

# CSCI-1200 Data Structures — Spring 2023

## Lab 2 — C++ Classes

### Checkpoint 1

*estimate: 15-25 minutes*

For the first checkpoint, you will be working in groups of 4 to design the `Animal.h` file for a new class. Keep in mind that you should only put the class definition in the header file, you are **not** writing the actual implementation. Make sure that everyone in the group participates and understands the material - it is possible that all of you will have to answer questions to get checked off!

Each instance of the `Animal` class will describe several characteristics about an animal. Every `Animal` must have a name at all times. This is the only value that will be passed in when a new object is declared. It should be possible to set the weight of the animal, if the animal can survive on land, if the animal can survive in water, if the animal eats meat, and if the animal eats plants. All of these values (including the name) should be accessible from outside the class as well. In addition, the class should be able to indicate if the animal in question is an omnivore (eats both meat and plants) and if they are amphibious (can survive on land and in water).

Make sure to explain the purpose of every function with a comment. Consider the return type, whether each argument should be passed by value, reference, or constant reference, and whether or not the function is a constant member function (has **const** after the argument list). Be prepared to justify your choices. To get checked off, show your completed header file and answer any questions asked by the TA/mentor.

**NOTE: Only Checkpoint 1 is a team exercise.** For the rest of this lab, you will implement a simple C++ class named `Time`. It represents all possible times in a 24-hour period, including hours, minutes and seconds. An immediate representation issue is how to handle morning (am) and afternoon (pm) times. We could have a separate `bool` indicating whether the time is am or pm. It is easier, however, to represent the hours in *military time*. This means that the hours of the day are numbered from 0 to 23, with 13 being 1 pm, 14 being 2 pm, etc.

Your notes from Lecture 3 with the example `Date` class will be helpful in completing this lab.

### Checkpoint 2

*estimate: 20-40 minutes*

In the second checkpoint you will get started by implementing the initial class design, several member functions, and a simple main program to test your class.

The instructions below describe how to build your executable using from the command line using `g++` or `clang++` using the WSL or UNIX terminal. Even if you plan to use Visual Studio or another IDE for the bulk of your work this semester, you are required to also show that you can successfully build and run this lab using `g++` from a terminal on your own machine.

[http://www.cs.rpi.edu/academics/courses/spring23/csci1200/labs/02\\_classes/main.cpp](http://www.cs.rpi.edu/academics/courses/spring23/csci1200/labs/02_classes/main.cpp)

- Make a subfolder inside of your Data Structures labs directory for lab 2. We provide basic testing code in `main.cpp`. You'll need to create 2 new empty code files named `time.h` and `time.cpp`. Note that in C++ the name of the header and implementation file are not required to exactly match the name of the class, but it is good coding style to do so.
- Begin work on `time.h`. Within the file, declare a class called `Time`. Follow the form and syntax of the `Date` class from Lecture 3. Read the syntax carefully (such as the semi-colon at the end of the class declaration). Add private member variables for the `hour`, `minute` and `second`. In the public area of the class, declare two constructors: one, the default constructor, should initialize each of the member variables to 0; the other, having three arguments, accepts initial values for the hour, minute and second

as function call arguments. Declare member functions to access the values of the hour, the minute and the second (three different member functions). It will be crucial for Checkpoint 3 to make these `const`. (Recall: a `const` member function can not change the member variables.)

Don't write the body of any of the functions in the `time.h` file. Save all the implementation for the `time.cpp` file.

- Review the provided `main.cpp`. Note that we must `#include "time.h"` in addition to including `#include <iostream>`. (Note: We use angle brackets for standard library includes and double quotes for our custom header files in the working directory.) The main program creates multiple `Time` objects, using the two different constructors and uses the functions that access the values of hour, minute and second by printing the two times.

Note: There is a common confusion when creating a new variable using the default constructor:

```
Time t1(5,30,59); // calls the non-default constructor w/ 3 integer arguments
Time t2();        // COMPILE ERROR - a buggy attempt to call the default constructor
Time t3;          // the *correct* way to call the default constructor
```

- Now implement all of the class constructors and member functions in the file `time.cpp`. Don't forget to add the line to `#include "time.h"`. Any file that uses or implements `Time` functionality must include the `Time` class header file.
- Now, compile your program and remove errors. Here's where the difference between compiling and linking matters.

