Classes

Part 3

CMSC 202

Warmup

Using the following **part** of a class, implement the Sharpen() method, it removes 1 from the length:

```
class Pencil
{
  public:
    bool Sharpen();
  private:
    int m_length;
};
```

Class Review

```
class DayOfYear
{
    public:
        void Input( );
        void Output( );

        void Set( int newMonth, int newDay );
        void Set( int newMonth );

        int GetMonthNumber( );
        int GetDay( );
    private:
        int m_month;
        int m_day;
};

// Declaring a DayOfYear object
DayOfYear today;
```

Facilitators: Input( ), Output( )

Mutators: Set(...)

Accessors: GetMonthNumber( ), GetDay( )

What's going on here? (pointing to `DayOfYear today;`)

Constructors

Special Methods that "build" (construct) an object
- Supply default values
- Initialize an object

Syntax:

```
ClassName();
ClassName::ClassName(){ /* code */ }
```

Notice
- No return type
- Same name as class!

Constructor Example

```
class DayOfYear
{
  public:
   DayOfYear( int initMonth, int initDay );

   void Input( );
   void Output( );

   void Set( int newMonth, int newDay );
   void Set( int newMonth );

   int GetMonthNumber( );
   int GetDay( );
  private:
   int m_month;
   int m_day;
};
```

Constructor Example Implementation

```
DayOfYear::DayOfYear( int initMonth, int initDay )
{
  m_month = initMonth;
  m_day = initDay;
}

// Improved version
DayOfYear::DayOfYear( int initMonth, int initDay )
{
  Set(initMonth, initDay);
}
```

How can this method be improved?

Why use a mutator?

Constructor Example Implementation

Initialization Lists

- Alternative to assignment statements (sometimes necessary!)
- Comma-separated list following colon in method definition

Syntax:

```
DayOfYear::DayOfYear( int initMonth, int initDay )
  : m_month( initMonth ), m_day( initDay )
{
}
```

Overloading Functions

C limitation

- Functions are unique based on name

C++ extention

- Functions are unique based on name AND parameter list (type and number)

Overloading

- Declaring two or more functions with same name
- Must have different parameter lists
  - Return types are NOT used to differentiate functions

Overloading Constructors

Yes – different parameter lists

Example

```
class DayOfYear
{
  public:
   DayOfYear( int initMonth, int initDay );

   DayOfYear( int initMonth );

   DayOfYear( );

   // other public methods…
  private:
   int m_month;
   int m_day;
};
```

Overloading Example

```
int AddTwo( int a, int b)
{
   return a + b;
}

double AddTwo( double a, double b)
{
   return a + b;
}

int main()
{
   cout << AddTwo(3, 4) << endl;
   cout << AddTwo(3.0, 4.0) << endl;
   cout << AddTwo(3, 4.0) << endl;
   cout << AddTwo(3.0, 4) << endl;
   return 0;
}
```

Interesting…

What happens with this?

```
int AddTwo( int a, int b){
   return a + b;
}

double AddTwo( double a, double b) {
   return a + b;
}

int main() {
   cout << AddTwo(3.0, 4) << endl;
   return 0;
}
```

Overloading Constructors

```
DayOfYear::DayOfYear( int initMonth, int initDay )
{
  Set(initMonth, initDay);
}

DayOfYear::DayOfYear( int initMonth )
{
  Set(initMonth, 1);
}

DayOfYear::DayOfYear( )
{
  Set(1, 1);
}
```

What would be another alternative to having all 3 of these methods?

Overloading Constructors

```
class DayOfYear
{
  public:
   DayOfYear( int initMonth = 1, int initDay = 1 );

   // other public methods…
  private:
   int m_month;
   int m_day;
};

DayOfYear::DayOfYear( int initMonth, int initDay  )
{
  Set(initMonth, initDay);
}
```

Default Parameters!

Constructors

- Why haven't we seen this before?
  - Compiler builds a default constructor
    - Unless you define a constructor…
- Think about the following:
  - DayOfYear bachBirthday;
    - Calls default constructor for DayOfYear!
- What if something goes wrong?
  - Throw exception (later…)

Const and Objects

- With an Object

```
const DayOfYear jan1st(1, 1);
jan1st.Set(1, 5);     // ERROR
```

```
myfile.cpp: In function `int main()':
myfile.cpp:20: passing `const DayOfYear' as
  `this' argument of `void DayOfYear::Set(int,
  int)' discards qualifiers
```

Const and Methods

Const member functions
- Promise not to modify the current object
  - Usually accessors, print functions, …

Compiler checks
- Directly – is there an assignment to data member in method?
- Indirectly – is there a call to a non-const method?

