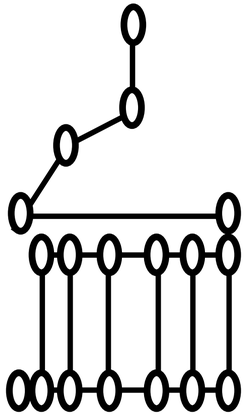
Lecture: Composition & Constant Members

ENGR 2730: Computers in Engineering



Constant data members

Constant data members

*Use the keyword **const** to specify that an object is not modifiable and that any attempt to modify an object should result in a compilation error.*

requires that you ONLY use constant member functions with the object

Side note: we have already seen **const** member functions (used to indicate that a member function will not modify its data members)

```
void print() const;
```

Constant data members

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But how do we "initialize" constant data members if we can only call constant member functions with the object?

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void print() const;
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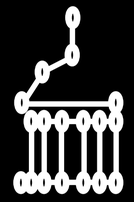

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But how do we "initialize" constant data members if we can only call constant member functions with the object?

Use a **member initializer list** with the constructor.

Composition

Composition (*has-a* relationship)

With composition, a class has objects of other classes as data members.

Analogous to real-life objects:

A car has four tires, a body, an engine, a radio, ...

A polynomial has a set of terms...

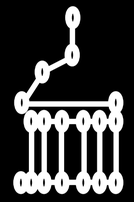
A classroom has desks, a computer, a projector, a teacher, students...

Case study: The Employee class

```
class Employee
{
public:
    Employee( const string &first, const string &last,
              const Date &dateOfBirth, const Date &dateOfHire );
    void print() const;

private:
    string firstName;      // composition: member object
    string lastName;       // composition: member object
    const Date birthDate;  // composition: member object
    const Date hireDate;   // composition: member object
};
```

Employee.h



Case study: The Employee class

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};
```

custom Date class

Employee.h

The Date class

monthsPerYear has the same value for all instantiated objects.

Share a single classwide static copy of monthsPerYear.

```
class Date
{
public:
    static const int monthsPerYear = 12; // number of months in a year
    Date (int mn = 1, int dy = 1, int yr = 1900); // constructors
    void print() const; // print date in month/day/year format

private:
    int month; // 1-12 (January-December)
    int day;   // 1-31 based on month
    int year;  // any year

    // utility function to check if day is proper for month and year
    int checkDay( int testDay ) const;
};
```

Date.h

Static variables & Member functions

- static data members have ONE copy shared between ALL instance objects of a class
- static function local variables have ONE copy shared for all calls of the member function
- static variables are often good for constants that are required to be the same for all objects
- static variables are often good when their value takes a long time to compute, but then never changes

Performance Tip 9.5

Use `static` *data members to save storage when a single copy of the data for all objects of a class will suffice—such as a constant that can be shared by all objects of the class.*

Date member functions

```
// constructor confirms proper value for month; calls
// utility function checkDay to confirm proper value for day
Date::Date( int mn, int dy, int yr )
{
   if ( mn > 0 && mn <= monthsPerYear ) // validate the month
     month = mn;
   else
   {
      month = 1; // invalid month set to 1
      cout << "Invalid month (" << mn << ") set to 1.\n";
   }

   year = yr; // could validate yr
   day = checkDay( dy ); // validate the day

   // output Date object to show when its constructor is called
   cout << "Date object constructor for date ";
   print();
   cout << endl;
}
```

Date.cpp

Date member functions

This never changes, so one static copy can be created and shared for all calls of checkDay

```
// utility function to confirm proper day value based on
// month and year; handles leap years, too
int Date::checkDay( int testDay ) const
{
   static const int daysPerMonth[ monthsPerYear + 1 ] =
      { 0, 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };

   // determine whether testDay is valid for specified month
   if ( testDay > 0 && testDay <= daysPerMonth[ month ] ){
      return testDay;
   }

   // February 29 check for leap year
   if ( month == 2 && testDay == 29 && ( year % 400 == 0 ||
      ( year % 4 == 0 && year % 100 != 0 ) ) ){
      return testDay;
   }

   cout << "Invalid day (" << testDay << ") set to 1.\n";

   return 1; // leave object in consistent state if bad value
}
```

Date member functions

```
// print Date object in form month/day/year
void Date::print() const
{
   cout << month << '/' << day << '/' << year;
}
```

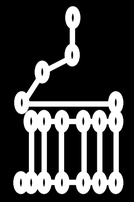
Date.cpp

Back to the Employee class

```
class Employee
{
public:
     Employee( const string &first, const string &last,
               const Date &dateOfBirth, const Date &dateOfHire );
     void print() const;
     ~Employee(); // provided to confirm destruction order
private:
     string firstName;       // composition: member object
     string lastName;        // composition: member object
     const Date birthDate;   // composition: member object
     const Date hireDate;    // composition: member object
};
```

What does the const mean here?

Employee.h



Constant data members

*Use the keyword **const** to specify that an object is not modifiable and that any attempt to modify an object should result in a compilation error.*

But how do we “initialize” constant data members if we can only call constant member functions with the object?

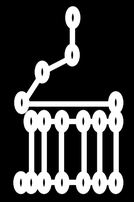
Use a **member initializer list** with the constructor.

Employee class example

