CIS1500 Assignment 1: Air Quality Index Generator

Total Marks: 10 marks
Weight: 10%
Due: Friday, 10th February 2023, at 11:59 pm

Welcome to your first CIS1500 assignment! Please ensure you read all the sections and **follow the instructions exactly** as we will grade your submission with an auto-grader. You must test your assignment on the SoCS Linux server, and it will be similarly graded on the SoCS Linux server for consistency.

You will receive a 0 if your code includes global variables (variables declared outside of functions), goto statements, or if your code fails to compile without errors. Similarly, the auto-grader will not accept if you name your zip file or program file incorrectly. More details are outlined in Section 4: Program Submission and Administration Information.

1. Background

In this assignment, you will create an air quality index generator based on values received from the user. The Air Quality Health Index (AQHI) is a scale developed for Canada and used to determine the impact of air quality on health. The scale starts at 1 and goes up to "Above 10" which is for very high-risk conditions. This is illustrated below:

Table 1: *AQHI Health Risk and Messages*

Health Risk	**Air Quality Health Index**	**Health Message to the General Population**
Low	1, 2 and 3	Ideal air quality for outdoor activities.
Moderate	4, 5 and 6	No need to modify your outdoor activities.
High	7, 8, 9 and 10	Consider reducing or rescheduling activities outdoors.
Very High	Above 10	Reduce or reschedule strenuous activities outdoors.

Adapted from http://www.airqualityontario.com/aqhi/index.php

1.1 AQHI Equations

To develop this, three pollutants were chosen, and their average concentration values for the last three hours are used to calculate the AQHI. These are ground-level ozone (O_3), fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2). This is calculated using the following equations depending on environmental conditions.

Standard Calculation:

$$AQHI = \left(\frac{1000}{10.4}\right) \times [(e^{0.000537 \times O_3} - 1) + (e^{0.000871 \times NO_2} - 1) + (e^{0.000487 \times PM_{2.5}} - 1)]$$

Cool Conditions (disregards the effect of O_3):

$$AQHI_{cool} = \left(\frac{1000}{6.43}\right) \times [(e^{0.000457 \times NO_2} - 1) + (e^{0.000462 \times PM_{2.5}} - 1)]$$

Warm Conditions:

$$AQHI_{warm} = \left(\frac{1000}{12.8}\right) \times [(e^{0.00104 \times O_3} - 1) + (e^{0.00101 \times NO_2} - 1) + (e^{0.000621 \times PM_{2.5}} - 1)]$$

A few things about the calculation:

1. If any pollutant's average concentration value is unavailable, the AQHI cannot be calculated.
2. The result is rounded off to the nearest positive integer; however, if the calculation is less than 0.5, it is rounded off to 1.
3. The warm vs cold condition is determined by the season: warm season is April–September and cool season is October–March.

You can refer to Air Quality Health Index, Equations (page 8) and Air Quality Ontario for more information if you are interested! You can also see sample values for on an hourly basis on Air Quality Ontario – Pollutant Concentrations (note that there are many more equations for this calculation, so results here may differ). Note that you do not need any more information about the AQHI than that provided in this document to work on this assignment.

You may use any values you like to test your program, you do not need to obtain any real data for this assignment. Selecting logical input/output pairs is a critical part of programming and developing software; take some time to pick a test cases that will cover many outcomes. When testing we will only enter data of a valid type, ex if you ask for a number we might test by entering –10 or 60000, but we will not enter "hello".

1.2 AQHI Equation Samples

To illustrate this, here are some examples using the various equations.

1. In standard conditions, when the concentration of O_3 is 27 ppb, that of NO_2 is 4.2 ppb, and that of $PM_{2.5}$ is 5 µg/m^{3,} the calculation will look like:

$$(e^{0.000537\times O_3} - 1) = (e^{0.000537\times 27} - 1) = 1.01460462 - 1 = 0.01460462$$

$$(e^{0.000871\times NO_2} - 1) = (e^{0.000871\times 4.2} - 1) = 1.00366489 - 1 = 0.00366489$$

$$(e^{0.000487\times PM_{2.5}} - 1) = (e^{0.000487\times 5} - 1) = 1.00243796 - 1 = 0.00243796$$

$$AQHI = \left(\frac{1000}{10.4}\right) \times [(e^{0.000537\times O_3} - 1) + (e^{0.000871\times NO_2} - 1) + (e^{0.000487\times PM_{2.5}} - 1)]$$