When **compiling using g++** on the command line, the two separate command lines:

```
g++ -c main.cpp -Wall -Wextra
g++ -c time.cpp -Wall -Wextra
```

compile the source code to create two object code files called `main.o` and `time.o` separately. The `-c` means "compile only". Compiler errors will appear at this point. If there are errors in `main.cpp` (or `time.cpp`), then the files `main.o` (or `time.o`) will not be created. Use the `ls` command to check.

*Important Note: We only compile .cpp files.* We do not directly compile header files. Header files are compiled only indirectly when included in a `.cpp` file.

Once you have driven out all of the compiler errors, you can "link" the program using the command:

```
g++ main.o time.o -o time_test.exe
```

to create the executable called `time_test.exe`. If you have not defined all of the necessary member functions in the `Time` class, then you would see "linking" errors at this point. You can combine all three command lines (compiling each of the 2 `.cpp` files to 2 object files and linking all object files) with this command:

```
g++ main.cpp time.cpp -o time_test.exe -Wall -Wextra
```

Which is more similar to what we did last lab. Equivalently, if those are the only two `.cpp` files in the current directory, you can compile and link using the command line wildcard:

```
g++ *.cpp -o time_test.exe -Wall -Wextra
```

Note that this will not create the intermediate `.o` files and will only proceed to the linking step if the two files compile cleanly.

**To complete this checkpoint:** Show compilation of the program **using g++/clang++ within the WSL or UNIX terminal**, with all compiler errors removed and demonstrate correct execution of your program. *Yes, please show us you can compile from the terminal with g++, even if you plan to primarily use Visual Studio or another IDE for the rest of the semester.*

## Checkpoint 3

*estimate: 30-45 minutes*

Create and test a few more member functions. This will require modifications to all three of the files. You should uncomment the provided tests in `main.cpp` as you work, and *add your own tests*.

- `setHour`, `setMinute`, `setSecond`. Each should take a single integer argument and change the appropriate member variable. For now, do not worry about illegal values of these variables (such as setting the hour to 25 or the minute to -15). Assume whoever calls the functions does the right thing. In general, this is a bad assumption, but we will not worry about it here.
- `PrintAmPm` prints time in terms of am or pm, so that 13:24:39 would be output as 1:24:39 pm. This member function should have no arguments. Note that this requires some care so that 5 minutes and 4 seconds after 2 in the afternoon is output as 2:05:04 pm. The output should be to `std::cout`.
- Finally, let's create a vector of times, sort it, and output the final order. You'll need to create a *non-member* function called `IsEarlierThan` which has the prototype:

```
bool IsEarlierThan(const Time& t1, const Time& t2);
```

*It is very important that the two time objects are passed by constant reference.* The prototype should be in `time.h` (in the file, but outside of the class declaration) and the implementation should be in `time.cpp`. It should return true if `t1` is earlier in the day than `t2`. The tough part, from the logic viewpoint, is being able to compare two times that have the same hour or even the same hour and the same minute. Test your function `IsEarlierThan`.

If your `IsEarlierThan` function is correct, sorting becomes very easy. You just need to pass the function to the sorting routine (make sure to `#include <algorithm>`). Be sure to study the output and convince yourself things are debugged before asking a TA/mentor for checkoff.

```
sort(times.begin(), times.end(), IsEarlierThan);
```

**Importance of const and reference:** After you have debugged and tested this checkpoint, experiment with `const` and pass-by-reference on the argument types for the function `IsEarlierThan`. Change them from `const` pass-by-reference to pass-by-reference w/o the `const`. Use the `-Wall` compiler flag to enable all warnings.

You *may* see compiler errors/warnings with some OS/compiler. The problem is that the compiler expects the parameters of the comparison function (the 3rd argument to the `sort` function) to be in a certain form and complains that it can not find the function when the parameters are not in this form. Basically the STL `sort` function doesn't want to sort a collection of data if that data is changing during/because of the sorting process!

Note: Make sure to try this with the `g++` compiler as the Visual Studio compiler may not be as strict with `const` type checking. Also, try `IsEarlierThan` with pass-by-value parameters. What's the difference? Switch the function back to `const` pass-by-reference parameters before asking for a checkoff.

**To complete this checkpoint:** Show a TA your tested and debugged extensions. Be prepared to discuss your implementation and `const` and pass-by-reference.