

Answer *THREE* questions, including question 1 or question 2 (or both).

1. a. Design a C++ function called `bar_graph` which takes an array of integers along with the size of this array and displays a bar graph corresponding to the values passed. The function should use simple characters as graphics. A bar graph is just a drawing consisting of vertical columns where the height of the columns corresponds to the integers provided. For example, if `my_array` is set up as follows,

```
int my_array [] = {2, 5, 4, 10, 3, 3, 7, 0, 1};
```

Then the result of the function call,

```
bar_graph(my_array, 9);
```

should be that the following is displayed on the screen.

```
 *
 *
 *
 *  *
 *  *
* * *
***  *
*****
*****
***** *
```

The first column has height 2, corresponding to the first integer in the array, the second column has height 5, corresponding to the second integer in the array, and so on. You may not assume the existence of any C++ functions other than those you write from scratch, although you may make use of `cout` in the usual way to print on the screen. Your answer should include a full design, and properly commented C++.

[28 marks]

- b. Briefly explain, giving examples where necessary, how you would test the function designed in the first part of the question.

[5 marks]

[Total 33 marks]

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2. Throughout this question you may use the functions `strlen` and `strcpy` but you may not assume that other functions are automatically available to you. You may make use of `cout` in the usual way to print on the screen.

a. Design a C++ class called `Meeting` to represent meetings in a diary. Something of type `Meeting` should store a time of the day in hours and minutes, a location (such as “room 205”), and the meeting’s subject (such as “Examiner’s meeting”). Location and subject can be stored as strings, but their length should be unlimited. The class should include a constructor and a destructor, and the following member functions:

1. `set_time`. This should take the description of a time of day and set the stored time accordingly.
2. `set_location`. This should take the description of a location and set the stored location accordingly.
3. `set_subject` This should take the description of the subject of a meeting and set the stored subject accordingly.
4. `add_time`. This should take two parameters, representing numbers of hours and minutes, and advance the stored time by the specified amount.

[17 marks]

b. Write an overload of `operator<<` which prints out the information stored in something of type `Meeting` in the following form:

```
Meeting in room 205 at 12-30pm. Subject: Examiner's meeting.
```

[8 marks]

c. Write an overload of `operator<` that returns a 1 if the time stored in the `Meeting` on the left hand side of `<` falls before the time stored in the `Meeting` on the right hand side, and returns a 0 otherwise.

[8 marks]

[Total 33 marks]

CONTINUED

3. a. Explain what it means to say that a C++ function is recursive. What are the advantages and disadvantages of the use of recursion? What properties should a recursive function have in order to insure its correct operation?

[7 marks]

- b. Describe in detail, including a pseudo-code description and illustrating your answer with suitable examples, the operation of the bubblesort algorithm.

[8 marks]

- c. Describe in detail, including a pseudo-code description, the operation of the treesort algorithm. Your answer should include as an example a discussion of how the algorithm would sort the numbers 5, 3, 10, 1, 4, 11, 4, 7 into *decreasing* order.

[18 marks]

[Total 33 marks]

4. Write an essay on the subject of copy semantics in C++ programming. Your essay should include, but not be limited to, the definition of the term, an explanation of why copy semantics can be important, and how a C++ program can be made to have copy semantics. Your essay should be illustrated with examples of C++ code.

[Total 33 marks]

5. a. Briefly describe each of the following features of C++ and explain how they are used, including examples of C++ code where necessary: constants, pointers, constructors, operator overloading, templates.

[25 marks]

- b. Explain, including examples, the difference between passing a parameter to a function by value, and passing a parameter to a function by reference. What are the advantages and disadvantages of passing a parameter by reference?

[8 marks]

[Total 33 marks]

END OF PAPER