CS-202

C++ Classes – Operator(s) (Pt.1)

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Course Week

Course , Projects , Labs:

Monday	Tuesday	Wednesday	Thursday	Friday
			Lab (9:00-12:50)	
	CLASS		CLASS	
PASS Session	PASS Session	**Project DEADLINE**	NEW Project	

Your 4th Project will be announced today Thursday 9/21.

4th Project Deadline was this Wednesday 9/20.

- NO Project accepted past the 24-hrs delayed extension (@ 20% grade penalty).
- Send what you have in time!
- Check out **WebCampus** CS-202 Announcements for some **help** !

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 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.
- **`mixedCase`** 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:

- Capitalize first letter.

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 (->)

- 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 (->)

- 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 (tin[i]<… || tin[i]>…){ return false; }
  }
  for (int i=0;i<16;++i){
    m_engineTiming[i]=tin[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 (tin[i]<… || tin[i]>…) return false;
  }
  for (int i=0;i<16;++i){
    m_engineTiming[i]=tin[i];
  }
  return true;
}
```

Class Cheatsheet

Classes and Code File Structure

Program File: `car_prog.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;

   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 you have to define a *Default* (empty) constructor.

```
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];
};
```

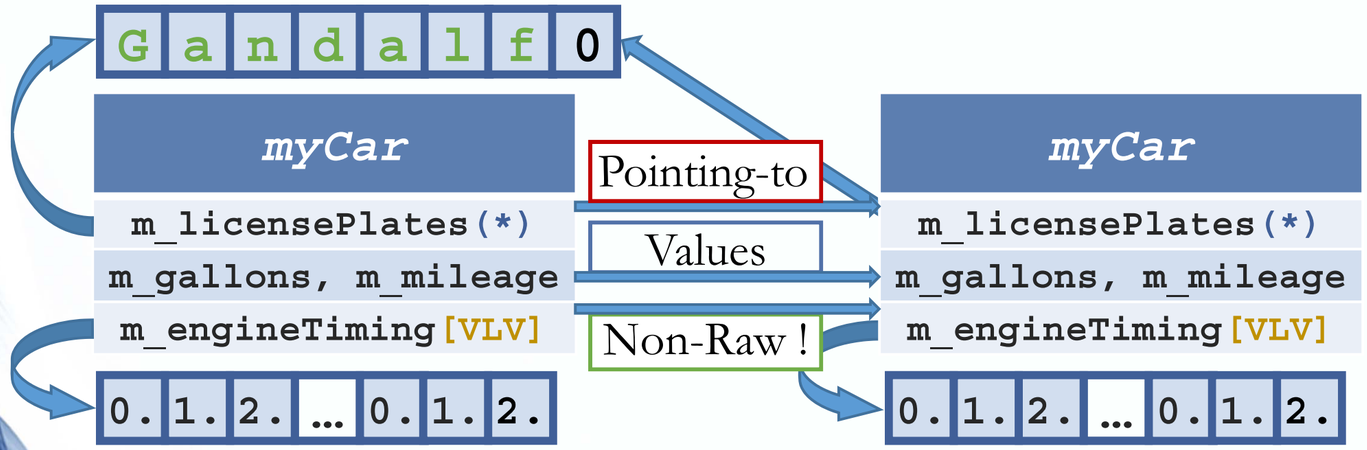
Class Cheatsheet

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, 19); //forever 19
```

```
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):

- *Aggregate* Class 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 licPlts[PLT], int fId) :
 Car(licPlts, DFT_GLNS,0, fId, DFT_TIM);
```

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 licPlts[PLT], int fId) :
Car(licPlts,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(){ carFactoryCnt++; } //dflt ctor

cout << Car::carFactoryCnt;     //via class
Car myCar1; //call dflt ctor, increment cnt
cout << myCar1.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:
 …
 static int carFactoryCnt;
};
```

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

int Car::carFactoryCnt = 0; //init
int Car::GetCarFactoryCnt(){
  return Car::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`

Note: 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 SetEngineTiming(double[VLV]);
 double m_engineTiming[VLV];
 const int m_frameId;
 static int carFactoryCnt;
};
```

