CS-202

C++ Classes – Operator(s) (Pt.2)

C. Papachristos
Autonomous Robots Lab
University of Nevada, Reno

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 is *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
- Operator Overloading

Class `friend`(s)

Keyword `this`

Operator Overloading (continued)

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

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.

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.

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];
};
```

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];
};
```

Class Cheatsheet

Class Object Pointers:

```
<type_name>* <variable_name_Pt>;

Car myCar;

Car* myCar_Pt;

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

Object

Pointer to Object

- 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];
};
```

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];
};
```

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 !

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];
};
```

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];
};
```

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];
};
```

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.

A *Derived* Class

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

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

```
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];
};
```

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];
};
```

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];
};
```

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];
};
```

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;
}
```

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];
};
```

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]
    {0.,1.,2.,3.,…,3.,0.,1.,2.});
```

or

```
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];
};
```

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];
};
```

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];
};
```

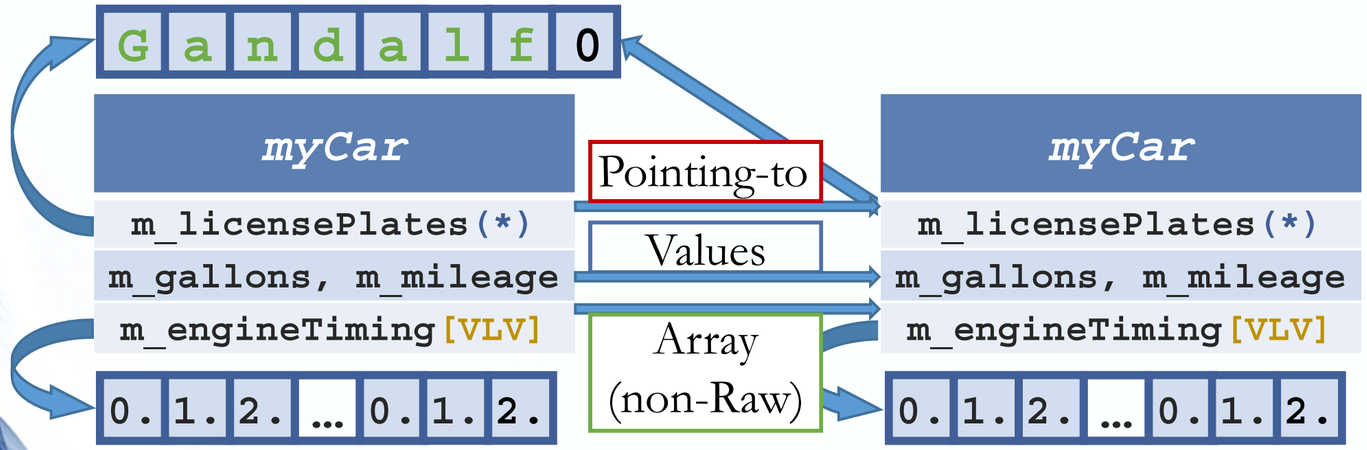
Class Cheatsheet

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];
};
```

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;
};
```

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;
};
```

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;
};
```

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;
};
```

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;
};
```

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;
};
```

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;
};
```

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;
};
```

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 Friend(s)

Friend Functions

Remember: Operator Overloads as no-Member function:

- Access of data through *Accessor* and *Mutator* functions.
- Very inefficient (call overhead).

Class `friend`(s) can directly access `private` Class data.

- Any function can be a Class `friend`.
- Make non-Member Operator Overloads `friend`(s) (no overhead, more efficient).

Operator Overloads as non-Member Class `friend`(s).

- Most common use (avoids need to go through Setter / Getter functions interface).
- Need data access anyway.

Class Friend(s)

Friend Functions

A `friend` Function of a Class is:

- *Not* a Member Function, but still has direct access to `private` members.
- Specified in Class Declaration (keyword `friend`) but still isn't a Member Function.

Friends and *Purity*:

- "Spirit" of OOP dictates all Operators and Functions must be Member Functions. (many believe `friend`(s) violate basic OOP principles.

However: Very advantageous for Operators:

- Allow automatic type conversion.
- Encapsulation is retained – `friend` is in Class Declaration.
- Improves efficiency.

Class Friend(s)

Friend Classes

A **friend** Class of another Class:

- Has direct access to **private** members.
- Is specified in Class Declaration (keyword **friend**).

Example: **class F** is **friend** of **class C**

- All **class F** Member Functions are **friend**s of **class C**.
- Not reciprocated relationship, **friend**ship granted, not taken!

