is also aware that Derived Inherits from Base.

`Protected`

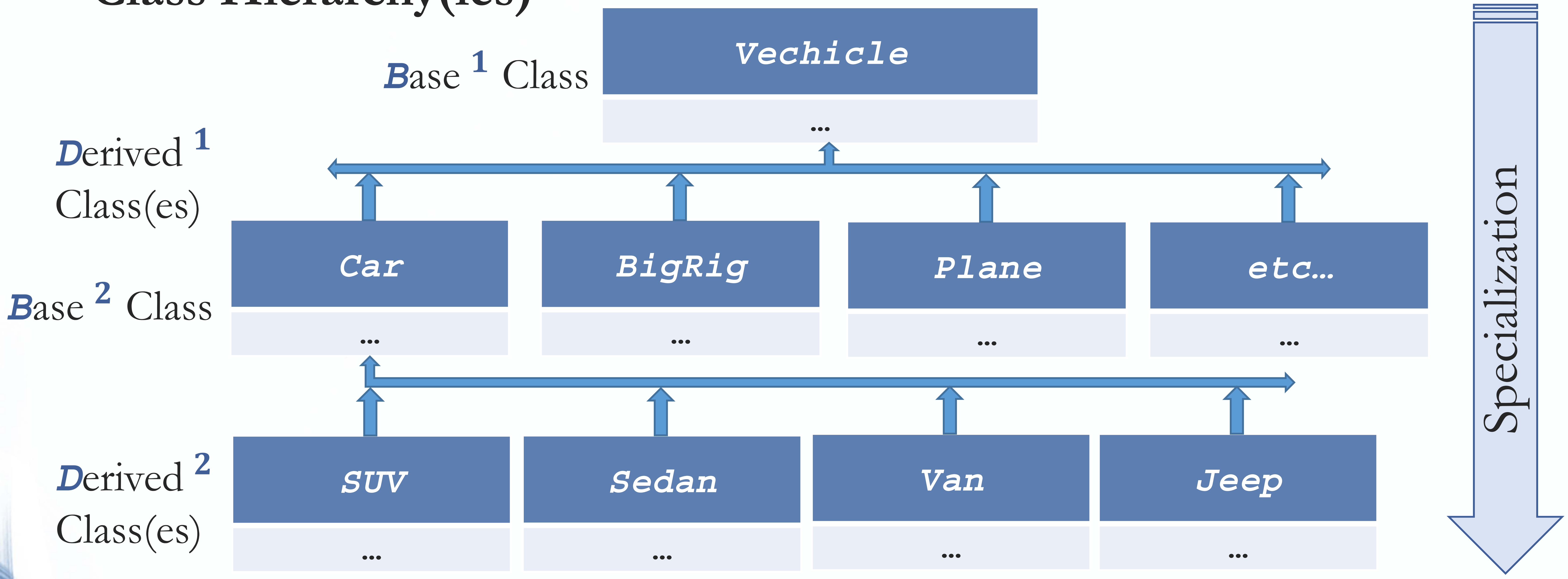
- Only Derived/Child and its own Derived/Children, are aware that they Inherit from Base.

`Private`

- No one other than Derived/Child is aware of the Inheritance.

Inheritance

Class Hierarchy(ies)



