



Lab 1: Tools for EECS 281

Instructions:

Work on this document with your group, then enter the answers on the canvas quiz.

Note:

Please **complete the Prelab** (found in the Lab 1 Canvas folder)! Be prepared before you meet with your lab group, and read this document so that you know what you must submit for full credit. You can even start it ahead of time and then ask questions during any lab section for help completing it.

You MUST include the following assignment identifier at the top of every file you submit to the autograder as a comment. This includes all source files, header files, and your Makefile (if there is one). If there is not autograder assignment, you may ignore this.

Project Identifier: CD7E23DEB13C1B8840F765F9016C084FD5D3F130

1 Logistics

1. What is the due date of project 1?
 - A. 2/9/2021
 - B. 2/5/2020
 - C. 3/10/2021
 - D. 4/23/2021

2. What is the date of the Midterm?
 - A. 2/9/2021
 - B. 2/5/2020
 - C. 3/10/2021
 - D. 4/23/2021

3. What percentage of your grade is each project worth?
 - A. 1
 - B. 5
 - C. 10
 - D. 20

2 Tools

4. What is the correct login string for CAEN?

NOTE:

In this class, when we want to indicate that you should use a variable but we are writing text in a document, we will surround the variable with `<` and `>`. For example, for option A in the following answers, Dr. Paoletti's personal login string would be `paoletti@login.engin.umich.edu`, because he would replace `<username>` with his username (paoletti).

- A. `ssh <username>@login.engin.umich.edu`
 - B. `ssh <username>@engin.umich.edu`
 - C. `ssh <username>@caen.umich.edu`
 - D. `ssh <username>@potatobot.com`
5. Why do we use Makefiles?
- A. They can create the submission files automatically.
 - B. They automate the (sometimes long and complex) compilation process for us.
 - C. They can run custom testing scripts.
 - D. Typing out compilation commands every time is annoying.
 - E. All of the above.
6. Will your program compile on the autograder without the project identifier?
- A. Yes.
 - B. NO, and I'll waste the submission.
7. What is the Makefile command to create a submission file that includes custom test cases?
- A. `make`
 - B. `make all`
 - C. `make partialsubmit`
 - D. `make fullsubmit`
8. Which of the following is a debugging tool?
- A. `Makefile`
 - B. `perf`
 - C. `valgrind`
 - D. `cin`
9. What does `perf` do?
- A. Detects segmentation faults in a program and displays line numbers that they occurred at.
 - B. Profiles program execution time.
 - C. Profiles program memory usage.
 - D. Automates the testing process.

10. You have to use `perf` on CAEN to complete the following question. If you are having trouble logging on to CAEN, please contact a staff member or email `eecs281admin@umich.edu`. After successfully connecting to CAEN, follow the instructions below:

- Visit the lab 1 repository on the EECS 281 Gitlab: <https://gitlab.umich.edu/eecs281/lab-1-music-sorting>.
- Retrieve the contents of the repository. There should be two folders: `music_sorting` and `perf_profiling`. In the `perf_profiling` folder, find the `profiling.cpp` file.
- Compile the code on CAEN (with `make`, the Makefile is already supplied in that folder ready to go) and then use the `perf` tool (on CAEN) to profile the program. Note that running profiling (including the `perf` command) will probably take around 10 seconds, so don't panic if it seems like it's not doing anything.
- Type the following commands to build the program, time it, and display the results (be sure that you use `make debug` and `./profiling_debug`, otherwise you will get incorrect results):

```
make debug
perf record -F 1000 --call-graph dwarf -e cycles:u ./profiling_debug < test-1.txt
perf report
```

Answer the following two questions based on the results of the process above. Choose the best answer for both questions. You may have to make your terminal window wider to see the full function name(s). Both questions are worth 0.5 points each. When you're done, make sure to remove the `perf.data` file: it can be up to 100 MB in size! The `make clean` command included in the lab files will remove the executable, object files, and the `perf.data` file.