```
class Employee
{
public:
    Employee( const string &first, const string &last,
              const Date &dateOfBirth, const Date &dateOfHire );
    void print() const;

private:
    string firstName;        // member object
    string lastName;         // member object
    const Date birthDate;    // constant member object
    const Date hireDate;     // constant member object
};
```

Employee.h



Employee class example

```
Employee::Employee(const string &first, const string &last,
    const Date &dateOfBirth, const Date &dateOfHire)
    : firstName(first),       // initialize firstName
      lastName(last),         // initialize lastName
      birthdate(dateOfBirth), // initialize birthDate
      hireDate(dateOfHire)    // initialize hireDate
{
  // output Employee object to show when constructor is called
  cout << "Employee object constructor: " << firstName
       << ' ' << lastName << endl;
}

Employee::print() const {
    cout << lastName << ", " << firstName << "  Hired: ";
    hireDate.print();
    cout << "  Birthday: ";
    birthDate.print();
}
```

Employee.cpp

birthDate & hireDate are constants
They must be instantiated in the member initializer list.

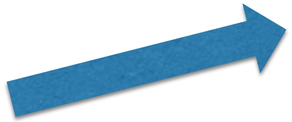
Employee class example

```
int main(){
    Date birth(7, 24, 1949);
    Date hire(3, 12, 1988);
    Employee manager("Bob", "Blue", birth, hire);

    cout << endl;
    manager.print();
    cout << endl;
}
```

main.cpp

Five constructor calls
Two constructor calls were to copy constructor
Nothing was printed in copy constructor



Output

```
Date object constructor for date 7/24/1949
Date object constructor for date 3/12/1988
Employee object constructor: Bob Blue

Blue, Bob  Hired: 3/12/1988  Birthday: 7/24/1949
```

Example #2: Cross Country Record Keeping

```
class TrialTimes {
public:
    TrialTimes(string name = "trialRunner", int num = 0) : m_name{name}, m_number{num} { }
    void addTime(double time) { m_times.push_back(time); }
    double getAverageTime( ) const;
    void print() const {cout << m_name << " (# " << m_number << "): "
                                << getAverageTime() << " s" << endl;}
private:
    const string m_name;
    const int m_number;
    vector<double> m_times;
};
```

```
double TrialTimes::getAverageTime( ) const
{
    double total = 0;
    for (const double t : m_times )
    {
        total += t;
    }
    if (m_times.size() > 0)
    {
        total /= m_times.size();
    }
    return total;
}
```

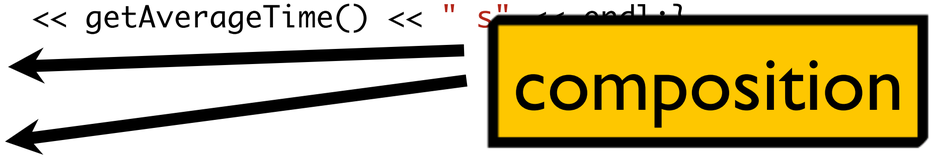
```
int main()
{
    TrialTimes runnerBob("Bob", 1134);
    runnerBob.addTime(20.0);
    runnerBob.addTime(21.6);
    runnerBob.addTime(19.6);
    runnerBob.print();

    TrialTimes runnerSue("Sue", 1532);
    runnerSue.addTime(18.2);
    runnerSue.addTime(17.6);
    runnerSue.addTime(19.5);
    runnerSue.print();

    return 0;
}
```

Example #2

```
class TrialTimes {
public:
    TrialTimes(string name = "trialRunner", int num = 0) : m_name{name}, m_number{num} { }
    void addTime(double time) { m_times.push_back(time); }
    double getAverageTime( ) const;
    void print() const {cout << m_name << " (# " << m_number << "): "
                                << getAverageTime() << " s" << endl;}
private:
    const string m_name;
    const int m_number;
    vector<double> m_times;
};
```



composition

```
double TrialTimes::getAverageTime( ) const
{
    double total = 0;
    for (const double t : m_times )
    {
        total += t;
    }
    if (m_times.size() > 0)
    {
        total /= m_times.size();
    }
    return total;
}
```

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int main()
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    void addTime(double time) { m_times.push_back(time); }
    double getAverageTime( ) const;
    void print() const {cout << m_name << " (# " << m_number << "): "
                                << getAverageTime() << " s" << endl;}
private:
    const string m_name;
    const int m_number;
    vector<double> m_times;
};
```

constant data members

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constant member functions

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    runnerSue.addTime(18.2);
    runnerSue.addTime(17.6);
    runnerSue.addTime(19.5);
    runnerSue.print();

    return 0;
}
```

CQ: Consider the Mystery class below. Which of the following member function definitions will compile?

```
class Mystery {
public:
    Mystery(char correctOption)
       : m_correctOption(correctOption)
       { m_other = 'A'; }

    bool isCorrect(char option) const;
    void switchB( ) const;
    void switchC( );

private:
    const char m_correctOption;
    char m_other;
};
```

A.
```
bool Mystery::isCorrect(char option) const
{
   return m_correctOption == option;
}
```

B.
```
void Mystery::switchB( ) const
{
   m_other = m_correctOption;
}
```

C.
```
void Mystery::switchC( )
{
   m_correctOption = m_other;
}
```

D. option A and option B.

E. option A and option C.

F. option B and option C.

Main messages for today

- Composition: you are allowed to use objects generated by other class defintions as data members of a class.
- Constant data members: if you declare a data member as constant, you are not allowed to change its value (after initialization).