CIS 190: C/C++ Programming

Lecture 8

Classes in C++

Outline

- Procedural Programming vs OOP
- Classes
  - Example: Morphing from Struct
  - Basics
  - Access
  - Constructors
  - Overloading
- Livecoding

Procedural Programming

- up until now, everything we've been doing has been ***procedural programming***

- code is divided into multiple procedures
  - procedures operate on data (structures), when given correct number and type of arguments

- examples: PrintTrain(), ReadSingerFile(), DestroyList(), ProcessEvents(), etc.

Object-Oriented Programming

- now that we're using C++, we can start taking advantage of ***object-oriented programming***

- adding OOP to C was one of the driving forces behind the creation of C++ as a language
  - C++'s predecessor was actually called "C with Classes"

Object-Oriented Programming

- in OOP, code and data are combined into a single entity called a ***class***
  - each ***instance*** of a given class is an ***object*** of that class type

- principles of Object-Oriented Programming
  - encapsulation
  - inheritance
  - polymorphism

OOP: Encapsulation

- ***encapsulation*** is a form of information hiding and abstraction
- data and functions that act on that data are located in the same place (inside a class)

- *ideal:* separate the interface/implementation so that you can use the former without any knowledge of the latter

OOP: Inheritance

- ***inheritance*** allows us to create and define new classes from an existing class

- this allows us to re-use code
  - faster implementation time
  - fewer errors
  - easier to maintain/update

OOP: Polymorphism

- ***polymorphism*** is when a single name can have multiple meanings
  - normally used in conjunction with inheritance

- we'll look at one form of polymorphism today:
  - overloading functions

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Example: Date

```
typedef struct date {
   int    month;
   int    day;
   int    year;
} DATE;
```

Parts of a Struct

```
typedef struct date {
   int    month;
   int    day;
   int    year;
} DATE;
```

name of the struct

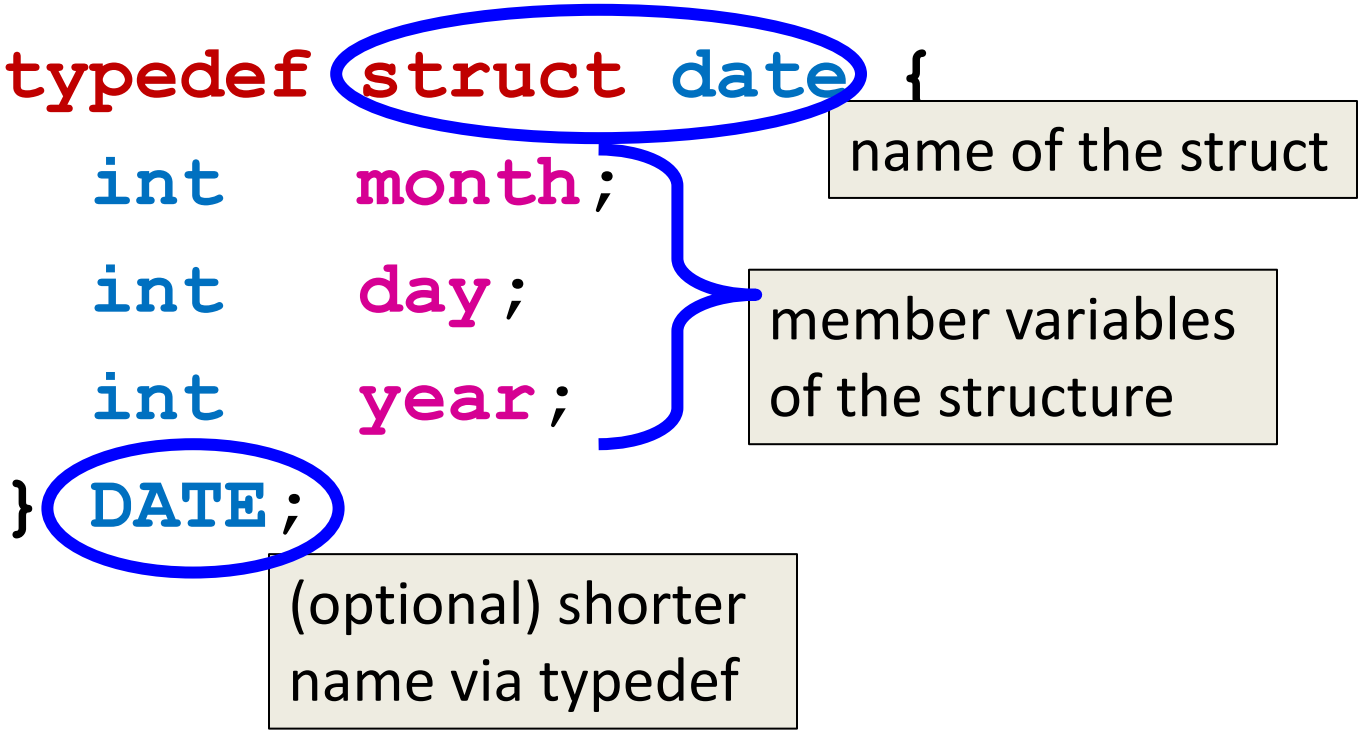
Parts of a Struct

```
typedef struct date {
   int    month;
   int    day;
   int    year;
} DATE;
```