- (a) Approximately what percentage of time was spent in the `insertionSort()` function? Make sure that you are looking at the `self` column of the output.
- A. 10%
 - B. 20%
 - C. 40%
 - D. 60%
 - E. 80%
- (b) Approximately what percentage of time was spent running the vector subscript operator (it will appear as `std::vector<...>::operator[]`)? Again, use `self` data.
- A. 10%
 - B. 20%
 - C. 40%
 - D. 60%
 - E. 80%

3 Debugging

We have found in previous semesters that students entering 281 are not comfortable in their development environments, specifically with using git, gcc/clang, make, valgrind and debuggers. These tools and more are vital for success in projects and labs in 281, but also in future EECS courses you may take, and in industry. This assignment uses small toy programs to help you get more comfortable and hopefully learn a thing or two before jumping into more complex projects. **For each question, assume that the given code is compiled according to the flags given in the Makefile (shown below), under the CAEN Linux environment.**

Assume that all the programs are complete and that no other source files exist.

11. What is wrong with the following program?

```
int add(int a, int b);
int main() {
    int x = 1;
    int y = 5;
    return add(x, y);
}
```

- A. `add()` has no definition.
- B. `add()` is called with `x` and `y`, but accepts `a` and `b`.
- C. The program does not compile because `main()` cannot return a value of 6.
- D. A function cannot be called after a `return` statement.
- E. Nothing is wrong with this program.

12. What is wrong with the following program?

```
int main() {
    int x = 0;
    return x + y;
}
```

- A. `main()` cannot return the result of an arithmetic expression.
- B. `main()` cannot return `x + y` because `x + y` is a `double`.
- C. `main()` does not contain a declaration for `y`.
- D. `main()` cannot return an integer.
- E. Nothing is wrong with this program.

13. What is wrong with the following program?

```
#include <vector>
int* get_some_ints() {
    std::vector<int> ints = {1, 2, 3, 4, 5};
    return ints.data();
}
int main() {
    int* some_ints = get_some_ints();
    delete[] some_ints;
    return 0;
}
```

- A. The memory pointed to by `some_ints` is freed twice.
- B. `main()` leaks the memory pointed to by `some_ints`.
- C. A function cannot return a pointer.
- D. `some_ints` is a pointer and not an array, so `delete` should be used instead of `delete[]`.
- E. Nothing is wrong with this program.

14. What is wrong with the following program?

```
struct Thing { };
int main() {
    Thing a;
    Thing b;
    bool less = a < b;
}
```

- A. `main()` cannot declare an instance of a `Thing` object.
- B. `main()` must have a return value.
- C. `Thing` cannot have an empty definition, so this code does not compile.
- D. `main()` tries to use the `<` operator, which is not defined for the `Thing` type.
- E. Nothing is wrong with this program.

15. What is wrong with the following program?

```
int main() {
    int some_ints[5] = { 1, 2, 3, 4, 0 };
    for (int* p = some_ints; p; ++p)
        *p = 0;
    return 0;
}
```

- A. `main()` indexes out of the bounds of `some_ints`.
- B. `main()` leaks the memory pointed to by `some_ints`.
- C. `some_ints` points to uninitialized memory.
- D. The `for` loop is missing a curly brace, so the code will not compile.
- E. Nothing is wrong with this program.

16. What is wrong with the following program?

```
#include <iostream>
int sum_ints() {
    int *some_ints = new int [50];
    for (int i = 0; i < 50; ++i) {
        some_ints[i] = i;
    }
    int sum = 0;
    for (int i = 0; i < 50; ++i) {
        sum += some_ints[i];
    }
    return sum;
}
int main() { std::cout << sum_ints(); }
```

- A. `sum_ints()` indexes out of the bounds of `some_ints`.
- B. `sum_ints()` leaks the memory pointed to by `some_ints`.
- C. `some_ints` points to uninitialized memory.
- D. `main()` must have a return value.
- E. Nothing is wrong with this program.

17. What is wrong with the following program?

```
int factorial(int n) { return n * factorial(n - 1); }
int main() { return factorial(3) - 6; }
```

- A. `factorial(3)` returns an uninitialized value.
- B. A mathematical operation cannot follow a `return` statement.
- C. `factorial(3)` never returns (and may cause a stack overflow).
- D. `main()` cannot return the result of a recursive function.
- E. Nothing is wrong with this program.