Syntax

```
retType methodName(parameters) const;
```

Const Example

```
class DayOfYear
{
  public:
   DayOfYear( int initMonth = 1, int initDay = 1 );

   void Input( );
   void Output ( ) const;

   void Set( int newMonth, int newDay );
   void Set( int newMonth );

   int GetMonthNumber ( ) const;
   int GetDay( ) const;
  private:
   int m_month;
   int m_day;
};
```

Promise not to alter data members!

Const Rules

Const member functions
- Can be called on const and non-const objects
- Can call other const member functions
- Cannot call non-const member functions

Non-const member functions
- Can be called only on non-const objects
  - Otherwise, compiler error!
- Can call const and non-const member functions

Const objects
- Can be passed as const argument

Non-const objects
- Can be passed as const or non-const argument

Practice

What is wrong with this?

```
int DayOfYear::GetDay ( ) const
{
   if (m_day < 1 )
      Set( m_month, 1 );
   return m_day;
}
```

Practice

What is wrong with this?

```
void Bob ( const DayOfYear& doy)
{
   OutputDayOfYear ( doy );

   cout << "Please enter your birth month and day \n";

   int birthMonth, birthDay;
   cin >> birthMonth >> birthDay;

   doy.Set( birthMonth, birthDay );
}
```

Implementing with Const

- Start from the beginning
  - Don't try to add const at the end of implementing
- Use for
  - Member functions that don't change object
    - Facilitators (maybe) and Accessors (most definitely)
  - Parameters whenever reasonable
    - Not with pass-by-value
    - Yes with pass-by-reference

Aggregation

Objects can hold other objects!

- Class defines a private data member of another Class-type
- "has-a" relationship

Example

```
class Student
{
    public:
        // some methods…
    private:
        Address m_address;
        // more data…
};
```

Aggregation – Another Look

```
class Vacation
{
    public:
        Vacation( int month, int day, int nbrOfDays );
        // more methods…
    private:
        DayOfYear m_startDay;
        int m_lengthOfTrip;
        // more data…
};

Vacation::Vacation( int month, int day, int nbrOfDays )
    : m_startDay(month, day), m_lengthOfTrip(nbrOfDays)
{
    // code…
}
```

What's going on here?

Implicit call to the Constructor! Remember – initializer lists were important! Only way to call Constructor!

Aggregation

```
class Vacation
{
    public:
        Vacation( int month, int day, int
          nbrOfDays );
        // more methods…
    private:
        DayOfYear m_startDay;
        int m_lengthOfTrip;
        // more data…
};
```

Can Vacation access DayOfYear's private data members?

Aggregation

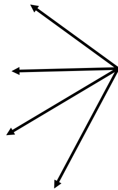
House "has-a"
- Front Door
- Set of bedrooms
- Garage
- Address

Garage "has-a"
- Lawnmower
- Rake
- Car

Car "has-a"
- Driver
- Set of passengers

Driver "has-a"
- Name
- Address

...



You can have as many layers of aggregation as you need – until you get to a set of primitive types!

Static

```
int foobar()
{
   int a = 10;
   ++a;
   return a;
}
```

```
int foobar()
{
   static int a = 10;
   ++a;
   return a;
}
```

Static and Classes

Static data member
- ALL objects share data
- If one changes, affects all

Static methods
- Can access static data
- CANNOT access non-static data or methods

Regular methods
- Can access static data
- Can access non-static data and methods

Static Example

```
class Person
{
    public:
        static bool SpendMoney(int amount);
    private:
        static Wallet m_wallet;
        Wallet m_moneyClip;
};

// In Person.h

Wallet Person::m_wallet(0);

bool Person::SpendMoney( int amount )
{
    m_wallet.RemoveMoney(amount);
    m_moneyClip.RemoveMoney(amount); // compiler error!!!
}
```

```
// In main

// Create a person
Person Bob;

// Bob adds money to the wallet
Bob.AddMoney(100);

// Anyone can call SpendMoney!
Person::SpendMoney(100);

// Bob has no money!
Bob.SpendMoney(10); // fails!!
```

Designing Classes

- Ask yourself the following questions:
  - What are the responsibilities of this type of object?
  - What actions can an object take?
  - What actions can another function take on an object?
  - What information does an object store?
  - What information does an object need access to?
- For each method:
  - What parameters (const, ref, const-ref, val)?
    - Preconditions – what values are legal for parameters?
  - What return value (const, ref, const-ref, val)?
    - Postconditions – what was altered by method?
  - Does this method change the object (const, non-const)?

Incremental / Modular Development & Compilation

- General Programming Approach
  - Bottom-Up Development
    - Work on one class
    - Write one method at a time
      - Develop, test, repeat
    - Test class in isolation
  - Bottom-Up Testing
    - Test one class in isolation
    - Test two classes in isolation
      (when they are connected)
    - …
    - Test all classes together