$$\rightarrow AQHI = \left(\frac{1000}{10.4}\right) \times [0.01460462 + 0.00366489 + 0.00243796] = \frac{1000 \times 0.0207047}{10.4}$$
$$= 1.99$$

$$\rightarrow AQHI = 2$$

2. In cool conditions, when the concentration of of NO_2 is 2 ppb, and that of $PM_{2.5}$ is 3 µg/m^{3,} the calculation will look like:

$$AQHI_{cool} = \left(\frac{1000}{6.43}\right) \times [(e^{0.000457\times 2} - 1) + (e^{0.000462\times 3} - 1)]$$

$$\rightarrow AQHI_{cool} = \left(\frac{1000}{6.43}\right) \times [0.00091441 + 0.00138696] = 0.3579$$

$$\rightarrow AQHI_{cool} = 1$$

3. In warm conditions, when the concentration of O_3 is 27 ppb, that of NO_2 is 16.6 ppb, and that of $PM_{2.5}$ is 8 µg/m^{3,} the calculation will look like:

$$AQHI_{warm} = \left(\frac{1000}{12.8}\right) \times [(e^{0.00104\times 27} - 1) + (e^{0.00101\times 16.6} - 1) + (e^{0.000621\times 8} - 1)]$$

$$\rightarrow AQHI_{warm} = \left(\frac{1000}{12.8}\right) \times [0.028477959 + 0.016907338 + 0.0049890361] = 3.935$$

$$\rightarrow AQHI_{warm} = 4$$

2. Program Requirements

The program starts by asking the user to select from a menu:

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
        1. Calculate in Standard Conditions
        2. Calculate Season-Based Conditions
        3. Exit
```

If they select 2, they are asked the month to determine whether to use warm or cool equations:

```
Enter the month for the readings
(January = 1, February = 2, etc.)
```

And finally the user is asked to enter the concentrations of the appropriate pollutants, dependent on month entered above (if 2 is selected):

```
Please enter the concentration of ground-level ozone:
Please enter the concentration of fine particulate matter:
Please enter the concentration of nitrogen dioxide:
```

Then, you must calculate the AQHI in the expected conditions, for example:

```
AQHI for cool conditions:
-------------------------------------------------------------------------------------------------
| Location  | AQHI      | Health Risk | Health Message                                          |
| Guelph    | 1.00      | Low         | Ideal air quality for outdoor activities                |
-------------------------------------------------------------------------------------------------
```

Section 3 shows many samples of the input/output expected and gives hints on how to format correctly.

2.1 The First 6 Marks

This is the bulk of the assignment, in which you will receive input from a user, do a calculation, and output the result. We will run several tests using different input values (for selecting the type of calculation, and average pollutant concentration values) then compare your output against the expected output. This is the majority of your grade, each test we run will be worth marks.

To create the air quality index generator:

- You will prompt the user to select one of standard calculation, season-based calculation or exit, and take their choice in as input.
- If they exit, an end of program message must be displayed (see 3.7 Sample Flow VII). Hint: you can use the return statement to exit the program at any time. Returning 0 indicates there were no errors, non-zero values indicate an error.
- If it is season-based calculation, you will take in a number representing the month of the readings taken (January will be 1, February will be 2, etc.)
    - Make sure only valid input is accepted. An error message must be displayed if the value is not valid. (see 3.5 Sample Flow V)
    - If the months are between April and September, inclusive of the two, then you must carry out the warm calculation; otherwise, assume cool conditions.
    - Accordingly, you will need to prompt the user for the three or two (in case of cool conditions) average pollutant concentration values.
- The values for ground-level ozone (O_3), fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2) will be taken from the user.
    - Assume you are only doing so for a single location.
    - Only prompt for the value of ground-level ozone if the user requires the calculation to be done in standardly or in warm conditions.
    - If the user enters a negative value for a reading, the value is unavailable, and you must display an error message accordingly. You should not prompt the user for any other values if a negative value is entered (see 3.2 Sample Flow II). An accurate value will always be ≥ 0.
- You will calculate the AQHI using the selected equation.
    - Be careful with rounding off the result correctly.
    - See 1. Background for the equation and rounding off details.
    - You will need to include math.h for this calculation – make sure to compile with the flag -lm (see 4.2 Program Expectations)
- Based on your calculation, you must display the location, AQHI value, applicable health risk and health message from Table 1 to the user. The location for this assignment will be Guelph.

You will write a single main function to carry out the above requirements and take user input for each value needed. **Refer to the sample flows provided for how your program is expected to run (see 3 Sample Flows)**.

You are not permitted to use global variables or goto statements. This will result in a grade of zero on the entire assignment.

2.2 The Next 2 Marks

Your output text formatting will be graded out of 2 i.e. it will be worth 20% of this assignment. We will flag differences in spellings, spaces, tables, new lines, etc. and test against different input values using the auto-grader, so make your you follow the output exactly. For each unique error, 0.5 marks will be deducted. The formatting grade will not be negative, it will only range from 0 to 2.

Refer to the sample flows provided for how your program is expected to run (2.4 Sample Flows). Altering/customizing sentences will not be accepted, and you will receive a zero in this category if you do so.

2.3 The Final 2 Marks

Style: Indentation, variable names, and comments.

Comments are most commonly used to explain confusing or not easily understood parts of code or for depicting that the following code carries out a certain piece of logic. These are also used to explain the program and add a header to it. A file header comment is a type of comment that appears at the top of your program before the #include line(s). **Comment grades include header comments (see 3.3 File Header Comment Format) and meaningful comments throughout your code.**

Each code block should be **indented for readability** (if/else statements are an example of a code block). We are looking for **meaningful variable names** that depict the values they are representing – this will make it easier for you to remember what each variable is for and for us to grade you!

3. Sample Flows

Here are some samples for you to test against. To ensure your output matches ours, we are providing you with the spacing/size counts at different points in the output.

- Calculation type menu choices are indented by a single \t
- The first two lines of creating the table are given below, use this to correctly create the table entry for Guelph:

  printf("\n----------\n");

  printf("| %-10s| %-10s| %-12s| %-58s|\n", "Location", "AQHI", "Health Risk", "Health Message");

- The AQHI value should be displayed with two decimal places.
- If the AQHI value is greater than 10, display “Above 10” (see 3.8 Sample Flow VIII)

Note that **your submission will be either fully or partially graded by an auto-grader**. To get full grades you need to match our output requirements exactly.

Make sure to cover the following sample flows:

3.1 Sample Flow I

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
        1. Calculate in Standard Conditions
        2. Calculate Season-Based Conditions
        3. Exit
1

Please enter the concentration of ground-level ozone:
0

Please enter the concentration of fine particulate matter:
3

Please enter the concentration of nitrogen dioxide:
2

AQHI for standard conditions:

-----------------------------------------------------------------------------------------------
| Location  | AQHI      | Health Risk | Health Message                                          |
| Guelph    | 1.00      | Low         | Ideal air quality for outdoor activities.               |
-----------------------------------------------------------------------------------------------
```

3.2 Sample Flow II

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
        1. Calculate in Standard Conditions
        2. Calculate Season-Based Conditions
        3. Exit
1

Please enter the concentration of ground-level ozone:
-27

Error: invalid input, value must be greater than or equal to 0. Exiting program...
```

3.3 Sample Flow III

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
        1. Calculate in Standard Conditions
        2. Calculate Season-Based Conditions
        3. Exit
2

Enter the month for the readings
(January = 1, February = 2, etc.)
1

Please enter the concentration of fine particulate matter:
3

Please enter the concentration of nitrogen dioxide:
2

AQHI for cool conditions:

-----------------------------------------------------------------------------------------------
| Location  | AQHI      | Health Risk | Health Message                                          |
| Guelph    | 1.00      | Low         | Ideal air quality for outdoor activities.               |
-----------------------------------------------------------------------------------------------
```

3.4 Sample Flow IV

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
        1. Calculate in Standard Conditions
        2. Calculate Season-Based Conditions
        3. Exit
2

Enter the month for the readings
(January = 1, February = 2, etc.)
8

Please enter the concentration of ground-level ozone:
27

Please enter the concentration of fine particulate matter:
8

Please enter the concentration of nitrogen dioxide:
16.6

AQHI for warm conditions:

-----------------------------------------------------------------------------------------------
| Location  | AQHI      | Health Risk | Health Message                                          |
| Guelph    | 4.00      | Moderate    | No need to modify your outdoor activities.              |
-----------------------------------------------------------------------------------------------
```

3.5 Sample Flow V

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
        1. Calculate in Standard Conditions
        2. Calculate Season-Based Conditions
        3. Exit
2

Enter the month for the readings
(January = 1, February = 2, etc.)
13

Error: invalid option - input must be between 1 and 12. Exiting program...
```