```
class C {
  friend bool operator==(const C& c1,const C& c2); //A friend regular function
  friend class F;  //A friend class (all its member functions are friends)
  …
}
```

Functions have direct access to any private Members
(Data and Functions of **class C**)

Cascading

Return by-Reference – Cascading

Remember: Overloading Operator (`[]`)
Get `<type_id>&`, internal Member Reference:

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

```
class Money{
 int& operator[](const int i);
 int m_transID[T_HIST];
};
```

Another utility for Operator Overloading:

- Cascading (daisy-chaining):

```
double& chainableFun(double& var)
{  return var;  }

double x;
chainableFun(chainableFun(…(chainableFun(x))…));
```

Note: Cannot do `return var+1.0;`
`double&+double` has no Reference!
(it's a **rvalue** – and that's our limit – for now …)

```
error: invalid initialization of non-
const reference of type 'double&' from
an rvalue of type 'double'
```

Operator Overloading

Return by-Reference – Cascading

Overloading Operator (`<<`):

- Insertion (*Binary*) Operator.
- Used with `cout` Object (from `<iostream>` library).

Example:

```
cout << "Hello world!";
```

2nd Operand: C-string Literal

1st Operand: `class ostream` Object

Instead of:

```
hugeCheck.output();
```

We can overload it for a `class Money` type 2nd operand:

```
Money hugeCheck(1000000,0);
cout << hugeCheck;
```

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

Operator Overloading

Return by-Reference – Cascading

Overloading Operator (**<<**):

- Insertion (*Binary*) Operator.
- Used with ***cout*** Object (from **<iostream>** library).

Cascading how-to: Return by-1st-operand-Reference.

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

```
Money myMoney(99,25), yourMoney(0,75);
cout <<"Mine:"<<myMoney<<" Yours:"<<yourMoney;
```

Like calling:

```
operator<<(operator<<(operator<<(operator<<(cout
,"Mine:"),myMoney)," Yours:"),yourMoney);
```

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

Operator Overloading

Return by-Reference – Cascading

Overloading Operator (**>>**):

- Extraction (*Binary*) Operator.
- Used with ***cin*** Object (from **<iostream>** library).

Overloading and Cascading (return by-1st-operand-Ref).

```
istream& operator>>(istream& is, Money& mn){
   char dollarChar;
   is >> dollarChar;
   if (dollarChar=='$'){
     double dollarsDouble;
     is >> dollarsDouble;
     mn.m_dollars = dollarsDouble;
     mn.m_cents = 100*(dollarsDouble-mn.m_dollars);
   }
   return is;
}
```

```
class Money{
 public:
  Money();
  Money(int d, int c=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;
};
```

Operator Overloading

Overloading Operators (<<) , (>>)

```
1   #include <iostream>
2   #include <cstdlib>
3   #include <cmath>
4   using namespace std;

5   //Class for amounts of money in U.S. currency
6   class Money
7   {
8   public:
9       Money( );
10      Money(double amount);
11      Money(int theDollars, int theCents);
12      Money(int theDollars);
13      double getAmount( ) const;
14      int getDollars( ) const;
15      int getCents( ) const;
16      friend const Money operator +(const Money& amount1, const Money& amount2)
17      friend const Money operator -(const Money& amount1, const Money& amount2)
18      friend bool operator ==(const Money& amount1, const Money& amount2);
19      friend const Money operator -(const Money& amount);
20      friend ostream& operator <<(ostream& outputStream, const Money& amount);
21      friend istream& operator >>(istream& inputStream, Money& amount);
22  private:
23      int dollars; //A negative amount is represented as negative dollars and
24      int cents; //negative cents. Negative $4.50 is represented as -4 and -50.
25      int dollarsPart(double amount) const;
26      int centsPart(double amount) const;
27      int round(double number) const;
28  };
```

```
class Money{
 public:
  Money();
  Money(int d, int c=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;
};
```

Operator Overloading

Overloading Operators (<<) , (>>)

```
49  ostream& operator <<(ostream& outputStream, const Money& amount)
50  {
51      int absDollars = abs(amount.dollars);
52      int absCents = abs(amount.cents);
53      if (amount.dollars < 0 || amount.cents < 0)
54          //accounts for dollars == 0 or cents == 0
55          outputStream << "$-";
56      else
57          outputStream << '$';
58      outputStream << absDollars;
59      if (absCents >= 10)
60          outputStream << '.' << absCents;
61      else
62          outputStream << '.' << '0' << absCents;

63      return outputStream;
64  }
65
66  //Uses iostream and cstdlib:
67  istream& operator >>(istream& inputStream, Money& amount)
68  {
69      char dollarSign;
70      inputStream >> dollarSign; //hopefully
71      if (dollarSign != '$')
72      {
73          cout << "No dollar sign in Money input.\n";
74          exit(1);
75      }

76      double amountAsDouble;
77      inputStream >> amountAsDouble;
78      amount.dollars = amount.dollarsPart(amountAsDouble);
79      amount.cents = amount.centsPart(amountAsDouble);

