C++ Programming Exercises

Association

Write a program that represents a squash league in which teams play each other. Define and implement a `League` class that holds references to all the teams and can print out the current league table. Define a `Team` class to hold each team's results (number of games won, drawn and lost).
To make things more interesting, hide the League class inside the `Team` class as a static member; then, in the main program you will not have to explicitly refer to the `League` class.
The main program should be on the lines:

```
int main()
{
    Team spurs("Spurs");
    Team rangers("Rangers");
    Team rockets("Rockets");
    Team stingray("Stingray");
    spurs >> rangers;
    rockets >> spurs;
    rockets >> stingray;
    stingray >> spurs;
    Team::printTable();
}
```

where,
1. `printTable()` method calls a corresponding `print()` function in the League class.
2. `operator>>()` is overloaded such that the left hand team beats the right hand team.

Note that the above design will mean that the `Team` class will refer to the `League` class and vice-versa. To avoid problems with a single pass compiler you will have to define each class in separate `.cpp` and `.h` files.

Operator Overloading

Define and implement a `Matrix` class that represents an N by M matrix using the `vector` class from the STL. Overload the operators: `+ - *` to provide basic matrix operations and provide `print()` and `transpose()` methods. A suitable test harness is:

```
int main()
{
    Matrix product;
    Matrix a = { {{1,2,3},{4,5,6}} };
    Matrix b = { {{10,20},{30,40},{50,60}} };
    product = a * b;
    product.print();
    cout << endl;

    Matrix m1{ {{11,12,13},
               {21,22,23},
               {31,32,33},
               {41,42,43}} };
    Matrix m2{ {{2,3,4},
               {5,6,7},
               {9,8,7},
               {10,2,4}} };
    m1.transpose();
    m1.print();
    cout << endl;
    m1.transpose();
    m1.print();
    cout << endl;

    Matrix m = m1 + m2;
    m.print();
}
```

Inheritance

Create an inheritance hierarchy where `BankAccount` is the base class and `CreditAccount` and `SavingsAccount` are two separate derived classes.

Create the `CreditAccount` class with methods:

- `deposit()`
- `withdraw()`
- `display()`

with attributes:

- `name`
- `accountNumber`
- `balance`
- `overdraft_limit`

Create the `SavingsAccount` class with methods:

- `deposit()`
- `display()`
- `apply_interest()`

with attributes:

- `name`
- `accountNumber`
- `balance`
- `interest_rate`

Some of the above attributes and methods can be hoisted to the base class - decide which.

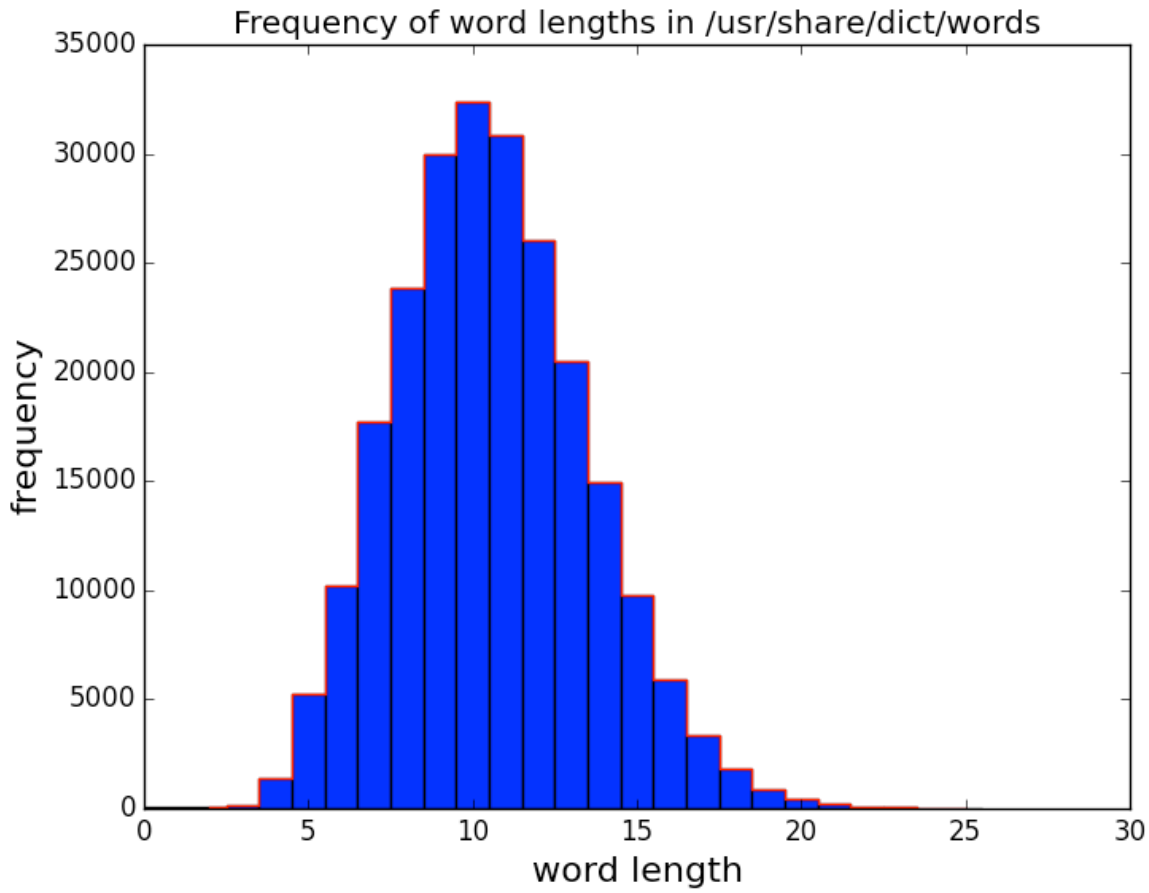
Use a `Money` class to represent the balance in these classes. The `CreditAccount` must prevent account holders from exceeding their overdraft limit. The `SavingAccount` should apply interest to the current balance each year,. Use the following test harness:

```
int main()
{
    CreditAccount john("John", Money(100, 50), Money(250, 0));
    CreditAccount susan("Susan", Money(50, 10), Money(100, 0));
    SavingsAccount thomas("Thomas", Money(5250, 25), 1.5);
    SavingsAccount christine("Christine", Money(1000, 0), 1.0);
    john.deposit(Money(125, 15));
    john.deposit(Money(125, 40));
    john.display();
    try
    {
        susan.withdraw(Money(2, 99));
        susan.withdraw(Money(152, 25));
        susan.withdraw(Money(152, 25));
    } catch(InsufficientFundsException& e) {
        cout << "Insufficient funds, ";
        susan.display();
    }
```

```
        thomas.applyInterest();
        thomas.applyInterest();
        thomas.applyInterest();
        thomas.display();
    }
```

