C++ Application Development Assignment – 3

Complex Number

Practical Work

By using Microsoft Visual Studio Community 2019, develop an object-oriented console application that will perform calculations on complex number. While you are responsible for the final design of the console application, your program is expected to contain a class called `complexNum` representing a Complex Number ($x + y\mathbf{i}$), where x and y are the real part and the imaginary part of the number respectively, both are of type `double`; and $\mathbf{i}$ is the imaginary unit (which satisfies the equation $\mathbf{i}^2 = -1$ but is not important to this assignment.) Within the class, you are required to write public member function(s) to realise one of the following five tasks. The task to do should be determined by the remainder obtained from dividing your team number by 5. For example, if your team number is SEVEN, 7%5 = 2, and you should do Task 2) of this assignment.

Task:
0) The function performs an addition with another complex number and returns the result as a complex number. For example, if this complex number is 2 + 3$\mathbf{i}$, the complex number to be added is 5 + 7$\mathbf{i}$, the function should return (2+5) + (3+7)$\mathbf{i}$ = 7 + 10$\mathbf{i}$, i.e., a complex number of $x = 7$ and $y = 10$.
1) The function performs a subtraction with another complex number and returns the result as a complex number. For example, if this complex number is 2 + 3$\mathbf{i}$, the complex number to be subtracted is 5 + 7$\mathbf{i}$, the function should return (2−5) + (3−7)$\mathbf{i}$ = −3 − 4$\mathbf{i}$, i.e., a complex number of $x = -3$ and $y = -4$.
2) The function performs a multiplication with another complex number and returns the result as a complex number. For example, if this complex number is 2 + 3$\mathbf{i}$, the complex number to be multiplied is 5 + 7$\mathbf{i}$, the function should return (2×5−3×7) + (3×5+2×7)$\mathbf{i}$ = −11 + 29$\mathbf{i}$, i.e., a complex number of $x = -11$ and $y = 29$.
3) The function performs a division with another complex number and returns the result as a complex number. For example, if this complex number is 2 + 3$\mathbf{i}$, the complex number to be divided is 5 + 7$\mathbf{i}$, the function should return $\left(\frac{2\times5+3\times7}{5^2+7^2}\right) + \left(\frac{3\times5-2\times7}{5^2+7^2}\right)\mathbf{i} = 0.4189 + 0.0135\mathbf{i}$, i.e., a complex number of $x = 0.4189$ and $y = 0.0135$.
4) The function finds the reciprocal of the complex number and returns the result as a complex number. For example, if this complex number is 5 + 7$\mathbf{i}$, the function should return $\left(\frac{5}{5^2+7^2}\right) + \left(\frac{-7}{5^2+7^2}\right)\mathbf{i} = 0.0676 - 0.0946\mathbf{i}$, i.e., a complex number of $x = 0.0676$ and $y = -0.0946$.

In your `complexNum` class, a private member variable `errNumber` should be defined, which is of type `bool` with an initial value of `false`. In ALL of the above tasks, before the member function performs the required operation in the task, it should check that the operand (5 + 7$\mathbf{i}$ in the above examples) is non-zero, i.e., not 0 + 0$\mathbf{i}$; otherwise, `errNumber` should be set to `true` instead of doing the operation. A public member function that reads the value of `errNumber` should be developed.

References:
https://en.wikipedia.org/wiki/Complex_number

- It is required that the class and the implementation of its member functions should be built as a separate static library and linked into the console application.
- Your console application is expected to provide a text-mode user interface so that users can repeatedly display and enter complex numbers (by providing the values of x and y), and do operations for different complex numbers until the user chooses to end the application. Also, all the member functions defined in the class `complexNum` must be tested by this console application.
- Should you want to get a credit, you should design the application such that when a user wants to start it, the user needs to login the application with a username first, which will be checked with the content of a file that stores username-password pairs. If the username is new, the application will ask for a password from the user and store it into that file. If the username can be found in that file, the application will start only if the password is correct. The application will end if the user fails to provide the correct password in three consecutive trials.

- Should you want to get a distinction, you should implement a member function to the class that can compute the square root of the complex number $(x + y\mathbf{i})$, which is $\pm(\gamma + \delta\boldsymbol{i})$,

  where $\gamma = \sqrt{\dfrac{x+\sqrt{x^2+y^2}}{2}}$ and $\delta = \text{sgn}(y)\sqrt{\dfrac{-x+\sqrt{x^2+y^2}}{2}}$

  $\text{sgn}(\cdot)$ is the signum function defined as follows,
  $$\text{sgn}(y) = \begin{cases} -1, \text{if } y < 0 \\ 0, \text{if } y = 0 \\ 1, \text{if } y > 0 \end{cases}$$
  The square root of a real number can be obtained by including the header file `<math.h>`, and call the following library function:

  ```
  double sqrt(double);
  ```

  For example, calling `sqrt(9)` will return the `double` value of 3.

Report

Your report should include:
1. **Abstract**: Summarise the objectives and achievement of your assignment in less than 100 words.
2. **Introduction**: Describe the assignment's objectives and requirements in detail and give a brief account of the methodology.
3. **Methodology**: It contains
   - How your team divides the work among the team members. <u>It will be used as a reference for assessment</u>.
   - The schedule and steps of developing the project
   - The detail of the developed application, including
     - The specifications of the classes defined, and the public/private member functions/variables inside - <u>explain as far as possible why your group makes such choices for the class members</u>
     - The flow of execution. (It is good to include a flow chart to help illustration.)
   - The problems your group encounters, and how your group solves the problems
   - The way to validate your application, i.e., confirm that the solution is correct.
4. **Results**
   - Include the results of executing your program captured from the screen.
5. **Conclusion and further development**
   - Summarize the experience gained in the assignment
   - Indicate how your program can be extended and improved if more time is allowed.

The report should be in PDF format with your class number, team number, student names, student IDs, and task number on the front page. It is <u>NOT</u> required to include the complete source code in the report. Instead, you should zip the folder(s) containing all your project folders and files (including your report file) into a zipped file for submission. (See the General Description below.)

General Description

1. Each team should comprise THREE students. Students must obtain prior approval from the subject lecturer if they want to form a team with fewer or more team members.
2. Unless you get prior approval from your subject lecturer/tutor, you <u>must</u> observe the following:
   - Do NOT use any technique or C++ constructs not taught in the subject
   - Unless mentioned on this instruction sheet, any library function not mentioned in the subject must NOT be used.
3. Each team should upload the zipped file to the Blackboard (under `Groups`, select `File Exchange` after clicking your team number) on or before **<u>27 Nov. 2021</u>**.
4. Ensure your submitted code can be successfully built using Visual Studio Community 2019. The developed application can run in Command Prompt on any PC with Windows 10. <u>Assessment will only be made based on your submitted zipped file.</u> To lower the chance of incomplete submission, you are advised to zip one whole folder that contains <u>all</u> folders and files of the project**s** for this assignment.
5. The documentation for your assignment is important. Your ability to write good comments for the source code will also be an important factor in the final assessment of your assignment.

6. It is compulsory to use a word processing tool to write your report. The font size must not be bigger than 12 or smaller than 10. Use 1.5 lines spacing on both sides of a page. Including all figures and tables, if any, the length of the report should not be shorter than 7 pages.