Lab 7: C++
Creating Classes

Reading: Chapter 16

For coding classes in C++, we will be using the concept of
"Separating Interface from Implementation" which is covered in section 16.7.

Turn in:

1) **UML Diagram for your class**
2) **Oscillator.h**
3) **Oscillator.cpp**
4) **yourtestprogram.cpp**

Expected time to completion…somewhere between 6 and 10 hours.

Warning: Working together on assignments is considered cheating in this class. Copying code from books, web sites or other sources is also considered cheating.

Cheating will result in a grade of zero for the assignment.

Assignment: Design and implement a class that represents a simple harmonic oscillator. The design and implementation must be your own work. The grade on this assignment will be based on how well your class satisfies the guidelines listed below.

Guidelines:

Use appropriate names for filenames, class, data members, and member functions. Use camel case for names of variables and functions. Use all caps for names of constants. Follow conventions shown in class for naming accessor and mutator functions.

Separate the interface from the implementation. Class definition with prototypes of member functions goes in the .h file. Function definitions go in the .cpp file.

Enforce encapsulation.

Choose appropriate types for the data members. In the description below, the data members are represented by the variable names: A, k, m, and ϕ. (Note: these are NOT appropriate data member names)

Member functions should be provided as follows:

- default constructor
- other constructor if it makes sense to you
- accessor and mutator for each data member
- functions to allow the user to obtain the force (given x), the position (given t) , and the period.

Ask questions about this assignment at least 24 hours before the deadline. The sooner you get started, the better.

Design. Plan. Design some more. Plan more.

The coding step will go very quickly if your design is complete.

Background Information: from http://en.wikipedia.org/wiki/Harmonic_oscillator

A simple harmonic oscillator is an oscillator that is neither driven nor damped. It consists of a mass *m*, which experiences a single force, *F*, which pulls the mass in the direction of the point *x*=0 and depends only on the mass's position *x* and a constant *k*. Balance of forces (Newton's second law) for the system is

$$F = ma = m\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = m\ddot{x} = -kx.$$

Solving this differential equation, we find that the motion is described by the function

$$x(t) = A\cos(\omega t + \phi),$$

where

$$\omega = \sqrt{\frac{k}{m}} = \frac{2\pi}{T}.$$

The motion is periodic, repeating itself in a sinusoidal fashion with constant amplitude, *A*. In addition to its amplitude, the motion of a simple harmonic oscillator is characterized by its period *T*, the time for a single oscillation or its frequency $f = {}^{1}\!/_{T}$, the number of cycles per unit time. The position at a given time *t* also depends on the phase, φ, which determines the starting point on the sine wave. The period and frequency are determined by the size of the mass *m* and the force constant *k*, while the amplitude and phase are determined by the starting position and velocity.

The velocity and acceleration of a simple harmonic oscillator oscillate with the same frequency as the position but with shifted phases. The velocity is maximum for zero displacement, while the acceleration is in the opposite direction as the displacement.

The potential energy stored in a simple harmonic oscillator at position *x* is

$$U = \frac{1}{2}kx^2.$$