Inheritance

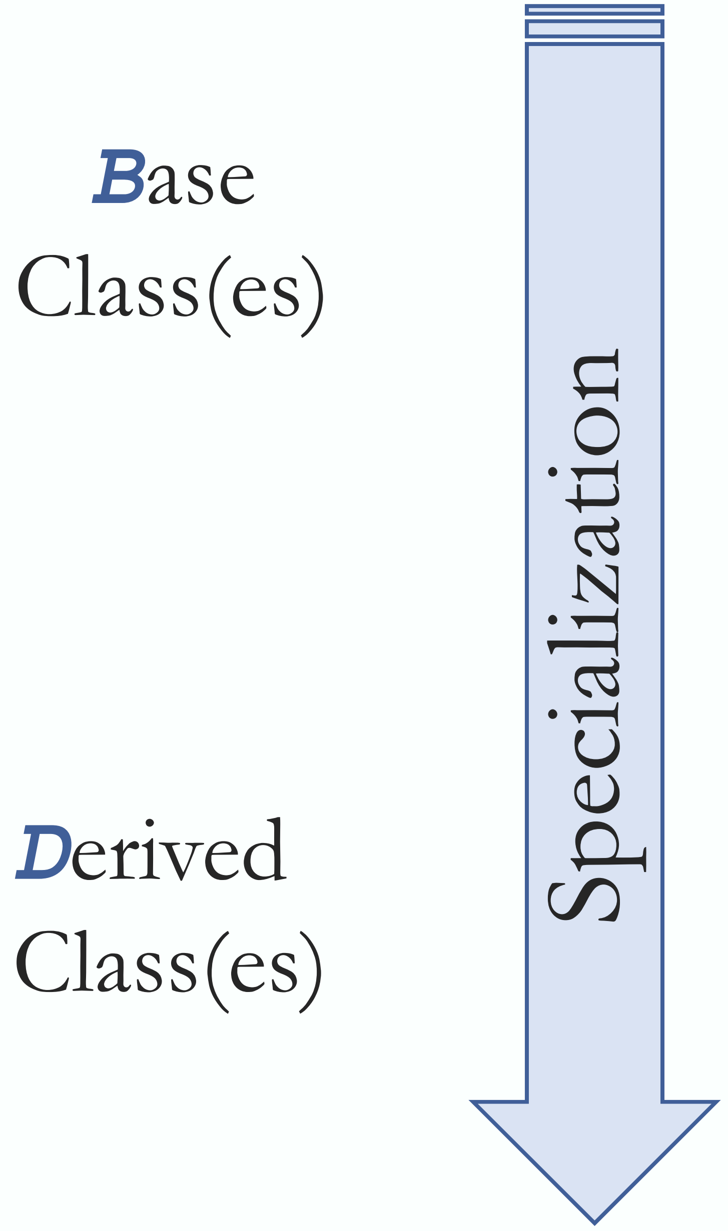
Class Hierarchy(ies)

More general Class (e.g. `Vehicle`) is called:

- Parent Class
- Base Class
- Super-Class

The more specialized Class (e.g. `Car`) is called:

- Derived Class
- Child Class
- Sub-Class



Inheritance

Class Hierarchy(ies)

Parent/Base Class:

- Contains all that is common among its child classes (less specialized).

Example:

A `Vehicle` has members like max speed, weight, etc. because all vehicles have these.

Member Variables and Functions of the Parent/Base Class are Inherited:

- By all of its Child/Derived Classes (Inherited *doesn't always* mean directly accessible!)

Note: Parent/Base Class `protected` & `public` Member Variables:

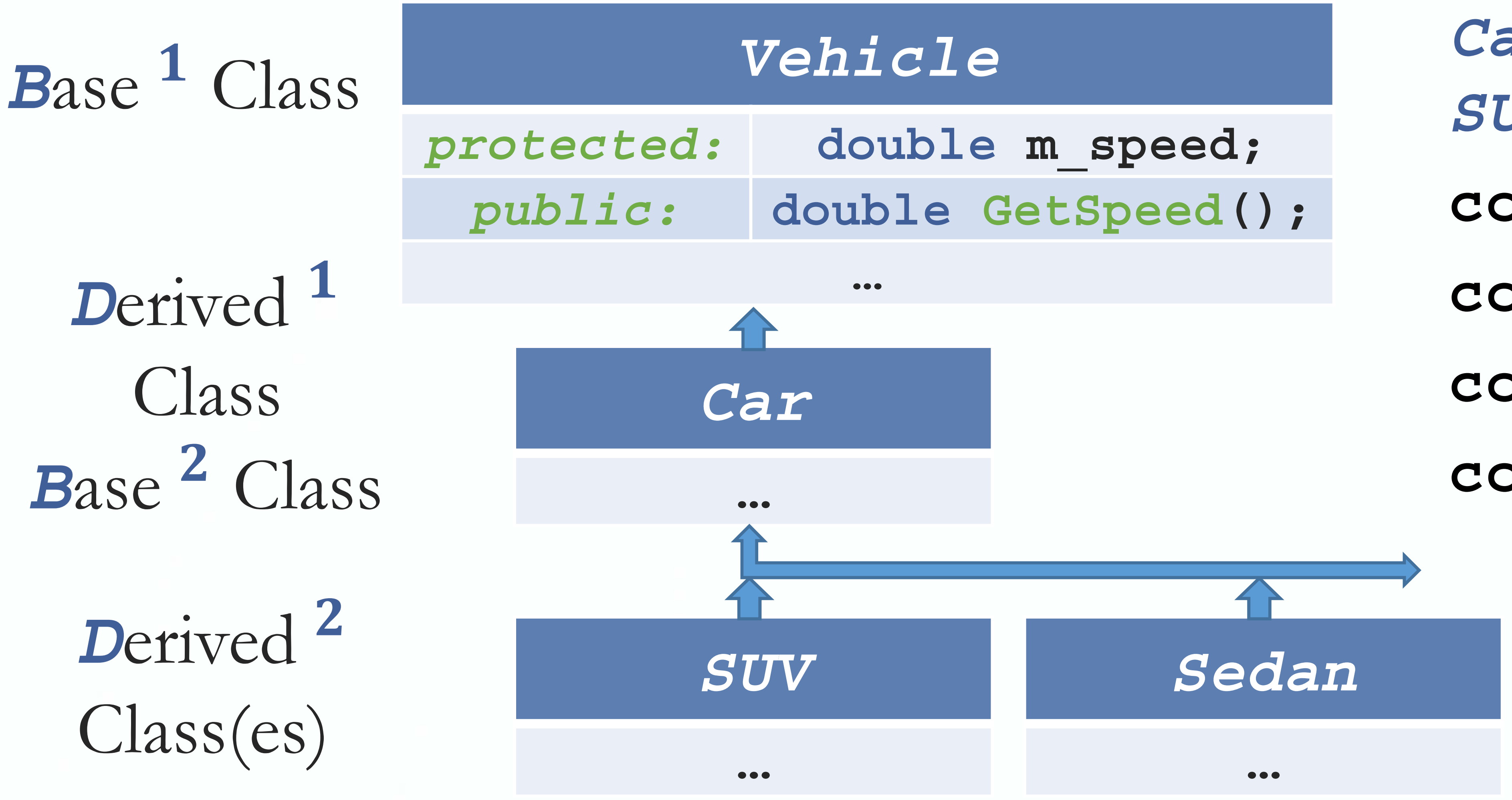
- Directly accessible by Derived/Child Class.

Inheritance

Class Hierarchy(ies)

Derived/Child Class has access to all **public** Methods of Base/Parent Class.

➢ Can be used on Derived/Child Class Objects!



Base ^{1} Class

Vehicle	
protected:	double m_speed;
public:	double GetSpeed();
…	

Derived ^{1} Class

Base ^{2} Class

Car
…

Derived ^{2} Class(es)

SUV
…

Sedan
…

```
Car myCar;
SUV mySUV;
cout << myCar.m_speed;
cout << myCar.GetSpeed();
cout << mySUV.m_speed;
cout << mySUV.GetSpeed();
```

Inheritance

Class Hierarchy(ies)