name of the struct

(optional) shorter name via typedef

Parts of a Struct



Using a Struct

- if we want to print a date using the struct, what should our function prototype be?

```
____ PrintDate(_________);
```

Using a Struct

- if we want to print a date using the struct, what should our function prototype be?

```
void PrintDate(DATE day);
```

Using a Struct

- if we want to print a date using the struct, what should our function prototype be?

```
void PrintDate(DATE day);
```

- if we want to change the year of a date, what should our function prototype be?

```
____ ChangeYear(_____________________);
```

Using a Struct

- if we want to print a date using the struct, what should our function prototype be?

```
void PrintDate(DATE day);
```

- if we want to change the year of a date, what should our function prototype be?

```
void ChangeYear(DATE day, int year);
```

Morphing from Struct to Class

```
typedef struct date {
   int    month;
   int    day;
   int    year;
} DATE;
```

Morphing from Struct to Class

```
struct date {
   int    month;
   int    day;
   int    year;
};
```

- remove the **`typedef`** – we won't need it for the class

Morphing from Struct to Class

```
class date {
   int    month;
   int    day;
   int    year;
};
```

- change **`struct`** to **`class`**

Morphing from Struct to Class

```
class Date {
   int    month;
   int    day;
   int    year;
};
```

- capitalize date – according to the style guide, classes are capitalized, while structs are not

Morphing from Struct to Class

```
class Date {
   int m_month;
   int m_day;
   int m_year;
};
```

- add **m_** to the variable names – classes are more complicated, this can help prevent confusion about which vars are member vars

Morphing from Struct to Class

```
class Date {
public:
   int m_month;
   int m_day;
   int m_year;
};
```

- make the variables **`public`**,
  to be able to access them
  - by default, members of a class are private

Morphing from Struct to Class

```
class Date {
public:
   int m_month;
   int m_day;
   int m_year;
};
```

- syntax highlighted colors change

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Functions in Classes

- unlike structs, classes have ***member functions*** along with their member variables

- member functions go inside the class declaration
- member functions are called on an object of that class type

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```
iStream.open("file.txt");
```

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iStream.open("file.txt");
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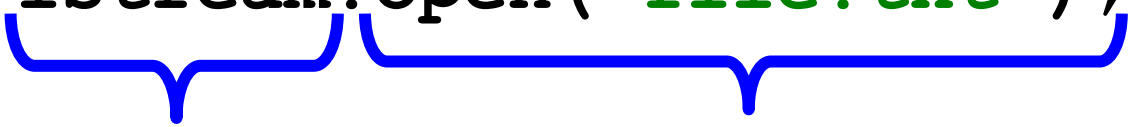

Example: OutputMonth() Function

- let's add a function to the class that will print out the name of the month

```
class Date {
public:
   int m_month;
   int m_day;
   int m_year;
};
```

Example: OutputMonth() Function

- let's add a function to the class that will print out the name of the month

```
class Date {
public:
   int m_month;
   int m_day;
   int m_year;
   void OutputMonth();
};
```

Example: OutputMonth() Function

- let's add a function to the class that will print out the name of the month, given the number

```
class Date {
public:
   int m_month;
   int m_day;
   int m_year;
   void OutputMonth();
};
```

function prototype

OutputMonth()

```
void OutputMonth();
```

- nothing is passed in to the function – why?

OutputMonth() Prototype