Operator Overloading

Operators in Classes – Introduction

Remember Aggregate Class Initialization:

```
class Vacation{
  public:
    Vacation(int numDays, const Date& firstDay);
  private:
    int m_tripLength;
    Date m_startDay;
};

Vacation::Vacation(int numDays, const Date& firstDay){
  m_tripLength = numDays;
  m_startDay = firstDay;
}
```

```
class Date{
 public:
 Date();
 Date(int month,
  int day=DFT_D,
  int year=DFT_Y,
  bool gregorian=true);
 Date(const Date &date);

 void SetM/D/Y(int mdy);
 int GetM/D/Y() const;
 void ShiftNextDay();
 private:
 int m_month, m_day,
     m_year;
 const bool m_gregorian;
};
```

Operator Overloading

Operators in Classes – Introduction

Remember Aggregate Class Initialization:

```
class Vacation{
  public:
    Vacation(int numDays, const Date& firstDay);
  private:
    int m_tripLength;
    Date m_startDay;
};

Vacation::Vacation(int numDays, const Date& firstDay){
  m_tripLength = numDays;
  m_startDay = firstDay;
}
```

What would be the "meaning" of this (=) among **Date**s ?

Compiler creates a default *Assignment* Operator (=) for Class Objects: a ***Member****-Copy*.

```
class Date{
 public:
 Date();
 Date(int month,
  int day=DFT_D,
  int year=DFT_Y,
  bool gregorian=true);
 Date(const Date &date);

 void SetM/D/Y(int mdy);
 int GetM/D/Y() const;
 void ShiftNextDay();
 private:
 int m_month, m_day,
     m_year;
 const bool m_gregorian;
};
```

Operator Overloading

Operators (`+`, `-`, `%`, `==`, etc.) **and Built-in Types** (`int`, `double`, etc.)

In reality they represent Functions.

- Simply "called" with different syntax:

```
x + 7;
```

(`+`) is binary operator with x and 7 as operands.

- It's just a more intuitive notation for humans, instead of:

```
+(x, 7);
```

Function Arguments

Function Name

Operator Overloading

Operator(s) and Custom Types

Useful to have an Operator work with user-defined types?

- Operator (**+**) :

```
classObject3 = classObject1 + classObject2;
```

```
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;
};
```

Operator Overloading

Operator(s) and Custom Types

Useful to have an Operator work with user-defined types?

- Operator (**+**) :

```
classObject3 = classObject1 + classObject2;
```

Meaningful to apply it on a user-defined type?

- `myMoney = myMoney + salaryMoney;` Makes sense?
- `someDate = startDate + endDate;`

```
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;
};
```

Operator Overloading

Operator(s) and Custom Types

Useful to have an Operator work with user-defined types?

- Operator (**+**) :

```
classObject3 = classObject1 + classObject2;
```

Meaningful to apply it on a user-defined type?

- `myMoney = myMoney + salaryMoney;` Makes sense?
- `someDate = startDate + endDate;` Makes sense?

```
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;
};
```

Operator Overloading

Operator(s) and Custom Types

Useful to have an Operator work with user-defined types?

- Operator (+) :

```
classObject3 = classObject1 + classObject2;
```

Meaningful to apply it on a user-defined type?

- `myMoney = myMoney + salaryMoney;` Makes sense?
- `someDate = startDate + endDate;` Makes sense?

Particular challenges to keep it meaningful?

- `myMoney = myMoney + salaryMoney;`

```
${1000,125} =  ${0,75}  +  ${1000,50}
```

```
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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading *Binary* Operator (**==**):

- Non-Member Function of Class ***Money***.
- Like overloading functions, Operator is Function name.

Syntax:

```
bool operator ==(const Money& amount1,
                 const Money& amount2);
```

```
83  bool operator ==(const Money& amount1, const Money& amount2)
84  {
85      return ((amount1.getDollars( ) == amount2.getDollars( ))
86              && (amount1.getCents( ) == amount2.getCents( )));
87  }
```

- "Compares" ***Money*** Objects.