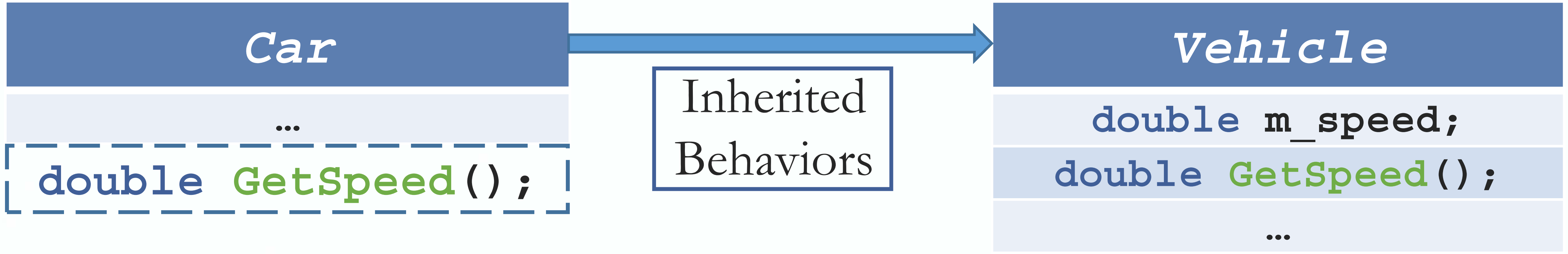
Derived/Child Class has access to all `public` Methods of Base/Parent Class.

- Can be used on Derived/Child Class Objects!
- Derived/Child Classes can *Use*, *Extend*, or *Replace* the Base/Parent Class behaviors.

Use

Derived/Child Class takes advantage of the Parent Class behaviors exactly as they are:

- E.g. Mutators and Accessors from the Parent Class.



Inheritance

Class Hierarchy(ies)

Derived/Child Class has access to all **`public`** Methods of Base/Parent Class.

- ➢ Can be used on Derived/Child Class Objects!
- ➢ Derived/Child Classes can *Use*, *Extend*, or *Replace* the Base/Parent Class behaviors.

Extend

Derived/Child Class creates entirely new behaviors:

- ➢ E.g. A ***`RepaintCar`*****`()`** function for the ***`Car`*** Child Class.

  Sets of Mutators & Accessors for new Member Variables.

`Car`
`double m_steeringWheelAngle;`
`double GetSteeringWheelAngle();`
…

Own more specialized behaviors

Inheritance

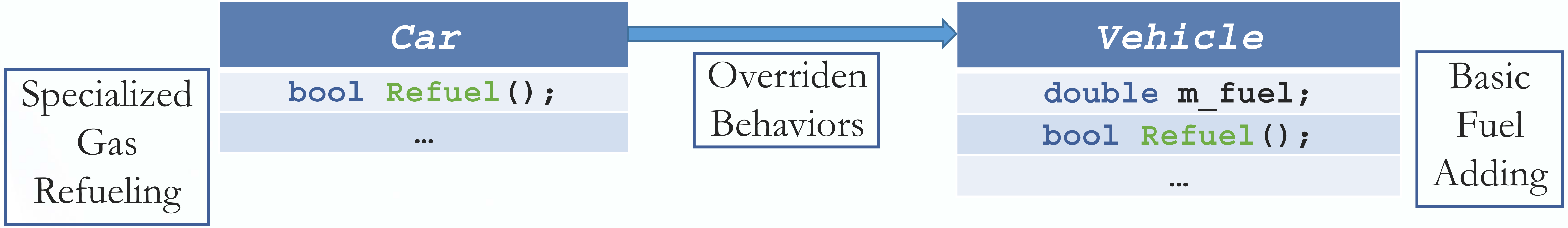
Class Hierarchy(ies)

Derived/Child Class has access to all **`public`** Methods of Base/Parent Class.

- ➢ Can be used on Derived/Child Class Objects!
- ➢ Derived/Child Classes can *Use*, *Extend*, or *Replace* the Base/Parent Class behaviors.

Replace

Derived/Child Class **`override`**s Base/Parent Class's behaviors.