```
void OutputMonth();
```

- nothing is passed in to the function
- because it only needs access to see the variable **`m_month`**
  - which is a ***member variable*** of the Date class
  - just like OutputMonth() is a ***member function***

OutputMonth() Definition

```
void Date::OutputMonth()  {




}
```

OutputMonth() Definition

```
void Date::OutputMonth()  {

}
```

specify class name; more than one class can have a function with the same name

OutputMonth() Definition

```
void Date::OutputMonth()  {



}
```

this double colon is called the ***scope resolution operator***, and associates the ***member function*** **`OutputMonth()`** with the class **`Date`**

OutputMonth() Definition

```
void Date::OutputMonth() {
   switch (m_month) {
      case 1: cout << "January "; break;
      case 2: cout << "February "; break;
      case 3: cout << "March "; break;
      /* etc */
      default:
         cout << "Error in Date::OutputMonth";
   }
}
```

OutputMonth() Definition

```
void Date::OutputMonth() {
   switch (m_month) {
      case 1: co
      case 2: co
      case 3: co
      /* etc */
      default:
         cout << "Error in Date::OutputMonth";
   }
}
```

we can directly access **m_month** because it is a ***member variable*** of the **Date** class, to which **OutputMonth** ( ) belongs

Print Functions

- is the following valid code?

```
cout << today.OutputMonth();
```

Print Functions

- is the following valid code?

```
cout << today.OutputMonth();
```

- no, because **`OutputMonth()`** returns nothing for **`cout`** to print
  - if the function returned a string, this would be valid code

Using the Date Class

```
Date today;
```

Using the Date Class

```
Date today;
```

variable **`today`** is an ***instance*** of the class **`Date`**

it is an ***object*** of type **`Date`**

Using the Date Class

```
Date today;

cout << "Please enter dates as DD MM YYYY"
     << endl;

cout << "Please enter today's date: ";
cin >> today.m_day >> today.m_month
    >> today.m_year;
```

Using the Date Class

```
Date today;

cout << "Please enter dates as DD MM YYYY"
     << endl;

cout << "Please enter today's date: ";
cin >> today.m_day >> today.m_month
    >> today.m_year;
```

when we are not inside the class (as we were in the **`OutputMonth()`** function) we must use the dot operator to access **`today`**'s ***member variables***

Using the Date Class

```
Date today;

cout << "Please enter dates as DD MM YYYY"
     << endl;

cout << "Please enter today's date: ";
cin >> today.m_day >> today.m_month
    >> today.m_year;

cout << "Today's date is ";
today.OutputMonth();
cout << today.m_day << ", "
     << today.m_year << endl;
```

Using the Date Class

```
Date today;

cout << "Please enter dates as DD MM YYYY"
     << endl;

cout << "P
cin >> tod
    >> tod

cout << "T

today.OutputMonth();
cout << today.m_day << ", "
     << today.m_year << endl;
```

we also use the dot operator to call the ***member function*** **`OutputMonth()`** on the **`Date`** object **`today`**

again, note that we do not need to pass in the ***member variable*** **`m_month`**

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Access Specifiers

- in our definition of the **Date** class, everything was **public** – this is not good practice!

- why?

Access Specifiers

- we have three different options for ***access specifiers***, each with their own role:
  - public
  - private
  - protected

- specify access for members inside the class

Toy Example

```
class Date {
public:
   int m_month;
private:
   int m_day;
protected:
   int m_year;
};
```

Using Public, Private, Protected

- **`public`**
  - anything that has access to a **`Date`** object also has access to all public member variables and functions

- not normally used for variables;
  used for most functions

- need to have at least one item be public

Using Public, Private, Protected

- **`private`**
  - private members variables and functions can only be accessed by ***member functions*** of the **`Date`** class; cannot be accessed in main(), etc.

- if not specified, members default to private
  - should specify anyway – good coding practices!

Using Public, Private, Protected

- **`protected`**
  - protected member variables and functions can only be accessed by ***member functions*** of the **`Date`** class, and by member functions of any derived classes
  - (we'll cover this later)

Access Specifiers for Date Class

```
class Date {
???????:
  void OutputMonth();
???????:
  int m_month;
  int m_day;
  int m_year;
};
```

Access Specifiers for Date Class