Wordlength Frequencies

Read the file `/usr/share/dict/words` and print a histogram of the occurrence of each size (in percent), giving output similar to the one below:



Obviously we don't have access to MatPlotLib, so numerical results will suffice.

Roman Numerals

Create two functions that convert a decimal number in the range 1 to 4000 to Roman numerals, and back. Use the `map` class from the STL to define two lookup tables to simplify the code:

```
DecimalToRomanMap lookup = {
        {0, ""},
        {1, "I"},
        {2, "II"},
        {3, "III"},
        {4, "IV"},
        {5, "V"},
        {6, "VI"},
        {7, "VII"},
        {8, "VIII"},
        {9, "IX"},
       {10, "X"},
       {20, "XX"},
       {30, "XXX"},
       {40, "XL"},
       {50, "L"},
       {60, "LX"},
       {70, "LXX"},
       {80, "LXXX"},
       {90, "XC"},
      {100, "C"},
      {200, "CC"},
      {300, "CCC"},
      {400, "CD"},
      {500, "D"},
      {600, "DC"},
      {700, "DCC"},
      {800, "DCCC"},
      {900, "CM"},
     {1000, "M"},
     {2000, "MM"},
     {3000, "MMM"},
     {4000, "MMMM"}
};

RomanToDecimalMap symbols = {
        {'M',1000},
        {'D',500},
        {'C',100},
        {'L',50},
        {'X',10},
        {'V',5},
        {'I',1}
};
```

Popular Stems

Word prefixes are also called stems. Write a program that reads the file `/usr/share/dict/words` that has one word per input line and finds the most popular stems of size 2 upwards (if you get a tie, just pick one). Your results should be similar to:

```
2:  un -> 20358
3: non -> 7804
4: over -> 4041
5: inter -> 1889
6: quasi- -> 1026
7: counter -> 777
8: anthropo -> 133
9: straight- -> 60
10: philosophi -> 31
11: anthropomor -> 26
14: anthropomorp -> 26
13: anthropomorph -> 26
14: anthropomorphi -> 18
15: transcendentali -> 11
16: overintellectual -> 9
17: electroencephalog -> 8
18: electroencephalogr -> 8
19: electroencephalogra -> 8
```

Abstract Classes and Interfaces

In this exercise you create both an interface ans an abstract class and derive three concrete classes. To make things more interesting we will use a template for the abstract class. The idea is to create a list of players in the base class and provide methods in the derived classes to manipulate these lists. The base class is templated because the lists in the derived classes have different types. Note that although we are using virtual functions in the base and interface classes, we are not using polymorphism.

To begin with create an abstract class called "Groupings" that is templated on T. In this class:

1) define a private attribute:

```
T list;
```

2) create a pure virtual method:

```
virtual string info() = 0;
```

3) create non virtual methods:

```
T getList();
void setList(T);
```

4) create a constructor:

```
Groupings(T list);
```

Now create 3 concrete classes that implement the virtual method `info()` with the following values of T:

```
Singles with T=string
```

```
Doubles with T=pair<string,string>
FiveASideTeam with T=tuple<string,string,string,string,string>
```

You might find the following typedef's useful:

```
typedef pair<string,string> tuple2;
typedef tuple<string,string,string,string,string> tuple5;
```

Make sure that the constructors for each class that call the constructor in the templated base class passing the appropriate list. This will be a single `string` for the `Single` class, a `pair` for the `Double` class and a `tuple` for the `FiveASideTeam` class.

Implement the `info()` method to return the list in each class.

In the main program, instantiate each class and call the `info()` method:

```
Singles tom("Tom Sheridan");
Doubles philAndGeorge("Phil Tandy", "George Ball");
FiveASideTeam galaxy("Jim", "Susan", "Peter", "Luke", "Zoe");
cout << tom.info() << endl;
cout << philAndGeorge.info() << endl;
cout << galaxy.info() << endl;
```

Test the above is working before continuing.

Now define an interface with a single virtual method:

```
virtual void swapPlayers(const string& current,
                         const string& replacement) = 0;
```

and modify the 3 concrete classes such that they inherit and implement this interface. Modify the main program to test this method in each class.

Define a `bad_swap` exception that is derived from `std::exception` and include your own `what()` method. Check that if an invalid replacement is used that an exception of type `bad_swap` is thrown; you will need to add a try block to the main program of the form:

```
try
{
    ...
}
catch(const bad_swap& e)
{
    cout << e.what() << endl;
}
```