80      return inputStream;
81  }
```

In the `main` *function,* `cout` *is plugged in for* `outputStream`.

For an alternate input algorithm, see Self-Test Exercise 3 in Chapter 7.

Returns a reference

In the `main` *function,* `cin` *is plugged in for* `inputStream`.

Since this is not a member operator, you need to specify a calling object for member functions of `Money`.

Returns a reference

```
class Money{
 public:
  Money();
  Money(int d, int c=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;
};
```

Operator Overloading

Overloading Operators (<<) , (>>)

```
29  int main( )
30  {
31      Money yourAmount, myAmount(10, 9);
32      cout << "Enter an amount of money: ";
33      cin >> yourAmount;
34      cout << "Your amount is " << yourAmount << endl;
35      cout << "My amount is " << myAmount << endl;
36
37      if (yourAmount == myAmount)
38          cout << "We have the same amounts.\n";
39      else
40          cout << "One of us is richer.\n";
41      Money ourAmount = yourAmount + myAmount;
42      cout << yourAmount << " + " << myAmount
43           << " equals " << ourAmount << endl;
44      Money diffAmount = yourAmount - myAmount;
45      cout << yourAmount << " - " << myAmount
46           << " equals " << diffAmount << endl;
47      return 0;
48  }
```

Since << returns a reference, you can chain << like this. You can chain >> in a similar way.

SAMPLE DIALOGUE

Enter an amount of money: **$123.45**
Your amount is $123.45
My amount is $10.09.
One of us is richer.
$123.45 + $10.09 equals $133.54
$123.45 - $10.09 equals $113.36

```
class Money{
 public:
  Money();
  Money(int d, int c=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;
};
```

Operator Overloading

Operators (++) , (--) (half the story, the rest for later)

Overloading Pre-Increment Operator(s):

- No arguments (for compiler *disambiguation*).

```
Money Money::operator++(){
  m_cents++;
  if (m_cents…){ m_dollars=…; m_cents=…; } //and fix
  return Money(m_dollars,m_cents);
}
```

Note:
Modifies calling Object and **return**s a Copy of it.

```
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;
};
```

Operator Overloading

Operators (**++**) , (**--**) (half the story, the rest for later)

Overloading Post-Increment Operator(s):

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

```
Money Money::operator++(int dummy){
   Money moneyCopy(m_dollars, m_cents);
   m_cents++;
   if (m_cents…){ m_dollars=…; m_cents=…; } //fix
   return moneyCopy;
}
```

Note: Keeps a Copy of calling Object to **return** and then modifies calling Object.

```
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;
};
```

This

Keyword `this`

A Pointer to the Calling Object.

- Inside a Class Member Function, we can address the Calling Object itself (and its members) "by-name" !
- Keyword `this` provides a way to address the entire Calling Object inside a Member Function call.

```
Money& Money::thisFunction(){
   this -> m_dollars = 1000; //access data
   this -> setC(99);         //call a method
   return *this;
}
```

Note: A Member Function can return a Reference to the Calling Object that invoked it.

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

Keyword `this`

Overloading Pre-Increment Operator(s) (now for the rest):

- 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;
};
```

Keyword `this`

Overloading Post-Increment Operator(s) (now for the rest) :

- 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;
};
```

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;
}
```

➢ Example: To protect from (unwillingly) tampering with own self:

```
Money cashiers[100];
Money* active_desk = cashiers;
active_desk += rand_desk_offset;

for (int i=0; i<100; ++i)
 active_desk->accrue(cashiers[i]);
```

Sums contents of all onto itself, but should avoid adding its own data twice (skip if Calling Object `active_desk` is the same as `cashiers[i]`)

```
class Money{
 public:
  Money();
  Money(int d, int c=0);
  Money(const Money &m);
  bool thisCheck(const
                 Money& m);
  void accrue(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;
};
```

Keyword `this`

Overloading Assignment Operator (`=`) (now for the rest) :

- `return` Reference to Calling Object, maintain Assignment Operator sequencing:

```
Money& Money::operator=(const Money& rhs){
  m_dollars = rhs.m_dollars;
  m_cents = rhs.m_cents;
  return *this;
}
```

- Maintain Assignment Operator sequencing:

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

a = b = c;
```

Can now do this too!

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

Keyword `this`

Overloading Assignment Operator (**=**) (now for the rest) :

- Check if calling object is trying to assign from itself (**r**ight-**h**and-**s**ide (**rhs**) argument is the same Object) :

```
Money& Money::operator=(const Money& rhs){
  if (this != &rhs) {
     m_dollars = rhs.m_dollars;
     m_cents = rhs.m_cents;
   }
   return *this;
}
```

- Protect from Self-Assignment:

```
Money a(4, 50);
a = a;
```

- Avoid unnecessary assignments.
- Protect dynamically allocated data …

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

CS-202

Time for Questions !