```
class Date {
public:
   void OutputMonth();
private:
   int m_month;
   int m_day;
   int m_year;
};
```

New Member Functions

- now that **`m_month`**, **`m_day`**, and **`m_year`** are ***private***, how do we give them values, or retrieve those values?

New Member Functions

- now that **`m_month`**, **`m_day`**, and **`m_year`** are ***private***, how do we give them values, or retrieve those values?

- write public member functions to provide indirect, controlled access for the user
  - *ideal:* programmer only knows interface (public functions) not implementation (private variables)

Member Function Types

- there are many ways of classifying types, but here's a few of the basics we'll use:

- accessor functions
- mutator functions
- auxiliary functions

Member Functions: Accessor

- *convention*: start with **`Get`**
- allow retrieval of private data members

- examples:

```
int GetMonth();
int GetDay();
int GetYear();
```

Member Functions: Mutator

- *convention*: start with **`Set`**
- allow changing the value of a private data member

- examples:

```
void SetMonth(int m);
void SetDay(int d);
void SetYear(int y);
```

Member Functions: Auxiliary

- provide support for the operations
  - public if generally called outside function
  - private/protected if only called by member functions

- examples:

```
void OutputMonth();      public
void IncrementDate();    private
```

Access Specifiers for Date Class

```
class Date {
public:
   void OutputMonth();
   int  GetMonth();
   int  GetDay();
   int  GetYear();
   void SetMonth(int m);
   void SetDay  (int d);
   void SetYear (int y);
private:
   int m_month;
   int m_day;
   int m_year;
};
```

Access Specifiers for Date Class

```
class Date {
public:
   void OutputMonth();
   int  GetMonth();
   int  GetDay();
   int  GetYear();
   void SetMonth(int m);
   void SetDay  (int d);
   void SetYear (int y);
private:
   int m_month;
   int m_day;
   int m_year;
};
```

for the sake of brevity, we'll leave out the accessor and mutator functions from now on

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Constructors

- special ***member functions*** used to create (or "construct") new objects

- automatically called when an object is created
  - implicit: `Date today;`
  - explicit: `Date today(10, 15, 2014);`

- initializes the values of all data members

Date Class Constructors

```
class Date {
public:
   void OutputMonth();
   Date (int m, int d, int y);
private:
   int m_month;
   int m_day;
   int m_year;
};
```

Date Class Constructors

```
class Date {
public:
   void OutputMonth();
   Date(int m, int d, int y);
private:
   int m_month;
   int m_day;
   int m_year;
};
```

exact same name as the class

Date Class Constructors

```
class Date {
public:
   void OutputMonth();
   Date (int m, int d, int y);
pr
                month;
   int m_day;
   int m_year;
};
```

no return type, not even void

Constructor Definition

```
Date::Date (int m, int d, int y)
{



}
```

Constructor Definition

```
Date::Date (int m, int d, int y)
{
   m_month = m;
   m_day = d;
   m_year = y;
}
```

Constructor Definition

```
Date::Date (int m, int d, int y)
{
    m_month = m;

    m_day = d;

    m_year = y;
}
```

Constructor Definition

```
Date::Date (int m, int d, int y)
{
  if (m > 0 && m <= 12) {
    m_month = m; }
  else { m_month = 1; }
  if (d > 0 && d <= 31) {
    m_day = d; }
  else { m_day = 1; }
  if (y > 0 && y <= 2100) {
    m_year = y; }
  else { m_year = 1; }
}
```

Constructor Definition

```
Date::Date (int m, int d, int y)
{
  if (m > 0 && m <= 12) {
    m_month = m; }
  else { m_month = 1; }
  if (d > 0 && d <= 31) {
    m_day = d; }
  else { m_day = 1; }
  if (y > 0 && y <= 2100) {
    m_year = y; }
  else { m_year = 1; }
}
```

is this the best way to handle this?

Constructor Definition

```
Date::Date (int m, int d, int y)
{
  if (m > 0 && m <= 12) {
    m_month = m; }
  else { m_month = 1; }
  if (d > 0 && d <= 31) {
    m_day = d; }
  else { m_day = 1; }
  if (y > 0 && y <= 2100) {
    m_year = y; }
  else { m_year = 1; }
}
```

is this the best way to handle this?

what might be a better solution?

Constructor Definition

