

# VIRTUAL FUNCTIONS

Workshop 9 (out of 10 marks – 3.75% of your final grade)

In this workshop, you are to define a function in type-generic form.

## LEARNING OUTCOMES

Upon successful completion of this workshop, you will have demonstrated the abilities to

- to code a function template
- to implement a call to a template function
- to describe the syntax of a constrained cast and its purpose
- to describe what you have learned in completing this workshop

## SUBMISSION POLICY

The *in-lab* section is to be completed during your assigned lab section. It is to be completed and submitted by the end of the workshop period.

If you attend the lab period and cannot complete the *in-lab* portion of the workshop during that period, ask your instructor for permission to complete the *in-lab* portion after the period. You must be present at the lab in order to get credit for the *in-lab* portion.

If you do not attend the lab, you can submit the *in-lab* section along with your *at-home* section (see penalties below). The *at-home* portion of the lab is due on the day that is four days after your scheduled *in-lab* workshop (@23:59) (even if that day is a holiday).

All your work (all the files you create or modify) must contain your name, Seneca email and student number.

You are responsible to back up your work regularly.

## LATE SUBMISSION PENALTIES

- *In-lab* portion submitted late, with *at-home* portion: **0** for *in-lab*. Maximum of **7**/10 for the entire workshop.
- If any of *in-lab*, *at-home* or *reflection* portions is missing, the mark for the workshop will be **0**/10.

## IN-LAB (60%)

As a secret agent, you have discovered the headquarters of an international supervillain, a mastermind of crime. In one room you come across an old USB flash drive containing FBI data on crime statistics in the USA. The data is in file `crimedata_lab.csv`. There is some code to analyze the data in files `ws9_lab.cpp`, `Data.h` and `Data.cpp`. The program needs to be completed.

You suspect that the data is fake, but you need to prove it. You cannot transmit the data back to your own headquarters. They have instructed you to complete the program and to answer 4 questions. They will use your answers to authenticate the data. While reading the file records, you discover that some records contain integer data, and some records contain floating-point data.

The contents of file `crimedata.csv` are shown below. You can open the file in excel to show the columns better.

```
5
Year,2000,2001,2002,2003,2004
Population,281421906,285317559,287973924,290788976,293656842
ViolentCrime,1425486,1439480,1423677,1383676,1360088
ViolentCrime_Rate,506.5,504.5,494.4,475.8,463.2
GrandTheftAuto,1160002,1228391,1246646,1261226,1237851
GrandTheftAuto_Rate,412.2,430.5,432.9,433.7,421.5
```

The first record has a single integer that holds the number of columns of data in each record of the file. Each line in the file contains a string (with no spaces) that describes the data in that record. The data in each record consists of comma-separated numbers. These numbers can be integers or floating-point numbers.

The largest data value allowed in this file is 1,000,000,000. (1 billion; that is 1 followed by 9 zeros). The smallest number allowed in this file is 0. The field width for output of each record's description is 20. The field width for output of each data field in each record is 15.

The records with integer data are `Year`, `Population`, `ViolentCrime`, and `GrandTheftAuto`.

The records with floating-point data are `ViolentCrime_Rate` and `GrandTheftAuto_Rate`.

The `main()` program reads the records in the order that they are in the file, one record at a time. The `readRecord()` function reads a single record at a time. The program then displays the data and the answers to the questions below.

`bool readRow(istream& input, const char* name, double* data, int n)`: The *Data* module includes two functions named `readRow()` with different signatures. Since both functions contain the same logic, replace them with a single template function of the same name, store that function in `Data.h`, and remove the original function definitions `Data.cpp`.

`void answers()`: Complete this function in `Data.cpp`. The code in this function computes answers to the following questions.

1. What is the total population growth from the beginning to the end of the data? **Hint:** the beginning of the data is at `population[0]`, and the end of the data is at `population[n - 1]`.
2. Between the first and last year, did violent crime go up or down?
3. What is the average number of Grand Theft Auto incidents over all the years? Format it to show millions.
4. What is the minimum and maximum number of Violent Crime incidents?