Specialized Gas Refueling

Car

```
bool Refuel();
…
```

Overriden Behaviors

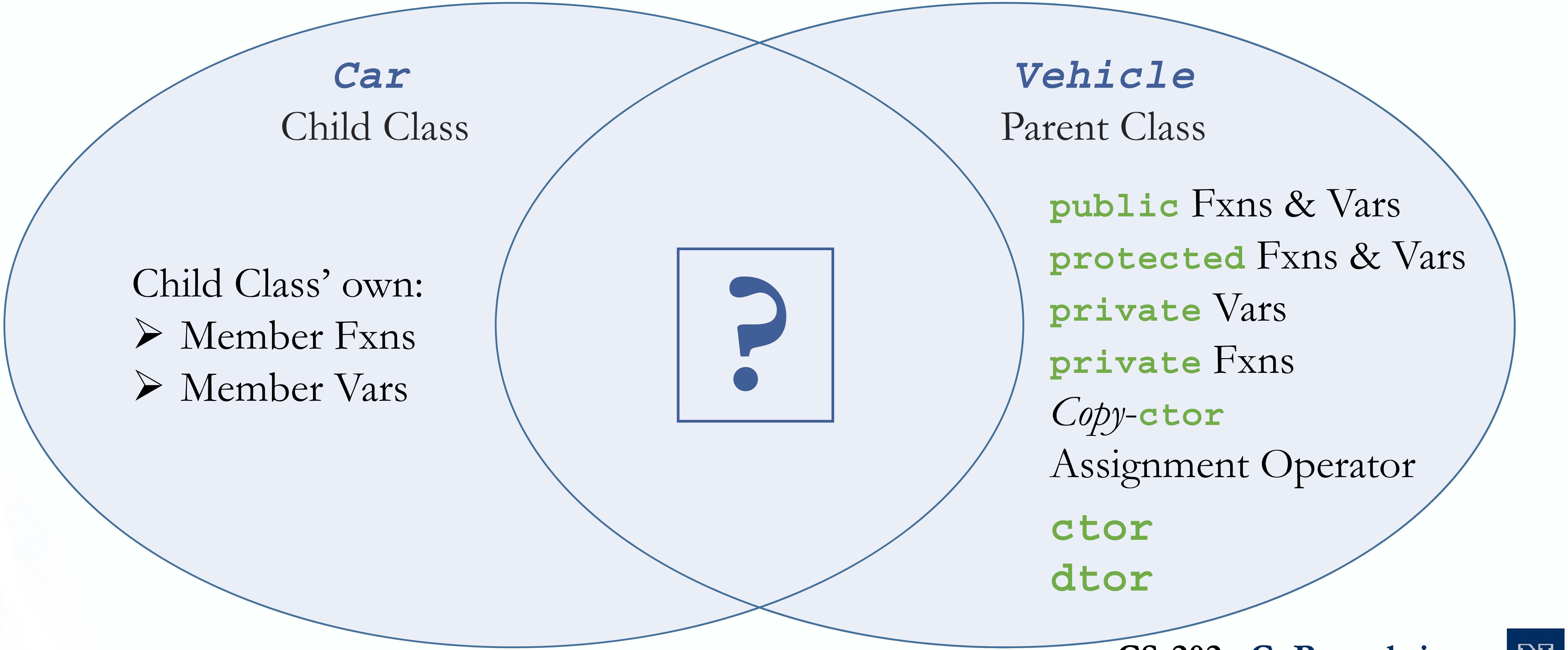
Vehicle

```
double m_fuel;
bool Refuel();
…
```

Basic Fuel Adding

Inheritance

Inherited Member(s)



Car

Child Class

Child Class' own:

- Member Fxns
- Member Vars

?