```
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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading *Binary* Operator (`==`):

- Non-Member Function of Class ***Money***.
- Like overloading functions, Operator is Function name.

Syntax:

```
bool operator ==(const Money& amount1,
                 const Money& amount2);
```

```
83  bool operator ==(const Money& amount1, const Money& amount2)
84  {
85      return ((amount1.getDollars( ) == amount2.getDollars( ))
86              && (amount1.getCents( ) == amount2.getCents( )));
87  }
```

- "Compares" ***Money*** Objects.

```
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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading *Unary* Operator (**-**):

- Non-Member Function of Class ***Money***.
- Like overloading functions, Operator is Function name.

Syntax:

```
const Money operator -(const Money& amount) {
 return Money(-amount.GetD(),-amount.GetC());
}
```

Example:

```
Money moneyIn(1000, 0);
Money moneyOut = - moneyIn;
```

- "Negates" a ***Money*** Object.
- Returns an *Unnamed* 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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading *Unary* Operator (**-**):

- Non-Member Function of Class ***Money***.
- Like overloading functions, Operator is Function name.

Syntax:

```
const Money operator -(const Money& amount) {
 return Money(-amount.GetD(),-amount.GetC());
}
```

Example:

```
Money moneyIn(1000, 0);
Money moneyOut = - moneyIn;
```

- "Negates" a ***Money*** Object.
- Returns an *Unnamed* 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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (**+**):

- Non-Member Function of Class ***Money***.
- Like overloading functions, Operator is Function name.

Syntax:

```
const Money operator +(const Money& amount1,
                       const Money& amount2);
```

"Adds" ***Money*** Objects:

- Overloads **+** for operands of type ***Money***.
- Uses **const**-Reference Parameters for efficiency.
- Returned value is of type ***Money***, *Unnamed* 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;
};
```

Operator Overloading

Overloading Operator(s)

Still, like a regular *Overloaded* Function:

- Non-Member Function of Class ***Money***.
- More "involved" than Member-by-Member adding.

```
52  const Money operator +(const Money& amount1, const Money& amount2)
53  {
54      int allCents1 = amount1.getCents( ) + amount1.getDollars( )*100;
55      int allCents2 = amount2.getCents( ) + amount2.getDollars( )*100;
56      int sumAllCents = allCents1 + allCents2;
57      int absAllCents = abs(sumAllCents); //Money can be negative.
58      int finalDollars = absAllCents/100;
59      int finalCents = absAllCents%100;

60      if (sumAllCents < 0)
61      {
62          finalDollars = -finalDollars;
63          finalCents = -finalCents;
64      }

65      return Money(finalDollars, finalCents);
66  }
```

```
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;
};
```

Operator Overloading

Overloading Operator(s)

Still, like a regular *Overloaded* Function:

- Non-Member Function of Class ***Money***.
- More "involved" than Member-by-Member adding.

```
52  const Money operator +(const Money& amount1, const Money& amount2)
53  {
54      int allCents1 = amount1.getCents( ) + amount1.getDollars( )*100;
55      int allCents2 = amount2.getCents( ) + amount2.getDollars( )*100;
56      int sumAllCents = allCents1 + allCents2;
57      int absAllCents = abs(sumAllCents); //Money can be negative.
58      int finalDollars = absAllCents/100;
59      int finalCents = absAllCents%100;

60      if (sumAllCents < 0)
61      {
62          finalDollars = -finalDollars;
63          finalCents = -finalCents;
64      }

65      return Money(finalDollars, finalCents);
66  }
```

```
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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (**+**):

- A Member Function of Class ***Money***.

Syntax (Function Prototype):

```
const Money operator +(const Money& m) const;
```

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (**+**):

- A Member Function of Class ***Money***.
- Calling Object serves as 1st parameter.

Syntax (Function Prototype):

```
const Money operator +(const Money& m) const;
```

Example:

```
Money cost(1, 50), tax(0, 15), total;
total = cost + tax;
```

Intuitively:

```
total = cost .operator+(tax);
```

Calling Object

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (**+**):

- A Member Function of Class ***Money***.
- Calling Object serves as 1st parameter.

Syntax (Function Prototype):

```
const Money operator +(const Money& m) const;
```

Example:

```
Money cost(1, 50), tax(0, 15), total;
total = cost + tax;
```

Intuitively:

```
total = cost .operator+(tax);
```

Operator Member Function

Calling Object

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (+):

- Non-Member Function version.