```
Date::Date (int m, int d, int y)
{
   SetMonth(m);
   SetDay(d);
   SetYear(y);
}
```

- this allows us to reuse already written code

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Overloading

- we can define multiple versions of the constructor – we can ***overload*** it

- different constructors for:
  - when all values are known
  - when no values are known
  - when some subset of values are known

All Known Values

- have the constructor set user-supplied values

```
Date::Date (int m, int d, int y)
{
   SetMonth(m);
   SetDay(d);
   SetYear(y);
}
```

All Known Values

- have the constructor set user-supplied values

```
Date::Date (int m, int d, int y)
{
   SetMonth(m);
   SetDay(d);
   SetYear(y);
}
```

invoked when constructor is called with all arguments

No Known Values

- have the constructor set all default values

```
Date::Date ()
{
   SetMonth(1);
   SetDay(1);
   SetYear(1);
}
```

No Known Values

- have the constructor set all default values

```
Date::Date ()
{
   SetMonth(1);
   SetDay(1);
   SetYear(1);
}
```

invoked when constructor is called with no arguments

Some Known Values

- have the constructor set some default values

```
Date::Date (int m, int d)
{
   SetMonth(m);
   SetDay(d);
   SetYear(1);
}
```

Some Known Values

- have the constructor set some default values

```
Date::Date (int m, int d)
{
   SetMonth(m);
   SetDay(d);
   SetYear(1);
}
```

invoked when constructor is called with two arguments

Overloaded Date Constructor

- so far we have the following constructors:

```
Date::Date (int m, int d, int y);
Date::Date (int m, int d);
Date::Date ();
```

Overloaded Date Constructor

- so far we have the following constructors:

```
Date::Date (int m, int d, int y);
Date::Date (int m, int d);
Date::Date ();
```

- would the following be a valid constructor?

```
Date::Date (int m, int y);
```

Avoiding Multiple Constructors

- defining multiple constructors for different sets of known values is a lot of unnecessary code duplication

- we can avoid this by setting ***default parameters*** in our constructors

Default Parameters

- in the ***function prototype*** only, provide default values you want the constructor to use

```
Date (int m      , int d      ,
      int y      );
```

Default Parameters

- in the ***function prototype*** only, provide default values you want the constructor to use

```
Date (int m = 10, int d = 15,
      int y = 2014);
```

Default Parameters

- in the ***function definition*** nothing changes

```
Date::Date (int m, int d, int y) {
   SetMonth(m);
   SetDay(d);
   SetYear(y);
}
```

Using Default Parameters

- the following are all valid declarations:

```
Date graduation(5,18,2015);
Date today;
Date halloween(10,31);
Date july(4);
```

Using Default Parameters

- the following are all valid declarations:

```
Date graduation(5,18,2015);
Date today;
Date halloween(10,31);
Date july(4);

// graduation: 5/18/2015
// today:      10/15/2014
// halloween:  10/31/2014
// july:       4/15/2014
```

Using Default Parameters

- the following are all valid declarations:

```
Date graduation(5,19,2014);
Date today;
Date hallowe
Date july(4)

// graduatio
// today:          10/15/2014
// halloween:      10/31/2014
// july:           4/15/2014
```

NOTE: when you call a constructor with no arguments, you do not give it empty parentheses

Default Constructors

- a ***default constructor*** is provided by compiler
  - will handle declarations of **`Date`** instances

- this is how we created **`Date`** objects in the slides before we declared and defined our constructor

Default Constructors

- **but**, if you create **any** other constructor, the compiler doesn't provide a default constructor

- so if you create a constructor, make a default constructor too, even if its body is just empty

```
Date::Date ()
{
  /* empty */
}
```

Function Overloading

- functions in C++ are uniquely identified by both their names and their parameters
  - **but NOT their return type!**

- we can overload any kind of function
  - we can even use default values, like with constructors

Overloading Example

```
void PrintMessage (void) {
   cout << "Hello World!" << endl;
}

void PrintMessage (string msg) {
   cout << msg << endl;
}
```

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Example: Rectangle Class

- width and height member variables
- accessors and mutators
- functions for IsSquare(), CalcArea(), CalcPerim(), and PrintRectInfo()

- what happens when we give a constructor that uses default parameters and calls mutators invalid arguments?

LIVECODING

Parts of a Class (so far)

- class name
- member variables
- member functions
  - constructors
    - default parameters
  - accessors
  - mutators
  - auxiliary (private and public)