Vehicle

Parent Class

`public` Fxns & Vars

`protected` Fxns & Vars

`private` Vars

`private` Fxns

Copy-`ctor`

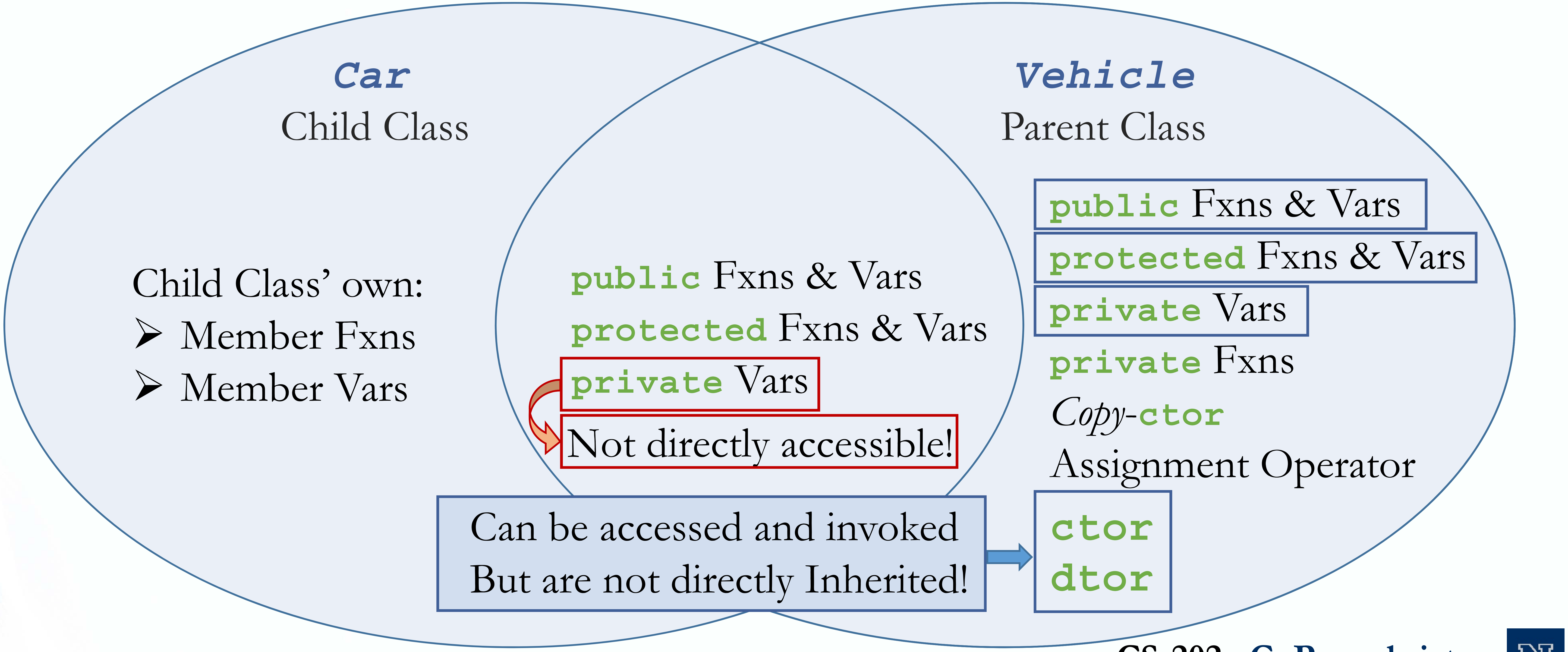
Assignment Operator

`ctor`

`dtor`

Inheritance

Inherited Member(s)



Car
Child Class

Child Class' own:

- ➢ Member Fxns
- ➢ Member Vars

`public` Fxns & Vars
`protected` Fxns & Vars
`private` Vars
Not directly accessible!

Can be accessed and invoked
But are not directly Inherited!

Vehicle
Parent Class

`public` Fxns & Vars
`protected` Fxns & Vars
`private` Vars
`private` Fxns
Copy-`ctor`
Assignment Operator
`ctor`
`dtor`

CS-202

Time for Questions !