18. What is wrong with the following program?

```
#include <iostream>
int what_is_2x281() {
    int x, y = 281;
    return x += y;
}
int main() { std::cout << "What is 2 x 281?\n" << what_is_2x281(); }
```

- A. The `+=` operator cannot be used after a `return` statement, since `x` would be returned before being added to `y`.
- B. `what_is_2x281()` returns an uninitialized value.
- C. The type of `y` is not defined.
- D. `main()` must have a return value.
- E. Nothing is wrong with this program.

19. What is wrong with the following program?

```
void takes_an_integer(int x) {}  
int main() {  
    size_t x;  
    std::cin >> x;  
    takes_an_integer(x);  
}
```

- A. The code does not compile because `takes_an_integer()` has an empty definition.
- B. `main()` must have a return value.
- C. `takes_an_integer()` takes an `int` but is called with a `size_t`, which may cause a loss of precision.
- D. `size_t` is not a valid type.
- E. Nothing is wrong with this program.

4 File Input & Output

20. This code applies to the next two questions.

```
int main(int argc, char []* argv) {
    int i;
    // Read in an integer from a file.
}
```

- (a) Which line(s) of code would read an integer from a file using file redirection?
- A. `ifstream readfile; readfile >> i;`
 - B. `cout << i;`
 - C. `cin >> i;`
 - D. `ofstream writefile; writefile << i;`
- (b) Which of the following command line commands would run the above program (in `main.cpp`, already compiled to the executable `main`) with input file redirection?
- A. `make all`
 - B. `./main input_file.txt`
 - C. `./main > input_file.txt`
 - D. `./main < input_file.txt`

21. A text file contains a list of words that are all on separate lines, with only a trailing newline after every word. One program, program T1, reads the file with `cin >>`, reading in to a `string`, S1. Another program, program T2, reads the file with `getline`, also reading into a `string`, S2.

- (a) What will be the difference, if any, between the two resulting `string` variables?
- A. S2 will contain a trailing space, while S1 will not.
 - B. Both strings will be exactly the same.
 - C. S1 will have a newline character at the end, while S2 will not.
 - D. T1 will not read the file.
- (b) What if there is a space at the end of each word in the file?
- A. S2 will contain a trailing space, while S1 will not.
 - B. Both strings will be exactly the same.
 - C. S1 will have a newline character at the end, while S2 will not.
 - D. T1 will not read the file.

5 Getopt

22. You're writing a simple text-based game on the command line. When the user runs your executable (`./281quest`) the game starts at the first level. If the user wants to skip to a certain level, they can instead run the program with the command `./281quest --level 5` (where `--level` is followed by the level they want to skip to). Which of the following correctly specifies this flag for `getopt`?
- A. `{"level", no_argument, nullptr, 'l' }`
 - B. `{"level", optional_argument, nullptr, 'l' }`
 - C. `{"level", required_argument, nullptr, 'l' }`
23. Short Options You're writing a program that will take five command line options: `-p` – paoletti, `-d` – darden, `-a` – angstadt, `-m` – markov, and `-g` – garcia. Options `d`, `m`, and `g` will have required arguments. The rest take no arguments. Which of the following strings is a correct short options string?
- A. `pd:am:g`
 - B. `p:d:a:m:g`
 - C. `p:dam:g:`
 - D. `pd:am:g:`
 - E. `p:da:mg`

6 Resize & Reserve

24. The following code applies to the next set of questions.

```
vector<int> v = { 5, 4, 3, 8, 9, 2, 8, 1, 4 };  
v.resize(5);
```