3.6 Sample Flow VI

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
        1. Calculate in Standard Conditions
        2. Calculate Season-Based Conditions
        3. Exit
4

Error: invalid option - input must be between 1 and 3. Exiting program...
```

3.7 Sample Flow VII

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
        1. Calculate in Standard Conditions
        2. Calculate Season-Based Conditions
        3. Exit
3

Thank you for using the Air Quality Index Generator! Exiting program...
```

3.8 Sample Flow VIII

```
Welcome to the Air Quality Index Generator!

Choose your AQHI settings:
       1. Calculate in Standard Conditions
       2. Calculate Season-Based Conditions
       3. Exit
1

Please enter the concentration of ground-level ozone:
200

Please enter the concentration of fine particulate matter:
200

Please enter the concentration of nitrogen dioxide:
200

AQHI for standard conditions:

-------------------------------------------------------------------------------------------------
| Location  | AQHI      | Health Risk | Health Message                                          |
| Guelph    | Above 10  | Very High   | Reduce or reschedule strenuous activities outdoors.     |
-------------------------------------------------------------------------------------------------
```

Program Submission and Administration Information

The following section outlines what is expected when submitting the assignment and various other administration information with respect to the assignment. To submit your assignment, upload a single zip file to the Dropbox box for A1 on Courselink.

4.1 The Submission File

The following is expected for the file that is to be submitted upon completing the assignment:

- You are to submit **one zip file containing one source code file** for your program.
- The name of the **zip file** follows the following format: **studentNumberA1.zip**
  - Example: John Snow's student number is 1770770 then the zip file name is 1770770A1.zip
- The single file within the zip you are to submit is a non-compiled code C file (ends with .c) containing your code
  - Do not include any other files or folders in your submission; they will be ignored.
  - Do not include this file inside another folder; it will be ignored by the auto-grader.
- The name of the **C file** follows the following format: **studentNumberA1.c**
  - Example: John Snow's student number is 1770770 then the C file name is 1770770A1.c
- **Incorrect zip file or C file name will result in a grade of 0.**
- To ensure you zip correctly and in the right format, we require you to zip your submission through the command line using the following command:

  zip studentNumberA1.zip studentNumberA1.c

Make sure to replace studentNumber with your own student number.
You may wish to download your own submission from dropbox, transfer a copy back to the SoCS server and re-test after submission. This way you can be 100% certain you have submitted the correct document.

4.2 Program Expectations

Your program is expected to follow the outlined information exactly. Failure to do so will result in deductions to your assignment grade.

- Your program should be compiled and tested on the SoCS Linux server.
- You must use the following command to compile your code:

  gcc -Wall -std=c99 studentNumberA1.c -lm
  - Example: For John Snow's submission, the command would be:
    gcc -Wall -std=c99 1770770A1.c -lm
- The program file you submit must compile with no errors
  - **Programs that fail to compile will be given a mark of zero.**
- Programs that produce warnings upon compilation will receive a deduction of 1 mark for each type/category of warning
- The program file must contain instructions for the TA on how to compile and run your program in a file header comment (see 3.3 File Header Comment Format).

4.3 File Header Comment Format

Note: This sample uses the same John Snow example; the file name, student name, student ID, etc., and file descriptions must be changed per student.

```
/************************** 1770770A1.c **************************

Student Name: John Snow                          Student ID: 1770770

Due Date: Friday, 10th February 2023, at 11:59 pm   Course Name: CIS*1500

I have exclusive control over this submission via my password.

By including this statement in this header comment, I certify that:

1) I have read and understood the University policy on academic integrity; and

2) I have completed assigned video on academic integrity.

I assert that this work is my own. I have appropriately acknowledged any and all material (code, data, images, ideas or words) that I have used, whether directly quoted or paraphrase. Furthermore, I certify that this assignment was prepared by me specifically for this course.

****************************************************************

This file contains…

Describe the program, functions, important variables, etc.

****************************************************************

The program should be compiled using the following flags:

-std=c99

-Wall

-lm

Compiling:

gcc -Wall -std=c99 1770707A1.c -o A1 -lm

OR

Gcc -Wall -std=c99 1770707A1.c -lm


Running the program:

./A1

OR

./a.out

****************************************************************/
```