```
const Money operator+(const Money&a,const Money&b){
  return Money(a.GetD() + b.GetD(),
               a.GetC() + b.GetC() );
}
```

No access to Parameter `private` Members

- Member Function of Class ***Money*** version.

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

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (+):

- Non-Member Function version.

```
const Money operator+(const Money&a,const Money&b){
  return Money(a.GetD() + b.GetD(),
               a.GetC() + b.GetC() );
}
```

- Member Function of Class *Money* version.

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

Calling Object's Members

Class Method (access to Parameter `private` Members)

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (+) , Twice:

- Non-Member Function version.

```
const Money operator+(const Money&a,const Money&b)
{   return Money(1);   }
```

- Member Function of Class *Money* version.

```
const Money Money::operator+(const Money&b) const
{   return Money(2);   }
```

```
warning: ISO C++ says that these are ambiguous, even
though the worst conversion for the first is better
than the worst conversion for the second.
```

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (+) , Twice:

- Non-Member Function version.

```
const Money operator+(const Money&a,const Money&b)
{  return Money(1);  }
```

- Member Function of Class *Money* version.

```
const Money Money::operator+(const Money&b) const
{  return Money(2);  }
```

```
warning: ISO C++ says that these are ambiguous, even
though the worst conversion for the first is better
than the worst conversion for the second.
```

```
Money m1,m2, m3 = m1 + m2;
```
Result: 1

```
Money m1,m2, m3 = m1 .operator+ ( m2 );
```
Result: 2

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (-) , Twice (w/ intention):

- Non-Member Function: *Unary.*

```
const Money operator-(const Money &amount){
  return Money(-amount.GetD() , -amount.GetC());
}
```

- Member Function of Class: *Binary.*

```
const Money Money::operator-(const Money&b) const{
  Money tmpMoney(m_dollars - b.m_dollars,
                 m_cents   - b.m_cents );
  /* create temporary object and work with it
     as we go, code to try and fix rollover. */
  return tmpMoney;
}
```

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (-) , Twice (w/ intention):

- Non-Member Function: *Unary*.

```
const Money operator-(const Money &amount){
  return Money(-amount.GetD() , -amount.GetC());
}
```

- Member Function of Class: *Binary*.

```
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 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (-) , Twice (w/ intention):

- Non-Member Function: *Unary.*

```
const Money operator-(const Money &amount);
```

- Member Function of Class: *Binary.*

```
const Money Money::operator-(const Money&b) const;
```

Note:
Cannot change Operator Precedence, Associativity rules.

Example calls:

```
Money myPocket(10), myDebts(6,25);
Money myLiving = myPocket - myDebts;
```
{3,75}

Binary

```
Money notMyDebts = - myDebts;
```
{-6,-25}

Unary

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (**=**) :

- Must be Member Operator.
- If not specified, defaults to Member-Copy Assignment.
- *Remember* ***Deep****-Copy* vs ***Shallow****-Copy*.

```
void Money::operator=(const Money &amount){
  m_dollars = amount.dollars;
  m_cents = amount.m_cents;
  strcpy(m_owner, amount.m_owner);
}
```

Value-copy

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(const Money &m);
 void operator =
       (const Money& m);
 void SetD/C(int dc);
 int GetD/C() const;
 private:
 int m_dollars;
 int m_cents;
 char* m_owner;
};
```

Operator Overloading

Overloading Operator(s)

Overloading Operator (**=**) :

- Must be Member Operator.
- If not specified, defaults to Member-Copy Assignment.
- *Remember* ***Deep****-Copy* vs ***Shallow****-Copy*.