- (a) What is the state of memory before the call to `resize`? Assume that the vector size starts at 1 and doubles every time the capacity is reached.
- A. size = 9, capacity = 9, v = 5, 4, 3, 8, 9, 2, 8, 1, 4
 - B. size = 16, capacity = 16, v = 5, 4, 3, 8, 9, 2, 8, 1, 4
 - C. size = 9, capacity = 16, v = 5, 4, 3, 8, 9, 2, 8, 1, 4
 - D. size = 16, capacity = 9, v = 5, 4, 3, 8, 9, 2, 8, 1, 4
- (b) What is the state of memory after the call to `resize`?
- A. size = 5, capacity = 9, v = 5, 4, 3, 8, 9, 2, 8, 1, 4
 - B. size = 5, capacity = 5, v = 5, 4, 3, 8, 9
 - C. size = 5, capacity = 5, v = 9, 2, 8, 1, 4
 - D. size = 5, capacity = 9, v = 5, 4, 3, 8, 9
- (c) What is the state of memory after the call to `resize`, if instead of `v.resize(5);`, `v.resize(11);` is called instead? (As in, `v.resize(5);` was never called).
- A. size = 11, capacity = 11, v = 5, 4, 3, 8, 9, 2, 8, 1, 4, 0, 0
 - B. size = 11, capacity = 16, v = 5, 4, 3, 8, 9, 2, 8, 1, 4, 5, 4
 - C. size = 11, capacity = 16, v = 5, 4, 3, 8, 9, 2, 8, 1, 4
 - D. size = 11, capacity = 11, v = 5, 4, 3, 8, 9, 0, 0, 0, 0, 0, 0

7 Handwritten Problem

This problem is to be submitted independently. We recommend trying it on your own, checking your answer with your group and discussing solutions, and then submitting it to Gradescope. These will be graded on completion, not by correctness. However, we want to see that you were thinking about the problem. Please implement your solution in `palindrome.cpp`. The starter files can be found on Canvas.

25. **Linked-List Palindrome** Given the `start` and `end` nodes of a doubly linked list, determine if the values create a palindrome. A palindrome is a sequence that is the same backwards and forwards. See the definition of the `Node` struct below, or in `palindrome.h`. Return `true` if the list is a palindrome.

```
struct Node {
    Node* prev;
    Node* next;
    char value;
}

bool isPalindrome(Node* start, Node* end);
```

8 Coding Assignment

You can work on these problems by yourself or with your group, but a solution must be submitted to the autograder for each individual.

For this lab, you will be familiarizing yourself with the `get_opt` function, as well as our Makefile and the autograder. To accomplish this task, go to the `music_sorting` directory from the repository you retrieved from Canvas or Gitlab (<https://gitlab.umich.edu/eecs281/lab-1-music-sorting>). To clone the directory on to your local machine, go to your terminal and type the command `git clone https://gitlab.umich.edu/eecs281/lab-1-music-sorting.git`.

There should be two files present, `sorting.h` and `lab1.cpp`. There is nothing for you to do in `sorting.h`, but you need to have it in the same directory as `lab1.cpp` for the code to compile. Make sure to step through `lab1.cpp` to find and complete all the TODO statements. There is one test file for you to test your code on in the folder.

`lab1.cpp` contains a definition for a `MusicLibrary` object. This object will read a CSV file, put the entries into a vector, and then sort the vector and print the top `n` songs based on several command line options that will be processed with `get_opt`. Carefully read the comments and observe what is happening in the code; there are a lot of concepts contained in the functionality that will help you later in the course.

`sorting.h` contains the `Song` definition, as well as an overloaded `operator<<` for printing the songs. Please look around the file, but there's nothing that you have to do in the code.

Once you have completed the coding portion, take a look at the Makefile. There are a few TODO statements in the Makefile as well. If the Makefile is confusing, don't worry; we will go over it in lab. Once you have a grasp of how to use it, compile your code and use the command `make fullsubmit`.

Finally, submit your code to the autograder. When you run the `make fullsubmit` command in the Makefile, there will be a tarball in the directory that contains all of the files. Go to the autograder, click 'choose file' under Lab 1, and find the tarball in your file system. Then upload your submission and watch as the test cases run!

Make sure that all code files submitted to the autograder include the assignment identifier listed on the first page of this assignment, or below.

Project Identifier: CD7E23DEB13C1B8840F765F9016C084FD5D3F130