Code the following functions as template functions and store them in `Data.h` along with your `readRow()` template function. Use these functions to read data and find the answers to questions above.

`T min (const T* data, int n)`: This function returns the smallest element in the array received as parameter. The array contains `n` elements.

`T max (const T* data, int n)`: This function returns the largest element in the array received as parameter. The array contains `n` elements.

`T sum (const T* data, int n)`: This function calculates the sum of all elements in the array.

`double average (const T* data, int n)`: This function calculates the average of the elements in the array.

`bool read (istream& input, T* data, int n)`: Reads `n` comma-separated data elements from input. Returns `true` if successful, `false` otherwise.

`void display (const char* name, const T* data, int n)`: Display name right-justified in a field of size 20 and each data element in a field of 15

## IN-LAB EXPECTED OUTPUT

Year	2000	2001	2002	2003	2004
Population	281421906	285317559	287973924	290788976	293656842
ViolentCrime	1425486	1439480	1423677	1383676	1360088
ViolentCrimeRate	506.5	504.5	494.4	475.8	463.2
GrandTheftAuto	1160002	1228391	1246646	1261226	1237851

GrandTheftAutoRate	412.2	430.5	432.9	433.7	421.5
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Population change from 2000 to 2004 is 12.23 million

Violent Crime trend is down

There are 1.23 million Grand Theft Auto incidents on average a year

The Minimum Violent Crime rate was 463

The Maximum Violent Crime rate was 506

## IN-LAB SUBMISSION

To test and demonstrate execution of your program use the same data as the output example above.

If not on matrix already, upload `Data.h`, `Data.cpp`, and `w9_in_lab.cpp` to your matrix account. Compile and run your code and make sure everything works properly.

Then, run the following command from your account (use your professor's Seneca userid to replace `profname.proflastname`, and your section ID to replace `XXX`, i.e., SAA, SBB, etc.):

```
~profname.proflastname/submit 244XXX_w9_lab<ENTER>
```

and follow the instructions.

**IMPORTANT:** Please note that a successful submission does not guarantee full credit for this workshop. If your professor is not satisfied with your implementation, your professor may ask you to resubmit. Resubmissions will attract a penalty.

## AT-HOME (40%)

### REFLECTION

Study your final solution, reread the related parts of the course notes, and make sure that you have understood the concepts covered by this workshop. **This should take no less than 30 minutes of your time.**

Create a file named `reflect.txt` that contains your **detailed description of the topics that you have learned** in completing this workshop and mention any issues that caused you difficulty. Include in your explanation—**but do not limit it to**—the following points:

1. What happens if you try to put your template functions in `Data.cpp`? Does your source code compile if you move all functions to `Data.h`?
2. Move one template function into `ws9_lab.cpp`. Does it work now? Do you need to define the template function above `main()`, before it is used, or can you define it below `main()`?
3. Could you have done this lab without templates, by just overloading your functions in `Data.h` to accept integer and double arguments? What is the advantage of using templates?
4. What is the difference between `template<class T>` and `template<typename T>`?
5. What have you learned doing this workshop?

### Quiz Reflection

Add a section to `reflect.txt` called **Quiz X Reflection**. Replace the **X** with the number of the last quiz that you received and list the numbers of all questions that you answered incorrectly.

Then for each incorrectly answered question write your mistake and the correct answer to that question. If you have missed the last quiz, then write all the questions and their answers.

### AT-HOME SUBMISSION

Upload `reflect.txt`, `Data.h`, `Data.cpp`, and `w9_in_lab.cpp` to your matrix account. To submit, run the following command from your account (use your professor's Seneca userid to replace `profname.proflastname`, and your section ID to replace `XXX`, i.e., SAA, SBB, etc.):

`~profname.proflastname/submit 244XXX_w9_home`<ENTER>

and follow the instructions.

**IMPORTANT:** Please note that a successful submission does not guarantee full credit for this workshop. If the professor is not satisfied with your implementation, your professor may ask you to resubmit. Resubmissions will attract a penalty.