```
void Money::operator=(const Money &amount){
  m_dollars = amount.dollars;
  m_cents = amount.m_cents;
  strcpy(m_owner, amount.m_owner);
}
```

Value-copy

User-guaranteed Data-copy on raw Pointers

Note: Class `ctor` needs to have properly allocated memory for the raw Pointer Data.

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(const Money &m);
 void operator =
       (const Money& m);
 void SetD/C(int dc);
 int GetD/C() const;
 private:
 int m_dollars;
 int m_cents;
 char* m_owner;
};
```

Operator Overloading

Return by-const-Value

Overloading Operator (+) , again:

- Returned: type *Money*, *Unnamed* Object.

```
const Money operator+(const Money&a,const Money&b){
   return Money(a.GetD() + b.GetD(),
                a.GetC() + b.GetC() );
}
```

Why const-Value ?

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

Evaluates to: *Unnamed* Object

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Return by-`const`-Value

Overloading Operator (**+**) , again:

- Returned: type ***Money***, *Unnamed* Object.

```
const Money operator+(const Money&a,const Money&b){
   return Money(a.GetD() + b.GetD(),
                a.GetC() + b.GetC() );
}
```

Why `const`-Value ?

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

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

Evaluates to: *Unnamed* Object

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

OK…

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Return by-const-Value

Overloading Operator (+) , again:

- Returned: type *Money*, *Unnamed* Object.

```
const Money operator+(const Money&a,const Money&b){
   return Money(a.GetD() + b.GetD(),
                a.GetC() + b.GetC() );
}
```

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…

```
error: passing 'const Money' as 'this' argument discards
       qualifiers [-fpermissive]
```

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Return by-`const`-Reference (?)

Overloading Operator (**+**) , again:

- Returned: type ***Money&***, *Unnamed* Object Reference.

```
const Money& operator+(const Money&a,const Money&b)
{  return Money(a.GetD() + b.GetD(),
                a.GetC() + b.GetC() );  }
```

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

- Makes a temporary Object, goes out of scope!

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Return by-`const`-Reference (?)

Overloading Operator (+) , again:

- Returned: type ***Money&***, *Unnamed* Object Reference.

```
const Money& operator+(const Money&a,const Money&b)
{  return Money(a.GetD() + b.GetD(),
                a.GetC() + b.GetC() );  }
```

```
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!

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(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;
};
```

Operator Overloading

Return by-Reference

Overloading Operator (`[]`):

- Returned: `<type_id>&`, internal Member Reference.

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

- Accessing (`private`) Data Member by-Reference.

```
class Money{
 public:
 Money();
 Money(int dollars,
  int cents=0);
 Money(const Money &m);
 int& operator[](const
              int index);
 void SetD/C(int dc);
 int GetD/C() const;
 private:
 int m_dollars;
 int m_cents;
 int m_transID[T_HIST];
};
```

Operator Overloading

Return by-Reference

Overloading 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);
 void SetD/C(int dc);
 int GetD/C() const;
 private:
 int m_dollars;
 int m_cents;
 int m_transID[T_HIST];
};
```

Operator Overloading

Remember All Operators ?

Overload just about anything, but be VERY careful…

- `[ ]`
- `*` : Multiplication, Pointer Dereference
- `/` : Division
- `+` : Addition, Unary Positive
- `-` : Subtraction, Unary Negative
- `++` : Increment, Pre-and-Post
- `--` : Decrement, Pre-and-Post
- `=` : Assignment
- `<=`, `>=`, `<`, `>`, `==`, `!=` : Comparisons
- Many, many others…

Operator Overloading

Remember All Operators ?

Some are out, some should be kept untouched…

- `?` : Ternary Conditional is not Overloadeable.

- `&&`, `||`, built-in versions are defined for `bool` types.
  Use "Short-Circuit Evaluation", also available in C++.
- When overloaded no longer uses "Short-Circuit", but "Complete Evaluation".
  Generally should not overload these operators,
  (also Operator Overloading had better "make sense").

CS-202

Time for Questions !